



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

MODEL FEASIBILITY REPORT

PREPARED BY

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History of Revision

Revision No.	Date	Prepared/Revised by	Description
R00	21 st Aug 2012	R.K.Soni (RKS)	First edition Issued (Draft Report).
R01	22 nd Aug 2012	RKS	Minor Revision (Draft Report).
R02	04 th Dec 2012	RKS	Revised edition submitted based on the discussions held in CEA on 7 th Sep 2012
R03	16 th July 2013	RKS	Revised edition submitted based on the comments of the Task Force received on 14 th May 2013 and the meeting held in CEA on 11 th June 2013.
R04	25 th Sep 2014	RKS	Revised to incorporate left out comments
R05	15 th Jan 2016	RKS	Clause 6.4.12 revised to include 'Possibility of Automatic Switching'

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BACKGROUND

What is R&M (Renovation & Modernization) of Thermal Power Plants?

Coal based power stations contribute more than 70% share of total power generation in India. Thermal Power Stations are designed for an economical and stable life span of 25 years, after which, the level of performance starts deteriorating as a result of degradation of its equipments, components and materials. Deterioration in performance can also take place before the completion of useful life of 25 years, if the units are not properly operated and maintained. Deterioration in performance is reflected in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. This results in costly repair and loss of revenue. Renovations & Modernization (R&M) and Life Extension (LE) programme of thermal power station is an activity of carrying out repairs, refurbishments and replacement of defective equipments & components so as to extend the life of the power plant by at least 20 years and to restore the performance parameters to equal or better than the original design parameters.

Need of R&M

In spite of new capacity additions, India continues to face shortages of varying degree in the supply of energy and peaking power. Implementation of fresh capacity additions for bridging the demand supply gap involves huge investments and long gestation periods primarily due to the process of land acquisition and getting the required fuel and water allocations, permits & clearances, particularly, the environmental clearance.

On the other hand, R&M activity of existing old power plants which requires less investment and can be completed in shorter duration has been recognized as a techno-economically viable option to supplement the fresh capacity addition for maximizing the energy generation. Also it helps in reducing the emissions by adopting upgraded modern technologies.

Objectives of R&M and R&M/LE Programme

As per the Guidelines issued by Central Electricity Authority (CEA) the following should be the objectives of R&M and R&M/LE Programmes.

Objectives of R&M Programme:

- To restore rated capacity and design parameters such as Heat Rate, Auxiliary Power Consumption and Secondary Oil Consumption etc.
- To make the operating units well equipped with modified/ augmented latest technology.
- To overcome technological obsolescence and non-availability of spares.
- To improve the performance parameters in terms of Plant Load Factor, Efficiency, Forced Outages, Availability and Reliability.

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- To reduce maintenance requirements and enhance the ease in maintenance.
- Compliance of stringent environmental norms, safety and other statutory requirements.

Objectives of R&M/LE Programme:

- Extension of useful economic life of generating units by another 20 years.
- To focus on full load operation of the unit beyond their original design life.
- To restore rated capacity and design parameters such as heat rate,
- Improvement in Auxiliary Power Consumption Secondary Oil Consumption etc
- Up-rating of Generating Unit.
- Improvement beyond design parameters.

Criteria for the Consideration of R&M and R&M/LE Programmes

As per the Guidelines issued by Central Electricity Authority (CEA) the following criteria is to be adopted for considering the R&M and R&M/LE Programmes.

- Estimated cost of unit for complete R&M/ LE works should be limited to 50% of cost of new unit.
- Cost of Main Plant (BTG) should be limited to 50% cost of new BTG unit.
- Plant Life should be extended by about 20 years.
- The Pay Back Period should be from 5 to 7 years.

Need of Preparation of Model R&M Documents

The countrywide R&M programme was first initiated in 1980 when Government of India approved the scheme of Central Loan Assistance (CLA) of Rs. 500 crores benefitting 34 power stations mostly of 50/60/100/110/120/140 MW capacities. R&M in a structured manner was initiated as a centrally sponsored programme during the 7th Five Year Plan. The momentum of carrying out R&M works was continued through 8th and 9th Plans but the same could not be sustained during the 10th Plan.

Based on the discussions held with Ministry of Power, various utilities, PFC and BHEL, CEA prepared a document on “National Perspective Plan for Renovation & Modernization and Life Extension and Up-rating (LE&U) of thermal power stations up to the year 2016-17”. This document which also includes revised guidelines for Renovation & Modernization / Life Extension works on coal/lignite based thermal power stations was released by Honourable Minister of Power on 14th December 2009. Plan-wise Achievements of R&M and R&M/LE Programmes starting from 7th Five Year Plan till 11th Five Year Plan is furnished below:

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Feasibility Report For R&M of Unit No.[..]Capacity [..]of [Name of the Power Plant]	[Logo of Utility]
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Plan–Wise Achievements

S.No.	Plan	Year	No. of TPS / No. of Units	Capacity (MW)	Additional Generation Achieved MU/ Annum	Equivalent MW
1	7 th Plan and Two Annual Plans	85-86 to 89-90 & 90-91, 91-92	34 / 163	13570	10000	2000
2	8 th Plan (R&M) (LEP)	92-93 to 96-97	44 / 198 43/(194) 1/ (4)	20869 (20569) (300)	5085	763
3	9 th Plan (R&M) (LEP)	97-98 to 2001-02	37 / 152 29/ (127) 8/ (25)	18991 (17306) (1685)	14500	2200
4	10 th Plan (R&M) (LEP)	2002-03 to 2006-07	9/ 25 (14 out of 57 planned) (11 out of 106)	3445 (2460) (985)	2000	300

11th Plan R&M Programme & Achievements (2007-12)

	Programme (MW)	Achievement (MW)
Life Extension Programme (LEP)	7318 (53 units)	1291 (13 Units)
R&M Programme	18965 (76 units)	14855 (59 units)
Total	26383 (129 units)	16146 (72 units)

In the past, R&M measures were hampered due to lack of proper planning. Proper investigation to identify the R&M works to be carried out and preparation of technical bid documents based on the investigation was not done. This resulted in unsystematic and additional work during execution phase and uncertainty about costs resulting in excessive implementation time, long shutdown periods of plants and cost overruns. In the absence of standard commercial rules and policies, suppliers showed little interest in R&M work. Therefore a strong need was felt for providing standardized bidding procedures as well as model contracts, formats and specifications etc. to the utilities. Standardization will harmonize the requirements of all the stakeholders and will lead to their increased participation.

The Indo-German Energy Forum (IGEF)

The Indo-German Energy Forum (IGEF), inaugurated in 2006, provides a platform to discuss energy related issues of mutual interest. The first meeting of the ad-hoc sub-group on “energy

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efficiency in thermal power stations”, constituted as per decision of meeting of IGEF in December 2007, was held under the chairmanship of Joint Secretary (Thermal), Ministry of Power on 12th March, 2008 in which preparation of standard tendering document for the purpose of R&M activities was, inter-alia, identified as an area of the activities. The scope of the assignment was divided in two parts as under:-

Phase-I Activity:

Phase-I activity comprised an assessment of tendering procedures currently being followed by public utilities in India and a review of documents used for standard R&M projects and the documents which have already been developed for energy efficient R&M projects financed by particularly World Bank. This activity was carried out by M/s Evonik (India) under the grant provided by GTZ. M/s Evonik (India) submitted the report in September 2009.

Phase-II Activity

Phase-II activity comprised the preparation of the model documents / templates in consultation with Task Force, power utilities & financing agencies.

In the 3rd meeting of Indo-German Energy Forum (IGEF) convened in Berlin on 4th November 2009, KfW proposed to finance and carryout the work programme of phase-II Activity, on behalf of CEA & in consultation with the Task Force. In a meeting held in MOP on 17th December 2009, chaired by Joint Secretary (Thermal), MOP, the representative of KfW suggested that CEA may act as “Project Executing Agency” for the phase-II activity. Accordingly Ministry of Power, Govt. of India have entrusted the task of “Project Executing Agency” to CEA for implementing Phase-II activity. Under Indo-German Energy Forum (IGEF) assisted programme, M/s Lahmeyer International (India) was appointed on 16th March 2012 to provide the consultancy services for ‘Development of tendering procedures and model contract document for R&M of Fossil Fuel Based Power Plants in India.’ The scope of consultancy services included the preparation of the following model documents:

- I) Standard Bidding Procedure for engagement of Consultants and R&M Works Contractor.
- II) Residual Life Assessment (RLA) / Condition Assessment (CA) Report.
- III) Energy Audit (EA) Report.
- IV) Feasibility Report.
- V) Detailed Project Report.
- VI) Request for Qualification (RFQ) & (RFP) Documents for R&M Consultants and R&M Contractors.
- VII) Technical Specifications.

Due Diligence done by LII of the R&M Documents of other Projects

Before the preparation of this model document, LII did a thorough review of the R&M Documents of the following Power Plants:

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Documents Provided by CEA

- Remaining Life Assessment / Condition Assessment Report- Nasik Unit-3 of MAHAGENCO.
- Energy Audit Report- Nasik Unit- 3 of MAHAGENCO.
- Detailed Feasibility Report- Nasik Unit-3 of MAHAGENCO.
- Draft Detailed Project Report -Kolaghat Unit-3 of WBPDC.
- Service Contract- R&M of Unit-1 Panipat TPS of HPGCL.
- Tender document for Supply, Erection, Testing and Commissioning of Air Preheater for Unit 5 & 6 Koradi TPS, MAHAGENCO.
- Tender document for replacement of 6.6 KV station transformer incoming breaker & Tie-breaker of Koradi TPS, MAHAGENCO.
- Tender specification for Design, Engineering, Supply, Erection, Testing and Commissioning of Rotary Air Preheater for Units 4 & 5, Nasik TPS of MAHAGENCO.

Documents Provided by WBPDC

- Energy Audit Report of Bandel Unit -5 (210 MW) of WBPDC.
- Detailed Project Report of Bandel Unit -5 (210 MW) of WBPDC.
- Project Design Report of Bandel Unit -5 (210 MW) of WBPDC.
- Technical Specifications. (Vol. II of RFP Document for R&M Contractor).
- RLA for Boiler for Bandel Unit -5.
- RFP for R&M Consultant for Bandel Unit -5.
- Commercial Volume-I of RFP for Bandel Unit -5 for R&M Contractor.

KfW Documents

- Model Contract Document issued by KfW.
- Guidelines issued by KfW for the assignment of Consultants.

World Bank Documents

- Standard Bidding Document for Procurement of Plant, Design, Supply and Installation.
- Standard Request for Proposal for the Selection of Consultants

This Feasibility Report has been prepared to conceptualize the systematic methods and procedures to be implemented for carrying out R&M works for the Thermal Power Plants, taking into account the different practices followed in the past, the practices and methodologies being adopted by KfW and World Bank, as indicated in the various documents indicated above. Detailed standard documents like DPR, RFP & RFQ documents to carry out R&M works for the Thermal Power Plants shall be prepared based on this Feasibility Report.

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GUIDELINES FOR USING THE MODEL FEASIBILITY REPORT

Central Electricity Authority (CEA), the Project Executing Agency / Employer has appointed Lahmeyer International India Pvt. Ltd. (LII), the Consultant to Develop Standard Procedures and Model Documents for the Renovation and Modernization (R&M) of Fossil Fuel based Power Plants in India. The above assignment is being financed by KfW Entwicklungsbank. Accordingly, this Model Feasibility Report has been prepared for the guidance of Project Authorities who may decide to carryout R&M of their old Coal based Power Plants so as to extend the life of their plants and make them energy efficient and reduce emissions.

The purpose of this model document is to standardize the format of the Feasibility Report for R&M works. Since majority of 200/210 MW units are potential candidates for consideration of Renovation as they have crossed 20 to 25 years of useful life, the enclosed format has been prepared keeping those 200 MW/210 MW units in view. Since in due course of time, many 500 MW units will also become due for R&M, the Utilities are advised to suitably modify this document for its application to 500 MW units.

The format of Feasibility Report contains two kinds of texts written in black and in blue colours. The text in blue italics and enclosed in square bracket ([...]) represents variable information which may differ from project to project. The text and numbers in blue colour are written for the sake of citing an example. The Utilities and their Consultants are advised to check the relevance of the same and replace these texts and numbers with the ones as may be applicable to their specific Project. A few guidelines have also been provided in blue italics enclosed within red curly brackets ({...}), wherever applicable.

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ABBREVIATIONS TO BE USED

{The utilities are advised to use the following standard abbreviations while preparing Feasibility Report for their power plant.}

AAQ	Ambient Air Quality
ACB	Air Circuit Breaker
ACG	Automatic Control Gear
AHP	Ash Handling Plant
AHU	Air Handling Unit
ANSI	American National Standard Institute
ASME	American Society of Mechanical Engineers
ATRS	Automatic Turbine Run up System
ATT	Automatic Turbine Testing
AVR	Automatic Voltage Regulator
BAS	Boiler Auxiliary Steam
BFD	Boiler Feed Pump Discharge
BFP	Boiler Feed Water Pump
BMCR	Boiler Maximum Continuous Rating
BOP	Balance of Plant
CAVT	Cold Air Velocity Air Flow Test
CBD	Continuous Blow Down
CCTV	Closed Circuit Television
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CEMS	Continuous Emission Monitoring System
CER	Certified Emission Reduction
CERC	Central Electricity Regulatory Commission
CHP	Coal Handling Plant

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CRH	Cold Re-Heat
CLCS	Closed Loop Control System
COC	Cycle of Concentration
COG	Cost of Generation
CT	Cooling Tower
CV	Control Valve
CW	Cooling Water
CWIP	Capitalized Work in Progress
DCDB	Direct Current Distribution Board
DDCMIS	Digital Distributed Control Monitoring Information System
DG	Diesel Generator
DGA	Dissolved Gas Analyzer
DM	Demineralization
DMCW	Demineralised Cooling Water
DP	Differential Pressure
ECO	Economizer
EEP	Energy Efficiency Programme
EHC	Electro-Hydraulic Control
ELCID	Electromagnetic Core Imperfection Detection
EOT	Electrically Operated Travelling Crane
ESP	Electro Static Precipitator
ESV	Emergency Stop Valve
ETP	Effluent Treatment Plant
EWS	Engineer's Work Station
FO	Fuel Oil
FSSS	Furnace Safeguard Supervisory System
GC	Gland Condenser

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GCV	Gross Calorific Value
GT	Generator Transformer
HART	Highway Addressable Remote Transducer
HCA	Host Country Approval
HEA	High Energy Pulsed Arc
HMI	Human Machine Interface
HP	High Pressure
HRH	Hot Re-Heat
HT	High Tension
HVAC	Heating, Ventilation and Air Conditioning
HVWS	High Velocity Water Spray System
IBD	Intermittent Blow Down
ICB	International Competitive Bidding
IFI	International Financing Institution
IGV	Inlet Guide Vane
I/O	Input / Output
IPT	Intermediate Pressure Turbine
IPR	Inter Posing Relay
IRR	Internal Rate of Return
ISMB	Indian Standard Medium Beam
IV	Interceptive Valve
LCP	Local Control Panel
LDO	Light Diesel Oil
LE	Life Extension
LMZ	Leningradsky Metallichesky Zavod
LP	Low Pressure
LPA	Loss Prevention Association of India
LPT	Low Pressure Turbine

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LRSB	Long Retractable Soot Blower
LT	Low Tension
LTSH	Low Temperature Super Heater
LVS	Large Video Screen
MCCB	Module Case Circuit Breaker
MOCB	Minimum Oil Circuit Breaker
MoEF	Ministry of Environment & Forest
MS	Main Steam
MSSV	Main Stream Safety Valve
OPC	Object linked embedded Process Control
OWS	Operator Working Station
PA	Primary Air
PCN	Project Concept Note
PDD	Project Design Document
PLF	Plant Load Factor
PRDS	Pressure Reducing De-superheating Station
PLC	Programmable Logic Controller
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RH	Reheater
RLA	Residual Life Assessment
RO	Reverse Osmosis
RSO	Recurrent Surge Oscillograph
RTD	Resistance Temperature Detector
SADC	Secondary Air Damper Control
SH	Super Heater
SWAS	Steam and Water Analysis System

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TDH	Total Dynamic Head
TFT	Thin Film Transistor (Monitor)
TMCR	Turbine Maximum Continuous Rating
TPS	Thermal Power Station
TR	Tons of Refrigeration
TAC	Tariff Advisory Committee
TC	Thermocouple
TSE	Turbine Stress Evaluator
TSI	Turbine Supervisory Instruments
UCR	Unit Control Room
UPS	Uninterruptible Power Supply
VVVF	Variable Voltage and Variable Frequency Drive
WACC	Weighted Average Cost of Capital

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MEASUREMENT UNITS

{The utilities are advised to use the following abbreviations for the measurement units while preparing Feasibility Report for their power plant.}

°C	:	Degree Celsius
cm ²	:	Square Centimeter
dB (A)	:	Decibels Absolute
hr	:	Hour
Hz	:	Hertz
kCal	:	Kilo Calorie
kg	:	Kilogram
kl	:	Kilo Liter
km	:	kilo meter
kV	:	kilo Volt
kVA	:	kilo Volt Ampere
kW	:	kilo Watt
kWh	:	Kilo Watt hour
m	:	Meter
m ²	:	Square Meter
m ³	:	cubic meter
mg	:	Milligram
MJ	:	Millions of Joule
mm	:	Millimeter
cm	:	centimeter
MVA	:	Mega Volt Ampere
MW	:	Mega Watt
ppm	:	Parts per million
rpm	:	Revolutions per minute

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TPH / T/hr	:	Tonnes Per Hour
mg/Nm ³	:	Milligram per Normal cubic meter
µg/m ³	:	Micrograms per cubic meter

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1 EXECUTIVE SUMMARY

This Feasibility Report has been prepared for carrying out the Renovation & Modernization (R&M)/ Life Extension (LE) of Unit No... ofThermal Power Plant, located at [...], in District [...] in the State of [...] and having a configuration of [...x...MW].

The unit no. [...] was first commissioned in the year [...]. After [...] years of operation, the performance of the unit has gradually deteriorated resulting in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. It is proposed to carry out required refurbishments and replacements in the plant so as to restore the unit's performance parameters and to extend its life of by at least [...] years.

The report discusses the salient features and operational history of the power plant and also the specific problems being faced from the operation of various plant equipment & systems.

To determine the residual life of critical components of the plant, various studies namely the Residual Life Assessment (RLA), Condition Assessment (CA) and Energy Audit have been conducted during the period [...]. Based on the recommendations of RLA/CA & EA Studies, review of the performance data and discussions with the plant engineers, [five R&M options] were formulated by the R&M Consultant.

Estimated cost for each option was worked out after taking into account the scope of R&M measures to be implemented for each option. Cost Benefit analysis of each option was then performed. After cost-benefit analysis of [Five] options, the most attractive option has been identified for implementation of the R&M Project.

The cost of the R&M Project is estimated as [Rs.....Crores]. The Payback Period is estimated as [.....Years]. The R&M activity is expected to bring out the improvements as indicated in the following table:

Improvements Expected after R&M of the Unit

S.No.	Parameters	Units	Before R&M	After R&M
1.	Residual Plant Life	Years	[.....]	[.....]
2.	Capacity	MW	[.....]	[.....]
3.	Plant Load Factor	%	[.....]	[.....]

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S.No.	Parameters	Units	Before R&M	After R&M
4.	Heat Rate	kCal/ kWh	[.....]	[.....]
5.	Auxiliary Power Consumption	%	[.....]	[.....]
6.	Specific Oil Consumption	ml/kWh	[.....]	[.....]
7	Specific Coal Consumption	kg/kWh	[.....]	[.....]
8.	Emission of Solid Particulate Matter	mg/Nm ³	[.....]	[.....]
9.	SOx- (Ground Level Concentration)	µg/m ³	[.....]	[.....]
10.	NOx- (Ground Level Concentration)	µg/m ³	[.....]	[.....]
11.	Noise Level during day time at plant boundary.	dB (A)	[.....]	[.....]
12	Noise Level during night time at plant boundary	dB (A)	[.....]	[.....]

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2 INTRODUCTION

2.1 Description

The Power Plant, having a configuration of [...x...MW] is located at [...], in District [...] in the state of [...].The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The consumptive water for the unit is being sourced from [...]. The primary fuel [coal / lignite] for the unit is being sourced from [...]. The boiler for the unit is of [PF/CFBC] design. The boiler is provided with [front & rear/ corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [... substation]. The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [.....&.....] coal mines. The consumptive water for the power plant is being sourced from [.....river/.....sea].

2.2 Operational Background

After the first commissioning during the year [...], the unit was giving a stable operation with [... MW] of Gross Power Output at an average PLF of [... %] and a Gross Heat Rate of [...kCal/kWh]. The Auxiliary Power Consumption after the first commissioning was [...%]. [Based upon the recommendations of RLA / CA and EA Studies conducted during the year major replacements were made during the year..... comprising.....and]. The unit is presently performing with a maximum Gross Power Output of [... MW] with an average PLF of [...%] and a Gross Heat Rate of [...kCal/kWh]. The present Auxiliary Power Consumption is [...%].

2.3 Objective of the Feasibility Study

The feasibility study has been carried out to establish the cost effectiveness of the proposal for taking up R&M measures to improve the efficiency and performance parameters of the plant and to extend its life. During the course of feasibility study, the following sub-studies were carried out.

- Cold Walk-down and Hot Walk-down Survey.
- Discussion with the Plant Engineers.
- Review of the operational history of the power plant, reports of Condition Assessment (CA) and Residual Life Assessment (RLA) studies carried out earlier and major replacements done in the past, prior to taking up this study.
- Review of reports of Condition assessment (CA) and Residual Life Assessment (RLA) of major equipment and systems of the power plant carried out recently.
- Review of reports of Energy Audit of main equipments and auxiliary systems carried out recently to identify the reasons and sources of excess power consumption.

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- f. Review of recommendations of R&M Consultant for carrying out R&M measures for increasing the useful life, efficiency and output of the plant as well as for meeting the latest environment standards prescribed by the regulating agencies at the national and state level.
- g. Study of the financial impact of the R&M Measures proposed.
- h. Financial analysis based on internal rate of return and cost benefit ratio.

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3 SALIENT FEATURES OF POWER PLANT

{Describe in this chapter, the Design Parameters and Salient Features of all the important Equipment and Systems of the Power Plant as mentioned below}

3.1 Boiler & Auxiliaries

a) Boiler

[The Steam Generator is of natural circulation, pulverized fuel fired, dry bottom, balanced draft using direct firing system. The design parameters of the Boiler are furnished below]

Description	Units	Design Parameters
Steam Flow at Final SH outlet	T / hr	[....]
Steam Pressure at SH outlet	kg/cm ²	[....]
Steam Temperature at SH outlet	°C	[....]
Re-heater Flow	T / hr	[....]
Steam Pressure at RH outlet	kg/cm ²	[....]
Steam Temperature at RH outlet	°C	[....]
Feed Water Flow	T / hr	[....]
Feed Water Pressure at inlet of Economiser	kg/cm ²	[....]
Feed Water Temperature at inlet of Economiser.	°C	[....]

b) Furnace

[The boiler is equipped with a water cooled furnace of balanced draft and fusion welded membrane wall construction. It is equipped with.....numbers of coal burners and.....numbers of oil burners located at numbers of elevations. The design parameters of the Furnace are furnished below.]

Description	Units	Design Parameters
Type of Firing	[.....]
Combustion Chamber Volume	m ³	[.....]

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Description	Units	Design Parameters
Furnace Dimensions (Width x Depth x Height)	m	[.....]
Heating Surface Areas		[.....]
i) Water Walls	m ²	[.....]
ii) Superheaters	m ²	[.....]
iii) Reheaters	m ²	[.....]
iv) Economiser	m ²	[.....]
v) Air Heater	m ²	[.....]
vi) Steam Coil Air Heater	m ²	[.....]
vii) Temperature Measurement of Super-heater tubes	Yes / No	[.....]
viii) Temperature Measurement of Re-heater tubes	Yes / No	[.....]

c) Super Heaters and Re-Heater

[The super heaters are composed of four sections, a platen section, a pendant section, a rear low temperature section and a steam cooled wall & roof section. The Re-heater consists of two sections, the front pendant and the rear pendant sections. The details are given below:]

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Low Temperature Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]

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Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Platen Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Pendant Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Ceiling and Enclosure Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Front Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Rear Assembly	[.....]	[.....]	[.....]	[.....]	[.....]

d) **Economiser**

[The Economizer is of a single stage, continuous finned tube and horizontal, mixed flow type, located in the second pass of the boiler]

e) **Air Pre-Heater**

[The air pre-heater is of regenerative rotary type. Special sealing arrangements have been provided in the air pre-heater to prevent leakage between air and gas sides. Adjustable sector plates have also been provided to prevent the leakage during expansion. The heating surfaces of the air pre-heater have been provided with two types of cleaning systems, soot blowing and water washing system.]

f) **Raw Coal Bunkers**

[Each boiler is provided with [...] raw coal bunkers. The total capacity of the bunkers is to meet [...] hour's requirement at maximum mills capacity of the unit. The upper portion of the bunkers is of cylindrical shape made of carbon steel plate, while the conical portion is made of stainless steel plate. Each outlet of the bunker is provided with an isolation gate which is motor operated. In addition to the isolation gates, rod gates have been provided to control the flow of coal from the bunkers]

g) **Raw Coal Feeders**

[One gravimetric type of raw coal feeder has been provided for each coal mill. The coal feeders have been provided with micro-processor based controls with variable frequency drive. The feeders have been provided with dual independently measuring

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load cells. All parts of the feeders coming in contact with coal, except the belt, are made of stainless steel]

h) Fuel Firing System

[The boiler is working on a direct firing system. The pulverized coal is being dried and transported to the coal burners by means of hot primary air being supplied by two primary air fans. The boiler is having [front and rear/corner/down shot] firing system. There are [...] pulverized coal burners and [...] oil burners. The burners are located at [...] floors.

i) Coal Mills

[The unit is provided with numbers of BHEL make XRP-783 bowl type mills, out of which mills are designed to work with designed coal andnumbers of mills are standby . The rated capacity of each mill isT/hr.]

Description	Units	Design Parameters
Make and Model of Mills	.....	[...]
Capacity of Mills	T/hr	[...]
Total Number of Mills per boiler	Nos.	[...]
Number of Mills to work per boiler with design coal quality	Nos.	[...]
Motor Rating	kW	[...]

j) Primary Air Fans

[Two Primary Air (PA) Fans have been provided for each boiler. Each PA Fan is designed to meet 60% MCR condition of the boiler. The PA Fans are Hot PA Fans. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Hot Air	°C	[...]

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Description	Units	Design Parameters
Motor Rating	kW	[...]
Method of Regulation	[...]

k) **Forced Draft Fans**

[Two Forced Draft (FD) Fans have been provided for each boiler. Each FD Fan is designed to meet 60% MCR condition of the boiler. The FD Fans supply combustion air to the boiler, mill air through PA Fans and tempering air to control the classifier temperature of the mills. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Air	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]

l) **Induced Draft Fans**

[Two Induced Draft (ID) Fans have been provided for each boiler. Each ID Fan is designed to meet 60% MCR condition of the boiler. Each ID Fan evacuates flue gases through two parallel paths of ESP and discharge them into stack through separate ducting. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	[...]
Number of Fans per Boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]

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Description	Units	Design Parameters
Temperature of Flue Gases	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]

m) **Wall Blowers and Long Retractable Soot Blowers (LRSBs)**

[Adequate number of Wall Blowers and Long Retractable Soot Blowers (LRSBs) are being used for cleaning the soot deposited on the heating surfaces of the water walls and super heaters respectively. Automatic sequential soot blowing system has been provided. Details are given below:]

Description	Units	Design Parameters
Wall Blowers		
Make and Model of Wall Blowers	....	[...]
No. of Wall Blowers per boiler at water walls	Nos.	[...]
Medium of soot blowing at water walls	....	[...]
LRSBs		
Make and Model of LRSBs	.....	[...]
No. of LRSBs per boiler at pendant surfaces of pressure parts	Nos.	[...]
Medium of soot blowing at pendant surfaces of pressure parts	.....	[...]
No. of LRSBs per boiler at convection pass tube banks	Nos.	[...]
Medium of soot blowing at convection pass tube banks	.....	[...]

n) **ESP**

[An Electrostatic Precipitator (ESP) has been installed on the cold end side of the Air Pre-heater to remove the particulate matter from the flue gases. The ESP has been

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provided with Gas Distribution System, Collecting Electrodes, Discharge Electrodes, Transformer Rectifier Sets and [electrically/mechanically] operated rapping system. The hoppers of ESP have been provided with capacitance type level indicators and thermostatically controlled heating elements. Details are given below:]

Description	Units	Design Parameters
Make and Model of ESP	.....	[....]
Number of Passes per ESP	Nos.	[....]
Number of fields per pass	Nos.	[....]
Dust concentration at outlet	mg/Nm ³	[....]
Type of Control	.....	[....]
Gas Velocity in ESP	m/sec	[....]
Specific Collection Area	m ² /m ³ /sec	[....]
Aspect Ratio	.....	[....]
Particle Migration Velocity	cm/sec	[....]
Plate Area/TR Set	m ² /TR Set	[....]
Storage Capacity of ESP Hoppers	hrs	[....]
Pressure Drop	mmwc	[....]
Dust Collection Efficiency with (N-1) fields in operation	%	[....]

3.2

Turbine & Auxiliaries

a) Steam Turbine

[The steam turbine is of three cylinder, 3000rpm, tandem compound, condensing type designed to operate on a re-heat and re-generative feed water cycle. The LP stage of turbine is designed with Bauman exhaust. The turbine is provided with HP/LP bypass system of 60% capacity of Steam Generator MCR. The turbine is provided with an electro - hydraulic control system, automatic turbine run up system and turbo supervisory instrumentation. The condensing system consists of a surface condenser of single shell and two pass, divided water box construction. Cooling water being supplied to the condenser is of raw water/ clarified water quality. The design parameters of the steam turbine are furnished below]

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Description	Units	Design Parameters
Pressure of Steam at inlet of ESV of HPT	kg/cm ²	[...]
Temperature of Steam at inlet of ESV of HPT	⁰ C	[...]
Pressure of Cold Reheat (CRH) Steam	kg/cm ²	[...]
Temperature of Cold Reheat (CRH) Steam	⁰ C	[...]
Pressure of Hot Reheat (HRH) Steam	kg/cm ²	[...]
Temperature of Hot Reheat (HRH) Steam	⁰ C	[...]
Pressure at the inlet of LP Turbine	kg/cm ²	[...]
Temperature at the inlet of LP Turbine	⁰ C	[...]

b) Condenser

[The condenser is a [single/twin] shell, horizontal, surface type with integral air cooling section designed to maintain a pressure of 76 mm of Hg at turbine exhaust with a cooling water temperature of [...] deg C and an outlet temp of [...] deg C. The condenser is capable of operation with [...] % tubes plugged and has hot well storage capacity of [...] minutes.]

Description	Units	Design Parameters
Make and Model	.....	[...]
Type of Condenser	.....	[...]
Total Cooling Surface	m ²	[...]
Number of Cooling Water Tubes	.....	[...]
Material of Tubes	.....	[...]
Diameter and thickness of tubes	mm	[...]
Cooling Water Quantity through Condenser	m ³ /h	[...]
Cooling Water Temperature at the inlet to Condenser	⁰ C	[...]

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Description	Units	Design Parameters
Condenser Vacuum	mm Hg	[...]

c) **Ejectors**

[The Condenser is provided with two quick starting ejectors which operate in parallel to remove large volumes of air for raising the initial vacuum during the starting of the Unit. Two main ejectors of 100% capacity each have been provided remove air and non condensable gases from the condenser to maintain the required vacuum in the condenser during the normal operation of the unit.]

d) **Condensate Extraction Pumps**

[Condensate extraction pumps are of vertical, multistage, centrifugal pumps of cannister type.]

Description	Units	Design Parameters
Make and Model	.....	[...]
Type	.....	[...]
Capacity	m ³ /h	[...]
TDH	mwc	[...]
Speed	rpm	[...]
Motor Rating	kW	[...]

e) **Gland Steam Cooler**

[A Gland Steam Cooler has been provided to condensate the leak-off steam from intermediate chambers of end sealings of HP and IP turbine, thereby heating the main condensate water. The Gland Steam Cooler consists of shell, tube bundle and removable water box.]

f) **LP Heaters and Drain Coolers**

[Each steam turbine is provided with four numbers of low pressure heaters to increase the temperature of the condensate in stages. LP Heater -1 consists of two halves and is installed in neck of the condenser. The remaining LP Heaters are of shell and tube design and have been placed vertically. An integral drain cooling section is provided in each LP Heater. The design details of LP Heaters are furnished in the table below.]

Heater No.	1	2	3	4
Extraction	[...] stage of IP	[...] stage of	[...] stage of	[...] stage of

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Steam taken from	turbine	IP turbine	IP turbine	IP turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]	[...]

g) **Deaerator**

[The deaerator is of [horizontal spray cum tray type]. It is designed to remove dissolved oxygen from the condensate in excess of 0.005 cc per liter. The feed water storage tank has a capacity of [...] minutes feed water requirement of the boiler corresponding to TMCR Heat Balance]

h) **Boiler Feed Pumps**

[The boiler feed pumps are horizontal, multi stage centrifugal pumps of barrel type, motor driven pumps taking the suction from the deaerator. The boiler feed pumps discharge feed water through HP heaters to the economizer of the boiler.]

Description	Units	Design Parameters
Make and Model	.....	[...]
Type	.....	[...]
No of stages	Nos.	[...]
Capacity	m ³ /h	[...]
Head	mwc	[...]
Feed water temp	°C	[...]
Gland sealing arrangement	[...]
Minimum flow	m ³ /h	[...]
NPSH required at design condition	mwc	[...]

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Description	Units	Design Parameters
Method of Speed Regulation	[...]
Type of Coupling	[...]
Motor Rating	kW	[...]

i) **HP Heaters**

[Each steam turbine is provided with three numbers of high pressure heaters to increase the temperature of the feed water in stages. The Heaters are of shell and tube design and have been placed vertically. The design details of HP Heaters are furnished in the table below.]

Heater No.	1	2	3
Extraction Steam taken from	[...] stage of HP turbine	[...] stage of HP turbine	[...] stage of HP turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]

j) **HP/ LP Bypass**

[HP/LP bypass system has a capacity of 60% of BMCR (Boiler Maximum Continuous Rating). HP bypass system has been provided between the Main Steam Line and Cold Reheat Line. LP bypass system has been provided between the Hot Reheat Line and the Condenser. HP bypass water spray has been taken from the discharge of Boiler Feed Pumps. LP bypass water spray has been provided from the discharge of Condensate Extraction Pumps.]

k) **Turbine Governing System**

[The turbine is equipped with a electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. The system is designed to sustain full load dump from the generator. The system is provided with a quick closing Emergency Stop Valve (ESV), to interrupt the supply of steam from the boiler and stop the turbine under emergency conditions. The turbine governing system includes, speed governor,]

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l) **Lube Oil System**

[The lube oil system consists of Main Oil Tank, Turbine driven main oil pump, AC driven bearing oil pump, DC driven emergency oil pump, AC driven jacking oil pump and oil coolers of 3x50% capacity, Lube oil is being purified by means of a centrifuge. Oil storage tanks consisting of Clean Oil Tank and Dirty Oil Tank have been provided.]

m) **Turbine Gland Sealing System**

[Turbine Gland Sealing System consists of gland steam condenser, gland steam exhauster, all associated motors, associated piping, valves & fittings, strainers / filters etc]

3.3

Electrical System

a) Generator

[The Generator is a 15.75 kV, 50 Hz, 0.85 power factor machine, operating at 3000 rpm, with.....type of excitation system and digital programmable voltage regulator. The Generator has direct water cooled stator winding and direct hydrogen cooled rotor winding. The stator winding cooling water is cooled in a closed cycle cooling system using DM water, while the hydrogen in the machine is cooled in gas to water hydrogen coolers mounted inside the machine. The Parameters of the Generator are briefly mentioned below.]

Description	Units	Design Parameters
Rated MW Capacity	MW	[...]
Rated MVA Capacity	MVA	[...]
Rated Terminal Voltage	kV	[...]
Rated Power Factor	.....	[...]
Rated Stator Current	kA	[...]
Rated Speed	rpm	[...]
Rated Frequency	Hz	[...]
Efficiency at Rated Power Output and Rated Power Factor	%	[...]
Excitation Current	kA	[...]

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Description	Units	Design Parameters
Excitation Voltage at Rated Power Output and Rated Power Factor	kV	[...]
Short Circuit Ratio	.....	[...]
Rated Hydrogen Pressure	kg/cm ²	[...]
Negative Sequence Current	Amp	[...]
Phase Connection	.....	[...]
Type of Excitation	.....	[...]
Method of Cooling the Rotor	.....	[...]
Method of Cooling the Stator	.....	[...]

b) Station Transformer

[Two Station Transformers have been provided to meet the station auxiliary loads of the power plant. The Station Transformers have been provided with on-load tap changers to keep the station 6.6 kV voltage constant. Cooling of this transformer is ONAN/ONAF/OFAF and has 2x50 % separately mounted radiators and 2x50% oil pumps. The Parameters of the Station Transformers are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[...]
Capacity / Rating	MVA	[...]
Voltage Ratio	.....	[...]
Type of Cooling	.....	[...]
Quantity	Nos.	[...]

c) Generator Transformer

[The power output from each Generator is being stepped up to 220/400 kV through a 240 MVA step up Generator Transformer. It has 3x50% coolers and 3x50% oil pumps. The Parameters of the Generator Transformer are briefly mentioned below]

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Description	Units	Design Parameters
Make	[...]
Capacity	MVA	[...]
Voltage Ratio	[...]
Type of Cooling	[...]

d) Unit Auxiliary Transformer

[Two unit auxiliary transformers have been provided for each unit for meeting all unit auxiliary loads. These transformers have been provided on-load tap changers. The Parameters of unit auxiliary transformers are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[...]
Capacity	MVA	[...]
Voltage Ratio	.....	[...]
Type of Cooling	.....	[...]
Quantity	Nos.	[...]

e) Electrical Distribution System

[Unit auxiliaries receive their normal power supplies at 6.6 kV through two (2) nos. unit transformers. For lower size drives, 6.6 kV is further stepped down to 415 V by two (2) nos. unit service transformers. The 415 V distribution system feeds a number of Motor Control Centers (MCCs) for running 415 V drives. 6.6 kV unit switchgears are connected to station switchgear for start up and emergency power supply. The details are mentioned below]

Description	Units	Design Parameters
Voltage Level	kV	[...]
Type of Breaker	[...]
Type of Grounding	[...]

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Type of Protection	[...]
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f) DC System

[Each unit has its own DC system located in the BC bay at ground floor of the Power House. Separate DC systems have been provided in switchgear control room, intake pump house and DM plant for controlling the systems. Each DC system comprises of the Storage Battery, the Battery charger and the distribution boards. The details are mentioned below]

Description	Units	Design Parameters
Make	[...]
Capacity / Rating	[...]
Voltage	V	[...]
Type of Charger	[...]
Area of Application	[...]
Area of Application	[...]

g) Emergency Power Supply System

[Diesel generating sets are installed for meeting the power requirements of essential auxiliaries (viz. jacking oil pumps, AC lube oil pump, hydrogen seal oil pump, float charger for DC battery, emergency lighting, scanner air fan and stator cooling water pump) during total failure of AC Power Supply in the power station. Diesel generating sets are located in the CD bay at the ground floor. The details are mentioned below]

Description	Units	Design Parameters
Make of DG Sets	.....	[...]
Rating of DG Sets	kVA	[...]
Quantity	Nos.	[...]

3.4

Control & Instrumentation

[The existing control and instrumentation system generally is an old analogue based system and requires large scale replacement owing to obsolescence of the existing equipments. Furnace Supervisory Safeguard System (FSSS) is of obsolete design for which, no spares are available. Soot blowers are of manual type. No online Boiler Tube Leakage detection system has been provided. Control system for the existing

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turbine auxiliaries is relay based. Turbine Supervisory system is of electromagnetic type. No continuous monitoring system has been provided for observing the health of the turbine. HP- LP bypass system is in the form of standalone control panel. Integrated microprocessor based closed loop control, open loop control, sequential control and bulk data acquisition system for SG & auxiliaries, TG & auxiliaries, station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level are therefore to be envisaged for the plant.]

3.5

Balance of Plant

a) Coal Handling Plant

[Coal Handling Plant is a common facility which is feeding all the units of the power plant having a total installed capacity of...x....MW. Coal to the power plant is brought through railways by 'Box N' wagons and is unloaded by wagon tipplers. One crusher has been provided for crushing the coal from 250 mm size to 25 mm size. The plant is provided with one stacker reclaimer to stock the crushed coal. The coal stock yard has a storage capacity of 20 days. For feeding the coal to the bunkers of all the units, two streams of conveyors having a capacity ofTPH have been provided. The coal handling plant operates for 16 hrs a day.]

Description	Units	Design Parameters
Track Hopper Size	m	
No. of Wagon Tipplers	Nos.	[....]
Rating of Wagon Tipplers	T/hr	[....]
No. of streams of conveyor	Nos.	[....]
Capacity of each conveyor	T/hr	[....]
Type of Crushers	Nos.	[....]
Number of Crushers	Nos.	[....]
Capacity of Crushers	T/ hr	[....]
No. of Stacker Reclaimers	Nos.	[....]
Stacking Reclaiming Capacity	TPH	[....]
Storage Capacity of Stock Yard	days	[....]

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b) Ash Handling Plant

[Ash Handling System is of continuous type. The bottom ash from the furnace falls into bottom ash hopper having a storage capacity of [...] hrs. The ash is ground to the size [...] mm by the clinker grinders and is removed with the help of submerged Scrapper Chain Conveyors. The ash from the air pre-heater and economizer hoppers is being disposed off along with bottom ash. The ash in the form of ash slurry is conveyed through sluice channels to the ash slurry pump house with the help of high pressure jets, from where, it is pumped to the ash pond located the distance of [...] km. The ash slurry disposal system is having [...] numbers of identical streams of ash slurry pumps connected to [...] numbers of ash slurry pipelines going to the ash pond. Fly ash is collected in dry form below the ESP hoppers and the same is then conveyed by vacuum system to surge hoppers from where it is either conveyed through pressurized system to dry fly ash silos or is sent to ash pond in the form of slurry. From the dry fly ash silos, the ash is disposed off through the covered trucks. The datasheet indicating the particulars of major equipments for hopper ash handling and fly ash handling system is furnished below.]

c) Raw Water System

[The consumptive water for the plant is sourced from [...] river/sea located at a distance of [...] km from the plant boundary. The intake water pump house is installed with [...] intake pumps of capacity [...] m³/hr, out of which [...] pumps are normally working and the remaining [...] pumps are standby. The raw water is pumped from the intake water pump house to the in-plant raw water reservoir, which has a storage capacity of [...] days.]

d) CW / ACW System and Cooling Towers

[CW system for the power plant works on re-circulating system with induced draft cooling towers. The CW system uses raw/clarified quality of water and is working on [...] cycles of concentration. CW pump house is a common facility for all the units of the power plant. There are two CW pumps of capacity [...] m³/hr provided for each unit. In addition, there are two standby CW pumps common to all the units. The requirement of ACW system is being tapped from the cold CW header feeding the condenser. The hot return ACW water after cooling the auxiliaries of boiler and turbine joins the hot CW header and is sent to the cooling towers for cooling. The cold water from the cooling water flows to the fore bay of CW Pump House for recirculation into the system. One (Induced draft / Natural Draft) Cooling Tower has been provided for each unit. The cooling tower cools the water from [...] deg C to [...] deg C. The cooling tower has been designed for an ambient wet bulb temperature of [...] deg C and Relative Humidity of [...] %. The cooling towers are of cross flow/ counter flow design. The Cooling Tower fills are made of (RCC/PVC/ Polypropylene).

e) Water Pre-Treatment Plant

Water Pre-Treatment Plant is a common facility for all the units of the power plant. Pre-treatment plant supplies clarified water to DM plant, cooling water to the auxiliaries of BOP system, coal handling plant dust suppression and to the drinking water system.

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There are two numbers of clarifiers of [...].m³/hr capacity to meet all the clarified water requirements of the whole plant, except DM plant. The clarified water requirement for DM plant is met by a separate clarifier of capacity [...] m³/hr.]

f) DM Plant

[DM plant consists of three streams, each of [...] m³/hr capacity. There are two DM water tanks of [...].m³ capacity. A common regeneration system has been provided for all the three streams. DM plant operates on semi-automatic system with PLC controls.]

g) Air-Conditioning and Ventilation System

[The central control room, switchyard control room, ESP controls room and selected areas of service building have been provided with centralized air-conditioning system. The central air-conditioning system of chilled water type has been provided for various control rooms and DX type of plant has been provided for ESP control room, switchyard control room and other areas in the service building. Packaged type of air-conditioners has been provided for water treatment plant control room. Evaporative ventilation system has been provided for TG building along with roof extractors. Other areas are ventilated by a combination of exhaust and supply air fans].

h) Fire Fighting System

[Fire fighting system is a common facility provided for all the units. This consists of pressured hydrant system for all the auxiliary buildings, pump houses and administrative building. Automatic high velocity sprinklers system has been provided for power transformers, turbine oil tanks and lube oil system equipments. Medium velocity sprinkler system has been provided for cable galleries and coal conveyor galleries. Portable types of fire extinguishers have been provided throughout the plant for fighting small and localized fires.]

i) Plant and Instrument Air System

[Plant and instrument air system is a common facility for all the units of the plant. For meeting the instrument air requirement, [...] number of oil free screw compressors [...] working and [...] standby, each of [...] m³/hr capacity and discharge pressure of [...] kg/cm (g) have been provided along with dryers. Equal number of air compressors of similar rating has been provided to meet the requirement of plant air system. The air drying plant for the instrument air has been provided to achieve a dew point of (-) 40°C at atmospheric pressure.]

j) Fuel Oil System

The fuel oil system has been designed for the use of Light Diesel Oil (LDO) for start-up and Heavy Fuel Oil (HFO) for load carrying and flame stabilization purposes. Two tanks of [...] kl each have been provided for the storage of HFO and two tanks of [...] kl each have been provided for the storage of LDO. The system has been provided with unloading, transferring and pressurization pumps along with necessary filters and heating arrangement.]

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3.6

Civil Works

Major civil facilities consist of the following:

a) Main Power House Building:

[3x200 MW units have been placed side by side. Centre to centre placing of units is [67.5 m.] The railway entry has been provided from the rear side of Power House Building. Turbine Generator (TG) Sets have been placed between AB rows of columns are laid out longitudinally. The TG bay, also houses, the Boiler Feed Pumps, Regenerative Heaters, Lube Oil System and other TG accessories. The total length of TG bay for 3x210 MW units is [276 m] and width [30 m]. The spacing of the column is at [7.5 m]. TG bay is provided with 2 Nos. of overhead EOT Cranes. In order to make the handling facilities of the cranes available to the heat exchangers, boiler feed pumps and other equipments, removable chequered plates have been provided at appropriate locations.

A sub zero floor has been avoided except for the localized pits required for Condensate Pump, pipe channels and HP Heaters etc. This sub zero pits are suitably connected and provided with a common sump for drainage purposes.

Three stairs for approaching the operating floor level at [+10 m] have been provided in this bay adjacent to B row columns. In addition, there are stairs for providing access to various equipments at intermediate platforms and sub zero pits.

Switchgear and Control Room bay has been provided in the BC bay which is [12 m] wide. The length of the bay is [249.0 m]. A common Control Room for all the three units is provided at [10 m] floor. In BC bay at [16 m] elevation, equipments for chemical dosing, air handling and MCC for soot blowers etc have been located. The deaerator is placed at an elevation of [23.0 m]. Air washer units and cooling water tanks are also located at [23.0 m] floor.

Mill Bunker Bay, designated as CD bay, has a span of [10.5 m] which accommodates coal bunkers, coal feeders and coal mills. CD bay houses the vertical mills at Zero m and has space for collection of disposal of mill rejects at sub zero levels adjacent to 'D' row. A stair to connect operating floor at [16.0 & 23.0 m] of BC & CD bay has been provided.]

b) Boiler Area

[In boiler area, the boiler with its auxiliaries like PA fan, FD fan, ID fan as well as Electrostatic Precipitator has been located.]

c) Transformer Yard

[A [60] m wide yard has been provided outside the 'A' row columns. The transformer yard houses station transformer, unit auxiliary transformers and generator transformers along with oil pits etc. To facilitating erection and maintenance of transformers, the area has been provided with rail tracks parallel to 'A' row at a distance of [45 m] from 'A' row which is further connected through cross tracks. In addition, space has been provided for laying the CW pipelines and locating the butterfly valve chambers.]

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d) Service building

[A common four storey building has been provided near the main plant building and it is connected with the operating floor of TG bay at [10 m] level.].

e) Chimney

[A single chimney having a height of [...] meters comprising of concrete wind shield has been provided for [...] units. The flue gases from each unit are let out through independent steel flues. The Chimney is provided with an elevator]

f) Cooling Tower.

[One Cooling Tower of (Induced draft / Natural Draft) has been provided for each unit. The dimensions of each Cooling Tower are [...]. The cooling towers are of cross flow/ counter flow design. The Cooling Tower fills are made of (RCC/PVC/ Polypropylene].

g) Miscellaneous buildings

[Besides the above, miscellaneous buildings like administrative building, CW Pump House, Fire Water Pump House, CHP Control Room, ESP Control Room, DM Plant Building, Chemical House and Ash Silos have been provided.]

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4 OPERATIONAL HISTORY OF THE UNIT

4.1 Operational History of the Plant

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ/KWU] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The deterioration experienced over the years in Plant's performance parameters is shown in Table 4.1. Table 4.2 illustrates variations over the last three years in the performance parameters.

Table 4.1- Unit's Performance Parameters over the life

Years after Installation	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
5	[...]	[...]	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Table 4.2- Unit's Performance Parameters in last three years

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
2 years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
1 year back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Current year	[...]	[...]	[...]	[...]	[...]	[...]	[...]

4.2 Stack Emissions, Ambient Air Quality and Process Effluents

The Project has been regularly monitoring the environmental parameters such as stack monitoring, ambient air quality (AAQ), noise pollution and liquid waste pollution by employing an agency approved by State Pollution Control Board and in accordance with applicable norms.

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{Indicate the environmental data of the unit for the past three years against the limits specified for different pollutants. Furnish the information for each year as per the table 4.3 below. Also provide the map(s) showing the locations for various measurements as Annexure to the Feasibility Report.}

Table 4.3
Status of Stack Emissions, Ambient Air Quality and Process Effluents

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
Stack Emissions	SPM (mg/Nm ³)	<i>Not to exceed</i> [...]	[...]		[...]	[...]
Ambient Air Quality		<i>On 24 Hrs Basis</i>	<i>On Annual Basis</i>	<i>On 24 Hrs Basis</i>	<i>On Annual Basis</i>	[...]
	SPM (µg/m ³)	[...]	[...]	[...]	[...]	
	RPM (µg/m ³)	[...]	[...]	[...]	[...]	
	SO ₂ (µg/m ³)	[...]	[...]	[...]	[...]	
	NO _x (µg/m ³)	[...]	[...]	[...]	[...]	
Process Effluent Leaving the Plant Boundary	ETP Treated Water Quality				[...]	[...]
	pH	[...]		[...]		
	Colour	[...]		[...]		
	Odour	[...]		[...]		
	Temperature	[...]		[...]		
	TSS	[...]		[...]		

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
	(mg/l)			[...]	[...]
	Oil & grease (mg/l)	[...]	[...]		
	COD (mg/l) (mg/l)	[...]	[...]		
	BOD (mg/l)	[...]	[...]		
	Chloride (mg/l)	[...]	[...]		
	Sulphate (mg/l)	[...]	[...]		
	TDS (mg/l)	[...]	[...]		
	Zinc (mg/l)	[...]	[...]		
	Fluoride (mg/l)	[...]	[...]		
	Mercury (mg/l)	[...]	[...]		

4.3 Tripping and Maintenance Record

{Indicate in the table below tripping & maintenance record for past three years.}

Table 4.4
Tripping and Maintenance Record

Year	Total Trippings	No. of Trippings due to Boiler Tube Leakages	Other Major Causes of Trippings	Maintenance carried out
Two Years	[.....]	[.....]		[.....]

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Year	Total Trippings	No. of Trippings due to Boiler Tube Leakages	Other Major Causes of Trippings	Maintenance carried out
Back				
One Year Back	[.....]	[.....]		[.....]
Current Year	[.....]	[.....]		[.....]

4.4 Maximum Achievable Load due to Performance Constraint of ESP

[Due to ESP's performance constraint, the maximum generation from the unit is restricted toMW, in order to keep SPM emission within the statutory limit of 50 mg/Nm³. The operational data at the above maximum load is indicated in the table below.]

Table 4.5
Nature of constraints causing limited Generation

Nature of constraint	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
[...]	[...]	[...]	[...]	[...]	[...]

4.5 Record of Reportable Accidents

[The record of reportable accidents for the past three years, is mentioned in the Table below]

Table 4.6
Record of Reportable Accidents

Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]

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Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Current Year	[.....]	[.....]	[.....]	[.....]

4.6

Operation & Maintenance Difficulties due to Plant Limitations

[Difficulties are being experienced in day to day maintenance of the plant due to design deficiency, layout of the plant, obsolescence of equipment and non availability of spare parts etc. These are mentioned in the Table below]

Table 4.7
Operation & Maintenance Difficulties due to Plant Limitations

S.No.	Nature of Difficulty	Specific Reason (Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

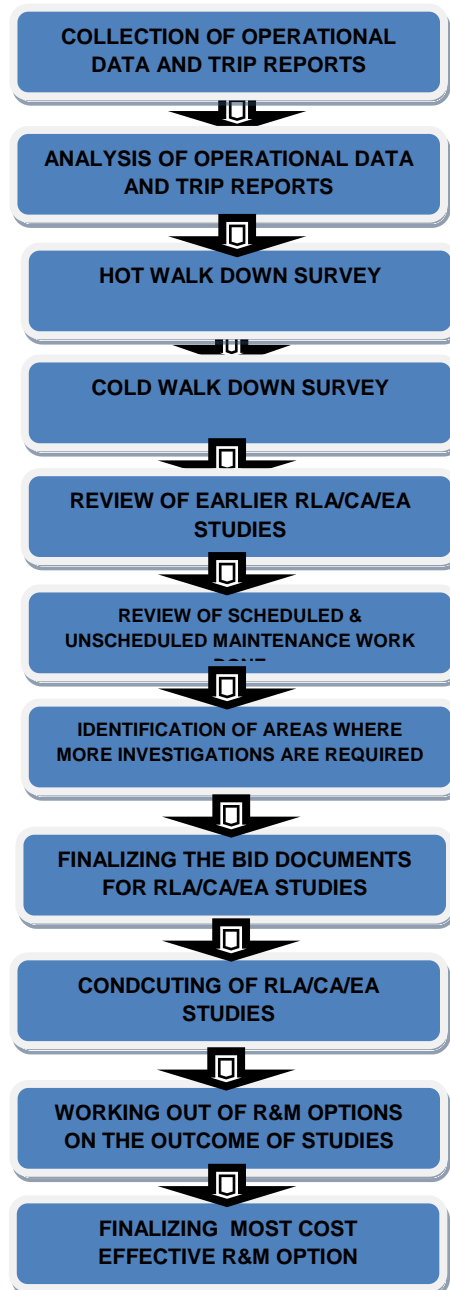
5 RESULTS OF RLA/CA AND EA STUDIES AND TECHNICAL SOLUTIONS

5.1 Approach Adopted

Complete approach adopted for finalizing the R&M option is shown in Figure 5.1.

Figure 5.1

Steps followed in arriving at the most cost effective R&M solution



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The existing condition of the Plant was assessed on the basis of the results of RLA/CA and EA studies. Various R&M options were formulated based on the alternative solutions available to extend the life and improve the efficiency of the unit. The above R&M options were examined on the basis of cost benefit analysis and the most attractive option was then selected for implementing the R&M works.

5.2 Equipments/Components subjected to Health Condition Assessment

The health condition of the unit was investigated by carrying out RLA/CA and EA Studies. The required tests were performed on the sub-systems / components listed below.

A) Boiler and Auxiliaries

S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
1.	[Mills]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
2.	[Furnace]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
3	[Boiler Pressure Parts]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
4.	[Air Pre-heater]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

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S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
5.	[Critical Piping]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
6.	[FD FANS]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
7.	[PA Fans]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
8.	[ID Fans]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
9.	[Wall Blowers & LRSBs]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
10.	[Electrostatic Precipitator]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

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S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
11.	[Any other Equipments]	[...] [...]	[...] [...]	[...] [...]

B) Turbine and Auxiliaries

S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
1.	[Steam Turbine]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
2.	[Condenser]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
3.	[Ejectors]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
4.	[Condensate Extraction Pumps]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
5.	[Gland Steam Cooler]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
6.	[LP Heaters and Drain Coolers]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
7.	[Deaerator]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

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8.	[Boiler Feed Water Pumps]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
9.	[HP Heaters]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
10.	[HP and LP Bypass System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
11.	[Turbine Governing System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
12.	[Lube Oil System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

C) Electrical System

S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
1.	[Generator]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
2.	[Station Transformers]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
3.	[Generator Transformer]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
4.	[Unit Auxiliary Transformer]	i) [...]	i) [...]	i) [...]

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S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
		ii) [...]	ii) [...]	ii) [...]
5.	[Electrical Distribution System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
6.	[DC System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
7.	[Emergency Power Supply System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

D) Balance of Plant

S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
1..	[Coal Handling Plant].	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
2..	[Ash Handling Plant.]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
3.	[Raw Water System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
4	[CW/ACW System and Cooling Towers]	i) [...]	i) [...]	i) [...]

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S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
		ii) [...] iii) [...] iv) [...]	ii) [...] iii) [...] iv) [...]	ii) [...] iii) [...] iv) [...]
5.	[Water Pre-Treatment Plant]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
6..	[DM Plant]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
7.	[Air Conditioning and Ventilation System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
8.	[Fire Fighting System.]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
9.	[Plant and Instrument Air System.]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
10.	[Fuel Oil System]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

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E) Civil Works

S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
1..	[Boiler].	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
2..	[TG Building.]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
3.	[Chimney]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
4.	[Coal Handling Plant]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
5.	[Ash Handling Plant]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
6.	[Water Pre-Treatment Plant]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

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S.No	Name of Sub System / Equipment	Name of the Component	Type of Test(s) Conducted	Brief Results/ Findings of the Tests
7.	[DM Plant]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
8.	[CW Pump House]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
9.	[Cooling Towers]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
10.	[Ash Dyke]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
11.	[Misc. Works]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

5.3

Formulation of R&M Options

[Based on the recommendations of RLA/CA & EA Studies, review of the performance data and discussions with the plant engineers, various R&M options were formulated. All the R&M options were aimed at achieving the following minimum objectives:

- i) Redesigning the boiler to suit the average coal quality likely to be available for the next 20 years.
- ii) Restoring the performance parameters to the original design values.
- iii) Extending the life of the unit by a minimum of 20 years.
- iv) Replacing the existing obsolete technology.
- v) Meeting the revised statutory emission standards.
- vi) Increasing Efficiency.
- vii) Reducing Auxiliary Power Consumption

The first option considered for R&M was for the case, in which the objectives were restricted to the bare minimum for restoring design output, design heat rate and Auxiliary Power Consumption of the unit and to extend the unit life by 15 years. Other options were formulated for not only the life extension of the unit but also for further improving its output, heat rate and auxiliary power consumption from the original design values, as discussed in the Table 5.1 below.]

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Table 5.1- R&M Options Considered for Cost Benefit Analysis

Option	Objectives to be achieved by carrying out R&M	Shut Down Period	Major Parameters after R&M
I	<p>i) [Designing Boiler to suit average coal quality likely to be available for the next 20 Years.</p> <p>ii) Increasing the output of the unit to [215 MW] from 200/210 MW by retrofitting the LP turbine without retrofitting Generator. Improving heat rate beyond the original design heat rate and restoring the Auxiliary Power Consumption to the original design values.</p> <p>iii) Replacing the existing obsolete technology.</p> <p>iv) Meeting the revised statutory emission standards.</p> <p>v) Extending the life of the unit by a minimum of 20 years.]</p>	[...]	<p>[Life Extension Years]</p> <p>[Output ..... ..MW]</p> <p>[Heat Rate ... kCal/kWh]</p> <p>[Aux. Power Consumption%]</p>
II	<p>i) [Designing Boiler to suit average coal quality likely to be available for the next 20 Years.</p> <p>ii) Increasing the output of the unit to [215 MW] from 200/210 MW by retrofitting the LP and HP turbine without retrofitting Generator. Improving heat rate beyond the original design heat rate and restoring the Auxiliary Power Consumption to the original design values.</p> <p>iii) Replacing the existing obsolete technology.</p> <p>iv) Meeting the revised statutory emission standards.</p> <p>v) Extending the life of the unit by a minimum of 20 years.]</p>	[...]	<p>[Life Extension Years]</p> <p>[Output ..... ..MW]</p> <p>[Heat Rate ... kCal/kWh]</p> <p>[Aux. Power Consumption ... %]</p>
III	<p>i) [Designing Boiler to suit average coal quality likely to be available for the next 20 Years.</p> <p>ii) Increasing the output of the unit to [215</p>	[...]	<p>[Life Extension Years]</p>

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Option	Objectives to be achieved by carrying out R&M	Shut Down Period	Major Parameters after R&M
	<p>MW] from 200/210 MW by retrofitting complete new energy efficient turbine without retrofitting Generator. Improving heat rate beyond the heat rate of option 'II' and restoring the Auxiliary Power Consumption to the original design values.</p> <p>iii) Replacing the existing obsolete technology.</p> <p>iv) Meeting the revised statutory emission standards.</p> <p>v) Extending the life of the unit by a minimum of 20 years.]</p>		<p>[Output ..........MW]</p> <p>[Heat Rate ... kCal/kWh]</p> <p>[Aux. Power Consumption%]</p>
IV	<p>i) [Designing Boiler to suit average coal quality likely to be available for the next 20 Years.</p> <p>ii) Increasing the Output to [220 MW] MW from 200/210 MW by retrofitting complete new energy efficient turbine along with new Generator, Generator Transformer and new static Excitation System. Improving heat rate better than the level of option 'III' and restoring the Auxiliary Power Consumption to the original design values.</p> <p>iii) Replacing the existing obsolete technology.</p> <p>iv) Meeting the revised statutory emission standards.</p> <p>v) Extending the life of the unit by a minimum of 20 years].</p>	[...]	<p>[Life Extension Years]</p> <p>[Output ..........MW]</p> <p>[Heat Rate ... kCal/kWh]</p> <p>[Aux. Power Consumption%]</p>
V	<p>i) [In situ major replacement of Boiler on the existing foundations, retrofitting complete new energy efficient turbine along with new Generator, Generator Transformer and new static Excitation System. Designing the boiler to suit the average coal quality likely to be available for the next 25 years.</p> <p>ii) Increasing the Output to [250/300 MW]. Achieving heat rate' and Auxiliary Power</p>	[...]	<p>[Life Extension Years]</p> <p>[OutputMW]</p>

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Option	Objectives to be achieved by carrying out R&M	Shut Down Period	Major Parameters after R&M
	<p><i>Consumption better than Options 'III' & 'IV'.</i></p> <p><i>iii) Replacing the existing obsolete technology.</i></p> <p><i>iv) Meeting the revised statutory emission standards.</i></p> <p><i>v) Extending the life of the unit by a minimum of 25 years.]</i></p> <p><i>{This option is advised only when the unit to be renovated is either the first or last unit of the power plant, since intermediate units are likely to have space constraint for installation of new Boiler and TG.}</i></p>		<p><i>[Heat Rate ... kCal/kWh]</i></p> <p><i>[Aux. Power Consumption%]</i></p>

{While evaluating the options, the utilities are advised to also check the residual life of the switchyard, the Balance of Plant and the Material Handling System. Further, the utilities should note that if the proposed calorific value of coal is inferior to the original calorific value for which the boiler was designed, then the boiler will require re-engineering.}

Estimated cost for each option was worked out after taking into account the scope of R&M measures to be implemented for each option. Cost Benefit analysis of each option was then performed. After cost-benefit analysis of [Five] options mentioned above, option [...] has been identified as most attractive option for implementation. Cost-benefit analysis of various options is discussed in Section 7.0.

5.4 R&M option identified for Implementation

Option [...] has been selected for implementation. This is expected to bring out the following improvements:

- Extending the Plant life to [...] years.
- Increasing the output rating to [... MW].
- Improving the Heat Rate to [... kCal/kWh].
- Restoring the Auxiliary Power Consumption to the original level and attempting to achieve the same to the level of CERC/SERC norms.
- Achieving the revised statutory emission standards.

System wise / Equipment wise Modifications / replacements proposed on the basis of CA/RLA/EA studies are discussed in Section 6.0

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6 PROPOSED MODIFICATIONS AND REFURBISHMENTS

6.1 Boiler and Auxiliaries

{Discuss in this section the following aspects for each item of the Boiler and its Auxiliaries:

i) The problems being faced from in view of the shortfall in achieving the performance parameters and

ii) The R&M measures to be adopted based on the recommendation of RLA/CA and EA studies.

It may please be noted that the check points mentioned in paragraphs below are of indicative nature only, whereas the same has to be as per the project specific requirements.}

6.1.1 Boilers

[.....
.....
.....]

{Note: Check the requirement of re-engineering the boiler and the capacity of the furnace in view of more quantity of coal of lower GCV is to be burnt in the boiler in place of existing design for higher GCV coal. Check for the possible requirements of refurbishment / replacement of boiler structure, down comers, safety valves, pressure parts like, drum, drum internals, water wall tubes, tube bends near gooseneck, bottom 's'-panels, coils and headers of super heaters, re-heater & economizers, refurbishing of air pre-heater by replacement of baskets & seals, modification of attemperators, retrofitting of low NOx burners, oil burners, wind box, burner tilting arrangement, high energy arc igniters, reapplication of refractory & insulation, penthouse pressurizing fans, buck stays, ducting, insulation, soot blowers, LRSBs, bottom ash evacuation system, clinker grinders, hangers and supports etc.}

6.1.2 Coal Mills

[.....
.....
.....]

{Note: Check for the possible requirements of replacement of existing mills with higher capacity mills in view of increased quantum of low quality coal to be fed to the boiler. Also check for the requirements of changing the grinding rolls, grinding rings, classifiers, drive motors, gears, oil pumps, cooling water circuit, sealing air system etc. Incorporate the recommendation of Performance Test.}

6.1.3 PA Fans

[.....
.....
.....]

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{Note: Check the capacity of fans in view of the higher capacity of mills. Check for the possible requirements of the replacement of impellers, casing, bearings etc. Incorporate the recommendation of Energy Audit Studies.}

6.1.4 ID Fans

[.....]
[.....]

{Note: Check the capacity of fans in view of the higher capacity of mills. Check for the possible requirements of the replacement of impellers, casing, bearings, VFD etc. Incorporate the recommendation of Energy Audit Studies.}

6.1.5 F D Fans

[.....]
[.....]

{Note: Check the capacity of fans in view of the higher capacity of mills. Check for the possible requirements of the replacing the impellers, casing, bearings, inlet vanes etc. Incorporate the recommendation of Energy Audit Studies. }

6.1.6 ESP

[.....]
[.....]

{Note: Check the capacity of the ESP in view of more quantity of inferior quality of fuel to be burnt in the boiler. Check for the possible requirements of refurbishment /replacement of Transformer Rectifier sets and ESP controllers, addition of fields, installation of bag filters etc. for meeting the revised statutory emission norms prescribed by the pollution control authorities. Incorporate the recommendation of the Performance Test.}

Summary of R&M Measures

R&M Measures to be adopted for the Boiler and its Auxiliaries have been discussed in detail at **Annexure 6.1** for all the [five] options along with their cost impact for each option.

6.2 Steam Turbine & Auxiliaries

{Discuss in this section the following aspects for each item of the Steam Turbine and its Auxiliaries:

i) The problems being faced from in view of the shortfall in achieving the performance parameters and

ii) The R&M measures to be adopted based on the recommendation of RLA/CA and EA studies.

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It may please be noted that the check points mentioned in paragraphs below are of indicative nature only, whereas the same has to be as per the project specific requirements.}

6.2.1 Steam Turbine

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of refurbishing / replacing the existing LP Turbine having Baumann Exhaust with more efficient LP turbine designed to suit local condensing conditions, replacing the HP/IP turbine rotors with three dimensional blade designs, replacement of HP / IP casings/ diaphragms, gland sealing, inter-stage packing, internal parts of ESV, IV, CV, servomotors, governing system, turning gear, jacking oil system etc.}

6.2.2 Condenser

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the condenser tubes, refurbishment/replacement of online tube cleaning system/ debris filter, application of anti-corrosive coating on water box/tube plates, replacement of air ejector with vacuum pump etc. Check the existing capacity of condenser, if a turbine of higher capacity is proposed. Incorporate the recommendation of Performance Test.}

6.2.3 Ejectors

[.....]
[.....]
[.....]

{Note: Check the condition of nozzles and diffusers of starting ejectors and main ejectors. Check the requirement of replacing the ejectors with the vacuum pumps. Check the existing capacity of ejectors, if a turbine of higher capacity is proposed.}

6.2.4 Condensate Extraction Pumps

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the impellers & bowl assemblies, retrofitting of energy efficient motors, replacement of recirculation valves, provision of auto changeover to standby pump, replacement of thrust bearings etc. Check the existing capacity of condensate extraction pumps, if a turbine of higher capacity is proposed. Incorporate the recommendation of performance Test.}

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6.2.5 LP Heaters

[.....]
[.....]

{Note: Check for the possible requirements of replacing the tube bundles with the new ones having the same material or alternatively with the material of stainless steel, retrofitting the LP Heaters with the modified ones having better Drain Cooler Approach etc. Check the existing capacity of LP Heaters, if a turbine of higher capacity is proposed. Incorporate the recommendation of Performance Test.}

6.2.6 Deaerator

[.....]
[.....]

{Note: Check for the possible requirements of replacing the spray nozzles and internals etc. Check the existing capacity of deaerator, if a turbine of higher capacity is proposed.}

6.2.7 Boiler Feed Pumps

[.....]
[.....]

{Note: Check for the possible requirements of replacing the cartridges with energy efficient models, replacement of booster pumps with modified versions, modification of cooling water circuit etc. Check the existing capacity of BFPs, if a turbine of higher capacity is proposed. Incorporate the recommendation of Energy Audit Studies.}

6.2.8 HP Heaters

[.....]
[.....]

{Note: Check for the possible requirements of replacing the tube bundles with the new ones having the same material or alternatively with the material of stainless steel, retrofitting the LP Heaters with the modified ones having better Drain Cooler Approach etc. Check the existing capacity of HP Heaters, if a turbine of higher capacity is proposed. Incorporate the recommendation of Performance Test.}

6.2.9 Critical Piping including valves

[.....]
[.....]

{Note: Check for the possible requirements of replacing the pipes, valves, fittings, hangers and supports for MS, CRH, HRH and Feed water piping, check for the replacement of bends and clamping areas, since these are prone to develop leakage.}

Summary of R&M Measures

Summary of R&M Measures to be adopted for the Steam Turbine and its Auxiliaries has been discussed in detail at **Annexure 6.2** for all the [five] options along with their cost impact.

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6.3 Balance of Plant

{Discuss in this section the following aspects for each item of the Balance of Plant:

i) The problems being faced from in view of the shortfall in achieving the performance parameters and

ii) The R&M measures to be adopted based on the recommendation of RLA/CA and EA studies.

It may please be noted that the check points mentioned in paragraphs below are of indicative nature only, whereas the same has to be as per the project specific requirements.}

6.3.1 Coal Handling Plant

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of augmenting the capacity of the existing coal handling plant due to much lower calorific value of coal being received than the calorific value for which the boiler was designed, requirement of installing additional wagon tippler, increasing the storage capacity of coal stock yard, refurbishment of coal crushers, installation of more effective dry fog dust suppression system at Wagon Tippler, Stock Pile, Transfer Points and Junction Towers, provision of stacker-reclaimer and facilities for coal blending etc.}

6.3.2 Ash Handling Plant

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of augmenting the capacity of the existing ash handling plant due to higher consumption of coal having higher ash content, improvements in bottom ash handling system/ fly ash handling system, storage capacity of ash silos & ash dyke, installing of evacuation & disposal system for the dry fly ash, installing of ash water recycling system (AWRS) for the bottom ash handling system, providing arrangement for maintaining continuous water blanket over the ash dyke to prevent pollution due to blowing of fugitive ash from the dried portion of ash dyke, checking the adequacy of the existing system for 100% utilization of fly ash etc. etc.}

6.3.3 Water Intake System

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of installation of Travelling water screens at the makeup water pump house, replacement of line shafts/ impellers / bowl assemblies of water intake pumps, motors, piping and valves etc }

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6.3.4 Water Pre-Treatment Plant

[.....]
[.....]

Note: Check for the possible requirements of renovating the pretreatment plant for a smaller output rating in view of substantial reduction in the requirement of makeup water quantity as a result of installation of dry fly ash handling system/ash water recycling system / increasing the value of COC etc. Check the condition of stirrers, mixing chambers rotating bridge, chlorination plant etc.}

6.3.5 DM Plant

[.....]
[.....]

{Note: Check for the possible requirements of refurbishing the pressure vessels, pipes, pumps, air blowers, valves, acid and alkali storage tanks, DM Water tanks etc}

6.3.6 CW & ACW System

[.....]
[.....]

{Note: Check for the possible requirements of installation of Travelling water screens at the CW pump house, replacement of line shafts/ impellers / bowl assemblies of CW pumps/ ACW pumps, motors, piping and valves etc}

6.3.7 Cooling Towers

[.....]
[.....]

{Note: Check for the possible requirements of refurbishing of riser pipes water distribution system, valves, fan motors, gear boxes, splash pipes and fills etc. Incorporate the recommendation of Performance Test.}

6.3.8 Fire Detection and Protection System

[.....]
[.....]

{Note: Check for the possible requirements of replacing the hydrants and sprinklers which do not work properly, replacement of air compressor, hydro pneumatic tank and jockey pump, renovation of emulsifier system for the transformers, provision of fire detection and protection system for the cable galleries etc. Check for the required changes to be made to ensure that the system meets the statutory requirements of TAC / LPA of Insurance Association of India.}

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6.3.9 Fuel Oil Handling System

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the damaged unloading hoses / defective portion of fuel oil pipeline, replacement of heat tracing system /pumps/ fittings / valves of fuel forwarding system etc.}

6.3.10 Compressed Air System

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the existing reciprocating type of air compressors with screw type air compressors, replacement of existing air driers with energy efficient Heat of Compression type air driers, replacement of damaged pipelines etc.}

6.3.11 Air Conditioning & Ventilation System

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of augmenting the existing air conditioning and ventilation system including the need of its relocation from relatively dusty to cleaner location. Explore the option of vapour absorption machines.}

6.3.12 EOT Crane in TG Hall

[.....]
[.....]

{Note: Check for the possible requirements of replacing the damaged / misaligned portions of railings, installing system for the remote operation & control of EOT Crane etc. Check the capacity of the crane by carrying out the load test.}

6.3.13 Effluent Treatment Plant

[.....]
[.....]

{Note: Check for the possible requirements of modifying the existing ETP to have zero discharge in line with the current practice of the Industry / the requirement of most of the State Pollution Control Boards, to recycle treated water from the ETP for use in ash handling system / coal dust suppression system etc.}

Summary of R&M Measures

R&M Measures to be adopted for the Balance of Plant have been discussed in detail at **Annexure 6.3** for all the [five] options along with the cost impact for each option.

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6.4 Electrical System

{Discuss in this section the following aspects for each item of the Electrical System:

i) The problems being faced from in view of the shortfall in achieving the performance parameters and

ii) The R&M measures to be adopted based on the recommendation of RLA/CA and EA studies.

It may please be noted that the check points mentioned in paragraphs below are of indicative nature only, whereas the same has to be as per the project specific requirements.}

6.4.1 Generator- Stator

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the stator winding bars, replacing the Class 'B' bitumen based insulation with epoxy based Class F insulation etc.}

6.4.2 Generator-Rotor

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the existing retaining ring with new type made of better material, replacement of Desiccant type of dryer with refrigerant type of dryer, providing the system for on-line dew point measurement of H₂, replacement of excitation system with dual channel Digital Voltage Regulator (DVR) etc.}

6.4.3 Generator Transformer

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the existing Generator Transformer with higher capacity Generator Transformer in case the capacity of the unit is being revised upwards. In case the existing Generator Transformer is to be retained, check for the need of replacing the windings/ bushings/ cooling system/ emulsifier system etc.}

6.4.4 Unit Auxiliary Transformer

[.....]
[.....]
[.....]

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{Note: Check for the possible requirements of replacing the existing Transformer with a new transformer of higher capacity to safely meet the increased auxiliary load of mills, coal handling plant and Ash Handling plant etc.}

6.4.5 Generator Protection & Synchronization

[.....]
[.....]
[.....]

{Note: Check for the implementation of latest protections. Check for the possible requirements of replacing the existing electromagnetic / static relays with numerical relays, replacement of existing system of manual synchronization with Auto synchronizer etc.}

6.4.6 Station Service Transformer

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing the existing Station Service Transformer with a new transformer of higher capacity to safely meet the increased auxiliary load of mills, coal handling plant and Ash Handling plant etc.}

6.4.7 6.6 kV System

[.....]
[.....]
[.....]

{Note: Check for the need of replacement/ retrofitting of the system due to increase in the electrical load as a result of replacement of existing mills with the higher capacity mills. Check for the possible requirements of change in the type of Circuit Breakers with SF6 breakers, replacement of electromagnetic / static type relays, with numerical relays, replacement of control wiring, providing Interposing relay (IPR) cabinet in Switchgear / Control Room to control the HT feeders / motors and selected LT feeders / motors from the DDCMIS etc.}

6.4.8 415 V System

[.....]
[.....]
[.....]

{Note: Check for the need of replacement/ retrofitting of the system due to increase in the electrical load as a result of addition of additional equipment, if any. Check for the possible requirements of replacing the existing LT boards with LT boards of draw out type, installing Air Circuit breakers (ACBs) for motors above 110 kW rating, providing latest microprocessor based protection for the motors, replacing electromagnetic relay based protection with numerical relay based protection, installing ammeters for motors above 30 kW rating and electronic energy meters for motors above 110 kW rating etc.}

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6.4.9 HT & LT Motors

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of replacing/refurbishing the Class 'B' insulation Motors with Class 'F' insulation energy efficient motors, modification of motors foundations etc}

6.4.10 DC system

[.....]
[.....]
[.....]

{Note: Check for the possible requirements of augmenting the ventilation system, replacing / refurbishing the battery charger and batteries, DC Distribution Boards, improvement of availability of redundant system etc.}

6.4.11 Public Address system

[.....]
[.....]
[.....]

{Note: Check for the possible requirement of a better and clearly audible public address system with latest modern features for providing good communication inside the power plant.}

6.4.12 Illumination System

[.....]
[.....]
[.....]

{Note: Check for the possible requirement of a better illumination system for providing optimum lux level at all important locations of the plant. The possibility of providing Automatic Switching System should also be checked.}

6.4.13 DG Sets

[.....]
[.....]
[.....]

{Note: Check for the possible requirement of refurbishing/ replacing/ augmenting the DG Sets for providing the power back up required. Explore the possibility of providing automatic switch on/off for energy conservation.}

Summary of R&M Measures

R&M Measures to be adopted for the Electrical System have been discussed in detail at **Annexure 6.4** for all the [five] options along with their cost impact.

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6.5 Control & Instrumentation

[The total control and instrumentation system generally requires large scale replacement owing to obsolescence of the existing equipments.

Integrated microprocessor based closed loop control, open loop control, sequential control and bulk data acquisition system for SG & auxiliaries, TG & auxiliaries, station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level are to be envisaged for the plant.

The unit control and instrumentation system and other major proprietary control systems will be based on integrated Microprocessor Based Distributed Digital Control and Management Information System (DDCMIS). Complete operation and control of Steam Generator, Turbine Generator, Station C&I and auxiliary systems will be carried out from DDCMIS.

Field process transmitters, Pneumatic control valve's & damper's positioners will be smart type. Each transmitter and positioner will communicate with the control system in the form of analog signal 4 – 20 mA DC along with superimposed digital signal through HART protocol to facilitate configuration, zero adjust, calibration and diagnostic from remote station in addition to configuration by hand held smart configurator. Separate PC based configuration station with 22" TFT monitor along with maintenance and diagnostic facility for HART devices will be provided in case the features are not achievable in DDCMIS. The DDCMIS will be interfaced with BOP control systems using soft links. DDCMIS Interface Requirements for Packages will be as per the Table given below]

Table 6.1
DDCMIS Interface Requirements for Packages

S.No.	System / package	Control System / Scope	Operation From		Interface with DDCMIS	Remarks
			Local Control	UCR		
1.	Coal Handling Plant & Auxiliaries	PLC based / BOP Package Bidder	Yes	No	Redundant, Uni-Directional OPC Link	PLC with Redundant hot standby processor and necessary HMI will be considered.
2.	Ash Handling Plant &	PLC based / BOP	Yes	Yes	Redundant, Uni-Directional OPC	PLC with Redundant hot

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S.No.	System / package	Control System / Scope	Operation From		Interface with DDCMIS	Remarks
			Local Control	UCR		
	Auxiliaries	Package Bidder			Link	standby processor and necessary HMI will be considered.
3.	Fuel Oil Handling System	PLC based / Relay based / BOP Package Bidder	Yes	Yes	Redundant , Bi-Directional OPC LINK	PLC with Redundant hot standby processor and necessary HMI will be considered.
4.	Fire Alarm & protection System	PLC based / BOP Package Bidder	Yes	Yes	Redundant, Uni-Directional OPC Link	PLC with Redundant hot standby processor and necessary HMI will be considered.
5.	Compressed Air system	PLC based / BOP Package Bidder	Yes	Yes	Redundant, Bi-Directional OPC Link	PLC with Redundant hot standby processor and necessary HMI will be considered.
6.	HVAC	PLC based / BOP Package	Yes		Redundant, Uni-Directional OPC	PLC with Redundant hot standby

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S.No.	System / package	Control System / Scope	Operation From		Interface with DDCMIS	Remarks
			Local Control	UCR		
		Vendor			Link	processor and necessary HMI will be considered.
7.	Raw Water System / Pre-Treatment Plant	PLC based / Relay Based / BOP Package Bidder	Yes	No	Redundant, Uni-Directional OPC Link (Optional)	PLC with Redundant hot standby processor and necessary HMI will be considered.
8.	DM Plant & Auxiliaries	PLC based / BOP Package Bidder	Yes	No	Redundant, Uni-Directional OPC Link	PLC with Redundant hot standby processor and necessary HMI will be considered.
9.	Chlorination Plant & Auxiliaries	PLC based / BOP Package Bidder	Yes	No	Redundant, Uni-Directional OPC Link	PLC with Redundant hot standby processor and necessary HMI will be considered
10.	Effluent Treatment Plant &	PLC based / Relay based / BOP Package	Yes	No	Redundant, Uni-directional OPC Link	PLC with Redundant hot standby processor and

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S.No.	System / package	Control System / Scope	Operation From		Interface with DDCMIS	Remarks
			Local Control	UCR		
	Auxiliaries	Bidder			(Optional)	necessary HMI will be considered.
11.	CW System & Auxiliaries	DDCMIS / BTG Package Vendor	Yes (Optional)	Yes	through DDCMIS Remote I/O Cabinet	For each set of CW systems, Control & Monitoring Will be through DDCMIS operating stations from CCR as well as from local control panel Room.
12.	ACW System & Auxiliaries	DDCMIS / BTG Package Vendor	Yes (Optional)	Yes	through DDCMIS Remote I/O cabinet	Control & Monitoring through OWS at Central Control Room will be provided.
13.	Switch Gear system and Auxiliaries (Switch Yard)	SCADA based / 400 kV Switch Yard Scope	Yes (See Remarks)	No	Remote consoles to be mounted in Control Room. Proven OPC LINK to SCADA to acquire monitoring data.	Switch yard control system will be controlled and monitored from Local switch yard control room. Generator synchronization facility will be provided

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S.No.	System / package	Control System / Scope	Operation From		Interface with DDCMIS	Remarks
			Local Control	UCR		
						from unit control room also through Hard ware / soft ware interface.]

6.5.1 DDCMIS

[The existing control system is old analogue based station controls, which have become obsolete and spares are no longer available. Hence DDCMIS should be provided. Boiler controls, turbine controls and station controls should be included in DDCMIS. DDCMIS operation will be from a set of TFT based Operator Workstations, TFT based EWS & TFT based shift in charge OWS. LVS will be provided to enable continuous display of many useful parameters and equipment status.

All Closed Loops, Open Loops as well as monitoring functions of both boiler and turbine will be included in DDCMIS.

Sequence of Events should be included within DDCMIS within the OWS. Data Communication system, Historical Storage and retrieval system, plant Performance Calculations and Optimization System, Management Information System will also be included in DDCMIS. Automatic Run-back will be provided on loss of critical auxiliaries.

Master Clock system based on Global Positioning System will be provided and it should be linked to plant DDCMIS and other PLC based system clock.

The DDCMIS will be compatible with OPC, Ethernet, TCP/IP communication for high speed LAN so that it can be connected seamlessly with other OPC compliant PLC / DDCMIS.]

6.5.2 Closed Loop Control System

[All control loops for boiler as well as TG will be included in the DDCMIS.]

6.5.3 Boiler & Auxiliaries

i) Existing Furnace Safeguard and Supervisory System (FSSS)

[Existing system is old obsolete system based on [.....] technology. Existing flame

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scanners are of old version being obsolete and spares are not available presently.

Hence considering all these facts, fully proven microprocessor based system for Furnace Safeguard & Supervisory System will be provided for boiler protection i.e. Master Fuel Trip (MFT), Boiler purge, oil burner controls, Pulverizer sequence control & protection; control of Seal air fans and scanner cooling fans and fuel oil systems etc.

Furnace supervisory and safeguard System (FSSS) will be preferably implemented in the DDCMIS or within a proven PLC system with adequate safety, self-diagnostic and redundancy with fault tolerant hardware and software.

ii) Soot Blower control

As per modern practice in thermal power plants the microprocessor based control system shall be provided for sequence operation replacing the existing manual operation.

iii) Automatic Tube leak detecting system

[At present there is no Online Boiler tube leak detection system. Automatic steam leak detection system will be provided for detecting leaks at different zones of boiler. The detecting sensors will be mounted in the boiler at suitable locations. The system will include necessary acoustic signal generator, signal receiver, air purging system, signal processor & controller, PC with KB & TFT colour monitor, cabinet, junction boxes, connecting cables and interface to DDCMIS. The system will be able to eliminate the affect of varying surrounding noise to obtain a high accuracy of leak detection. Separately isolated 4-20mA DC analog signals will be provided for monitoring the acoustic level in DDCMIS.]

6.5.4

Turbine & Auxiliaries

Turbine Protections

[Existing Turbine Protections are Relay based. Turbine Protections should be shifted to DDCMIS or within a proven PLC based system with suitable interface with DDCMIS by hardwire and software.

Existing over speed protection is only mechanical. Existing one tacho-generator gives speed measurement signal to control room. New eddy current type speed measurement system (redundant measuring probe and module will be incorporated within the new Turbine supervisory system. Electronic over speed sensing with tripping interlocks to be implemented with latest hardwires and software.)

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i) Turbine EHC

[The existing Hydraulic governing control will be replaced with electro--hydraulic control (EHC).]

ii) Turbine ATRS

[An automatic run-up system will be provided for safe and reliable automatic startup & shutdown of the Turbine.]

Turbine Supervisory System

[Old electromagnetic type TSI System is installed. TSI can be replaced with new system (Eddy Current type) with monitoring software.]

iii) Machine Condition Monitoring System

[At present there is no Continuous monitoring and analysis of the mechanical health of the turbine. This will be performed with proven and latest on-line Rotating Machine Condition Monitoring Systems. It will display shaft vibration, bearing vibration, key phasor and other relevant machine data like speed for the Turbine, Generator & Exciter.]

iv) Turbine Stress Evaluator

[At present Turbine Stress Evaluator (TSE) system is not included within the turbine control and monitoring system. A proven turbine stress evaluation and control system is to be provided, which will work in conjunction with turbine governing system and ATRS.]

v) Automatic Turbine Testing

[Automatic Turbine Testing (ATT) will be provided as presently it is not included.]

vi) HP-LP bypass & Aux PRDS system

[HP-LP bypass control will be included in DDCMIS, in place of existing stand alone control panel. Auxiliary PRDS system control should be included in DDCMIS. PRDS (2nos. Pressure CV and one Temperature CV) should be replaced by Special critical zero leak type valves with actuators.]

vii) Gland steam pressure control

[Existing pneumatic control valve is provided with electronic controller. Controller should be included in new DDCMIS].

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6.5.5 Primary, Secondary Instruments

All the existing Primary & Secondary instruments shall be replaced with latest available instruments. All transmitters shall be replaced with Smart type transmitters with HART protocol compatibility.

6.5.6 Control Valves

All the existing Control Valves will be replaced with new control valves with pneumatic actuators having smart HART compatible positioners

6.5.7 UPS

[Existing UPS system is obsolete and battery condition is also very poor. Hence new redundant UPS with suitable AC power distribution panel along with VRLS type Battery set should be provided to cover power supply for DDCMIS and other related control cabinets and operator stations.]

6.5.8 Analyzers, Steam and Water Analysis System

[Existing SWAS (Steam and Water Analyser System) are not working properly. Individual analysers are not in working condition. Total monitoring system is mainly based on manual measurement from plant chemical laboratory. Hence this system is required to be provided in totality. Complete Steam and Water Analysis System (SWAS) with dry and wet panel, stainless steel sampling line and sample conditioning system, analyzer monitors, and stainless steel grab sampling system with tray are to be considered.

6.5.9 Continuous Emission Monitoring System

New CEMS will be provided to monitor SO_x , NO_x , Particulates matter, CO & CO₂ emission from the chimney as per the latest guidelines received from the pollution control board.

6.5.10 Pipes & tubes

[Quality of existing Impulse lines in flue gas systems and other high pressure (more than 40 kg/cm²) systems are very poor. Hence total impulse lines should be replaced including root valves and drain valves. Process connection for instruments on line and vessel will be in accordance to standards such as ASME and other recognized international standards.]

6.5.11 Cables

[Old instrumentation cables will be replaced with are of 2.5 sq. mm. Height of cable gallery is very low. Removal of existing cables and laying of new cables in cable gallery will be very difficult. Suitable ventilation system in cable gallery should be provided. Terminating of all old field cables (2.5 sq. mm.) into marshalling cabinets and then,

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using of max 1 sq mm cable from marshalling cabinet to DDCMIS cabinets are to be followed.]

Summary of R&M Measures

R&M Measures to be adopted for C&I have been discussed in detail at **Annexure 6.5** for all the [five] options along with their cost impact.

6.6 Civil Works

{Discuss in this chapter the following aspects:

i) the nature of damage & distress caused to the foundations and civil & structural works of TG Building / Boiler Supporting Structure / Coal Handling Plant /Ash Handling Plant / Water Treatment Plant / Cooling Tower / CW Pump House / Chimney and Equipment foundations etc. and

ii) the R&M measures to be adopted based on the recommendation of visual examination, destructive & non destructive tests etc.

It may please be noted that the check points mentioned in paragraphs below are of indicative nature only, whereas the same has to be as per the project specific requirements.}

6.6.1 Boiler and Auxiliaries

[.....]
.....]
.....]

{Note: Check for the requirement of repair / replacement of the foundations of boiler, mills and fans etc.}

6.6.2 TG-Building

[.....]
.....]
.....]

{Note: Check for the requirement of repair / replacement of TG Building foundations, main and auxiliary columns, beams, bracings, walls, flooring, EOT crane rails etc.}

6.6.3 Chimney

[.....]
.....]
.....]

{Note: Check for the requirement of repair of concrete surface due to local spalling of concrete, exposure of reinforcement, damage to corbels etc.}

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6.6.4 Coal Handling Plant

[.....]
[.....]
[.....]

{Note: Check for the requirement of repair /replacement to the foundations & supporting structure of crusher house / coal conveying gallery, repair of concrete and plastered surfaces of track hopper/ wagon tippler hopper/ CHP control room building, civil works for the additional wagon tippler if any.}

6.6.5 Ash Handling Plant

[.....]
[.....]
[.....]

{Note: Check for the requirement of repair of ash silos, ash slurry pump house, ash pipe racks, pedestals of slurry disposal pipelines, ash dyke etc.}

6.6.6 Water Treatment Plant

[.....]
[.....]
[.....]

{Note: Check for the requirement of repairing the clariflocculator / chemical house / DM Plant building/ pump house, arresting the water seepage through the structures, fixing the displaced tiles in the neutralizing pit etc.}

6.6.7 Raw Water Reservoir

[.....]
[.....]
[.....]

{Note: Check for the requirement of repairing the dyke of the reservoir, de-silting the reservoir basin, replacement of lining, replacement of tilesetc..}

6.6.8 CW System

[.....]
[.....]
[.....]

{Note: Check for the requirement of repairing the fore bay, cold water ducts, leaking joints, anchors of CW piping bends, super structure & basin of cooling towers etc.}

6.6.9 Ash Pond

[.....]

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.....]
.....]

{Note: Check for the requirement of increasing the height of ash dyke to increase the capacity of Ash Pond, replacement of lining, replacement of tiles etc..}

6.6.10 Miscellaneous Works

[.....]
.....]
.....]

{Note: Check for the requirement of repairing the civil works of other buildings like, Administrative building, service building, canteen, stores, security building, de-silting basin, raw water reservoir, etc.}

Summary of R&M Measures

R&M Measures to be adopted for the Civil Works have been discussed in detail at **Annexure-6.6** for all the [five] options along with their cost impact.

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7 FINANCIAL EVALUATION OF R&M OPTIONS

7.1 Introduction

The scope and technical details of the *[five R&M options]* considered have already been discussed. This chapter evaluates the financial implication of the R&M options to decide whether to go for R&M and if yes, which R&M option is to be adopted for implementation. The objective of the financial evaluation is to make a comparative analysis of the financial implications of the *[five R&M options]* as well as the base case option of not undertaking any R&M project at all.

7.2 Capital Expenditure for R&M

The estimate of capital expenditure likely to be incurred for each R&M option comprises dismantling cost, supply cost, construction /erection /commissioning cost, taxes/duties, interest during construction, financing cost and contingency. The hard cost of each R&M option was estimated by summing up the estimated cost for the different components/activities of the R&M project. The cost for different constituent parts of the project was estimated on the basis of past cost data for similar work wherever available and/or budgetary quotes. The estimated capital cost of different R&M options is summarized at **Annexure 7.1**.

7.3 Impact on Tariff

[The tariff for electricity sent out from this power plant is determined by Tariff Norms of appropriate Electricity Regulator]. Capitalization of capital expenditure incurred for the project will affect cost of generation. Capitalization may increase Capacity Charge where as improvement in plant heat rate may bring down Energy Charge. Owner will have to take up the regulatory commission for acceptance of the revised tariff. The estimated Cost of Generation for different R&M options is shown in **Annexure 7.2**.

7.4 Basis of Comparison

Net Present Value (NPV) and Internal Rate of Return (IRR) have been used to compare the relative financial merit of different R&M options. Considering that expected economic plant life after R&M under different R&M options differ among themselves and also from the residual plant life without R&M, NPV has been used as the criterion for final decision as to whether R&M will be carried out and which R&M option will be adopted. Net Present Value is the sum of present value of all the project cash outflows and inflows using an appropriate discount rate. IRR is another metric used to assess the financial attractiveness of the different R&M options. IRR is the discount rate that makes the project NPV zero.

For the sake of comparison of different R&M options, the revenue stream of all the options have been calculated on the basis of a single indicative tariff per kWh of electricity for each year. Assuming that the regulator will prefer minimum tariff, the indicative tariff per unit for a year has been taken to be the minimum value among the calculated Costs of Generation (COG) as per Electricity Regulator's Norm for the different R&M options and base case tariff for that year. The estimated capital cost of each R&M option is used for calculation of Return on Equity and Depreciation.

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Normative Debt Equity ratio and depreciation rates are as per Tariff Regulation of appropriate Electricity Regulator. The revenue from electricity generation during a year in which plant is shut down is calculated considering normative availability/plant load factor. The loss of generation due to shut down for R&M is accounted for by considering that equivalent amount of electricity will have to be procured from the grid/market at the prevailing tariff. Therefore, the tariff at which power will be procured during shut down also affects the financial analysis. The negative cash flow due to shut down is calculated as the product of loss of generation and average tariff at which power will be procured from the grid net of variable cost .

7.5 Assumptions for Financial Comparison

- Cost of Generation calculation is done as per Tariff norms of appropriate Electricity Regulator
- O&M cost is taken as per Tariff norms of appropriate Electricity Regulator
- Average annual Availability/PLF of [85%] is considered for all R&M options for financial analysis. This is in line with Normative Availability Factor prescribed by Electricity Regulator. If any unit is operating at PLF higher than 85%, such higher PLF may be considered for Financial Analysis.
- Operating life of plant without R&M is [... years]. The lower plant life in base case captures the cost of closure of unit instead of undertaking R&M.
- Without R&M, the present Availability/PLF is considered [...% with linear reduction of PLF to% in year.]
- [For calculating the financial quantities of the Base Case of operating the plant for the residual economic life without undertaking any Renovation and Modernization activity, actual observed average annual Heat Rate is considered the plant Heat Rate during RLA and the plant heat rate is considered to increase by [%] per annum. For calculating the financial quantities of each option for which some Renovation & Modernization is undertaken, the design/guaranteed heat rate with operating margin of [6.5%] is considered the plant Heat Rate for all the years during the economic life after Renovation & Modernization.]
- In line with the approach followed in Tariff Norms of Electricity Regulators, single value is considered for Plant Gross Heat Rate for financial analysis over the plant life after R&M. This single value of Heat Rate includes suitable operating margin over Design Heat Rate. Similarly, single value of auxiliary power consumption and specific oil consumption is considered over the entire plant life after R&M for financial analysis.
- Specific oil consumption is considered [actual consumption in ml/kWh without R&M and 1 ml/kWh with R&M]
- An operating margin of [6.5%] on Design Gross Heat Rate is considered for all R&M options. For base case without R&M, [Heat Rate is escalated by% every year from present actual average heat rate.]

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- Present coal price and fuel oil prices are considered to be equal to the actual coal price and fuel oil prices for the unit.
- The discount factor and coal price escalation rate are taken to be [that notified by appropriate Electricity Regulator].

Table- 7.1
Factors for Financial Analysis

Description	Value of Factors
Escalation rate for domestic coal	[...%]
Discount Rate	[....%]
Return on Equity	[....%]
Interest Rate on Rupee Term Loan	[...%]
Interest Rate on Forex Loan plus cost of Forex Rate Coverage	[...%]

7.6 Comparison of Input for Different Options

Table – 7.2
Inputs for Options

	Base Case(No R&M)	Option I	Option II	Option III	Option IV	Option V
Capacity (MW)	[....]	[....]	[....]	[....]	[....]	[....]
Operating Life (in years)	[....]	[....]	[....]	[....]	[....]	[....]
Shutdown for R&M (months)	--	[....]	[...]	[....]	[....]	[....]
Project Implementation Period (months)	--	[....]	[....]	[....]	[....]	[....]

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	Base Case(No R&M)	Option I	Option II	Option III	Option IV	Option V
Gross Heat Rate (kcal/kWh)	[.....] (actual)	[.....]	[.....]	[.....]	[.....]	[.....]
Coal GCV	[.....] (actual)	[.....]	[.....]	[.....]	[.....]	[.....]
Operating Margin on Heat Rate		[.....]	[.....]	[.....]	[.....]	[.....]
Annual Degradation of Heat Rate	[.....]	-	-	-	-	-
Auxiliary Consumption	[...]	[...]	[...]	[...]	[...]	[...]
Specific Coal Consumption	[...]	[...]	[...]	[...]	[...]	[...]
Rate of annual increase of Specific Coal Consumption	[...]					
Specific Oil Consumption	[...]	[...]	[...]	[...]	[...]	[...]
Rate of annual increase of Specific Oil Consumption	[...]					
Project Cost:	----	[...]	[...]	[...]	[...]	[...]
Tariff for purchase of Power during		[...]	[...]	[...]	[...]	[...]

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	Base Case(No R&M)	Option I	Option II	Option III	Option IV	Option V
unit shutdown						

7.7 Selection of R&M Option

The NPV, IRR and Payback Period calculation for different R&M options and NPV for base case is summarized at **Annexure-7.3**. R&M option [...] is found to be having the highest NPV and hence selected for implementation.

Table – 7.3
Financial Evaluation of R&M Options

Option	Levelized COG (Rs/kWh)	IRR (%)	NPV (Rs Million)	Differential NPV w.r.t Base Case (Rs Million)	Payback Period (Years)
Base Case(No R&M)	[...]	—	[...]	—	—
I	[...]	[...]	[...]	[...]	[...]
II	[...]	[...]	[...]	[...]	[...]
III	[...]	[...]	[...]	[...]	[...]
IV	[...]	[...]	[...]	[...]	[...]
V	[...]	[...]	[...]	[...]	[...]

The selected R&M option [...] has Differential NPV of Rs [...] Million with respect to the base case for a project cost of [...]. The selected R&M option has IRR of [...%] against cost of capital of [... %]. The selected R&M option has payback period of [...] years.

7.8 Impact of Adverse Scenarios

R&M projects are complex in nature and are associated with many uncertainties. The cost and time for execution of the project may overshoot estimates and the project may fall short of achieving its objectives. The financial viability of the selected R&M option should have some level of tolerance for such uncertainties.

Renovation & Modernization projects are associated with high risk of Time overrun and cost overrun due to unique nature of each project and also due to the complexities and uncertainties associated with retrofitting work. The reasons for Time/Cost overrun

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are discussed in the Chapter on Risks (Chapter-11). Time overrun itself is a reason for Cost Overrun due escalation of hard cost, increase in overheads and increase in interest during construction. Therefore, R&M projects very often run into time overrun and cost overrun simultaneously. Time and/or cost overrun adversely affect the financial viability/attractiveness of R&M projects by negatively affecting Net Present Value and Internal Rate of Return of the project.

The three prime objectives of any R&M project are Heat Rate improvement, Electricity Output restoration/up rating and Plant Availability/Reliability enhancement with concomitant adverse impact on project financials. R&M projects are associated with the risk of partially or fully failing to achieve these objectives. Failure to achieve the desired Heat Rate may itself contribute to less than targeted electrical output. Therefore, in many cases, R&M projects are likely to miss Heat Rate and Output objectives simultaneously.

The financial impact of certain level of cost overrun, time overrun and shortfall in performance is depicted in Table-7.4.

Table – 7.4
Impact of Adverse Scenarios on Selected R&M Option

Scenario	Levelized COG (Rs/kWh)	IRR (%)	NPV (Rs Million)	Differential NPV w.r.t Base Case (Rs Million)
Cost Overrun (+10%)	[...]	[...]	[...]	[...]
Cost Overrun (+15%)	[...]	[...]	[...]	[...]
Cost Overrun (+20%)				
Time overrun (+6 months)	[...]	[...]	[...]	[...]
Time overrun (+12months)	[...]	[...]	[...]	[...]
Time overrun (+18months)	[...]	[...]	[...]	[...]
Cost Overrun (+10%) and Time overrun (+6 months)	[...]	[...]	[...]	[...]

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Scenario	Levelized COG (Rs/kWh)	IRR (%)	NPV (Rs Million)	Differential NPV w.r.t Base Case (Rs Million)
Cost Overrun (+15%) and Time overrun (+12 months)	[...]	[...]	[...]	[...]
Cost Overrun (+20%) and Time overrun (+18 months)	[...]	[...]	[...]	[...]
Capacity shortfall(-2 MW)	[...]	[...]	[...]	[...]
Capacity shortfall(-4 MW)	[...]	[...]	[...]	[...]
Capacity shortfall(-8 MW)	[...]	[...]	[...]	[...]
Heat Rate Increase (+1%)	[...]	[...]	[...]	[...]
Heat Rate Increase (+2%)	[...]	[...]	[...]	[...]
Heat Rate Increase (+4%)	[...]	[...]	[...]	[...]
Capacity shortfall (-2 MW) and Heat Rate Increase (+1%)	[...]	[...]	[...]	[...]
Capacity shortfall (-4 MW) and Heat Rate Increase (+2%)	[...]	[...]	[...]	[...]
Capacity shortfall (-8 MW) and Heat Rate Increase (+4%)	[...]	[...]	[...]	[...]

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Scenario	Levelized COG (Rs/kWh)	IRR (%)	NPV (Rs Million)	Differential NPV w.r.t Base Case (Rs Million)
Availability variation (-3%)	[...]	[...]	[...]	[...]
Availability variation (-5%)	[...]	[...]	[...]	[...]

{Note: Identify the scenarios for which the NPV of chosen R&M option becomes negative and analyze them in detail. Discuss the likelihood of occurrence of each such negative NPV scenarios. If a negative NPV scenario appears to be highly unlikely or remote possibility, then it may be neglected. However, in case a negative NPV scenario has a fair chance of becoming a reality, the impact of such a scenario on the owner utility may be deliberated upon and accordingly decide whether to go ahead with the implementation of the chosen R&M option.}

If the Project qualifies for any financial benefit due to reduction in carbon emission or enhancement of energy efficiency, resulting from Renovation and Modernization, it will enhance the financial viability/attractiveness of the R&M Project. However, it will be project specific. In case the project is likely to get any such benefit, it shall be factored into the financial evaluation. }

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CARBON CREDIT AND ENERGY EFFICIENCY CREDIT

[With growing worldwide concern regarding carbon emission and depletion of energy resources, governments and international bodies are trying to put in place incentive mechanisms to encourage reduction in carbon intensity of economic activities and promote energy efficiencies. The various initiatives in this regard are evolving both nationally and internationally. Projects that lead to carbon emission reduction and energy efficiency improvement have the potential to earn carbon credit and energy efficiency credit that can be sold and serve as an additional revenue stream.]

The R&M project will increase plant efficiency and reduce plant heat rate and specific coal consumption. This in turn, will result in reduction of emissions of Green House Gas carbon dioxide (CO₂) per unit of electricity generated. The selected R&M option envisages change in plant design (particularly change in turbine) so as to increase its efficiency beyond the original design efficiency and involves additional investment on this account. This R&M project may qualify for carbon credit benefits. Further, implementation of this energy efficient R&M project involves overcoming technological barriers as infrastructure for this kind of project implementation is not well established in India. Carbon Credit benefit will help make this project viable which is as such a challenging project from financial and technological stand point.]

{There are various mechanisms such as Clean Development Mechanism under Kyoto Protocol, Verified Carbon Standard, National Action Plan on Climate Change (PAT mechanism of National Mission on Enhanced Energy Efficiency) etc. that can be explored to have financial benefit on account of reduction in carbon emission and enhancement of energy efficiency. However, success in securing any benefit under these schemes will be project specific.}

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9 PROJECT FINANCE AND MARKET SCENARIO

9.1 About the Utility

{Give a description of the background of the company including its inception, history, ownership, nature of business, operating power stations portfolio, projects under implementation, R&M initiative etc.}

9.2 Financial Performance

The balance sheet and income statement information of Utility for the last 3 financial years is summarized below:

Table 9.1

Profit and Loss Statement Particulars	Amount in Rs. Crores
Income from Sale of Power	
Other Income	
Total Income	
Fuel Cost	
Employee Expenses	
Other Expense	
PBDIT (Profit Before Depreciation, Interest and Tax)	
Depreciation and Amortization	
PBIT (Profit Before Interest and Tax)	
Interest Expense	
PBT (Profit Before Tax)	
Tax	
PAT (Profit After Tax)	
Balance Sheet Particulars	Amount in Rs Crores

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Fixed Asset/CWIP	
Less Accumulated Depreciation	
Net Fixed Asset	
Investments	
Current Assets excluding cash	
Cash	
Total Asset	
Long Term Loan	
Working capital Loan	
Equity Share Capital	
Reserves and Surplus	
Total Liability	

9.3 Means of Finance

[Utility is implementing the project by leveraging the existing balance sheet to raise the debt required for the project. At present the Company has a debt equity ratio of ..., which is being leveraged to finance various projects including this R&M project.]

The cost of the Project is estimated to be Rs. [.....] million. Utility plans to fund it at a debt-equity ratio of 70:30, which is same as the normative debt equity ratio for financing of generation projects by the Central Electricity Regulatory Commission ("CERC") in the CERC (Terms and Conditions of Tariff) Regulations 2009. The debt and equity requirement for the Project works out to approximately Rs. [.....] million and Rs. [.....] million respectively. Utility plans to fund the equity component from internal accruals. Utility plans to raise the debt component of the Project cost through a combination of rupee term loan and foreign currency loan as follows]:

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Table 9.2
Means of Financing

Means of Financing	Amount
Equity	[....]
Debt:	[....]
Rupee Term Loan	[... .]
Foreign Currency Loan	[....]
Total	[....]

[Given the strong balance sheet, the utility can support this kind of financing arrangement.]

9.4

Market Scenario

{Discuss about the scarcity and demand of power in the state or region where the project is located. Discuss about the likely prospect of future demand growth and infer about the prospect of demand for power from the project after implementation}

Table 9.3
Energy and Peak Deficit in Electricity supply during the last Financial Year

Period	Peak Demand	Peak Met	Peak Deficit/ Surplus	Peak Deficit/ Surplus	Energy Requirement	Energy Availability	Energy Deficit/ Surplus	Energy Deficit / Surplus
	(MW)	(MW)	(MW)	(%)	(MU)	(MU)	(MU)	(%)
India	130,250	115,847	-14,403	-11.1	936,568	857,239	-79,329	-8.5
[Region]	[42,352]	36509	-5,843	-13.8	290423	257,408	-33,015	-11.4
[State]	21069	16417	-4,652	-22.1	141464	117804	--23660	-16.7]

[Availability of power in the state is not adequate to meet the present requirement. With rapid economic growth and socio-economic development, the power deficit is likely to widen in coming years. Therefore, the power generated from the renovated unit is likely to be sold without any special effort. Therefore, there is no demand-side constraint for this R&M project.]

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10 IMPLEMENTATION OF R&M PROJECT

[The scope of R&M works was decided on the basis of the most attractive option which was selected after the cost-benefit analysis and detailed study of various options recommended by R&M Consultant. For implementing the R&M Project, the total work will be divided in suitable number of packages. A PERT Chart is attached with this Report highlighting the various timelines, parallel activities and critical paths for the implementation of the R&M project. For the selection of R&M Contractors, the tendering procedure and bidding norms will be designed to ensure a fair and transparent competition.]

10.1 Project Team

*[.....
.....
.....]*

{Explain the organization structure of the Project Team along with the Organization Chart}

10.2 Project Schedule

*[.....
.....
.....]*

{Discuss the project completion schedule along with the schedule of completion of critical activities. Refer Annexure- 10.1}

10.3 Project Management

*[.....
.....
.....]*

{Discuss the various aspects of Project Management like, Contracting, Engineering, Procurement, Construction, Erection and Commissioning so as to ensure that the quality of work conforms to relevant codes / standards and statutory requirements.}

10.4 Project Monitoring

*[.....
.....
.....]*

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{Discuss the methods to be used for regular monitoring the progress of R&M activities, holding of progress review meetings etc to ensure the timely and successful completion of Project.}

10.5 Role of R&M Consultant

[.....
.....
.....]

{Discuss the role of the R&M Consultant to carry out the activities from initial study stage up to the stage of finalizing the R&M contract and to facilitate approval from regulatory agencies if required.}

10.6 Role of the ISC Consultant

[.....
.....
.....]

{Discuss the role of the Implementation Support Consultant for the review of design documents & drawings to ensure compliance with the spirit, intent & contents of the EPC contract, inspection & testing before dispatch, site supervision and witnessing of Performance Guarantee Tests of the equipments.}

10.7 Quality Management

[.....
.....
.....]

{Discuss the aspects of Field Quality Plans to ensure that the work performed by the contractor is as per the relevant codes / standards and statutory requirements.}

10.8 Performance Guarantee Test

After the commissioning of the unit post completion of R&M works, the unit shall be tested to demonstrate the following Guaranteed Parameters as per the provisions of the R&M Contract.

Table 10.1
Performance Guarantee Parameters

S. No.	Performance Guarantee Parameter	Value
1.0	Gross Output for the unit at Generator terminals at 100% TMCR	[...]

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S. No.	Performance Guarantee Parameter	Value
2.0	Steam Turbine Heat Rate for the unit at 100% TMCR conditions with 0% makeup.	[...]
3.0	Boiler Efficiency at 100% TMCR conditions while firing design coal	[...]
4.0	Auxiliary Power Consumption @ 100% TMCR while firing design coal	[...]
5.0	Emissions of SPM @ 100% TMCR while firing worst coal	[...]
6.0	Noise Level during day time at plant boundary.	[...]
7.0	Noise Level during night time at plant boundary.	[...]

10.9 Liquidated Damages

The R&M Contract shall have provisions of levying Liquidated Damages (LD) for:

- Delay in Completion of the Project and
- Shortfall in Performance.

LD for delay in shall accrue at a rate of Rs. [...] per MW per day for each day of delay up to [...] days of delay and Rs. [...] per MW per day for each day of delay beyond [...] days of delay. LD for shortfall in performance of the Unit shall be as per the values given in the following table.

Sl. No.	Parameter	Condition	LD Amount
1.0	Gross Output	For each kW of shortfall.	[...]
2.0	Turbine Heat Rate	For each 1 kCal/kWh of increase	[...]
3.0	Steam Generator efficiency	For every 0.1% short fall in efficiency	[...]
4.0	Auxiliary Power Consumption	For each 1 kW of increase	[...]

10.10 Health, Safety and Environment (HSE)

[.....]
[.....]
.....]

{Discuss the steps to be taken for the maintenance of healthy and safe working environment with the aim to complete the project without any accident and any

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adverse effect on the health of manpower. Discuss also the implementation of HSE Plan by the EPC contractor.}

10.11 Supply of Spares and Special Tools and Tackles

*[.....
.....
.....]*

{Discuss the R&M Contractor's scope to include the supply of spares and special tools & tackles.}

10.12 Training

*[.....
.....
.....]*

{Discuss the R&M Contractor's scope to impart training to the O&M staff of the utility for the required up-gradation in their skills.}

10.13 O&M Manuals

*[.....
.....
.....]*

{Discuss the R&M Contractor's scope to prepare and submit sufficient number of O&M Manuals, Technical Diaries indicating various Equipment Specifications, Process Parameters, Key Schematic Diagrams and As Built Drawings.}

10.14 Operation and Maintenance

*[.....
.....
.....]*

{Discuss the O&M Philosophy of the utility to carry out safe, efficient and reliable plant operation of the plant in compliance with environmental legislation. Discuss the strengthening of existing O&M Organization on modern lines. The O&M organization should necessarily include an Operation & Efficiency Cell to evaluate the actual efficiency, Heat Rate and Cost Of Generation on day to day basis, a Maintenance Planning Department for maintaining updated data base of assets of the unit as well as for carrying out condition monitoring of the rotating equipments on a weekly basis and for detailed planning of Annual and Capital

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Overhauls. A Trip Committee to diagnose the root cause of trippings and to minimize the incidents of forced outages should be set up.}

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11 RISKS

Renovation and Modernization projects are very complex in nature and associated with high level of uncertainty. The various risk factors along with mitigation measures are discussed below.

11.1 Limitation of CA, RLA and LE Studies

Information and inference flowing from Condition Assessment, Residual Life Assessment and Life Extension studies forms the basis of planning, designing, costing and tendering of R&M projects. However, these reports may not give accurate idea about actual state of the plant and equipment. Similarly, the rehabilitation and retrofitting programme may not lead to the intended life, reliability and performance of the plant. In some cases serious damage might be detected for plant and equipment during the implementation stage which could not be detected during the CA studies. Such surprises may adversely affect the cost estimate and schedule.

The probability and impact of such risks may be moderated by designing proper condition assessment plans. Further, contingencies may be built into cost estimates and contractual clauses may be suitably designed to take care of such surprises.

11.2 Regulatory Risk

The capital expenditure incurred for the R&M project has to be serviced by suitable electricity tariff. If the concerned Electricity Regulatory Commission does not allow adequate tariff to cover the expenses incurred, it will adversely affect the cash flow and net worth of the owner.

The regulatory risk may be mitigated by designing and implementing the R&M Project in compliance and in sync with the extant regulatory regime.

11.3 Risk of R&M Contractor and Personnel

There is limited availability of competent contractors and personnel for carrying out R&M works. There is dearth of contractors and personnel with expertise and experience in implementation of energy efficient R&M works.

Government and industry bodies can play big role in mitigating this risk by taking initiative expands contractor base and talent pool. Owner on its part can somewhat mitigate this risk by designing tendering process and contracts that encourages better participation by available contractors.

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11.4 Risk of Non-Availability of Spares.

As the units are very old, there may be difficulty in sourcing many spare parts. This risk may be obviated in some cases by devising suitable sourcing strategy or design modifications or reverse engineering.

11.5 Risk of Getting Shutdown for Implementation

As R&M of the complete plant calls for shutdown for considerable time and there is acute shortage of electricity, the grid condition may not permit shutdown period. This risk may be mitigated by proper planning and taking all stakeholders into confidence during the planning phase and adhering to the planned schedule.

11.6 Financing Risk

The owner may find it difficult to arrange equity and debt financing for the R&M project. This risk may be mitigated by proper financial planning. Similarly, the R&M contractor may face cash flow problem. This risk may be mitigated by specifying suitable financial qualification criteria in tender specification and incorporating suitable payment term in the contract.

11.7 Implementation Risk

Poor implementation of project may lead to cost and/or time overrun and deficiency in quality. This risk may be mitigated by efficient Project Management set up and selection of reliable R&M contractor.

11.8 Equipment Underperformance Risk

The renovated plant and equipment may not perform as envisaged due to deficiency in design, manufacturing and O&M practices. The risk of underperformance due to design and manufacturing shortcomings may be managed by selecting reliable contractor and incorporating appropriate LD clause in the contract. The risk of O&M deficiency can be mitigated by proper training of O&M personnel.

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12 CONFORMITY TO STATUTORY ENVIRONMENTAL NORMS

{Discuss in this chapter, the need of compliance to the conditions prescribed by MOEF and State Pollution Control Board (SPCB)}

12.1 Environmental Monitoring Cell

[.....
.....
.....]

{Discuss the role of Environment Monitoring Cell established at the project. Discuss the steps to be taken for strengthening the above cell to monitor and control the environmental impacts from the renovated plant, as per the revised stringent norms prescribed by the regulating authorities.}

12.2 Stack Emissions

[.....
.....
.....]

{Discuss the present levels of emissions of SPM, SO₂, NO_x and NH₃ from the stack, levels of Ground Level concentrations and the pollutants in the liquid effluents with respect to the statutory norms vis a vis the levels of emissions after the implementation of R&M Project. Discuss the methods and frequency to be adopted by the utility for monitoring and controlling these emissions as per the revised conditions prescribed by the regulating authorities.}

12.3 Ambient Air Quality (AAQ)

[.....
.....
.....]

{Discuss the National Ambient Air Quality Standards prescribed by MOEF and SPCB. Discuss the methods and frequency to be adopted by the utility for monitoring and controlling the Ground Level Concentrations (GLC).}

12.4 Liquid Effluents

[.....
.....
.....]

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{Discuss the quality of liquid effluents permitted by SPCB from different systems of the plant like, effluent from Water Treatment Plant, Boiler Blow down, Cooling Tower Blow down, recycled water from ash pond and sewage disposal from plant and colony. Discuss the recycling of ash water from ash pond and reuse of Cooling Tower Blow down for ash handling and coal dust suppression. Discuss the proposal of zero discharge, if applicable to your project.}

12.5 Noise

[.....
.....
.....]

{Discuss the noise level permitted during day and night and methods proposed to contain the noise level produced from power plant equipment within the limits imposed.}

12.6 Ash Utilization

[.....
.....
.....]

{Discuss the norms for the utilization of ash from the thermal power plants as per the latest notification from MOEF. Discuss the quantum of fly ash & bottom ash to be produced from the plant and implementation of ash utilization plan by the utility, after the completion of R&M project. Please note that as per MoEF notification dated 3rd November 2009, all the coal and lignite based thermal power stations operating before the date of the above notification are required to achieve the target of 100% utilization of fly ash before the expiry of a period of five years from the date of issue of the said notification.}

12.7 Corporate Social Responsibility

[.....
.....
.....]

{Discuss the initiatives proposed to be taken by the Project to actively contribute to the social and economic development of the weaker sections of the communities around which the Project is going to operate.}

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ANNEXURE-6.1

BOILER AND AUXILIARIES

Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Furnace	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Pressure Parts								
Drum	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Down Comers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Water Walls	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Super Heaters	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Re-Heaters	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Economiser	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Air pre-Heater	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Oil Burners	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Low Nox Burners	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Oil guns	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Igniters	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Refractory	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
insulation	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Buckstays	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Ducting	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Wall Soot blowers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
LRSBs	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Pent House	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Coal Mills	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Attemperators	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Bottom Ash Hoppers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Clinker Grinder	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
PA Fans	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
ID Fans	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
FD Fans	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
ESP	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Any other systems	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cost Impact for Boiler & Auxiliaries			[.....]					

{Note: Under Columns I to V, indicate (√) if the specific proposal is applicable and (x) if the same is not applicable.}

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ANNEXURE-6.2

STEAM TURBINE & AUXILIARIES

Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Steam Turbine	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Condenser	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Ejectors	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Condensate Extraction Pumps	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
LP Heaters	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Deaerator	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Boiler Feed Pumps	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
HP Heaters	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Critical Piping	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Any other systems	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cost Impact for Steam Turbine & Auxiliaries			[.....]					

{Note: Under Columns I to V, indicate (√) if the specific proposal is applicable and (x) if the same is not applicable.}

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ANNEXURE-6.3

BALANCE OF PLANT

Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Coal Handling Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Ash Handling Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Water Intake System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Water Pre-Treatment Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
DM Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
CW & ACW System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cooling Towers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Fire Fighting System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Fuel Oil Handling system	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Compressed Air System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Air Conditioning & Ventilation System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Effluent Treatment Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Any other systems	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cost Impact for Balance of Plant			[.....]					

{Note: Under Columns I to V, indicate (√) if the specific proposal is applicable and (x) if the same is not applicable.}

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ANNEXURE-6.4

ELECTRICAL SYSTEM

Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Generator Stator	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Generator Rotor	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Generator Transformer	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Unit Auxiliary Transformer	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Generator Protection and Synchronizer	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Station Service Transformer	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
6.6 kV System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
415 V System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
HT & LT motors	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
DC System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Public Address System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Illumination System	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
DG Sets	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Any other Systems	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cost Impact for Electrical System			[.....]					

{Note: Under Columns I to V, indicate (✓) if the specific proposal is applicable and (x) if the same is not applicable.}

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ANNEXURE –6.5

CONTROL AND INSTRUMENTATION

Component	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
DDCMIS	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Soot Blowers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Burner Tilt	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Component	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Boiler temperature MI thermocouple (K-Type)	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Boiler protections	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Turbine Protection	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Turbine Controls -EHC	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Component	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Turbine -ATRS	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Turbine supervisory system	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Machine conditioning monitoring system	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Automatic turbine testing	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Component	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Turbine Stress Evaluator (TSE)	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
HP LP Bypass , PRDS	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Gland steam pressure control	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Control valves/ Dampers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Furnace Draft	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Total Air Flow	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Component	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Mill A TEMP to --- MILL F TEMP	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
SH STM TEMP	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
RH STM TEMP	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
DRUM Level	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
BFP Scoop Tube	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Deaerator level	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Deaerator press	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Hot well LVL	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
HP Heaters LVL 5,6 & 7(3 no)	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
LP heaters LVL 2,3 GC2 &4 (4 no)	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Fuel oil	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
BFP Recirculation valve	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Feed water control valve	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Component	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Transmitters	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Pressure / DP Gauges	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Temp Gauges	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Pressure / DP Switch	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Temp Switch	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
RTD / TC 's	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Level measurement	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Flow measurement & primary	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Component	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
flow sensors								
Flow measurement & primary flow sensors	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Fuel flow measurement	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Analyzers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
UPS	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Impulse pipe	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Any other systems	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cost Impact for Control & Instrumentation			[.....]					

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Feasibility Report For R&M of Unit No.[..] of <i>[Name of the Power Plant]</i>	<i>[Logo of Utility]</i>
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{Note: Under Columns I to V, indicate (√) if the specific proposal is applicable and (x) if the same is not applicable.}

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-002	05	FEASIBILITY REPORT FOR R&M WORKS	[105]	15.01.2016

Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	[Logo of Utility]
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ANNEXURE-6.6

Civil Works

Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Boiler Foundations	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Mill Foundations	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Fan Foundations	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
ESP Foundations	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
TG Building	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Chimney	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Coal Handling Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Ash Handling Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Water Treatment Plant	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
CW Pump House	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cooling Towers	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]

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LII-GETS12021-G-00100-002	05	FEASIBILITY REPORT FOR R&M WORKS	[108]	15.01.2016

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Components	Recommendation	Reasons	Cost Impact	Options				
				I	II	III	IV	V
Miscellaneous Works	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Any other Systems	[.....]	[.....]	[..]	[..]	[..]	[..]	[..]	[..]
Cost Impact for Civil Works			[.....]					

{Note: Under Columns I to V, indicate (✓) if the specific proposal is applicable and (x) if the same is not applicable.}

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LII-GETS12021-G-00100-002	05	FEASIBILITY REPORT FOR R&M WORKS	[109]	15.01.2016

Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	<i>[Logo of Utility]</i>
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ANNEXURE-7.1

SUMMARY OF CAPITAL COST FOR VARIOUS R&M OPTIONS

Sl. No.	Item	FC	IC	Total
		Equiv. Rs.	Rs.	Rs.
1	Civil Works	[...]	[...]	[...]
2	Plant & Equipment	[...]	[...]	[...]
2.1	Mechanical Equipment	[...]	[...]	[...]
2.2	Electrical Equipment	[...]	[...]	[...]
2.3	Miscellaneous Equipment	[...]	[...]	[...]
	Sub-Total (2.0)	[...]	[...]	[...]
3	Contingency	[...]	[...]	[...]
4	Pre Commissioning Expenses	[...]	[...]	[...]
5	Project Engineering and Management	[...]	[...]	[...]
	Project Cost excluding IDC and FC (1.0 to 50)	[...]	[...]	[...]
6	Financing Charges	[...]	[...]	[...]
7	Interest During Construction (IDC)	[...]	[...]	[...]
	IDC + Financing Charges	[...]	[...]	[...]
	Project Cost incl. IDC &FC (1.0 to 7.0)	[...]	[...]	[...]

{Note: Project Capital Cost Summary for each of the R&M option is to be attached.}

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Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	[Logo of Utility]
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ANNEXURE – 7.2

COST OF GENERATION (COG) CALCULATION FOR VARIOUS R&M OPTIONS

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PLF (%)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Heat Rate (kCal/kWh)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Secondary Fuel Consumption (ml/kWh)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Landed Cost of Coal (Rs/tonne)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Landed Cost of Secondary Fuel (Rs/KL)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Auxiliary Consumption (%)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Energy Generated	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]

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Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	[Logo of Utility]
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(MU)																				
Energy Sent Out (MU)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Energy Charges:																				
Energy Charge per Unit (Rs/kWh)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Annual Energy Charge (Rs Million)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Capacity Charge:																				
Return on Equity (Rs Million)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Interest on Loan Capital (Rs Million)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Interest on Working Capital (Rs	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]

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Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	<i>[Logo of Utility]</i>
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Million)																				
Depreciation (Rs Million)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
O&M Charge (Rs Million)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Secondary Fuel Charge (Rs Million)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Capacity Charge per Unit (Rs/kWh)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Annual Capacity Charge (Rs Million)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Cost of Generation (Rs/kWh)	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Discounting Factor	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]	[.]
Levelized Cost of Generation	[.]																			

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Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	<i>[Logo of Utility]</i>
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(Rs/kWh)	
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{Note: Cost of Generation calculation for each of the R&M option is to be attached.

The number of years in the above table is indicative only. The CoG calculation will be done for each option for the number of years spanning the economic plant life after R&M. For base case, the calculation will be carried out for the residual life of the plant. }

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Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	<i>[Logo of Utility]</i>
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ANNEXURE-7.3

CASH FLOW AND RETURN ANALYSIS FOR VARIOUS R&M OPTIONS

Year	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PLF (%)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
(Normative PLF for R&M options and expected PLF for base case)																							
Average Heat Rate (kCal/kWh)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Auxiliary Consumption (%)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Coal GCV (Kcal/kg)																							
Specific Coal Consumption (kg/kWhr)																							
Specific Oil Consumption (ml/kWhr)																							
Normative Energy				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]

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Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	<i>[Logo of Utility]</i>
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Generated (MU)																								
Energy Sent Out (MU)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Loss of generation due to shut down for R&M (MU)				[..]	[..]																			
Landed Cost of Coal (Rs/tonne)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Landed Cost of Secondary Fuel (Rs/KL)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Indicative Tariff (Rs/kWh)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Cost of Purchasing Power from Grid net of variable charge (Rs/kWh)				[..]	[..]																			
Cash Inflow:																								
Annual Revenue (Rs Million)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Cash Outflow																								

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Annual Coal Cost (Rs Million)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Annual Oil Cost (Rs Million)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Annual O&M Cost (Rs Million)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Cost of Loss of Generation due to shut down for R&M (Rs Million)				[..]	[..]																		
Capex (Rs Million)	[..]	[..]	[..]	[..]	[..]																		
Interest Payment (Rs Million)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Principal Repayment (Rs Million)				[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Net Cash Flow (Rs Million)	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Discount Factor	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]	[..]
Net Present Value of Cash Flows (Rs Million)																							

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Feasibility Report For R&M of Unit No.[..] of [Name of the Power Plant]	<i>[Logo of Utility]</i>
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IRR (%)																								
Payback Period (Years)																								

{Note: Cash Flow and Return analysis for each of the R&M option and base case to be attached.

The number of years in the above table is indicative only. The analysis will be done for each R&M option for the number of years spanning the economic plant life after R&M. For base case, the analysis will be carried out for the residual life of the plant. }

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ANNEXURE – 10.1

PROJECT MILESTONE SCHEDULE FOR R&M CONTRACT

Milestones	Scheduled Start Date	Scheduled Finish Date
Zero Date	[.....]	[.....]
Site Office Development	[.....]	[.....]
Site visit and assessment of Equipment & System	[.....]	[.....]
Re-Engineering and Development	[.....]	[.....]
Supply of Equipment	[.....]	[.....]
Unit Shut-down	[.....]	[.....]
Dismantling Activities	[.....]	[.....]
Erection activities	[.....]	[.....]
Boiler Erection	[.....]	[.....]
Turbine Erection	[.....]	[.....]

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Milestones	Scheduled Start Date	Scheduled Finish Date
Erection of Balance of Plant	<i>[.....]</i>	<i>[.....]</i>
Erection of Electrical Equipment	<i>[.....]</i>	<i>[.....]</i>
Erection of C&I Equipment	<i>[.....]</i>	<i>[.....]</i>
Testing & Commissioning	<i>[.....]</i>	<i>[.....]</i>
Commercial Operation	<i>[.....]</i>	<i>[.....]</i>

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL RESIDUAL LIFE ASSESSMENT /
CONDITION ASSESSMENT REPORT**

PREPARED BY

LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
(CONSULTING ENGINEERS)
(AN ISO: 9001:2008 CERTIFIED COMPANY)

Model RLA/CA Report For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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History of Revisions

Revision No.	Date	Prepared /Revised by	Description
R00	28.08.2012	R.K.Soni (RKS)	First edition Issued (Draft Report).
R01	30.08.2012	RKS	Minor Revision (Draft Report).
R02	12.01.2013	RKS	Revised edition submitted based on the discussions held in CEA on 7 th Sep 2012.
R03	31.07.2013	RKS	Revised edition submitted based on the comments of the Task Force received on 14 th May 2013 and the meeting held in CEA on 11 th June 2013.
R04	25.09.2014	RKS	Revised edition submitted based on CEA's Requirement on left out comments.

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BACKGROUND

What is R&M (Renovation & Modernization) of Thermal Power Plants?

Coal based power stations contribute more than 70% share of total power generation in India. Thermal Power Stations are designed for an economical and stable life span of 25 years, after which, the level of performance starts deteriorating as a result of degradation of its equipments, components and materials. Deterioration may also take place before the completion of useful life of 25 years, if the units are not operated and maintained properly. Deterioration in performance is reflected in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. This results in costly repair and loss of revenue. Renovations & Modernization (R&M) and Life Extension (LE) Programme of thermal power station is an activity of carrying out repairs, refurbishments and replacement of defective equipments & components so as to extend the life of the power plant by at least 20 years and to restore the performance parameters to equal or better than the original design parameters.

Need of R&M

In spite of new capacity additions, India continues to face shortages of varying degree in the supply of energy and peaking power. Implementation of fresh capacity additions for bridging the demand supply gap involves huge investments and long gestation periods primarily due to the process of land acquisition and getting the required fuel and water allocations, permits & clearances, particularly, the environmental clearance.

On the other hand, R&M activity of existing old power plants which requires less investment and can be completed in shorter duration has been recognized as a techno-economically viable option to supplement the fresh capacity addition for maximizing the energy generation. Also it helps in reducing the emissions by adopting upgraded modern technologies.

Objectives of R&M and R&M/LE Programme

As per the Guidelines issued by Central Electricity Authority (CEA) the following should be the objectives of R&M and R&M/LE Programmes.

Objectives of R&M Programme:

- To restore rated capacity and design parameters such as Heat Rate, Auxiliary Power Consumption and Secondary Oil Consumption etc.
- To make the operating units well equipped with modified/ augmented latest technology.
- To overcome technological obsolescence and non-availability of spares.

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- To improve the performance parameters in terms of Plant Load Factor, Efficiency, Forced Outages, Availability and Reliability.
- To reduce maintenance requirements and enhance the ease in maintenance.
- Compliance of stringent environmental norms, safety and other statutory requirements.

Objectives of R&M/LE Programme:

- Extension of useful economic life of generating units by another 20 years.
- To focus on full load operation of the unit beyond their original design life.
- To restore rated capacity and design parameters such as heat rate,
- Improvement in Auxiliary Power Consumption Secondary Oil Consumption etc
- Up-rating of Generating Unit.
- Improvement beyond design parameters.

Criteria for the Consideration of R&M and R&M/LE Programmes

As per the Guidelines issued by Central Electricity Authority (CEA) the following criteria is to be adopted for considering the R&M and R&M/LE Programmes.

- Estimated cost of unit for complete R&M/ LE works should be limited to 50% of cost of new unit.
- Cost of Main Plant (BTG) should be limited to 50% cost of new BTG unit.
- Plant Life should be extended by about 20 years.
- The Pay Back Period should be from 5 to 7 years.

Need of Preparation of Model R&M Documents

The countrywide R&M programme was first initiated in 1980 when Government of India approved the scheme of Central Loan Assistance (CLA) of Rs. 500 crores benefitting 34 power stations mostly of 50/60/100/110/120/140 MW capacities. R&M in a structured manner was initiated as a centrally sponsored programme during the 7th Five Year Plan. The momentum of carrying out R&M works was continued through 8th and 9th Plans but the same could not be sustained during the 10th Plan.

Based on the discussions held with Ministry of Power, various utilities, PFC and BHEL, CEA prepared a document on "National Perspective Plan for Renovation & Modernization and

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Life Extension and Up-rating (LE&U) of thermal power stations up to the year 2016-17". This document which also includes revised guidelines for Renovation & Modernization / Life Extension works on coal/lignite based thermal power stations was released by Honourable Minister of Power on 14th December 2009. Plan-wise Achievements of R&M and R&M/LE Programmes starting from 7th Five Year Plan till 11th Five Year Plan is furnished below:

Plan-Wise Achievements

S.No.	Plan	Year	No. of TPS / No. of Units	Capacity (MW)	Additional Generation Achieved MU/ Annum	Equivalent MW
1	7 th Plan and Two Annual Plans	85-86 to 89-90 & 90-91, 91-92	34 / 163	13570	10000	2000
2	8 th Plan (R&M) (LEP)	92-93 to 96-97	44 / 198 43/(194) 1/ (4)	20869 (20569) (300)	5085	763
3	9 th Plan (R&M) (LEP)	97-98 to 2001-02	37 / 152 29/ (127) 8/ (25)	18991 (17306) (1685)	14500	2200
4	10 th Plan (R&M) (LEP)	2002-03 to 2006-07	9/ 25 (14 out of 57 planned) (11 out of 106)	3445 (2460) (985)	2000	300

11th Plan R&M Programme & Achievements (2007-12)

	Programme (MW)	Achievement (MW)
Life Extension Programme (LEP)	7318 (53 units)	1291 (13 Units)
R&M Programme	18965 (76 units)	14855 (59 units)
Total	26383 (129 units)	16146 (72 units)

In the past, R&M measures were hampered due to lack of proper planning. Proper investigation to identify the R&M works to be carried out and preparation of technical bid documents based on the investigation was not done. This resulted in unsystematic and additional work during execution phase and uncertainty about costs resulting in excessive implementation time, long shutdown periods of plants and cost overruns. In the absence of

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standard commercial rules and policies, suppliers showed little interest in R&M work. Therefore a strong need was felt for providing standardized bidding procedures as well as model contracts, formats and specifications etc. to the utilities. Standardization will harmonize the requirements of all the stakeholders and will lead to their increased participation.

The Indo-German Energy Forum (IGEF)

The Indo-German Energy Forum (IGEF), inaugurated in 2006, provides a platform to discuss energy related issues of mutual interest. The first meeting of the ad-hoc sub-group on “energy efficiency in thermal power stations”, constituted as per decision of meeting of IGEF in December 2007, was held under the chairmanship of Joint Secretary (Thermal), Ministry of Power on 12th March, 2008 in which preparation of standard tendering document for the purpose of R&M activities was, inter-alia, identified as an area of the activities. The scope of the assignment was divided in two parts as under:-

Phase-I Activity:

Phase-I activity comprised an assessment of tendering procedures currently being followed by public utilities in India and a review of documents used for standard R&M projects and the documents which have already been developed for energy efficient R&M projects financed by particularly World Bank. This activity was carried out by M/s Evonik (India) under the grant provided by GTZ. M/s Evonik (India) submitted the report in September 2009.

Phase-II Activity

Phase-II activity comprised the preparation of the model documents / templates in consultation with Task Force, power utilities & financing agencies.

In the 3rd meeting of Indo-German Energy Forum (IGEF) convened in Berlin on 4th November 2009, KfW proposed to finance and carryout the work programme of phase-II Activity, on behalf of CEA & in consultation with the Task Force. In a meeting held in MOP on 17th December 2009, chaired by Joint Secretary (Thermal), MOP, the representative of KfW suggested that CEA may act as “Project Executing Agency” for the phase-II activity. Accordingly Ministry of Power, Govt. of India have entrusted the task of “Project Executing Agency” to CEA for implementing Phase-II activity. Under Indo-German Energy Forum (IGEF) assisted programme, M/s Lahmeyer International (India) was appointed on 16th March 2012 to provide the consultancy services for ‘Development of tendering procedures and model contract document for R&M of Fossil Fuel Based Power Plants in India.’ The scope of consultancy services included the preparation of the following model documents:

- I) Standard Bidding Procedure for engagement of Consultants and R&M Works Contractor.
- II) Residual Life Assessment (RLA) / Condition Assessment (CA) Report.
- III) Energy Audit (EA) Report.
- IV) Feasibility Report.

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V) Detailed Project Report.

VI) Request for Qualification (RFQ) & (RFP) Documents for R&M Consultants and R&M Contractors.

VII) Technical Specifications.

Due Diligence done by LII of the R&M Documents of other Projects

Before the preparation of this model document, LII did a thorough review of the R&M Documents of the following Power Plants:

Documents Provided by CEA

- Remaining Life Assessment / Condition Assessment Report- Nasik Unit-3 of MAHAGENCO.
- Energy Audit Report- Nasik Unit- 3 of MAHAGENCO.
- Detailed Feasibility Report- Nasik Unit-3 of MAHAGENCO.
- Draft Detailed Project Report -Kolaghat Unit-3 of WBPDCCL.
- Service Contract- R&M of Unit-1 Panipat TPS of HPGCL.
- Tender document for Supply, Erection, Testing and Commissioning of Air Preheater for Unit 5 & 6 Koradi TPS, MAHAGENCO.
- Tender document for replacement of 6.6 KV station transformer incoming breaker & Tie- breaker of Koradi TPS, MAHAGENCO.
- Tender specification for Design, Engineering, Supply, Erection, Testing and Commissioning of Rotary Air Preheater for Units 4 & 5, Nasik TPS of MAHAGENCO.

Documents Provided by WBPDCCL

- Energy Audit Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Detailed Project Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Project Design Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Technical Specifications. (Vol. II of RFP Document for R&M Contractor).
- RLA for Boiler for Bandel Unit -5.
- RFP for R&M Consultant for Bandel Unit -5.
- Commercial Volume-I of RFP for Bandel Unit -5 for R&M Contractor.

KfW Documents

- Model Contract Document issued by KfW.
- Guidelines issued by KfW for the assignment of Consultants.

World Bank Documents

- Standard Bidding Document for Procurement of Plant, Design, Supply and Installation.
- Standard Request for Proposal for the Selection of Consultants

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.....
This Model Residual Life Assessment (RLA) / Condition Assessment (CA) Report has been prepared to conceptualize the format of the Report based on the systematic methods and procedures to be applied for checking the health of various equipments and components so as to identify such equipments and components which require replacement or refurbishments. Detailed standard documents like FR, DPR, RFP & RFQ documents to carry out R&M works for the Thermal Power Plants shall be prepared based on this RLA/CA Report.

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NOTES & GUIDELINES FOR USING THE MODEL RLA/CA REPORT

Central Electricity Authority (CEA), the Project Executing Agency / Employer has appointed Lahmeyer International India Pvt. Ltd. (LII), the Consultant to Develop Standard Procedures and Model Documents for the Renovation and Modernization (R&M) of Fossil Fuel based Power Plants in India. The above assignment is being financed by KfW Entwicklungsbank. Accordingly, this Model RLA/CA Report has been prepared for the guidance of Project Authorities who may decide to carryout R&M of their old Coal based Power Plants so as to extend the life of their plants and make them energy efficient and reduce emissions.

The purpose of this model document is to standardize the format of the RLA/CA Report for R&M works. Since majority of 200/210 MW units are potential candidates for consideration of Renovation as they have crossed 20 to 25 years of useful life, the enclosed format has been prepared keeping those 200 MW/210 MW units in view. Since in due course of time, many 500 MW units will also become due for R&M, the Utilities are advised to suitably modify this document for its application to 500 MW units.

This format of RLA/CA Report contains two kinds of texts written in black and in blue colours. The text in blue italics and enclosed in square bracket ([...]) represents variable information which may differ from project to project. The text and numbers in blue colour are written for the sake of citing an example. The Utilities and their Consultants are advised to check the relevance of the same and replace these texts and numbers with the ones as may be applicable to their specific Project. A few guidelines have also been provided in blue italics enclosed within red curly brackets ({...}), wherever applicable.

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LIST OF ABBREVIATIONS

{The utilities are advised to use the following standard abbreviations while preparing RLA/CA Report for their power plant.}

ACB	Air Circuit Breaker
ACG	Automatic Control Gear
AHP	Ash Handling Plant
AHU	Air Handling Unit
ASTM	American Society of Testing and Materials
ATRS	Automatic Turbine Run up System
ATT	Automatic Turbine Testing
AVR	Automatic Voltage Regulator
BFP	Boiler Feed Water Pump
BOD	Biological Oxygen Demand
BOP	Balance of Plant
CA	Condition ASSESSMENT
CAPO	A Trade Name of 'Pull Out Test'
CCTV	Closed Circuit Television
CEA	Central Electricity Authority
CHP	Coal Handling Plant
DGA	Dissolved Gas Analysis
DM	Demineralization
ECO	Economizer
EHC	Electro-Hydraulic Control

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ELCID	Electromagnetic Core Imperfection Detection
EOT	Electrically Operated Travelling Crane
ESCOT	A Trade Name of 'Pull Out Test'
ESP	Electro Static Precipitator
FO	Fuel Oil
FSSS	Furnace Safeguard Supervisory System
GC	Gland Condenser
GCV	Gross Calorific Value
GT	Generator Transformer
HCA	Host Country Approval
HEA	High Energy Pulsed Arc
HP	High Pressure
HT	High Tension
HVAC	Heating Ventilation Air Conditioning
HVWS	High Velocity Water Spray System
IGV	Inlet Guide Vane
IPT	Intermediate Pressure Turbine
IPR	Inter Posing Relay
IS	Indian Standards
LDO	Light Diesel Oil
LE	Life Extension
LP	Low Pressure

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LPT	Low Pressure Turbine
LRSB	Long Retractable Soot Blower
LT	Low Tension
LTSH	Low Temperature Super Heater
LVS	Large Video Screen
MCCB	Module Case Circuit Breaker
MOCB	Minimum Oil Circuit Breaker
MoEF	Ministry of Environment and Forest
MSSV	Main Stream Safety Valve
OWS	Operator Working Station
PA	Primary Air
PCN	Project Concept Note
PDD	Project Design Document
PLF	Plant Load Factor
PRDS	Pressure Reducing De-superheating Station
PLC	Programmable Logic Controller
R&M	Renovation & Modernization
RH	Re-heater
RLA	Residual Life Assessment
RO	Reverse Osmosis
RSO	Recurrent Surge Oscillograph
SADC	Secondary Air Damper Control

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SG	Steam Generator
SH	Super Heater
SPA	Steam Path Audit
SPM	Solid Particulate Matter
SPT	Special Purpose Test
SS	Stainless Steel
SWAS	Steam and Water Analysis System
TDH	Total Dynamic Head
TFT	Thin Film Transistor (Monitor)
TPS	Thermal Power Station
TR	Tons of Refrigeration
TC	Thermocouple
TSE	Turbine Stress Evaluator
UPS	Uninterruptible Power Supply
VVFD	Variable Voltage and Variable Frequency Drive

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MEASUREMENT UNITS

{The utilities are advised to use the following abbreviations of measuring units while preparing RLA/CA Report for their power plant.}

°C	:	Degree Celsius
cm ²	:	Square Centimeter
dB (A)	:	Decibels Absolute
hr	:	Hour
Hz	:	Hertz
kCal	:	Kilo Calorie
kg	:	Kilogram
kl	:	Kilo Liter
km	:	kilo meter
kV	:	kilo Volt
kVA	:	kilo Volt Ampere
kW	:	kilo Watt
kWh	:	Kilo Watt hour
m	:	Meter
m ²	:	Square Meter
m ³	:	cubic meter
mg	:	Milligram
mm	:	Millimeter
cm	:	centimeter
MVA	:	Mega Volt Ampere
MW	:	Mega Watt
ppm	:	Parts per million
rpm	:	Revolutions per minute
TPH / T/h	:	Tonnes Per Hour
mg/Nm ³	:	Milligram per Normal cubic meter
µg/m ³	:	Micrograms per cubic meter

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**MODEL RESIDUAL LIFE ASSESSMENT
AND
CONDITION ASSESSMENT REPORT
FOR
RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

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1

EXECUTIVE SUMMARY

This Residual Life Assessment and Condition Assessment Report has been prepared for carrying out the Renovation & Modernization (R&M) / Life Extension (LE) of Unit No [...] of [...] Thermal Power Plant, located at [...], in District [...] in the State of [...] and having a configuration of [...x...MW].

The unit no. [...] was first commissioned in the year [...]. After [...] years of operation, the performance of the unit has gradually deteriorated resulting in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. It is proposed to carry out required refurbishments and replacements in the plant so as to restore the unit's performance parameters and to extend its life of by at least [...] years.

The report discusses the salient features and operational history of the power plant and also the specific problems being faced from the operation of various plant equipment & systems.

To assess the health and determine the residual life of all the major components of the plant, various Residual Life Assessment (RLA) and Condition Assessment studies were conducted during the period [...]. The studies and tests conducted were based on the latest available technology.

Summary of Recommendations of RLA/ CA Studies are furnished below:

[.....]

]

{Describe above the major recommendations of RLA/ CA studies which could comprise Replacement/ Refurbishment of Boiler drum internals, Down comers, Water Wall Headers / Tubes, Headers/ Coils of Platen Super Heaters/ Final Super Heaters/ Convection Super Heaters/ Re-Heaters, Inlet/ Outlet Headers/ Coils of Economisers, Baskets/ Seals of Rotary Regenerative Air Pre-Heater, Wall Soot Blowers/ LRSBs, Coal Feeders, Wind Box, Low NOx Burners, Burner Tilting Arrangement, Boiler Structure, Buckstays, Ducting & Insulation, Bottom ash Hoppers, Clinker Grinders, ID/ FD/PA Fans, Grinding Rolls/ Gear Boxes/ Classifiers of Mills, Collecting Electrodes/ Emitting Electrodes/ Transformer Rectifier Sets of ESP, HP/IP/LP Modules of Steam Turbines, HP / IP Casings/ Diaphragms/ Gland Sealing System/ Inter-Stage Packing of Steam Turbines, Emergency Stop Valve, Interceptor Valves, Control Valves, Servomotors, Governing System, Turning Gear, Jacking Oil System, Online Tube Cleaning System of Condensers, Ejectors,

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Impellers of Condensate Extraction Pumps, Tube bundles of LP / HP Heaters, Booster Pumps/ Coupling/ Cartridges of Boiler Feed Pumps, Critical Piping, Hangers & Supports, Line shafts/ Impellers / Bowl assemblies/ Pumps/ Motors/ Piping/ Valves of CW/ ACW/ Intake Water Systems, Water Pretreatment Plant, Pressure Vessels/ Pipes/ Pumps/ Air blowers/ Valves/ Acid Storage Tanks/ Alkali Storage Tanks/ DM Water Storage Tanks of DM Plant, Wagon Tipplers/ Track Hoppers/ Stacker-Reclaimer/ Crushers/ Conveyor Belts of Coal Handling Plant, Dry Fly Ash Evacuation System, Ash Water Recycling System (AWRS), Ash Silos, Ash Dyke, Hydrants /Sprinklers/ Emulsifiers/ Hydro Pneumatic Tank / Jockey Pump of Fire Fighting System, Heat Tracing System /Pumps/ Fittings/ Valves of Fuel Handling System, Vapour Absorption Machines of Air Conditioning System, Screw Type Air Compressors/ Air Driers of Compressed Air System, Stator Winding Bars/ Insulation/ Retaining Rings/ Excitation System/ Hydrogen & Water Cooling System of Generator, Windings/ Bushings/ Cooling System of Power Transformers, Circuit Breakers, Switchgears, Battery Charger/ Batteries/ Distribution Boards of DC System, DG Sets, Public Address System, Illumination System, Power and Control Cables, Foundations of Boilers & TG Building, Steel Structures of Coal Handling/ Ash Handling Plant, Buildings of DM Plant/Chemical House/ Chlorination Plant, Chimney and Ash Dyke etc]

These recommendations are being hereby submitted to the Project Authorities for further discussions and for evolving various options for Renovation and Modernization of the Unit.

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2

INTRODUCTION

Unit No [...] of [...] Thermal Power Station was first synchronized on [...]. The Unit has been operating for more than [...] years and its performance has deteriorated gradually over the years. Extending the life of the unit and increasing its efficiency and output appears feasible by carrying out Renovation and Modernization of the Unit. This Residual Life Assessment (RLA) and Condition Assessment (CA) Report has identified those equipments and components of the Unit which need to be rehabilitated to prevent loss of generation, improve efficiency, enhance availability and enable the unit to produce power in conformity with the statutory environmental regulations in force.

The RLA & CA studies were conducted to assess the health condition and determine the residual life of all the major equipments like Boilers, Turbines, Generators, Power Transformers, Electrical Systems, Coal Handling Plant, Ash Handling Plant, Water Systems, Equipment Foundations and Civil Structures etc, which are the backbone of the generating unit to give its sustained performance. The studies comprised Visual Examination through Cold Walk Down Survey / Hot Walk Down Survey, Dimensional Measurements, Destructive & Non-Destructive Tests, Steam Path Audit and In-Situ Metallographic Tests etc. The studies and tests conducted were based on the latest available technology.

This report is based upon review of RLA & CA studies done during the period [...], review of the operation data of the unit and detailed discussions held with the project authorities as well as operating personnel.

The recommendations of the RLA/ CA studies have been discussed in detail in section 6.0 of this report. These recommendations are being hereby submitted to the Project Authorities for further discussions and for evolving various options for Renovation and Modernization of the Unit.

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3 DESCRIPTION AND OPERATIONAL HISTORY OF THE UNIT

3.1 Description

The Power Plant, having a configuration of [...x...MW] is located at [...], in District [...] in the state of [...]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The boiler for the unit is of [PF/CFBC] design. The boiler is provided with [front & rear/ corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [... substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...&.....] coal mines. The consumptive water for the power plant is being sourced from [.....river /.....sea].

3.2 Salient Features and Details of the Unit

{Describe in this sub-section, the Design Parameters and Salient Features of all the important Equipment and Systems of the Power Plant as mentioned below}

3.2.1 Boiler & Auxiliaries

a) Boiler

[The Boiler is of natural circulation, pulverized fuel fired, dry bottom, balanced draft using direct firing system. The design parameters of the Boiler are furnished below]

Description	Units	Design Parameters
Steam Flow at Final SH outlet	T / hr	[...]
Steam Pressure at SH outlet	kg/cm ²	[...]
Steam Temperature at SH outlet	°C	[...]
Re-heater Flow	T / hr	[...]
Steam Pressure at RH outlet	kg/cm ²	[...]
Steam Temperature at RH outlet	°C	[...]
Feed Water Flow	T / hr	[...]

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Description	Units	Design Parameters
Feed Water Pressure at inlet of Economiser	kg/cm ²	[...]
Feed Water Temperature at inlet of Economiser.	°C	[...]

b) Furnace

[The boiler is equipped with a water cooled furnace of balanced draft and fusion welded membrane wall construction. It is equipped with.....numbers of coal burners and.....numbers of oil burners located at numbers of elevations. The design parameters of the Furnace are furnished below.]

Description	Units	Design Parameters
Type of Firing	.....	[.....]
Combustion Chamber Volume	m ³	[.....]
Furnace Dimensions (Width x Depth x Height)	m	[.....]
Heating Surface Areas		[.....]
i) Water Walls	m ²	[.....]
ii) Superheaters	m ²	[.....]
iii) Reheaters	m ²	[.....]
iv) Economiser	m ²	[.....]
v) Air Heater	m ²	[.....]
vi) Steam Coil Air Heater	m ²	[.....]
vii) Temperature Measurement of Super-heater tubes	Yes / No	[.....]
viii) Temperature Measurement of	Yes / No	[.....]

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Description	Units	Design Parameters
Re-heater tubes		

c) Super Heaters and Re-Heater

[The super heaters are composed of four sections, a platen section, a pendant section, a rear low temperature section and a steam cooled wall & roof section. The Re-heater consists of two sections, the front pendant and the rear pendant sections. The details are given below:]

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Low Temperature Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Platen Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Pendant Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Ceiling and Enclosure Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Front Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Rear Assembly	[.....]	[.....]	[.....]	[.....]	[.....]

d) Economiser

[The Economizer is of a single stage, continuous plane tube and horizontal, mixed flow type, located in the second pass of the boiler]

e) Air Pre-Heater

[The air pre-heater is of regenerative rotary type. Special sealing arrangements have been provided in the air pre-heater to prevent leakage between air and gas sides. Adjustable sector plates have also been provided to prevent the leakage during expansion. The heating surfaces of the air pre-

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heater have been provided with two types of cleaning systems, soot blowing and water washing system.]

f) Raw Coal Bunkers

[Each boiler is provided with [...] raw coal bunkers. The total capacity of the bunkers is to meet [...] hour's requirement at maximum mills capacity of the unit. The upper portion of the bunkers is of cylindrical shape made of carbon steel plate, while the conical portion is made of stainless steel plate. Each outlet of the bunker is provided with an isolation gate which is motor operated. In addition to the isolation gates, rod gates have been provided to control the flow of coal from the bunkers]

g) Raw Coal Feeders

[One gravimetric type of raw coal feeder has been provided for each coal mill. The coal feeders have been provided with micro-processor based controls with variable frequency drive. The feeders have been provided with dual independently measuring load cells. All parts of the feeders coming in contact with coal, except the belt, are made of stainless steel]

h) Fuel Firing System

[The boiler is working on a direct firing system. The pulverized coal is being dried and transported to the coal burners by means of hot primary air being supplied by two primary air fans. The boiler is having [front and rear/corner/down shot] firing system. There are [...] pulverized coal burners and [...] oil burners. The burners are located at [...] floors.

i) Coal Mills

[The unit is provided with numbers of [BHEL] Make [XRP-783] bowl type mills, out of which mills are designed to work with designed coal andnumbers of mills are standby . The rated capacity of each mill isT/h.]

Description	Units	Design Parameters
Make and Model of Mills	.....	[....]
Capacity of Mills	T/h	[....]
Total Number of Mills per boiler	Nos.	[....]
Number of Mills to work per boiler with design coal quality	Nos.	[....]
Motor Rating	kW	[....]

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j) Primary Air Fans

[Two Primary Air (PA) Fans have been provided for each boiler. Each PA Fan is designed to meet 60% MCR condition of the boiler. The PA Fans are Hot PA Fans. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Type of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Hot Air	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]

k) Forced Draft Fans

[Two Forced Draft (FD) Fans have been provided for each boiler. Each FD Fan is designed to meet 60% MCR condition of the boiler. The FD Fans supply combustion air to the boiler, mill air through PA Fans and tempering air to control the classifier temperature of the mills. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Type of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Air	°C	[...]
Motor Rating	kW	[...]

Description	Units	Design Parameters
Method of Regulation	[...]

l) Induced Draft Fans

[Two Induced Draft (ID) Fans have been provided for each boiler. Each ID Fan is designed to meet 60% MCR condition of the boiler. Each ID Fan evacuates flue gases through two parallel paths of ESP and discharge them into stack through separate ducting. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Type of Fans	.....	[...]
Number of Fans per Boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Flue Gases	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]

m) Wall Blowers and Long Retractable Soot Blowers (LRSBs)

[Adequate number of Wall Blowers and Long Retractable Soot Blowers (LRSBs) are being used for cleaning the soot deposited on the heating surfaces of the water walls and super heaters respectively. Manually operated soot blowing system has been provided. Details are given below:]

Description	Units	Design Parameters
Wall Blowers		
Make and Model of Wall Blowers	.....	[...]
No. of Wall Blowers per boiler at water walls	Nos.	[...]
Medium of soot blowing at water	.....	[...]

Description	Units	Design Parameters
walls		
LRSBs		
Make and Model of LRSBs	.....	[....]
No. of LRSBs per boiler at pendant surfaces of pressure parts	Nos.	[....]
Medium of soot blowing at pendant surfaces of pressure parts	.....	[....]
No. of LRSBs per boiler at convection pass tube banks	Nos.	[....]
Medium of soot blowing at convection pass tube banks	.....	[....]

n) ESP

[An Electrostatic Precipitator (ESP) has been installed on the cold end side of the Air Pre-heater to remove the particulate matter from the flue gases. The ESP has been provided with Gas Distribution System, Collecting Electrodes, Discharge Electrodes, Transformer Rectifier Sets and [electrically/mechanically] operated rapping system. The hoppers of ESP have been provided with [capacitance] type level indicators and thermostatically controlled heating elements. Details are given below:]

Description	Units	Design Parameters
Make and Model of ESP	.....	[....]
Number of Passes per ESP	Nos.	[....]
Number of fields per pass	Nos.	[....]
Dust concentration at outlet	mg/Nm ³	[....]
Type of Control	.....	[....]
Gas Velocity in ESP	m/sec	[....]
Specific Collection Area	m ² /m ³ /sec	[....]
Aspect Ratio	[....]

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Description	Units	Design Parameters
Particle Migration Velocity	cm/sec	[...]
Numbers of TR Sets	.....	[...]
Rating of TR Sets	.....	[...]
Plate Area/TR Set	m ² /TR Set	[...]
Storage Capacity of ESP Hoppers	hrs	[...]
Pressure Drop	mmwc	[...]
Dust Collection Efficiency with (N-1) fields in operation	%	[...]

3.2.2 Steam Turbine & Auxiliaries

a) Steam Turbine

[The steam turbine is of three cylinder, 3000rpm, tandem compound, condensing type designed to operate on a re-heat and re-regenerative feed water cycle. The LP stage of turbine is designed with Bauman exhaust. The turbine is provided with HP/LP bypass system of 60% capacity of Steam Generator MCR. The turbine is provided with an electro - hydraulic control system, automatic turbine run up system and turbo supervisory instrumentation. The condensing system consists of a surface condenser of single shell and two pass, divided water box construction. Cooling water being supplied to the condenser is of raw water/ clarified water quality. The design parameters of the steam turbine are furnished below]

Description	Units	Design Parameters
Pressure of Steam at inlet of ESV of HPT	kg/cm ²	[...]
Temperature of Steam at inlet of ESV of HPT	°C	[...]
Pressure of Cold Reheat (CRH) Steam	kg/cm ²	[...]
Temperature of Cold Reheat (CRH) Steam	°C	[...]
Pressure of Hot Reheat (HRH) Steam	kg/cm ²	[...]
Temperature of Hot Reheat (HRH) Steam	°C	[...]

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Description	Units	Design Parameters
Pressure at the inlet of LP Turbine	kg/cm ²	[...]
Temperature at the inlet of LP Turbine	°C	[...]

b) Condenser

[The condenser is a [single/double] pass, horizontal, surface type with integral air cooling section designed to maintain a pressure of 76 mm of Hg at turbine exhaust with a cooling water temperature of [...] deg C and an outlet temp of [...] deg C. The condenser is capable of operation with [...] tubes plugged and has hot well storage capacity of [...] minutes]

Description	Units	Design Parameters
Make and Model	.....	[...]
Type of Condenser	.....	[...]
Total Cooling Surface	m ²	[...]
Number of Cooling Water Tubes	.....	[...]
Material of Tubes	.....	[...]
Diameter and thickness of tubes	mmxmm	[...]
Cooling Water Quantity through Condenser	m ³ /h	[...]
Cooling Water Temperature at the inlet to Condenser	°C	[...]
Condenser Vacuum	mm Hg	[...]

c) Ejectors

[The Condenser is provided with two quick starting ejectors which operate in parallel to remove large volumes of air for raising the initial vacuum during the starting of the Unit. Two main ejectors of 100% capacity each have been provided remove air and non condensable gases from the condenser to maintain the required vacuum in the condenser during the normal operation of the unit.]

d) Condensate Extraction Pumps

[Condensate extraction pumps are of vertical, multistage, centrifugal pumps of canister type.]

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Description	Units	Design Parameters
Make and Model	[...]
Type	[...]
Capacity	m ³ /h	[...]
TDH	mwc	[...]
Speed	rpm	[...]
Motor Rating	kW	[...]

e) **Gland Steam Cooler**

[A Gland Steam Cooler has been provided to condensate the leak-off steam from intermediate chambers of end sealings of HP and IP turbine, thereby heating the main condensate water. The Gland Steam Cooler consists of shell, tube bundle and removable water box.]

f) **LP Heaters and Drain Coolers**

[Each steam turbine is provided with four numbers of low pressure heaters to increase the temperature of the condensate in stages. LP Heater -1 consists of two halves and is installed in neck of the condenser. The remaining LP Heaters are of shell and tube design and have been placed vertically. An integral drain cooling section is provided in each LP Heater. The design details of LP Heaters are furnished in the table below.]

Heater No.	1	2	3	4
Extraction Steam taken from	[...] stage of IP turbine	[...] stage of IP turbine	[...] stage of IP turbine	[...] stage of IP turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]	[...]

g) **Deaerator**

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[The deaerator is of [horizontal spray cum tray type]. It is designed to remove dissolved oxygen from the condensate in excess of 0.005 cc per liter. The feed water storage tank has a capacity of [...] minutes feed water requirement of the boiler corresponding to TMCR Heat Balance]

h) Boiler Feed Pumps

[The boiler feed pumps are horizontal, multi stage centrifugal pumps of barrel type, motor driven pumps coupled with hydraulic coupling, taking the suction from the deaerator. The boiler feed pumps discharge feed water through HP heaters to the economizer of the boiler.]

Description	Units	Design Parameters
Make and Model	.....	[....]
Type	.....	[....]
No of stages	Nos.	[....]
Capacity	m ³ /h	[....]
Head	mwc	[....]
Feed water temp	°C	[....]
Gland sealing arrangement	.....	[....]
Minimum flow	m ³ /h	[....]
Method of Speed Regulation	.....	[....]
Type of Hydraulic Coupling	.....	[....]
NPSH required at design condition	mwc	[....]
Motor Rating	kW	[....]

i) HP Heaters

[Each steam turbine is provided with three numbers of high pressure heaters to increase the temperature of the feed water in stages. The Heaters are of shell and tube design and have been placed vertically. The design details of HP Heaters are furnished in the table below.]

Heater No.	1	2	3
Extraction	[...] stage of HP	[...] stage of HP	[...] stage of HP

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Steam taken from	turbine	turbine	turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]

j) HP/ LP Bypass

[HP/LP bypass system has a capacity of 60% of BMCR (Boiler Maximum Continuous Rating). HP bypass system has been provided between the Main Steam Line and Cold Reheat Line. LP bypass system has been provided between the Hot Reheat Line and the Condenser. HP bypass water spray has been taken from the discharge of Boiler Feed Pumps. LP bypass water spray has been provided from the discharge of Condensate Extraction Pumps.]

k) Turbine Governing System

[The turbine is equipped with an electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. The system is designed to sustain full load dump from the generator. The system is provided with a quick closing Emergency Stop Valve (ESV), to interrupt the supply of steam from the boiler and stop the turbine under emergency conditions. The turbine governing system includes, speed governor,]

l) Lube Oil System

[The lube oil system consists of Main Oil Tank, Turbine driven main oil pump, AC driven bearing oil pump, DC driven emergency oil pump, AC driven jacking oil pump and oil coolers of 3x50% capacity, Lube oil is being purified by means of a centrifuge. Oil storage tanks consisting of Clean Oil Tank and Dirty Oil Tank have been provided.]

3.2.3 Electrical System

a) Generator

[The Generator is a 15.75 kV, 50 Hz, 0.85 power factor machine, directly coupled with steam turbine operating at 3000 rpm, with.....type of excitation system and digital programmable voltage regulator. The Generator has direct water cooled stator winding and direct hydrogen cooled rotor winding. The stator winding cooling water is cooled in a closed

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cycle cooling system using DM water, while the hydrogen in the machine is cooled in gas to water hydrogen coolers mounted inside the machine. The Parameters of the Generator are briefly mentioned below.]

Description	Units	Design Parameters
Rated MW Capacity	MW	[...]
Rated MVA Capacity	MVA	[...]
Rated Terminal Voltage	kV	[...]
Rated Power Factor	.....	[...]
Rated Stator Current	kA	[...]
Rated Speed	rpm	[...]
Rated Frequency	Hz	[...]
Efficiency at Rated Power Output and Rated Power Factor	%	[...]
Excitation Current	kA	[...]
Excitation Voltage at Rated Power Output and Rated Power Factor	kV	[...]
Short Circuit Ratio	.....	[...]
Negative Sequence Current	Amp	[...]
Phase Connection	.....	[...]
Type of Excitation	.....	[...]
Method of Cooling the Rotor	.....	[...]
Method of Cooling the Stator	.....	[...]
Rated Hydrogen Pressure	kg/cm ²	[...]

b) Station Transformer

[Two Station Transformers have been provided to meet the station [common] auxiliary loads of the power plant. The Station Transformers have been provided with on-load tap changers to keep the station 6.6 kV voltage constant. Cooling of this transformer is ONAN/ONAF/OFAF and has 2x50 % separately mounted radiators and 2x50% oil pumps. The Parameters of the Station Transformers are briefly mentioned below]

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Description	Units	Design Parameters
Make	[...]
Capacity / Rating	MVA	[...]
Voltage Ratio	[...]
Type of Cooling	.....	[...]
Quantity	Nos.	[...]

c) Generator Transformer

[The power output from each Generator is being stepped up to 220/400 kV through a 240 MVA step up Generator Transformer. It has 3x50% coolers and 3x50% oil pumps. The Parameters of the Generator Transformer are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[...]
Capacity	MVA	[...]
Voltage Ratio	.....	[...]
Type of Cooling	.....	[...]

d) Unit Auxiliary Transformer

[Two unit auxiliary transformers have been provided for each unit for meeting all unit auxiliary loads. These transformers have been provided on-load tap changers. The Parameters of unit auxiliary transformers are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[...]
Capacity	MVA	[...]
Voltage Ratio	.....	[...]
Type of Cooling	.....	[...]
Quantity	Nos.	[...]

e) Electrical Auxiliary Power Distribution System

[Unit auxiliaries receive their normal power supplies at 6.6 kV through two (2) nos. unit transformers. For lower rating drives, 6.6 kV is further stepped down to 415 V by two (2) nos. unit service transformers. The 415 V distribution system feeds a number of Motor Control Centers (MCCs) for running 415 V drives. 6.6 kV unit switchgears are connected to station switchgear for start up and emergency power supply. The details are mentioned below]

Description	Units	Design Parameters
Voltage Level	kV	[...]
Type of Breaker	.....	[...]
Type of Grounding	.....	[...]
Type of Protection	.....	[...]

f) DC System

[Each unit has its own DC system located in the BC bay at ground floor of the Power House. Separate DC systems have been provided in switchyard control room, intake pump house and DM plant for controlling the systems. Each DC system comprises of the Storage Battery, the Battery charger and the distribution boards. The details are mentioned below]

Description	Units	Design Parameters
Make	[...]
Capacity /Rating	[...]
Voltage	V	[...]
Type of Charger	[...]
Area of Application	[...]

g) Emergency Power Supply System

[Diesel generating sets are installed for meeting the power requirements of essential auxiliaries (viz. jacking oil pumps, AC lube oil pump, hydrogen seal oil pump, float charger for DC battery, emergency lighting, scanner air fan and stator cooling water pump) during total failure of AC Power Supply in the power station. Diesel generating sets are located in the CD bay at the ground floor. The details are mentioned below]

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Description	Units	Design Parameters
Make of DG Sets	[...]
Rating of DG Sets	kVA	[...]
Quantity	Nos.	[...]

h) Public Address System

[The unit is provided with paging and party channels comprising handset stations with amplifiers, transmitters, receivers and loud speakers. The system facilitates paging, communication and also private conversation as on conventional telephone.]

i) Illumination System

[For indoor application, fluorescent/ energy saving compact fluorescent fixtures have been provided. For high bay areas and outdoor application, suitable high intensity discharge Mercury Vapour/ Sodium Vapour lighting fixtures have been installed. Aviation type fixtures have been installed at the Chimney]

3.2.4 Control & Instrumentation

[The existing control and instrumentation system generally is an old analogue based system and requires large scale replacement owing to obsolescence of the existing equipments. Furnace Supervisory Safeguard System (FSSS) is of obsolete design for which, no spares are available. Soot blowers are of manual type. No online Boiler Tube Leakage detection system has been provided. The turbine is equipped with an electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. Turbine Supervisory system is of electromagnetic type. No continuous monitoring system has been provided for observing the health of the turbine. HP- LP bypass system is in the form of standalone control panel. Integrated microprocessor based closed loop control, open loop control, sequential control and bulk data acquisition system for SG & auxiliaries, TG & auxiliaries, station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level are therefore to be envisaged for the plant.]

3.2.5 Balance of Plant

a) Coal Handling Plant

[Coal Handling Plant is a common facility which is feeding all the units of the power plant having a total installed capacity of...x.....MW. Coal to the power plant is brought through railways by 'Box N' /'BOBR' wagons and is unloaded by wagon tipplers/ track hopper. One crusher has been provided

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for crushing the coal from 250 mm size to 25 mm size. The plant is provided with one stacker reclaimer to stock the crushed coal. The coal stock yard has a storage capacity of 20 days. For feeding the coal to the bunkers of all the units, two streams of conveyors having a capacity ofTPH have been provided. The coal handling plant operates for 16 hrs a day.]

Description	Units	Design Parameters
No. of Wagon Tiplers	Nos.	[....]
Rating of Wagon Tiplers	T/h	[....]
Length of the Track Hopper	m	[....]
No. of streams of conveyor	Nos.	[....]
Capacity of each conveyor	T/h	[....]
Type of Crushers	Nos.	[....]
Number of Crushers	Nos.	[....]
Capacity of Crushers	T/ hr	[....]
No. of Stacker Reclaimers	Nos.	[....]
Stacking Capacity	TPH	[....]
Reclaiming Capacity	TPH	[....]
Storage Capacity of Stock Yard	days	[....]

b) Ash Handling Plant

[Ash Handling System is of continuous type. The bottom ash from the furnace falls into bottom ash hopper having a storage capacity of [...] hrs. The ash is removed with the help of submerged Scraper Chain Conveyors. The ash from the air pre-heater and economizer hoppers is being disposed off along with bottom ash. The ash in the form of ash slurry is conveyed through sluice channels to the ash slurry pump house with the help of high pressure jets, from where, it is pumped to the ash pond located the distance of [...] km. [...] The ash slurry pump house is provided with [...] numbers of ash slurry pumps of rating [...], out of which [...] pumps are normally working. The ash slurry disposal system is having [...].numbers of identical streams of ash slurry pumps connected to [...] numbers of ash slurry pipelines going to the ash pond. Fly ash is collected in dry form below the ESP hoppers and the same is then conveyed by vacuum system to surge hoppers from where it is either conveyed through pressurized system to dry

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fly ash silos or is sent to ash pond in the form of slurry. From the dry fly ash silos, the ash is disposed off through the covered trucks.]

c) Raw Water System

[The consumptive water for the plant is sourced from [...] river/sea located at a distance of [...] km from the plant boundary. The intake water pump house is installed with [...] intake pumps of capacity [...] m³/hr, out of which [...] pumps are normally working and the remaining [...] pumps are standby. The raw water is pumped from the intake water pump house to the in-plant raw water reservoir, which has a storage capacity of [...] days.]

d) CW / ACW System and Cooling Towers

[CW system for the power plant works on re-circulating system with induced draft cooling towers. The CW system uses raw/clarified quality of water and is working on [...] cycles of concentration. CW pump house is a common facility for all the units of the power plant. There are two CW pumps of capacity [...] m³/hr provided for each unit. In addition, there are two standby CW pumps common to all the units. The requirement of ACW system is being tapped from the cold CW header feeding the condenser. The hot return ACW water after cooling the auxiliaries of boiler and turbine joins the hot CW header and is sent to the cooling towers for cooling. The cold water from the cooling water flows to the fore bay of CW Pump House for recirculation into the system. One induced draft cooling tower (IDCT) has been provided for each unit. The cooling tower cools the water from [...] deg C to [...] deg C. The cooling tower has been designed for an inlet wet bulb temperature of [...] deg C].

e) Water Pre-Treatment Plant

[Water Pre-Treatment Plant is a common facility for all the units of the power plant. Pre-treatment plant supplies clarified water to DM plant, cooling water to the auxiliaries of BOP system, coal handling plant dust suppression and to the drinking water system. There are two numbers of clarifiers of [...].m³/hr capacity to meet all the clarified water requirements of the whole plant, except DM plant. The clarified water requirement for DM plant is met by a separate clarifier of capacity [...] m³/hr.]

f) DM Plant

[DM plant consists of three streams, each of [...] m³/hr capacity. There are two DM water tanks of [...].m³ capacity. A common regeneration system has been provided for all the three streams. DM plant operates on semi-automatic system with PLC controls.]

g) Air-Conditioning and Ventilation System

[The central control room, switchyard control room, ESP controls room and selected areas of service building have been provided with centralized air-conditioning system. The central air-conditioning system of chilled water type has been provided for various control rooms and DX type of plant has been provided for ESP control room, switchyard control room and other areas in the service building. Packaged type of air-conditioners has been

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provided for water treatment plant control room. Evaporative ventilation system has been provided for TG building along with roof extractors. Other areas are ventilated by a combination of exhaust and supply air fans].

h) Fire Fighting System

[Fire fighting system is a common facility provided for all the units. This consists of pressured hydrant system for all the auxiliary buildings, pump houses and administrative building. Automatic high velocity sprinklers system has been provided for power transformers, turbine oil tanks and lube oil system equipments. Medium velocity sprinkler system has been provided for cable galleries and coal conveyor galleries. Portable types of fire extinguishers have been provided throughout the plant for fighting small and localized fires.]

i) Plant and Instrument Air System

[Plant and instrument air system is a common facility for all the units of the plant. For meeting the instrument air requirement, [...] number of oil free screw compressors [...] working and [...] standby, each of [...] m³/hr capacity and discharge pressure of [...] kg/cm (g) have been provided along with dryers. Equal number of air compressors of similar rating has been provided to meet the requirement of plant air system. The air drying plant for the instrument air has been provided to achieve a dew point of (-) 40°C at atmospheric pressure.]

j) Fuel Oil System

[The fuel oil system has been designed for the use of Light Diesel Oil (LDO) for start- up and Heavy Fuel Oil (HFO) for load carrying and flame stabilization purposes. Two tanks of [...] kl each have been provided for the storage of HFO and two tanks of [...] kl each have been provided for the storage of LDO. The system has been provided with unloading, transferring and pressurization pumps along with necessary filters and heating arrangement.]

k) Cranes/Hoists

[For the maintenance of various equipments, manually /electrically operated cranes and hoists have been provided.]

3.2.6

Civil Works

Major civil works of the unit consist of the following:

(a) Main Power House Building:

[A common Power House Building has been provided to house [3x200 MW] units which are placed side by side. Centre to centre placing of units is [67.5 m.] The railway entry has been provided from the rear side of Power House Building. Turbine Generator (TG) Sets have been placed between AB rows of columns are laid out longitudinally. The TG bay, also houses, the Boiler Feed Pumps, Regenerative Heaters, Lube Oil System and other TG accessories. The total length of TG bay for 3x210 MW units is [276 m] and

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width [30 m]. The spacing of the column is at [7.5 m]. TG bay is provided with 2 Nos. of overhead EOT Cranes. In order to make the handling facilities of the cranes available to the heat exchangers, boiler feed pumps and other equipments, removable chequered plates have been provided at appropriate locations.

A sub zero floor has been avoided except for the localized pits required for Condensate Pump, pipe channels and HP Heaters etc. This sub zero pits are suitably connected and provided with a common sump for drainage purposes.

Three stairs for approaching the operating floor level at [+ 10 m] have been provided in this bay adjacent to B row columns. In addition, there are stairs for providing access to various equipments at intermediate platforms and sub zero pits.

Switchgear and Control Room bay has been provided in the BC bay which is [12 m] wide. The length of the bay is [249.0 m]. A common Control Room for all the three units is provided at [10 m] floor. In BC bay at [16 m] elevation, equipments for chemical dosing, air handling and MCC for soot blowers etc have been located. The deaerator is placed at an elevation of [23.0 m]. Air washer units and cooling water tanks are also located at [23.0 m] floor.

Mill Bunker Bay, designated as CD bay, has a span of [10.5 m] which accommodates coal bunkers, coal feeders and coal mills. CD bay houses the vertical mills at Zero m and has space for collection of disposal of mill rejects at sub zero levels adjacent to 'D' row. A stair to connect operating floor at [16.0 & 23.0 m] of BC & CD bay has been provided.]

(b) Boiler Area

[In boiler area, the boiler with its auxiliaries like PA fan, FD fan, ID fan as well as Electrostatic Precipitator has been located.]

(c) Chimney

[A common multi-flue Chimney of 220 m height has been constructed in which, flue cans of [3x200 MW] have been erected.]

(d) Transformer Yard

[A [60] m wide yard has been provided outside the 'A' row columns. The transformer yard houses station transformer, unit auxiliary transformers and generator transformers along with oil pits etc. To facilitating erection and maintenance of transformers, the area has been provided with rail tracks parallel to 'A' row at a distance of [45 m] from 'A' row which is further connected through cross tracks. In addition, space has been provided for laying the CW pipelines and locating the butterfly valve chambers.]

(e) Service building

[A common four storey building has been provided near the main plant building and it is connected with the operating floor of TG bay at [10 m] level.]

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(f) Miscellaneous buildings

[Besides the above, miscellaneous buildings like administrative building, CW Pump House, Fire Water Pump House, CHP Control Room, ESP Control Room, Chimney, DM Plant Building, Chemical House and Ash Silos have been provided.]

3.3 Operational History of the Plant

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The deterioration experienced over the years in Plant's Average Performance Parameters is shown in Table 3.1.

Table 3.1
Unit's Average Performance Parameters over the Life

Years after Installation	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
5	[...]	[...]	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Table 3.2 indicated below, illustrates variations over the last three years in the performance parameters.

{Furnish in the Table 3.2 below, the Average Values for the last three years, Maximum & Minimum values for Current year and the readings on the last day.}

Table 3.2
Unit's Performance Parameters during the Last Three Years

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
Average value for the last	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
Three Years							
Average value for the last Two Years
Average value for the last one Year.
Maximum & Minimum values for Current year.
Reading as on the last day.

3.4

Stack Emissions, Ambient Air Quality and Process Effluents

The Project has been regularly monitoring the environmental parameters such as stack monitoring, ambient air quality (AAQ), noise pollution and liquid waste pollution in accordance with applicable norms by employing [M/s....., which is an agency approved by State Pollution Control Board].

The existing environmental data and the limits specified for different pollutants, the locations of their measurements and the frequency of monitoring are given in the table below.

Table 3.3
Status of Stack Emissions, Ambient Air Quality and Process Effluents

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
Stack Emissions	SPM (mg/Nm ³)	Not to exceed [...]

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)			Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
Ambient Air Quality		On 24 Hrs Basis	On Annual Basis	On 24 Hrs Basis	On Annual Basis	[...]	[...]
	SPM (µg/m³)	[...]	[...]	[...]	[...]		
	RPM (µg/m³)	[...]	[...]	[...]	[...]		
	SO ₂ (µg/m³)	[...]	[...]	[...]	[...]		
	NO _x (µg/m³)	[...]	[...]	[...]	[...]		
Process Effluent Leaving the Plant Boundary	ETP Treated Water Quality					[...]	[...]
	pH	[...]		[...]			
	Colour	[...]		[...]			
	Odour	[...]		[...]			
	Tempera ture	[...]		[...]			
	TSS (mg/l)	[...]		[...]			
	Oil & grease (mg/l)	[...]		[...]			
	COD (mg/l) (mg/l)	[...]		[...]			
	BOD (mg/l)	[...]		[...]			

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
	Chloride (mg/l)	[...]	[...]		
	Sulphate (mg/l)	[...]	[...]		
	TDS (mg/l)	[...]	[...]		
	Zinc (mg/l)	[...]	[...]		
	Fluoride (mg/l)	[...]	[...]		
	Mercury (mg/l)	[...]	[...]		

3.5 Feedback from the Plant Operators

Detailed discussions with the Plant operators provided the feedback about the design and operation related problems about the various systems which are listed in the Table 3.4 below.

Table 3.4
Feedback from the Plant Operators

S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
1	[.....]	[.....]	[.....]
2	[.....]	[.....]	[.....]
3	[.....]	[.....]	[.....]
4	[.....]	[.....]	[.....]
5	[.....]	[.....]	[.....]
6	[.....]	[.....]	[.....]

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S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
7	[.....]	[.....]	[.....]
8	[.....]	[.....]	[.....]
9	[.....]	[.....]	[.....]
...	[.....]	[.....]	[.....]

3.6 History of Failures and Trend Analysis

The year wise record of failures experienced by the plant during the period of last ten (10) years is furnished in the Table 3.5 below.

{While giving the History of Failures during the last ten (10) years in the Table below, categorize the Failures into two types as follows:

- i) Failures leading to Tripping of Unit and
- ii) Failures leading to Reduced Generation.

Further, indicate for each category, the total number of occurrences of such incidents in a year and the corresponding time in hours for which the incidents persisted.}

Table 3.5
History of Failures

Year	Total Number of Failures in a Year	Incidents Leading to Tripping of Unit			Incidents Leading to Reduced Generation		Remarks
		Total Number of Boiler Tube Leakages in the Year	Total Number of Trippings in the Year	Total Hours of Tripping in the Year	Total Incidents in the Year	Total Hours of Reduced Generation	
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

Year	Total Number of Failures in	Incidents Leading to Tripping of Unit			Incidents Leading to Reduced Generation		Remarks
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[...]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

{Furnish the trend chart by plotting (i) number of trippings (ii) number of boiler tube leakages and (iii) number of incidents leading to reduced generation of the unit against successive years of operation since commissioning. Analyze the trend of failures and discuss the underlying reasons. Expand the table for the total years of operation.}

3.7

Major Replacements done in the Plant

{Furnish the record of major replacements done for the main plant (BTG) and the Balance of Plant right from the first date of commissioning. Expand the table for the total years of operation.}

Table 3.6
Major Replacements done till now

S.No.	Name of the System/Equipment	Reason for Replacement
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]
6	[.....]	[.....]
7	[.....]	[.....]
8	[.....]	[.....]

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S.No.	Name of the System/Equipment	Reason for Replacement
9	[.....]	[.....]
10	[.....]	[.....]
.....	[.....]	[.....]

{Note: Reports on major failure in the past should be reviewed by the consultant to identify any major cause of fault, rectifications carried out and performance after rectification. Based on such review, if any further Condition Assessment of test, over and above specified in this Model Report are required, same should be carried out and results and recommendations should be incorporated in Project specific Report.}

3.8 Objectives of R&M Solution

[Based on the condition and age, it is necessary to study the following renovation possibilities, if the unit's performance is to be improved;

- Restoring / up-rating of Generation Capacity on a continuous, safe and reliable basis to suit the present coal quality.
- Increasing unit availability and reliability on a sustainable basis to meet the current requirements like availability based tariff.
- Achieving rated or better efficiency of the unit so that the Cost of Generation (COG) remains competitive.
- Achieving an extended plant life by minimum twenty (20) years. Different options as per the FR are to be explored.
- Meeting current statutory environmental norms.
- Improving safety of plant and personnel.
- Reduction of Auxiliary Power Consumption.
- Replacing the existing obsolete technology.]

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4 RESIDUAL LIFE AND CONDITION ASSESSMENT OF EQUIPMENTS AND COMPONENTS

4.1 General

{Describe in this section, the operating data collected during the Walk Down Survey and the results and findings of various Residual Life Assessment and Condition Assessment Studies conducted on the equipments and components of the Boiler & Auxiliaries, Turbo Generator & Auxiliaries and all the systems of the Balance of Plant.}

4.2 Operating Data Collected During the Hot Walk Down Survey

Major Operating Parameters of the Plant as noted during the Hot Walk Down Survey are indicated in the Table 4.1 below:

Table 4.1
Operating Parameters of the Plant as per Hot Walk Down Survey

Description	Units	Design Parameters	Operating Parameters
Load	MW	[.....]	[.....]
GCV	kCal/kg	[.....]	[.....]
Water & Steam Parameters			
Main Steam Flow	T/h	[.....]	[.....]
Main Steam Temp.	Deg C	[.....]	[.....]
Main Steam Pressure	kg/cm ²	[.....]	[.....]
Cold Reheat Steam Pressure	kg/cm ²	[.....]	[.....]
Hot Reheat Steam Pressure	kg/cm ²	[.....]	[.....]
Hot Reheat Steam Temp (Left and Right)	Deg C	[.....]	[.....]
Cold Reheat Steam Temp (Left and Right)	Deg C	[.....]	[.....]
IP Turbine Exhaust Steam Temp (Left and Right)	Deg C	[.....]	[.....]
IP Turbine Exhaust Pressure	kg/cm ²	[.....]	[.....]
Turbine Exhaust Hood Temperature.	°C	[.....]	[.....]
Hot Well T Temperature.	°C	[.....]	[.....]

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Description	Units	Design Parameters	Operating Parameters
Condenser Vacuum	mmHg	[.....]	[.....]
C.W. Water flow	T/h	[.....]	[.....]
C.W. Inlet Temperature (L and R)	Deg C	[.....]	[.....]
C.W. Outlet Temperature (L and R)	Deg C	[.....]	[.....]
Drum pressure	kg/cm ²	[.....]	[.....]
Feed water flow	T/h	[.....]	[.....]
Feed water inlet temp to ECO	Deg C	[.....]	[.....]
Feed Water Pressure	kg/cm ²	[.....]	[.....]
Super Heater Spray	T/h	[.....]	[.....]
Reheater Spray	T/h	[.....]	[.....]
Air and Flue Gas Parameters			
Air temperature at Air Pre-Heater Inlet.	Deg C	[.....]	[.....]
Primary Air temperature at Air Pre-Heater Outlet.	Deg C	[.....]	[.....]
Secondary Air temperature at Air Pre-Heater Outlet.	Deg C	[.....]	[.....]
Total Quantity of Air	T/h	[.....]	[.....]
Flue Gas temperature at Air Pre-Heater Inlet.	Deg C	[.....]	[.....]
Flue Gas temperature at Air Pre-Heater Outlet.	Deg C	[.....]	[.....]
CO ₂ in Flue Gas	%	[.....]	[.....]
CO ₂ at Inlet of Air Pre-Heater	%	[.....]	[.....]
CO ₂ at Air Pre-Heater Outlet	%	[.....]	[.....]
CO ₂ in Flue Gas – Air Pre-Heater Outlet	%	[.....]	[.....]

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Description	Units	Design Parameters	Operating Parameters
CO ₂ in Flue Gas – Air Pre-Heater Inlet	%	[.....]	[.....]
% of Excess Air in Flue Gas at ID fan Outlet	%	[.....]	[.....]
No. of Mills in operation for full load.	Nos	[.....]	[.....]
Wind box Differential Pressure (Left and Right)	mmwc	[.....]	[.....]
Air Temperature	Deg C	[.....]	[.....]
Furnace Draft	mmwc	[.....]	[.....]
ID Fan margin	%	[.....]	[.....]
HP Heaters Parameters			
Extraction Steam Pressure HP Heater (HPH) No.7 at Heater End	kg/cm ²	[.....]	[.....]
Extraction Steam Pressure HPH No.6 at Heater End	kg/cm ²	[.....]	[.....]
Extraction Steam Pressure HPH No.5 at Heater End	kg/cm ²	[.....]	[.....]
Feed Water (FW) Pressure Entering HPH-5	kg/cm ²	[.....]	[.....]
F.W. Pressure Entering HPH-6	kg/cm ²	[.....]	[.....]
F.W. Pressure Entering HPH-7	kg/cm ²	[.....]	[.....]
F.W. Pressure Common Outlet of HPH	kg/cm ²	[.....]	[.....]
F.W. Temperature Entering HPH-5	Deg C	[.....]	[.....]
F.W. Temperature Leaving HPH-5	Deg C	[.....]	[.....]
F.W. Temperature Entering HPH-6	Deg C	[.....]	[.....]
F.W. Temperature Leaving HPH-6	Deg C	[.....]	[.....]

Description	Units	Design Parameters	Operating Parameters
F.W. Temperature Leaving HPH-7	Deg C	[.....]	[.....]
F.W. Temperature Common Outlet of HPH	Deg C	[.....]	[.....]
Drain Temperature Heater No.5	Deg C	[.....]	[.....]
Drain Temperature Heater No.6	Deg C	[.....]	[.....]
Drain Temperature Heater No.7	Deg C	[.....]	[.....]
Extraction Steam Temperature HPH-5 (Heater end)	Deg C	[.....]	[.....]
Extn. Steam Temp. HPH-6 (Heater end)	Deg C	[.....]	[.....]
Extraction Steam Temp. HPH-7 (Heater end)	Deg C	[.....]	[.....]
Deaerator Pressure	kg/cm ²	[.....]	[.....]
Gauge Glass on HPH-5, 6 and 7	mmwc	[.....]	[.....]
Level indication in UCB for HPH-5, 6 and 7	mmwc	[.....]	[.....]
Other Information			
Relative humidity	%	[.....]	[.....]
Oxygen in fuel	%	[.....]	[.....]
Distribution of fly ash	%	[.....]	[.....]
Distribution of bottom ash	%	[.....]	[.....]
Distribution of duct ash	%	[.....]	[.....]
Distribution of air heater ash	%	[.....]	[.....]
Secondary Fuel Oil Consumption	ml/ kWh	[.....]	[.....]
Currents Drawn by Auxiliary Equipments			
Boiler Feed Pump Current	Amp	[.....]	[.....]

Description	Units	Design Parameters	Operating Parameters
Mills Motor Current	Amp	[.....]	[.....]
ID Fan Motor Current	Amp	[.....]	[.....]
FD Fan Motor Current	Amp	[.....]	[.....]
PA Fan Motor Current	Amp	[.....]	[.....]
CEP Motor Current	Amp	[.....]	[.....]
CW Pumps Motor Current	Amp	[.....]	[.....]

4.3 Equipments Subjected to Various Tests and Results Obtained

{Summarize in the table below, various equipment & their components, subjected to various types of RLA&CA tests / inspections starting from the Walk Down Surveys and mention the results obtained from each of these tests. Identify each equipment by its unique tag number wherever applicable. Also attach the test reports of each test in the form of Annexure.

The Guidelines for conducting various Destructive and Non-Destructive type of tests, which are normally performed for the major equipments of the Power Plant are appended at the end of this report for general reference.

Formats for reporting the test results are also appended at the end of this report, for general reference.

Also attach the Major Operational Parameters of the Plant as noted down during the Hot Walk Down Survey.}

Table-4.2
Summary of Tests Conducted on Equipments and Results obtained

A) Boiler & Auxiliaries

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
1.	[Boiler Drum]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

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S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
2.	[Down Comers]	i) [...]	i) [...]	i) [...]	i) [...]
		ii) [...]	ii) [...]	ii) [...]	ii) [...]
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
		iv) [...]	iv) [...]	iv) [...]	iv) [...]
3.	[Water Walls]	i) [...]	i) [...]	i) [...]	i) [...]
		ii) [...]	ii) [...]	ii) [...]	ii) [...]
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
4.	[Water Wall Headers]	i) [...]	i) [...]	i) [...]	i) [...]
		ii) [...]	ii) [...]	ii) [...]	ii) [...]
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
5.	[Primary Super Heater]	i) [...]	i) [...]	i) [...]	i) [...]
		ii) [...]	ii) [...]	ii) [...]	ii) [...]
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
		iv) [...]	iv) [...]	iv) [...]	iv) [...]
6.	[Ceiling Super Heater]	i) [...]	i) [...]	i) [...]	i) [...]
		ii) [...]	ii) [...]	ii) [...]	ii) [...]
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
7.	[Platen Super Heater]	i) [...]	i) [...]	i) [...]	i) [...]
		ii) [...]	ii) [...]	ii) [...]	ii) [...]
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
8.	[Final Super Heater]	i) [...]	i) [...]	i) [...]	i) [...]
		ii) [...]	ii) [...]	ii) [...]	ii) [...]
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
9.	{Steam	i) [...]	i) [...]	i) [...]	i) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
	Headers]	ii) [...] iii) [...]	ii) [...] iii) [...]	ii) [...] iii) [...]	ii) [...] iii) [...]
10.	Economiser]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
11.	Air Pre-heater]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
12.	Wall Blowers]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
13.	LRSBs]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
14.	Coal Feeders]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
15.	Coal Pipes]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
16.	Coal Piping Control Valves]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
17.	[Wind Box]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
18.	[Dampers]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
19.	[Motors]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
20.	[Pulverized Fuel Burners]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
21.	[Oil Burners]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
22.	[Flame Scanners]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
23.	[Burner Tilting Arrangement]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
24.	[Critical Piping]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
25.	[Hangers and Supports]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
26.	[Buckstays]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
27.	[Ducts]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
28.	[Insulation]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
29.	[Cladding]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
30.	[Refractory]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
31.	[Boiler Structure]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
32.	[Mills]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
33.	[FD FANS]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
34.	[PA Fans]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
35.	[ID Fans]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
36.	[Electrostatic Precipitator]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
37.	[Any other Equipments]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

B) Turbine and Auxiliaries

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
1.	[HP Rotor]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
2.	[IP Rotor]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
3.	[LP Rotor]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
4.	[HP Turbine Casing]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
5.	[IP Turbine Casing]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
6.	[LP Turbine Casing]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
7.	[Diaphragms]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
8.	[HP Turbine Bolts]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
9.	[IP Turbine Bolts]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
10	[Bearings]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
11.	[Condenser Tube Plates]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
12.	[Condenser Online Tube Cleaning System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
13.	[Condenser Tubes]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
14.	[Condensate Extraction Pumps]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
15.	[Gland Steam Cooler]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
16.	[LP Heaters and Drain Coolers]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
17.	[Deaerator]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
18.	[Boiler Feed Pumps]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
19.	[HP Heaters]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
20.	[HP Bypass System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) i) [...] ii) [...] iii) [...]
21	[LP Bypass System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
22.	[Turbine Governing System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
23.	[Lube Oil System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
24.	[Any Other Equipments]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

C) Electrical System

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
1.	[Generator Stator Winding Bars]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
2.	[Retaining Rings of Generator]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
3.	[Hydrogen Coolers]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
4.	[Excitation System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
5.	[Automatic Voltage Regulator]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
6.	[Station Transformers]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
7.	[Generator Transformer]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
8.	[Unit Auxiliary Transformer]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
9.	[Circuit Breakers]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
10.	[415 V Switchgears]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
11.	[Battery Charger]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
12	[Distribution Boards]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
13.	[DG Sets]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
14.	[Illumination System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
15.	[Public Address System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
16.	[Any other Equipment]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]

D) Balance of Plant

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
1.	[Coal Handling Plant].	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
2.	[Ash Handling Plant.]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
3.	[Raw Water System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
4	[CW/ACW System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
5	[DMCW System]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
6	[Cooling Towers]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
7.	[Water Pre-Treatment Plant]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
8.	[DM Plant]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

S.No	Name of Equipment	Name of the Component	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
		iii) [...]	iii) [...]	iii) [...]	iii) [...]
9.	[Air Conditioning and Ventilation System]	i) [...] ii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
10.	[Fire Fighting System.]	i) [...] ii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
11.	[Plant and Instrument Air System.]	i) [...] ii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
12.	[Fuel Oil System]	i) [...] ii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
13	[Any other Equipment]	i) [...] ii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

Results of various RLA/CA Tests and Inspections have been attached at Annexure [4.1 to 4.18] of the Report.

5 CONDITION ASSESSMENT OF CIVIL AND STRUCTURAL WORKS

5.1 General

{Describe the methods adopted to assess the condition and residual life of the Civil and Structural Works.}

5.2 Tests Conducted and Results Obtained

{Summarize in the table below, one by one, the Equipment Foundations, and Civil Structures & Foundations of various Buildings, which were subjected to various RLA&CA tests /inspections, starting from the Walk Down Surveys, clearly mentioning the method of each test, the tools used and the foundations/ civil structures of the equipments/ buildings/ systems on which the respective test was performed. Also attach the test reports of each test in the form of Annexure.}

The Guidelines for conducting various Non-Destructive and Partially Destructive tests, which are normally performed for this purpose, are appended at the end of this report, for general reference

Formats for reporting the test results are also appended are appended at the end of this report, for general reference.}

Table-5.1

Summary of Tests / Inspections Conducted and Results Obtained

S.No	Name of Equipment Foundation/ Building Foundation /Civil Structure	Name of the Foundation / Civil Structure	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
1.	[Boiler].	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
2.	[TG Building.]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]

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S.No	Name of Equipment Foundation/ Building Foundation /Civil Structure	Name of the Foundation / Civil Structure	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
3.	[Chimney]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
4.	[Coal Handling Plant]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
5.	[Ash Handling Plant]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]	i) [...] ii) [...] iii) [...] iv) [...]
6.	[Raw Water Reservoir]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
7.	[Water Pre-Treatment Plant]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
8.	[Chemical House]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]	i) [...] ii) [...] iii) [...]
9.	[DM Plant Building]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

S.No	Name of Equipment Foundation/ Building Foundation /Civil Structure	Name of the Foundation / Civil Structure	Unique Tag Number	Type of Test(s) Conducted	Brief Results/Findings of the Tests
10.	[CW Pump House]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
11.	[Cooling Tower]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
12.	[Ash Dyke]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]
13.	[Misc. Works]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]	i) [...] ii) [...]

The Visual Examination Report is furnished at [Annexure-5.1] and the Detailed Examination Report is placed at [Annexure- 5.2].

6

RECOMMENDATIONS

The findings and recommendations of the RLA/ CA Tests are discussed as follows:

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
Boiler			
[Boiler Structure]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Boiler Drum]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Down Comers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Water Walls]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Water Headers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Wind Box]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Primary Super Heater]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Platen Super Heater]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Ceiling Super Heater]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Final Super Heater]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Re-Heater]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Steam Headers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
[Economiser]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Air pre-Heater]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Coal Feeders]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Coal Piping Control Valves]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Dampers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Motors]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Oil Burners]	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Pulverised Coal Burners]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Oil Guns]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Igniters]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Flame Scanners]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Refractory]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Insulation]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Buckstays]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Ducting]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Wall blowers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[LRSBs]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Pent House]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Cladding]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Mills]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
[Attemperators]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Clinker Grinder]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Bottom Ash Hopper]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[PA Fans including their drive shafts/ couplings etc.]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[ID Fans including their drive shafts/ couplings etc.]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[FD Fans including their drive shafts/ couplings etc.]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Electrostatic Precipitator (Emitting/ Collecting Electrodes/ Transformer Rectifier Sets)]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Any other systems]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
Steam Turbine and Auxiliaries			
[Steam Turbine including casings, diaphragms, rotating discs, and blades etc.]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Condenser]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Critical Piping]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Hangers & Supports]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Emergency]	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
Stop Valve]	[.....]	[.....]	[.....]
[Control Valves]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[HP Bypass]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[LP Bypass]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Condensate Extraction Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Shells and Tube Bundles of LP Heaters]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Deaerator]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Boiler Feed Pumps/ Cartridges/ Couplings/Booster Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Shells and	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
Tube Bundles of HP Heaters]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Any other systems]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
Balance of Plant			
[Wagon Tipplers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Track Hopper]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Crushers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Conveyor Belts]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Drive Pulleys]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Idlers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Metal Detector]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Magnetic Separator]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Ash Slurry Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Ash Slurry Pipes]	[.....]	[.....]	[.....]
[Ash Dyke]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Ash Water Recycling System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Water Intake Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Pre-Treatment Plant]	[.....]	[.....]	[.....]
[Clarified Water Pumps]	[.....]	[.....]	[.....]
[DM Plant Pressure Vessels]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Interconnecting pumps and piping of DM Plant]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[DM Storage Tanks]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[CW Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[ACW Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Cooling Towers Fans/ Gear Boxes/ Drive Shafts etc]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Fire Fighting Pumps- Motor Driven]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Fire Fighting]	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
Pumps- Diesel Engine Driven]	[.....]	[.....]	[.....]
[Fire Hydrants]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Emulsifiers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Hydro Pneumatic Tanks]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Jockey Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Fuel Oil Unloading Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Suction Heaters]	[.....]	[.....]	[.....]
[Steam/ Electric Heat Tracing]	[.....]	[.....]	[.....]
[Fuel Oil Pressuring & Forwarding Pumps]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Compressors]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Air Receivers]	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Air Driers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Air Conditioning System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Ventilation System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Effluent Treatment Plant]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Any other systems]	[.....]	[.....]	[.....]
Electrical System			
[Generator Stator]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Generator Rotor]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

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Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Generator Circuit Breaker]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Generator Transformer]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Station Transformer]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Unit Auxiliary Transformer]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Circuit Breakers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[LT Switchgear]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[HT Switchgear]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
[6.6 kV System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[415 V System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[HT & LT Motors]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[DC System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Public Address System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Illumination System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[DG Sets]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
[Any other Systems]	[.....]	[.....]	[.....]
Switchyard			
[Circuit Breakers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Isolators]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Lighting Arrestors]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Any other Systems]	[.....]	[.....]	[.....]
Control and Instrumentation			
[DDCMIS]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Soot Blowers]	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Burner Tilting Arrangement]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Boiler Temperature MI Thermocouple (K-Type)]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Boiler Protections]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Turbine Protection]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Turbine Controls –EHC]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Turbine –	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[ATRS]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Turbine Supervisory System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Machine Conditioning Monitoring System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Automatic Turbine Testing]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Turbine Stress Evaluator (TSE)]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[HP LP Bypass , PRDS]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Gland Steam Pressure Control]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Control Valves/ Dampers]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Furnace Draft Control System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Total Air Flow Control System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Mill A Temp to --- Mill F Temp Control System]	[.....]	[.....]	[.....]
[Super Heater Steam Temp Control System]	[.....]	[.....]	[.....]
[Re- Heater Steam Temp Control System]	[.....]	[.....]	[.....]
[Drum Level Control System]	[.....]	[.....]	[.....]
[BFP Scoop Tube]	[.....]	[.....]	[.....]
[Deaerator Level Control System]	[.....]	[.....]	[.....]
[Deaerator Pressure]	[.....]	[.....]	[.....]
[Hot Well Level]	[.....]	[.....]	[.....]
[HP Heaters Level]	[.....]	[.....]	[.....]
[LP heaters Level]	[.....]	[.....]	[.....]
[BFP]	[.....]	[.....]	[.....]

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Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
Recirculation Valve]			
[Feed Water Control Valve]	[.....]	[.....]	[.....]
[Transmitters]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Pressure / DP Gauges]	[.....]	[.....]	[.....]
[Temp Gauges]	[.....]	[.....]	[.....]
[Pressure / DP Switch]	[.....]	[.....]	[.....]
[Temperature Switch]	[.....]	[.....]	[.....]
[Resistance Temperature Detectors / Thermo Couples]	[.....]	[.....]	[.....]
[Level Measurement]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Flow Measurement & Primary Flow]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Sensors]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Fuel Flow Measurement]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[UPS]	[.....]	[.....]	[.....]
[Impulse Pipe & Fittings]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Steam & Water Analysis System]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[PLCs]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Transmitter Enclosures & Racks]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Junction Boxes]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Cable & Cable Trays]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
[Any other systems]	[.....]	[.....]	[.....]
Civil Works			
[Boiler Foundations]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[TG Building Foundations/ Civil Structures]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Chimney]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Wagon Tippler Hoppers/ Track Hopper]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Coal Handling Plant Crusher House/ Junction Towers/ Conveyor]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

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Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
Galleries]	[.....]	[.....]	[.....]
[Ash Slurry Pump House]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Clarifiers/ Chemical House of Pre-Treatment Plant]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[DM Plant Building]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[CW Pump House]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Cooling Tower]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Miscellaneous Works]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]

Model RLA/CA Report For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[LOGO OF UTILITY]

Equipment / Component	Recommendation	Reasons	Reference of RLA/CA Test Report
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]
[Any other Systems]	[.....]	[.....]	[.....]

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{GUIDELINES FOR RLA AND CA STUDIES ON EQUIPMENTS/COMPONENTS}

{The life assessment studies involve knowledge of prior history of operation and information of design & manufacturing of components of equipment. To carry out exhaustive diagnostic analysis about the condition of the critical components of the unit, various RLA/CA studies are conducted at the time of shut down of the unit. The purpose of these tests is to determine the extent of deterioration of the components from the original specifications. Various tests which are generally conducted for such RLA/CA studies are mentioned below.}

These tests are over and above the routine tests which are normally required to be conducted at an interval of two to three years as per the recommendations of the Original Equipment Suppliers namely the Insulation Resistance (IR) test & Polarization Index (PI) test etc for Generators / HT Motors, Dissolved Gas Analysis (DGA) for Transformers and Hydraulic & Pneumatic tests for the Generator Cooling System and Hydraulic Test for Regenerative LP/HP Heaters & Steam Condensers.

*A Check List for conducting various RLA&CA Tests for Equipments and Components of the main plant is placed at **Annexure - A**.*

(A) Non Destructive Tests (NDTs)

Non Destructive Tests are carried out to assess the integrity of a system or component without compromising its performance. A brief discussion on various tests is discussed below:

a) Visual Examination (VE)

Visual examination is the simplest NDT method which is carried out to broadly assess the material deterioration due to corrosion, erosion, swelling, cracking, bowing, sagging and misalignment etc of all the equipments and components of the Power Plant. Visual examination covers all equipments and their components.

Visual examinations are carried out both when the unit is in operation (Hot Walk Down Survey) and when the unit is shut down (Cold Walk Down Survey).

b) Fiberscopic/ Boroscopic Inspection

Fiberscopic / Boroscopic Inspections are extension of visual examinations. Borescope and fiberscope are two different instruments, commonly used for various visual inspections. Users can insert these typical instruments into confined spaces to see or even record images detected by these instruments. The purpose of both these scopes is to do non destructive inspection in confined spaces.

A Fiberscope is a flexible instrument made from optical fibers. A Fiberscope can be snaked and threaded into spaces located at an angle. In case of a fiberscope, light transmits down the optic fibers, thus illuminating the entire area.

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A Borescope, on the other hand, is relatively a rigid instrument fitted with lenses and mirrors, which allows light to bounce from the mirrors. The entire process is responsible for illuminating a particular area.

In order to carry out the inspection successfully, the inspector must be familiar with equipment internals, suspected locations of damage and should be able to recognize propagation of cracks and whether a condition is merely an insignificant aberration or potentially catastrophic.

Fiberscopic Inspections can be carried out to examine the internal condition of Water wall Headers and inlet & Outlet Headers of Final Super Heaters.

Boroscopic Inspections can be carried out to examine the internal condition of bores which are less deep, like studying the cracks in bore surfaces of rotors of HP/IP/LP Turbines (if rotors are provided with bores).

c) Dye Penetrant Test (DPT)

This test is carried out primarily to locate surface defects such as cracks, pitting, weld pinholes, porosity, and other flaws which occur in almost any material. This method involves application of [coloured / fluorescent] liquid dye on oxide-free, smooth cleaned surface, which penetrates into the surface flaw and is highlighted by using a developer. The developer absorbs the penetrant by capillary action thereby highlighting the flaw. Applicable Standard for Testing is ASTM D5 117-09.

Components like Economiser Outlet Header, Boiler Drum, Down-comers, Inlet and Outlet Headers of Super heaters & Re-heaters, Main Steam Piping, CRH & HRH Headers, CRH & HRH Piping, Steam inlet pipe weld joints, Strainer, Valve body, Turbine Rotors, Impellers of ID/FD/BFP/CEP Fans, Casings of Turbines, Casings of Gear Boxes, Turbine Blades, Diaphragms and bearing etc. can be subjected to DPT to locate surface defects such as cracks, pitting, porosity, and other flaws.

DPT can also be usefully conducted to assess the soundness of welds of Boiler structure & platforms etc and those of the Trestles of coal conveyors/ pipe-lines/ cables etc.

d) Magnetic Particle Inspection (MPI)

Magnetic Particle Inspection (MPI) is utilized to detect surface and sub-surface flaws in ferrite materials by inducing a magnetic field into the parent material. By sprinkling fluorescent magnetic particles on the surface of the parent material after the magnetic fields are induced, discontinuities are located by observing the patterns formed due to the distortions of the magnetic fields. Magnetizing is done at two mutually perpendicular fields to ensure detection of defects in all possible directions. Applicable Standard for Inspection is ASTM E 709-1995.

Components like Boiler Drum, Main Steam piping, CRH & HRH Headers, CRH Piping, HRH Piping, Turbine Rotors, Casings and Diaphragms, etc. can be subjected to Magnetic Particle Inspection.

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e) Ultrasonic Test -Scanning (UT-S)

One of the most effective examination techniques is ultrasonic testing. The UT-S technique for scanning is used to detect with high accuracy, the internal defects like wall thinning, pitting, metal embrittlement, cracking, or material defects. For flaw detection standard ultrasonic flaw detector is used. Applicable Standard for Testing is ASTM E164 and ASTM E114.

Components like Economiser Outlet Header, Boiler Drum, Down-comers, Inlet and Outlet Headers of Super heaters & Re-heaters, Main Steam Piping, CRH & HRH Headers, CRH & HRH Piping, Turbine Rotors and Casings etc. can be subjected to (UT-S).

f) Ultrasonic Thickness Testing (UT-T)

Ultrasonic techniques are also used to measure the wall thickness. For thickness measurement a pulse-echo ultrasonic transducer is used. The ultrasonic thickness gauge determines the thickness of a part by accurately measuring the time required for a short ultrasonic pulse generated by a transducer to travel through the thickness of the material reflected from the back and inside surface. Applicable Standard for Testing is ASTM-E787-05.

Components like Economiser Outlet Header, Boiler Drum, Down-comers, Inlet and Outlet Headers of Super heaters & Re-heaters, Main Steam Piping, CRH & HRH Headers, CRH & HRH Piping, Turbine Rotors, Blades and Casings etc. can be subjected to (UT-T).

g) Oxide Scale Thickness Measurement

Scale Deposits on the water side of the boiler tubes undesirably increase the heat transfer resistance and have long been recognized as a cause of boiler tube failures.

The oxide scale is generally a concern in 'Heat Affected Zones' (HAZ) of Super Heaters and Re-Heaters. The scale thickness within these zones may vary because of the range of temperatures. Selecting the circumferential location for scale thickness measurement is very important. Because of the temperature variations, the scale thickness may vary around the tube circumference. Oxide scale measurements should be performed at circumferential locations, which are expected to have experienced the highest temperature.

The thickest scale is expected on tubes located in the hottest sections. Thermocouple measurements are used to plan oxide scale measurement. History of prior overheat failures is also used to identify tubes for oxide scale measurement. Locations which have history of a large number of high temperature failures can be identified for inspection. Generally speaking, oxide scale thickness up to 200-250 microns is not critical for failure for the given tube material specification at corresponding temperature and pressure and hence the tubes having oxide scale deposition of more than the above stated value are only considered for calculation of residual life.

The ultrasonic method is used which is based on transmitting a high frequency sound wave of more than 50 MHz through the tube thickness.

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The thickness of oxide scale is calculated by measuring the time difference between the signals reflected from the tube / scale interface and the scale / fluid interface. The outer surface of the tube under inspection region is made free of fireside oxide deposit and polished to expose the base metal.

Using oxidation growth rate data for the specific material, the equivalent metal temperature of the tube under which it has been operating, can be determined indirectly.

The expected creep rupture life of a material is predicted with the knowledge of a commonly known parameter, the Larson Miller Parameter (LMP or P_{LM}) given by the following equation:

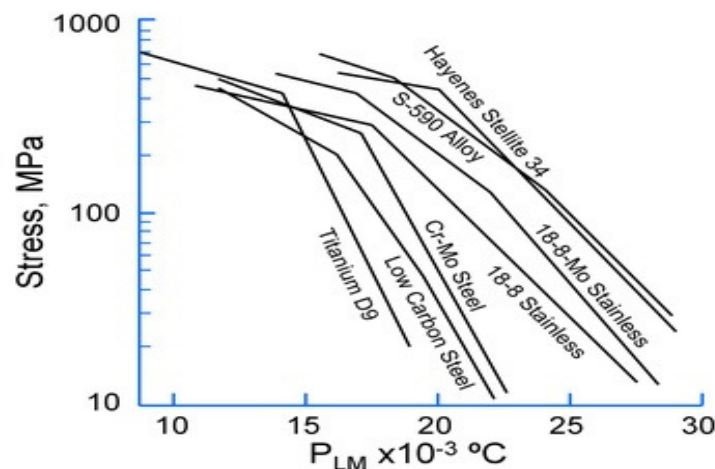
$$LMP \text{ or } P_{LM} = T [\text{Log } tr + C]$$

Where, T = Temperature in Kelvin,

tr = Stress Rupture Time (or Life) in hours and

C = a constant usually of the order 20.

Manufacturers usually conduct accelerated creep –rupture life tests of various materials. The data obtained from these tests includes temperature, stress and time to rupture. Based upon the test data, plots are generated between the values of stress and LMP, as shown in the figure below.



With the knowledge of working hoop stress and metal temperature, it is possible to determine the time for creep rupture failure. The remaining life of the tube is arrived at by calculating the difference between total expected creep rupture life at a given set of conditions minus the life the tube has already spent at those conditions.

The following methodology is used for the calculation of the residual life:

- (i) Data / Empirical formula that correlates the growth rate of oxide scale thickness with time is first used to compute the equivalent temperature of the tube metal under which it has been operating.

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- (ii) Larson Miller Parameter (LMP) is then determined for the hoop stress in the tube.
- (iii) Knowing the LMP and the tube metal temperature, the Stress Rupture Time (or Life) in hours is calculated.
- (iv) The remaining life of the tube is arrived at by calculating the difference between total expected creep rupture life at a given set of conditions minus the life the tube has already spent at those conditions.

Components like Final Super Heater Tubes, Platen Super Heater Tubes, and Re-Heater tubes can be subjected to oxide scale thickness measurement.

h) In-situ Microstructure Replica Analysis

Creep is one of the most critical factors affecting the integrity of the components working at elevated temperatures. Components subjected to creep stress have a limited lifetime. Under the influence of temperature and stress, materials undergo transformation which leads to segregation and precipitation in their micro-structure. Microstructure degradation norms being universally followed by the industry are based on the following classification of damage rating:

Damage Rating	Status of Microstructure
<i>Class 1</i>	<i>Undamaged</i>
<i>Class 2</i>	<i>Isolated Cavities</i>
<i>Class 3</i>	<i>Oriented Cavities</i>
<i>Class 4</i>	<i>Linked Cavities / Micro Cracks</i>
<i>Class 5</i>	<i>Macro Cracks</i>

For examining the microstructure, a cellulose acetate sheet is applied to a polished and etched surface to be examined which is first wetted with acetone. The details of component microstructure are retained by the acetate sheets in the form of replicas. These replicas are then examined under the microscope to determine the extent of damage caused to the microstructure. Damage rating is then correlated with the creep curve to estimate the remaining life of the components. Applicable Standard for Testing is ASTM E135.

Components like Boiler Drum and Headers of Super Heaters & Attemperators, Critical Piping, Turbine Rotors, Turbine Casings and Control Valves which are subjected to high temperatures continuously and where sample removal is either difficult or economically not viable can be subjected to in-situ metallographic Replica Analysis.

i) Hardness Measurement

Hardness measurements are indicators of real time mechanical properties and micro structural degradation due to thermal exposure and creep damage in components operating at high temperatures and pressures. A portable

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hardness tester is used for in-situ measurement of hardness of various critical components. All critical areas, especially the high temperature weld joints and heat affected zones are tested for their hardness values. Applicable Standard for Testing is ASTM E18-11.

j) Dimensional Measurement (DIM):

The components liable for deformation/ bulging due to wear/ creep, namely bolts, valves stems, bushing, bearings etc are thoroughly cleaned and dimension measured to compare with original dimensions. The Dimensional Measurement of outside diameter and thickness are carried out with the help of various precision measuring instruments like digital vernier calipers, screw gauges and bow gauges.

k) Steam Path Audit (SPA)

The purpose of the steam path audit is to verify the internal condition of the steam turbine. A steam path audit typically addresses the following areas of concern:-

1) Leakages:

- Past stationary stage blading.*
- Past rotating stage blading.*
- Past shaft end packings, where rotors emerge from casings.*
- Across poorly fitting joints.*
- Other miscellaneous leakages.*

2) Surface finish degradation:-

- Deposits.*
- Corrosion.*
- Solid particle erosion.*
- Mechanical damage.*

3) Flow blockages from:

- Deposits.*
- Foreign objects.*
- Mechanical damage.*

4) Flow path modification from:

- Solid particle erosion.*
- Water droplet erosion.*
- Mechanical damage*

The steam turbine is opened to examine the condition of all the components coming in the steam flow path, stage by stage. Sources of excess leakage are identified at the horizontal joint of the casing and packing at both the shafts ends and at the inter-stage. For determining the sources of excess leakage, radial clearances are measured at respective places.

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In addition, inspection is done on the blade geometry, increased surface roughness, solid particle erosion and mechanical damage caused due to foreign objects.

The Audit data so collected is compared with the new and clean condition of the turbine to quantify the impact of each problem on heat rate, power output and efficiency.

l) Eddy Current Test

Eddy current tests are used to detect cracks, discontinuities measurement of metal thickness, detection of metal thinning due to corrosion / erosion, determination of coating thickness and the measurement of electrical conductivity and magnetic permeability.

Recent advances in instrumentation technology has created significant opportunities for in place inspection of stationary and rotating blades of steam turbines for cracks and other damages. Eddy current inspections can also be performed on condenser tubes to find any defects that may be present before the tubes develop leakages.

The most basic eddy current testing instrument consists of an alternating current source, a coil of wire in the form of an inspection probe and an analog or digital instrument to measure the change in impedance/voltage. Eddy current probes are available in a large variety of shapes & sizes and can be custom designed for a variety of applications. As long as the material being tested is very uniform, the eddy current will be uniform and consistent. If there is any defect, the eddy current will be disturbed and the disturbance will be indicated by the instrument.

m) ELCID Test

The Electromagnetic Core Imperfection Detection (ELCID) Test is done to detect healthiness of stator core inter-laminar insulations of the Generator. Generator ranks high in terms of criticality and value among the major equipments in the power plant. As there is no standby Generator available at sites, its reliability is of paramount importance.

ELCID test is conducted to detect insulation failure between laminations of stator core of the Generator. The test has the advantage that it does not require a large energy source to test a large machine. Generally speaking, the test can be conducted with only 4% of a machine's rated flux using a toroidal winding of a few turns. A 3 kVA supply at 110 V is sufficient to produce the required excitation.

n) Recurrent Surge Oscillograph (RSO) Test

RSO test is performed to detect faults in rotor windings. The electrical faults in generator rotors fall into two main categories; faults from the winding to the rotor body (earth faults) and faults between parts of the winding (inter-turn winding faults). The existence of these faults frequently display excessive mechanical vibration and cause serious concern. An RSO test identifies the type of fault and pinpoints the position of the fault.

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The test is conducted by applying a 12V D.C Voltage step between one end of the rotor winding and the rotor body. The transmitted wave at the far end of the winding and the reflected wave at the input end of the winding is monitored using two oscilloscope channels. A healthy rotor winding will have two identical traces, which can be superimposed. A rotor with a fault has different traces and the position of the fault is deduced by scaling in the time domain.

o) Tan Delta Test

The Dielectric Loss Analysis (DLA) is an off line test used to determine both the dielectric loss energy and the loss tangent (Tan Delta) of a machine at various voltage steps up to line voltage. Dielectric Loss Analysis (DLA) and Tan Delta testing are well established tests and have been used for many years to evaluate the condition of the windings and the bushings of the transformers. Both dielectric loss energy and loss tangent are affected by the void content of the insulation, the higher the void content the higher the loss tangent and dielectric loss. The loss tangent represents the sum of solid material (conductive type) losses and the gaseous losses, as the voids within the insulation discharge causes breakdown and ionization. The dielectric loss energy is representative of the gaseous discharge losses within the voids and can also be affected by other external sparking type discharges. The results can also be affected by contamination, damp, corona shield and stress grading problems.

p) Furfural Test

Condition of a transformer is mainly decided by the condition of its insulating materials. The two major insulating materials in the Transformer are mineral insulating oil and insulating paper. Transformer core and winding have mainly paper insulation. Base of paper is cellulose.

While the condition of insulating oil of a transformer is periodically checked in the power plants through Dissolved Gas Analysis (DGA) test as a preventive maintenance measure, the condition of insulating paper of old transformers is checked by Furfural Test. The condition of insulating paper is determined by Furfural Test as per IEC: 1198.

The insulating paper degrades with time at rates which depend on factors like temperature, amount of air and moisture present. As the degradation progresses, the products of degradation are released in the oil in the form of organic compounds known as furfuraldehyde compounds and commonly referred to as 'furans'.

It is not possible to bring out a piece of paper insulation from a transformer in service, for testing purpose. However, through Furfural Test, the condition of paper insulation can be examined without touching it. This method is called 'Furfuraldehyde Analysis Test' or in short 'Furfural Test'. For conducting this test, samples are taken from the transformer oil and are tested for the presence of furans. Generally a value of less than 100 ppb (parts per billion) is considered normal and a value above than 1500 ppb in oil indicates high risk of insulation failure. In case the total furan content is

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more than 2500 ppb, the windings of the transformer need to be replaced or rewound.

Through DGA test also, it is possible to predict the condition of the insulating paper. In DGA test, the gases in the oil are extracted and the quantity of gases in a specific amount of oil is analyzed. By observing percentages of different gasses present in the oil, like Hydrogen (H_2), Methane (CH_4), Ethane (C_2H_6), Ethylene (C_2H_4), Acetylene (C_2H_2), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen (N_2) and Oxygen (O_2), one can predict the condition of transformer oil and take corrective action for its replacement. During DGA test, if the ratio of CO_2 / CO is less than 5.0, it is predicted that decomposition of insulation paper has set in. If the ratio of CO_2 / CO is less than 3.0, it can be concluded that severe deterioration of cellulose is taking place.

(B) Destructive Tests

Samples of selected portions of Water Wall Tubes and Super Heater Tubes are taken to evaluate their mechanical properties like Tensile Strength, Yield Strength and Elongation. The results of these destructive tests are correlated with the results of non destructive tests to finalize the assessment and recommendations.}

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Model RLA/CA Report For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[LOGO OF UTILITY]

ANNEXURE –A

INSPECTION CHECK LIST FOR RLA/ CA STUDIES OF BTG EQUIPMENT

COMPONENT	INSPECTION TECHNIQUES FOR RLA/CA STUDIES											
	VE	UT-T	UT-S	DPT	MPI	ET	HM	REP	FBT	DT	CA	SPT
BOILER & AUXILIARIES												
1. Boiler Drum	√	√	√	√	√		√	√			√	
2. Steam Headers	√	√	√		√		√	√	√			
3. Water Headers	√	√	√	√	√		√		√		√	
4. Steam Piping	√	√	√		√		√	√	√			
5. Super-Heater & Re-Heater Tubes	√	√		√						√		√ A
6. Water Wall Tubes	√	√		√					√	√	√	√ A
7. Ducting	√	√		√								
8. Impeller and Shafts of FD/ID/PA Fans	√			√								
9. Impeller Hub & Bearing Shell of FD/ID/PA Fans	√	√		√								
10. Casings of Boiler/APH/Hoppers and Ducts.	√	√		√								
11. ESP	√	√		√								
STEAM TURBINE & AUXILIARIES												
1. Turbine Assembly	√											√ B
2. Rotor	√		√		√		√	√	√			
3. Steam Chest	√	√	√		√		√	√				
4. Casing	√		√	√	√		√	√				
5. Blades	√		√	√	√	√					√	
6. High Temperature Bolts	√		√		√		√			√		
7. Condenser & LP/HP Heaters	√	√	√	√		√						√F, √G
GENERATOR, TRANSFORMERS & HT MOTORS												
1. Stator	√											√ C
2. Rotor	√		√		√							√ D
3. Retaining Rings	√		√		√							
4. Transformers	√											√ E
5. Generators/ HT Motors	√											√ H

NOTE: FOR LEGEND, REFER THE NEXT PAGE

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LEGEND

<i>VE</i>	:	<i>Visual Examination</i>	<i>CA</i>	:	<i>Chemical Analysis</i>
<i>UT-T</i>	:	<i>Ultrasonic Thickness Testing</i>	<i>SPT</i>	:	<i>Special Purpose Testing</i>
<i>UT-S</i>	:	<i>Ultrasonic Test Scanning</i>	<i>A</i>	:	<i>Oxide Scale Thickness Measurement</i>
<i>DPT</i>	:	<i>Dye Penetrant Testing</i>	<i>B</i>	:	<i>Steam Path Audit</i>
<i>MPI</i>	:	<i>Magnetic Particle Inspection</i>	<i>C</i>	:	<i>ELCID Test</i>
<i>ET</i>	:	<i>Eddy Current Testing</i>	<i>D</i>	:	<i>RSO Test</i>
<i>HM</i>	:	<i>Hardness Measurement</i>	<i>E</i>	:	<i>DGA Test, Tan Delta Test, Furfural Test</i>
<i>REP</i>	:	<i>In-situ Microscopic Replica Analysis</i>	<i>F</i>	:	<i>Helium Leak Detection Technique for Condensers.</i>
<i>FBT</i>	:	<i>Fiberscopic/ Boroscopic Inspection</i>	<i>G</i>	:	<i>Hydraulic Testing to identify failed tubes.</i>
<i>DT</i>	:	<i>Destructive Testing</i>	<i>H</i>	:	<i>Insulation Resistance (IR) Test & Polarization Index (PI) Test</i>

INSPECTION CHECK LIST FOR BOP EQUIPMENT

Condition Assessment of BOP Equipment should be done during the visual examination of cold walk down and Hot walk Down Survey. In addition, Performance Test and Auxiliary Power Consumption Test should be carried out as covered in the Energy Audit Report.

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{GUIDELINES FOR CONDITION ASSESSMENT OF CIVIL / STRUCTURAL WORKS}

{Normally, the life of Civil and Structural Works should be of the order of sixty (60) years and above, which is much more than the life of Mechanical and Electrical Components of Thermal Power Plants. However, in certain cases like exposure to harsh and corrosive environment or natural calamities, the buildings / structures/ foundations of a plant may get damaged or become weak due to corrosion or rusting etc. Therefore before taking up the R&M activity of any plant, it is utmost important to critically examine the condition of all the civil and structural works. Based on the examination, any part(s) of the civil and structural works which might have become weak or defective must be identified and solutions found for their repair, retrofitting or replacement so as to increase their service life.

On the basis of condition assessment, a building / structure can be placed into one of the following three categories:

- The building / structure does not show any signs of distress and It satisfies all the safety and serviceability requirements according to relevant Codes of Practice and hence, no action is needed towards retrofitting.*
- The building/structure is seen to be deficient (or distressed) but it can be repaired and strengthened to satisfy the Codal safety requirements or performance criteria set by the user.*
- The building/structure is badly damaged. It is to be demolished and a new building is to be built.*

One needs complete record of building and structure design, construction drawings including that of foundations, architectural details, specifications of materials used, geotechnical details of the area, details of any repair or retrofitting done from the time of construction and details of usage of the building including the loads. Some Non-Destructive Tests or Partially Destructive Tests may also be required to check the strength of concrete masonry etc. The various tests which should be conducted are listed below. Condition Assessment can be made both through visual examination and through detailed investigation.

(A) Visual Examination

The main purpose of visual investigation is to observe and note down all the items of distress or design deficiency and their locations, supported by sketches and drawings. The visual inspection includes:

- Identification of visible structural damage, such as concrete cracking or spalling and observations on quality of construction.*
- Identification of potential non-structural falling hazards, including ceilings, partitions, curtain Walls, parapets, fixtures, and other non-structural building elements.*
- Identification of major alterations made during the operating life of the plant.*

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- Observations on the changed condition of soil in very special cases like that of a natural calamity requiring a fresh geotechnical investigation, particularly when new equipment is required to be installed within the plant area.
- Documentation of existing conditions with photographs at key locations.

Based on the data collected about the details of the building, visual observation of damage/distress in different structural components and the system, the structural engineering experts can categorize the type and seriousness of damage and make judgments about further course of action.

A Check List for conducting Visual Examination is placed at **Annexure B**.

(B) Detailed Investigations

Detailed investigations may have to be carried out in the following events:

- When the visual examinations suggest corrosion and rusting of foundations/structures due to weathering effect, say, as a result of exposure to corrosive environment.
- When the adequacy of existing foundations is required to be checked for retrofitting of the machines and equipments and especially when the original construction drawings for the foundations may not be available.
- When a part of the building or structure might have been severely damaged due to a major accident.

Detailed investigations are required for making following types of checks.

- Checking the Strength of Concrete Structures.
- Assessment of Corrosion of Concrete in RCC Structures.
- Assessment of Corrosion of Reinforcement in RCC Structures.
- Health Assessment of Structural Steel Works.
- Checking the Strength of Concrete Structures.

The investigations may either be in the form of Non-Destructive Tests or Partially Destructive Tests which are discussed below.

Check List for conducting Detailed Investigations is placed at **Annexure-C**.

(a) Checking the Strength of Concrete Structures

Non Destructive Tests

i) Rebound Hammer Test

This test is based on the principle that when a spring-loaded mass strikes the surface of concrete, the rebound distance can be used to determine the surface hardness. A standard equipment known as Rebound Hammer or Schmidt Hammer is used for this purpose which gives the rebound number.

Surface hardness determined during the test also gives an idea about the soundness and quality of cover concrete. Locations having very low rebound numbers indicate weak surface concrete that may be affected by corrosion. The quality of concrete may be interpreted as shown in the Table below.

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Table A- Average Rebound Number and Quality of Concrete

Average Rebound Number	Quality of Concrete
> 40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
< 20	Poor concrete
0	Delaminated

ii) Ultrasonic Pulse Velocity (UPV) Test

The dynamic modulus of elasticity of concrete is determined by measuring the velocity of ultrasonic pulse through the concrete. The test equipment has provisions for generating ultrasonic pulse, transmitting it to concrete, receiving, amplifying and measuring the pulse and displaying its travel time. For this test, a good acoustic coupling is required to be established between the transducers and the concrete for correct measurement of the speed. Applicable Standard for Testing is BS1881 Part 203, IS: 13311 Part-2, IS:516-1959, IS:8900

By this test, one can assess the quality of concrete, such as, honey combing or quality of compaction as per the guidelines indicated in the table below. However, conducting this test requires special expertise. In case of any doubt, it will be desirable to carry out further tests.

Table B - UPV Value and Concrete Quality

UPV Value in km/sec	Concrete quality
> 4.5	Excellent
Between 3.5 and 4.0	Good
Between 3.0 and 3.5	Medium
Below 3.0	Doubtful

Partially Destructive Tests

These are surface zone tests, which require access to one exposed concrete face and cause some localized damage. This damage is sufficiently small to cause no loss in structural performance. The strength of concrete is estimated with the help of correlation charts. Different tests in this category

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are based on core sampling, penetration resistance, pull-out, pull-off and break-off.

i) Core Test

For core test, the samples are taken from the interior of the concrete. The core samples provide the visual inspection of the interior of the concrete and can be subjected to direct measurement of the compressive strength. Other physical properties, such as, density, water absorption, indirect tensile strength and expansion due to alkali-aggregate reaction can also be determined. After testing the compressive strength, these samples can be used for chemical analysis. Applicable Standard for Testing is BS 1881 Part 120.

In core testing, the determination of core size and location is a crucial factor. The test should be taken at points where minimum strength and maximum stress are likely to coincide. But, at the same time, the core cutting causes some damage to the member and may impair the future performance of the member. Therefore, in slender members, the core should be taken, away from the critical section. For compression testing, the diameter of the core should be at least three times the nominal maximum aggregate size. The accuracy of the test increases with the ratio of core diameter to the aggregate size. The generally recommended length to diameter ratio of the cores is between 1 to 2.

The core samples can be used for determination of voids and chemical analysis. Broken samples from the cores can also be used to determine the pH value and the chloride content in the sample. The chemical tests of core samples also provide information to assess the state of corrosion of reinforcing steel.

ii) Penetration Resistance

In penetration resistance testing, a specially designed bolt is fired into concrete with the help of a standardized explosive cartridge. The equipment and testing procedure have been standardized by ASTM C803. A consistent correlation has been found between the depth of penetration and the strength of concrete.

iii) Pull-Out Testing

In pull-out testing, the force needed to pull a bolt or some similar device embedded into concrete is measured and correlated with the strength of concrete. This correlation has been shown to be unaffected by the mix characteristics and the curing history. The bolt may be inserted at the time of casting of the concrete or it may be epoxy grouted into a hole drilled into the hardened concrete. Different versions of this test are in practice in different parts of the world, such as, Lok-test, North American Pull-out Method, Internal fracture test, ESCOT, CAPO test etc.

iv) Pull-off Testing

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Two versions of the test are possible. One application consists of in-situ measurement of tensile strength of concrete. Another application of the test is in testing of the bond between original and new concrete in repairs and strengthening. In first case a metallic disk is glued directly to the surface of concrete and pulled off to measure the force necessary to pull a piece of concrete away from the surface. In the second case partial coring is done with a standard diameter of 75 mm and the above procedure is repeated by gluing the disk at the top of the partial core. For assessing the bonding strength of the repairs with the original concrete, the depth of the partial coring should be below the surface of the original concrete.

(b) Corrosion Assessment of Concrete in Reinforced Concrete Structures

For effective inspection and monitoring of reinforced concrete structure, the condition assessment of reinforcement is an important step. Even for deciding appropriate repair strategy for a distressed concrete structure, the determination of corrosion status of reinforcing bars is a must. Most of NDT methods used for corrosion assessment are based on electrochemical process. The following Table gives guidelines for interpretation about corrosion.

Table C-Interpretation of Test Results on Corrosion

Test Results from Chemical Analysis	Interpretation
High pH value (> 11.5) and very low ($< 0.30\%$) chloride content.	No corrosion
High pH value (≥ 9.5) and high chloride content greater than 0.4% - 0.6% by weight of cement	Corrosion prone
Low pH value (< 7) and high chloride content greater than 0.4% - 0.6% by weight of cement.	Highly corrosion prone

Corrosion assessment of concrete in reinforced concrete structures can be made by conducting the following non-destructive tests.

i) Carbonation Test

This test measures the pH of the concrete. Freshly placed concrete normally has a pH between 12 and 13, which provides protection of the embedded steel and prevents corrosion even in the presence of water and oxygen. Concrete is considered carbonated when the pH falls below 11.5. At this pH level, only moisture is needed to initiate corrosion. Phenolphthalein solution is a typical color changing indicator that is used to perform the carbonation tests. The test solution is colorless at and below a pH of 8.2 and is pink/purple at a pH greater than 10.0. Other indicators are available that

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measure different pH intervals. One commercially available indicator measures pH from 1 to 14 with a rainbow spectrum.

Testing is performed by exposing a freshly broken face of a concrete surface. This is accomplished either by chipping off a small piece of concrete with a rock hammer and chisel, if the carbonation is shallow, or by drilling a hole with an electric hammer drill. The broken surface is washed with distilled water to remove dust that may contaminate the surface. The indicator solution is then sprayed on and the results recorded. The depth of the probe will need to be increased if only carbonated concrete is found. Applicable Standard for Testing is ASTM C 457.

ii) Chloride Concentration Test

In coastal areas, saline water may corrode structures; penetrate the concrete, eventually initiating the corrosion of any uncoated embedded reinforcement. The accepted threshold value for chloride content in concrete is 300 parts per million (ppm), above which active corrosion in the embedded steel will occur. This threshold becomes lower if the concrete is carbonated.

To determine the durability of the structure, it is important to determine the chloride environment around the location of rebar. Testing is performed by taking powder samples from the concrete with a small electric impact hammer to create a profile of chloride content versus depth. The sampling should be taken at approximately 25 mm intervals to a depth below the nearest level of reinforcement. Samples should be taken from visibly deteriorated areas, from visibly "clean" areas, and from areas where exposure to contaminants is unlikely, such as the un-cracked soffit of a parking structure. This last sampling area is necessary to establish background levels of chloride. There is always some level of chloride present in concrete that comes from the individual components. This is allowed, but limited, by codes. Applicable Standard for Testing is BS 1881 Part 124.

(c) Corrosion Tests for Embedded Steel in Reinforced Concrete Structures

Corrosion of reinforcement in concrete structures is a complex electrochemical process. Migration of moisture and aggressive chemicals through the porous cover concrete would cause corrosion of steel reinforcement. The factors that influence corrosion are:

- Cover thickness,
- Quality of concrete in the cover region, especially its permeability and diffusivity,
- Environmental conditions,
- Value of pH and level of chloride in concrete, and
- Presence of cracks.

Following non-destructive tests are found useful for the determination of corrosion of reinforcement.

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i) Half-Cell Potential Test

This test can give the probability of corrosion activity taking place at the point where the measurements of potentials are taken from a half-cell, typically, a copper-copper sulphate half-cell. An electrical contact established with the exposed steel and the half-cell is moved across the surface of concrete for measuring the potentials.

ii) Cover Thickness Test

This test is useful for the determination of concrete cover, location of embedded rebars & estimation of size of embedded rebars. The instrument is based on the magnetic technique and is calibrated for different purposes. The cover thickness is important from the point of view of estimation of initiation of corrosion. The location and estimation of bar diameter becomes useful in structures where no structural drawings are available. Applicable Standard is BS 1881 Part 204.

d) Health Assessment of Structural Steel

Flaws and cracks can play havoc with the performance of structures and for improving the performance, detection of these defects is very much necessary. Visual inspections do not give correct picture of internal structural defects. By using non-destructive testing methods, the structures can be evaluated to a greater degree of accuracy, without damaging them. The following non-destructive tests can be done for evaluating the quality of steel structures.

i) Dye Penetration Inspection (DPI).

ii) Magnetic Particle Inspection.

iii) Eddy current testing.

iv) Radiography testing.

v) Ultrasonic testing.

i) Dye Penetration Inspection (DPI)

Dye Penetration Inspection is a method that is used to reveal surface breaking flaws by bleed out of a colored or fluorescent dye from the flaw. The technique is based on the ability of a liquid to be drawn into a "clean" surface breaking flaw by capillary action. After a period of time called the "dwell," excess surface penetrant is removed and a developer applied. This acts as a "blotter." It draws the penetrant from the flaw to reveal its presence. Colored (contrast) penetrants require good white light while fluorescent penetrants need to be used in darkened conditions with an ultraviolet "black light". Applicable Standard for Testing is IS: 822-1957.

ii) Magnetic Particle Inspection (MPI)

Magnetic particle inspection is a NDT method used for defect detection in steel structures. This is a fast and relatively easy method to apply in field. MPI uses magnetic fields and small magnetic particles, such as iron fillings to detect flaws in components. The component being inspected must be

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made of a ferromagnetic particle such as iron, nickel, cobalt or some of their alloys. Ferromagnetic materials are materials that can be magnetic to a level that will allow the inspection to be effective.

The method may be used effectively for inspection of steel girders and other parts made of steel. Applicable Standard for Testing is IS: 822-1957.

iii) Eddy Current Test

Eddy current equipment can be used for a variety of applications such as detection of cracks, discontinuity, measurement of metal thickness, detection of metal thinning due to corrosion / erosion, determination of coating thickness and the measurement of electrical conductivity and magnetic permeability.

The most basic eddy current testing instrument consists of an alternating current source, a coil of wire connected to this source, and a voltmeter to measure the voltage change across the coil. An ammeter could also be used to measure the current change in the circuit instead of using the voltmeter. Applicable Standard for Testing is IS: 822-1957.

For inspection of major steel beams and columns, this technique can be used for detection of surface breaking cracks. This is an excellent method for detecting surface and near surface defects when the probable defect location and orientation is well known. Defects such as cracks are detected when they disrupt the path of eddy current and weaken their strength.

iv) Radiographic Testing

This is the technique of obtaining a shadow image of a solid using penetrating radiation such as X-rays or Gamma rays. These rays are used to produce a shadow image of an object on film. Thus if X-ray or Gamma ray source is placed on one side of a specimen and a photographic film on the other side, an image is obtained on the film which is in projection, with no details of depth within the solid. Images recorded on the films are known as radiographs. Applicable Standard for Testing is IS: 822-1957.

The contrast in a radiograph is due to different degrees of absorption of X-rays in the specimen and depends on variations in specimen thickness, different chemical constituents, non-uniform densities, flaws, discontinuities, or to scattering processes within the specimen.

v) Ultrasonic Testing

Mechanical vibrations of different kinds can travel through solids due to their elastic properties. Ultrasonic waves due to their higher frequency and smaller wave length provide a much better possibility to find defects and determine their size and their position. The vibrations are normally generated by the use of a piezoelectric crystal, which can be excited by an electrical pulse. The two most common test methods, the through transmission technique and the pulse echo technique are used to determine the test. Applicable Standard for Testing is IS: 822-1957.}

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ANNEXURE – B

Check List for Conducting Visual Examination of Civil / Structural Works.

Name of the Civil /Structural Works.	Name of Element					
	Foundations	Columns	Beams/ Slab/ Roof	Steel Frame	Bracings	Surface finish/ Painting/Cladding/ Lining
Main Power House Building	√	√	√	√	√	√
TG Foundation	√	√	√			
Boiler Structure	√	√	√	√	√	√
Chimney	√					√
ESP Structure	√	√	√	√	√	√
Transformer Yard (foundation)	√					
Machine foundations	√					
Switchyard	√					
Substation	√	√	√	√	√	√
Cooling Towers	√					√
Water Treatment Plant	√	√	√	√	√	√
CW Pump House	√	√	√	√	√	√
Coal Handling Plant and Railway siding	√	√	√	√	√	√
Ash Handling System.	√	√	√	√	√	√

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Name of the Civil /Structural Works.	Name of Element					
	Foundations	Columns	Beams/ Slab/ Roof	Steel Frame	Bracings	Surface finish/ Painting/Cladding/ Lining
Pipe racks	√			√	√	
Cable and Pipe Trenches	√			√	√	
Supporting system for Monorail / Hoist / EOT crane				√	√	
Roads and cross drainage works						√

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ANNEXURE- C
Check List for Conducting Detailed Investigations of Civil / Structural Works

Sl. No.	Property under investigation	Test	Equipment type	Reference Codes/ Standard
1.	Concrete Strength (*See Note Below)	Rebound Hammer Test	Mechanical	
		Ultrasonic Pulse Velocity Test	Electronic	BS1881 Part 203, IS: 13311 Part-2, IS:516-1959, IS:8900
		Core Test	Mechanical	BS1881 Part 120
		Penetration Resistance Test	Mechanical	
		Pull-Out Test	Mechanical	
		Pull-Off Test	Mechanical	
2.	Corrosion Resistance of Concrete in RC Structures.	Carbonation Test	Chemical/Microscopic	ASTM C457
		Chloride Concentration Test	Chemical/Electrical	BS1881 Part 124
3.	Corrosion of Embedded Steel	Half-Cell Potential Test	Electrical	
		Cover Depth Test	Electromagnetic	BS1881 Part 204
		Carbonation depth	Chemical/Microscopic	ASTM C457
		Chloride Concentration	Chemical/Electrical	BS1881 Part 124
4.	Structural Steel Health (For checking cracks, porosity, inclusions etc.)	Dye Penetration Test (DPT)	Chemical	IS:822-1997
		Magnetic Particle Inspection (MPI)	Electrical	IS:822-1997
		Eddy Current Test	Electrical	IS:822-1997
		Radiography Test	Radioactive	IS:822-1997
		Ultrasonic Test	Electrical/ Mechanical	IS:822-1997

*Note: Generally the first activity for rehabilitation work is to carry out conditional survey or visual examination of the structure. Visual examination should be carried out by a consultant in association with an experienced structural engineer. The kind of specific tests to be conducted has to be decided on the basis of the findings of the visual inspection of the structure and its future requirement.

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ANNEXURE- 4.1

VISUAL INSPECTION REPORT OF PLANT AND EQUIPMENT

Plant Name [.....]
Unit No. [.....]
Capacity [.....]
Inspection No. [.....]
Component [.....]
W.O. No. [.....]
Material Specification [.....]
Type of Inspection [Hot Walk Down Survey / Cold Walk Down Survey]

Observation:

1. [.....]
2. [.....]
3. [.....]
4. [.....]
5. [.....]
6. [.....]
7. [.....]

Recommendations:

[.....]
[.....]
[.....]
[.....]
[.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.2

FIBROSCOPIC INSPECTION

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]

[INSERT IMAGES OF FIBROROSCOPIC INSPECTON]

Observation Table

S.No.	Location	Observation
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]

Recommendation:

[.....]

]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.3

BOROSCOPIC INSPECTION

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]

[INSERT IMAGES OF BOROSCOPIC INSPECTON]

Observation Table

S.No.	Location	Observation
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]

Recommendation:

[.....]
 [.....]
 [.....]
 [.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.4

DYE PENETRATION TEST REPORT

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]

Test Details

Surface condition : [Free from loose scale, dust, paint, oil & Surface was clean & dry.]
 Temperature of part : [.....]
 Penetrant material used : [Colored / Fluorescent]

Name	Make	Model	Expiry Date
Penetant	[.....]	[.....]	[.....]
Cleaner	[.....]	[.....]	[.....]
Developer	[.....]	[.....]	[.....]

Penetrating time : [.....]
 Developing time : [.....]
 Standard : [ASTM E709-1995]

Test Result

S.No	Name of parts	Quantity		Finding/ Observation	Remark
		Inspected	Defect Noticed		
1	[.....]	[... %]	[.....]	[.....]	[.....]
2	[.....]	[... %]	[.....]	[.....]	[.....]
3.	[.....]	[... %]	[.....]	[.....]	[.....]

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Recommendations

[.....]
[.....]
[.....]

[Signature]

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ANNEXURE – 4.5

MAGNETIC PARTICLE INSPECTION REPORT

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Test No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]

Test Details:

Surface condition	:	[.....]
Equipment used	:	[.....], Make [.....]
Type of Magnetic Particles	:	[.....]
Method of Magnetizing	:	[.....]
Magnetising Current	:	[.....]
Direction of Field	:	[.....]
Sensitivity Checks	:	[.....]
Method of Demagnetization	:	[.....]
Test Code Followed	:	[.....]

Test Result

S. No.	Name of parts	Quantity		Finding/ Observation	Remark
		Inspected	Defect Noticed		
1	[.....]	[... %]	[.....]	[.....]	[.....]
2	[.....]	[... %]	[.....]	[.....]	[.....]
3	[.....]	[... %]	[.....]	[.....]	[.....]
4	[.....]	[... %]	[.....]	[.....]	[.....]
....	[.....]	[... %]	[.....]	[.....]	[.....]

Model RLA/CA Report For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[LOGO OF UTILITY]

Recommendation

[.....
.....
.....]

[Signature]

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ULTRASONIC TEST REPORT

ANNEXURE- 4.6

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]

Test Details

Equipment used : [Ultrasonic flaw detector, Model:,]
 Make : [.....]
 Technique : [Pulse echo, A-scan direct contact]
 Surface condition : [Free from loose scale, dust, paint, Surface was clean]
 Scanning : [Manual]
 Standard : [ASME Sec 5 & ASTM E164 & ASTM E114]

Test Results

S. No.	Name of parts	Quantity		Finding/ Observation	Remark
		Inspected	Defect Noticed		
1	[.....]	[...%]	[.....]	[.....]	[.....]
2	[.....]	[...%]	[.....]	[.....]	[.....]
3	[.....]	[...%]	[.....]	[.....]	[.....]
4	[.....]	[...%]	[.....]	[.....]	[.....]
5	[.....]	[...%]	[.....]	[.....]	[.....]
	[.....]	[...%]	[.....]	[.....]	[.....]

Model RLA/CA Report For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[LOGO OF UTILITY]

Recommendations

[.....]
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[Signature]

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ANNEXURE- 4.7

ULTRASONIC THICKNESS TEST REPORT

Plant Name [...]

Unit No. [...]

Capacity [...]

Test No. [...]

Component [...]

W.O. No. [...]

Material Specification [...]

Equipment used : [Ultrasonic flaw detector:.....; Make :]

Test Details:

S. No.	Location	Thickness (mm)			
		Front	Rear	Top	Bottom
1	[.....]	[...]	[...]	[...]	[...]
2	[.....]	[...]	[...]	[...]	[...]
3	[.....]	[...]	[...]	[...]	[...]
4	[.....]	[...]	[...]	[...]	[...]
5	[.....]	[...]	[...]	[...]	[...]

Test Results

S. No.	Finding/ Observation	Remarks
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

Model RLA/CA Report For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[LOGO OF UTILITY]

Recommendations

[.....]
[.....]
[.....]

[Signature]

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ANNEXURE- 4.8

OXIDE SCALE THICKNESS MEASUREMENT REPORT

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Test No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]
 Equipment used [Name:Make:Model:]

OBSERVATIONS:

Panel No.	Tube No.	Oxide scale readings (Microns)	Panel No.	Tube No.	Oxide scale readings (Microns)
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

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Panel No.	Tube No.	Oxide scale readings (Microns)	Panel No.	Tube No.	Oxide scale readings (Microns)
[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]

Recommendations

[.....]
[.....]
[.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.9

IN-SITU METALLOGRAPHIC REPORT

[INSERT IMAGES OF MICRO STRUCTURES]

[Signature]

[Name and Designation of Inspecting Engineer]

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Annexure 4.9 (continued)

OBSERVATIONS

Replica No.	Location	Metallographic Observation
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]
[...]	[.....]	[.....]

Recommendations

[.....]
[.....]
[.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE – 4.10

HARDNESS TEST REPORT (HB)

Instrument Used	[.....]
Model	[.....]
Make	[.....]
Measurement Mode	[.....]
Accuracy	[Mean uncertainty %]

Location	Hardness Measured (BHN)			Average Hardness (BHN)
	Metal	HAZ	Weld	
[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]
[.....]	[.....]	[.....]	[.....]	[.....]

REMARKS

[.....]
[.....]
[.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.11

DIMENSIONAL MEASUREMENT TEST REPORT

Plant Name [...]
 Unit No. [...]
 Capacity [...]
 Test No. [...]
 Component [...]
 W.O. No. [...]
 Material Specification [...]
 Equipment used [Name: ... Make: ... Model: ...]

Test Details:

S.No.	Location	Inside Diameter (mm)	
		X-X	Y-Y
1	A	[...]	[...]
2	B	[...]	[...]
3	C	[...]	[...]
4	D	[...]	[...]
5	E	[...]	[...]
6	F	[...]	[...]

Recommendations

[The component is found suitable for extended service till next major overhaul inspection].

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.12

Power Generation Loss Due to Deteriorated Condition of Turbine

S.No.	Turbine Part	Inter-stage Packing	Tip Seal Strips	End Packing's	Steam Seal System Loss	Flow Path Damage	Flow Change Impact	Cover Deposit	Surface Loss	Loss (kW)
1	HP Turbine	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
2	IP Turbine	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
3	LP- Governor End	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
4	LP - Generator End	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
5	Total Loss (kW)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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---	-------------------

ANNEXURE- 4.13

Increase in Heat Rate Due to Deteriorated Condition of Turbine

S.No	Turbine Part	Inter-stage Packing	Tip Seal Strips	End Packing's	Steam Seal System Loss	Flow Path Damage	Flow Change Impact	Cover Deposit	Increase in Heat Rate	Total Increase in Heat Rate (kCal/kWh)
1	HP Turbine	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
2	IP Turbine	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
3	LP- Governor End	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
4	LP - Generator End	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
5	Total Increase in Heat Rate (Kcal/kWh)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

[Signature]

[Name and Designation of Inspecting Engine]

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ANNEXURE- 4.14

ELCID TEST

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]
 Instruments used [.....]

EXCESSIVE LEAKAGE CURRENTS OBSERVED DURING ELCID TEST

S.No.	Slot No.	Pocket No.	Leakage Current (mA)	Observation
1	[...]	[...]	[...]	[.....]
2	[...]	[...]	[...]	[.....]
3	[...]	[...]	[...]	[.....]
4	[...]	[...]	[...]	[.....]
5	[...]	[...]	[...]	[.....]
6	[...]	[...]	[...]	[.....]
7	[...]	[...]	[...]	[.....]
8	[...]	[...]	[...]	[.....]
9	[...]	[...]	[...]	[.....]
10	[...]	[...]	[...]	[.....]

Recommendations

[.....]
 [.....]
 [.....]

[Signature]
 [Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.15

TAN DELTA TEST

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]
 Type of Inspection [Hot Walk Down Survey / Cold Walk Down Survey]
 Instruments used [.....]

OBSERVATIONS:

Winding Tan Delta Report

Phase Reference	Mode	Applied Voltage (V)	Measured Current (mA)	Capacitance (nf)	Dissipation Factor
[HV/LV+ Earth]	[GST]	[.....]	[.....]	[.....]	[.....]
	[GST]	[.....]	[.....]	[.....]	[.....]
	[GST]	[.....]	[.....]	[.....]	[.....]
[HV – LV]	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]
[LV/HV + Earth]	[GST]	[.....]	[.....]	[.....]	[.....]
	[GST]	[.....]	[.....]	[.....]	[.....]
	[GST]	[.....]	[.....]	[.....]	[.....]

HV Bushing Tan Delta Report

Phase Reference	Mode	Applied Voltage (V)	Measured Current (mA)	Capacitance (pf)	Dissipation Factor
R ph	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]
Y ph	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]
B ph	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]
	[UST]	[.....]	[.....]	[.....]	[.....]

Recommendations

[.....]
[.....]
[.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.16

DESTRUCTIVE TEST REPORT

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]
 Type of Inspection [Hot Walk Down Survey / Cold Walk Down Survey]
 Particulars of Sample Tested [.....]
 Applicable Standard [.....]

[Following tube samples were collected for destructive test:]

- 1) [WW Tube front side – Nos.]
- 2) [WW Tube RHS side – Nos.]
- 3) [WW Tubes rear side – Nos.]
- 4) [WW Tubes LHS side – Nos.]
- 5) [Platen super heater tube nos... &]
- 6) [Final super heater tube nos. &]

OBSERVATIONS:

S. No.	Details of Item	Dia width mm	Cross sectional area mm2	Tensile strength	Yield Strength	Hardness	Elongation %
1	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
2	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
3	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
4	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

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S. No.	Details of Item	Dia width mm	Cross sectional area mm ²	Tensile strength	Yield Strength	Hardness	Elongation %
5	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
6	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

Recommendations

[.....]
[.....]
[.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.17

EDDY CURRENT TEST

Plant Name	[.....]
Unit No.	[.....]
Capacity	[.....]
Inspection No.	[.....]
Component	[.....]
W.O. No.	[.....]
Instrument Used	[Make.....Model.....]

Observation Table

S.No.	Location	Observation
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]

Recommendation:

[.....]

]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE- 4.18

FUFURAL TEST

Plant Name	[.....]
Unit No.	[.....]
Capacity	[.....]
Inspection No.	[.....]
Details of Transformer	[.....]
W.O. No.	[.....]

Furan Analysis

Quantity of Transformer Oil Sample	Quantity of Furans present in Sample			Total Furan Concentration
	S.No.	Name of Furan Compound	Quantity	
	1.	[.....]	[.....]	[.....]
	2.	[.....]	[.....]	
	3	[.....]	[.....]	
	4	[.....]	[.....]	
	[.....]	[.....]	
	Total Quantity		[.....]	

Recommendation:

[.....]
 [.....]
 [.....]
 [.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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LII-GETS12021-G-00100-003	03	MODEL RLA/CA REPORT	[122]	25.09.2014

ANNEXURE 5.1

VISUAL EXAMINATION REPORT OF CIVIL AND STRUCTURAL WORKS

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]
 Type of Inspection [Hot Walk Down Survey / Cold Walk Down Survey]

OBSERVATIONS:

Sl. No.	Description	Observation
1.	Verification with original drawings	[.....]
2.	Identification of major alterations with respect to original drawings	[.....]
3.	Identification of visible structural damage	[.....]
3.1	Quality of construction	[.....]
3.2	Surface defects in concrete	[.....]
3.3	Concrete cracking or spalling	[.....]
3.4	Joints condition	[.....]
3.5	Surface defects in structural steel members	[.....]
4.	Identification of visible finishing damage	[.....]
4.1	Quality of painting	[.....]
4.2	Condition of plastering	[.....]

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Sl. No.	Description	Observation
4.3	Structural Painting	[.....]
4.4	Cladding	[.....]
4.5	Roof condition	[.....]
5.	Masonry condition	[.....]
6.	Road and drain condition	[.....]
7.	Patch Repair Requirement	[.....]
8.	Major Repair Requirement	[.....]
8.1	Addition and replacement of reinforcement	[.....]
8.2	Addition and replacement of structural steel	[.....]
8.3	Strengthening of structural element	[.....]
8.4	Strengthening of joints	[.....]
9.	Retro fitting requirement	[.....]
9.1	Alternative structural arrangement	[.....]
9.2	Requirement of redesigning	[.....]
9.3	Replacement and strengthening	[.....]
10.	Requirement of protective measures	[.....]
10.1	Protective coatings and special painting	[.....]
8.	Requirement of new construction	[.....]
10.	Condition of Lining	[.....]

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Sl. No.	Description	Observation
11.	Attached details	[.....]

RECOMMENDATIONS:

[.....]

]

[Signature]

[Name and Designation of Inspecting Engineer]

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ANNEXURE 5.2

DETAILED INVESTIGATION REPORT

Plant Name [.....]
 Unit No. [.....]
 Capacity [.....]
 Inspection No. [.....]
 Component [.....]
 W.O. No. [.....]
 Material Specification [.....]
 Type of Inspection [Hot Walk Down Survey / Cold Walk Down Survey]

OBSERVATIONS:

Plant Name	[.....]
Unit Name	[.....]
Capacity	[.....]
Inspection No	[.....]
Component	[.....]
Element	[.....]
Name of Test	[.....]
Name of Agency	[.....]
Reference code	[.....]
Test Result	[.....] [.....]

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RECOMMENDATIONS:

[.....]
.....
.....
.....
.....]

[Signature]

[Name and Designation of Inspecting Engineer]

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LII-GETS12021-G-00100-003	03	MODEL RLA/CA REPORT	[127]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

MODEL DETAILED PROJECT REPORT

PREPARED BY

**LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
CONSULTING ENGINEERS
(AN ISO: 9001:2008 CERTIFIED COMPANY)**

History of Revisions

Revision No.	Date	Prepared /Revised by	Description
R00	04.09.2012	R.K.Soni (RKS)	First edition Issued.
R01	08.02.2013	RKS	Revised on the basis of Comments received from CEA
R02	14.02.2013	RKS	Minor Revision
R03	31.07.2013	RKS	Revised on the basis of Comments of Task Force Received on 14 th May 2013 and the discussions with CEA on 11 th June 2013.
R04	25.09.2014	RKS	Left out comments incorporated

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-004	04	DETAILED PROJECT REPORT FOR R&M WORKS	[i]	25.09.2014

BACKGROUND

What is R&M (Renovation & Modernization) of Thermal Power Plants?

Coal based power stations contribute more than 70% share of total power generation in India. Thermal Power Stations are designed for an economical and stable life span of 25 years, after which, the level of performance starts deteriorating as a result of degradation of its equipments, components and materials. Deterioration may also take place before the completion of useful life of 25 years, if the units are not operated and maintained properly. Deterioration in performance is reflected in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. This results in costly repair and loss of revenue. Renovations & Modernization (R&M) and Life Extension (LE) programme of thermal power station is an activity of carrying out repairs, refurbishments and replacement of defective equipments & components so as to extend the life of the power plant by at least 20 years and to restore the performance parameters to equal or better than the original design parameters.

Need of R&M

In spite of new capacity additions, India continues to face shortages of varying degree in the supply of energy and peaking power. Implementation of fresh capacity additions for bridging the demand supply gap involves huge investments and long gestation periods primarily due to the process of land acquisition and getting the required fuel and water allocations, permits & clearances, particularly, the environmental clearance.

On the other hand, R&M activity of existing old power plants which requires less investment and can be completed in shorter duration has been recognized as a techno-economically viable option to supplement the fresh capacity addition for maximizing the energy generation. Also it helps in reducing the emissions by adopting upgraded modern technologies.

Objectives of R&M and R&M/LE Programme

As per the Guidelines issued by Central Electricity Authority (CEA) the following should be the objectives of R&M and R&M/LE Programmes.

Objectives of R&M Programme:

- To restore rated capacity and design parameters such as Heat Rate, Auxiliary Power Consumption, Secondary Oil Consumption etc.
- To make the operating units well equipped with modified/ augmented latest technology.

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- To overcome technological obsolescence and non-availability of spares.
- To improve the performance parameters in terms of Plant Load Factor, Efficiency, Forced Outages, Availability and Reliability.
- To reduce maintenance requirements and enhance the ease in maintenance.
- Compliance of stringent environmental norms, safety and other statutory requirements.

Objectives of R&M/LE Programme:

- Extension of useful economic life of generating units by another 20 years.
- To focus on full load operation of the unit beyond their original design life.
- To restore rated capacity and design parameters such as heat rate,
- Improvement in Auxiliary Power Consumption Secondary Oil Consumption etc
- Up-rating of Generating Unit.
- Improvement beyond design parameters.

Criteria for the Consideration of R&M and R&M/LE Programmes

As per the Guidelines issued by Central Electricity Authority (CEA) the following criteria is to be adopted for considering the R&M and R&M/LE Programmes.

- Estimated cost of unit for complete R&M/ LE works should be limited to 50% of cost of new unit.
- Cost of Main Plant (BTG) should be limited to 50% cost of new BTG unit.
- Plant Life should be extended by about 20 years.
- The Pay Back Period should be from 5 to 7 years.

Need of Preparation of Model R&M Documents

The countrywide R&M programme was first initiated in 1980 when Government of India approved the scheme of Central Loan Assistance (CLA) of Rs. 500 crores benefitting 34 power stations mostly of 50/60/100/110/120/140 MW capacities. R&M in a structured manner was initiated as a centrally sponsored programme during the 7th Five Year Plan. The momentum of carrying out R&M works was continued through 8th and 9th Plans but the same could not be sustained during the 10th Plan.

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Detailed Project Report For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

Based on the discussions held with Ministry of Power, various utilities, PFC and BHEL, CEA prepared a document on “National Perspective Plan for Renovation & Modernization and Life Extension and Up-rating (LE&U) of thermal power stations up to the year 2016-17”. This document which also includes revised guidelines for Renovation & Modernization / Life Extension works on coal/lignite based thermal power stations was released by Honourable Minister of Power on 14th December 2009. Plan-wise Achievements of R&M and R&M/LE Programmes starting from 7th Five Year Plan till 11th Five Year Plan is furnished below:

Plan–Wise Achievements

S.No.	Plan	Year	No. of TPS / No. of Units	Capacity (MW)	Additional Generation Achieved MU/ Annum	Equivalent MW
1	7 th Plan and Two Annual Plans	85-86 to 89-90 & 90-91, 91-92	34 / 163	13570	10000	2000
2	8 th Plan (R&M) (LEP)	92-93 to 96-97	44 / 198 43/(194) 1/ (4)	20869 (20569) (300)	5085	763
3	9 th Plan (R&M) (LEP)	97-98 to 2001-02	37 / 152 29/ (127) 8/ (25)	18991 (17306) (1685)	14500	2200
4	10 th Plan (R&M) (LEP)	2002-03 to 2006-07	9/ 25 (14 out of 57 planned) (11 out of 106)	3445 (2460) (985)	2000	300

11th Plan R&M Programme & Achievements (2007-12)

	Programme (MW)	Achievement (MW)
Life Extension Programme (LEP)	7318 (53 units)	1291 (13 Units)
R&M Programme	18965 (76 units)	14855 (59 units)
Total	26383 (129 units)	16146 (72 units)

In the past, R&M measures were hampered due to lack of proper planning. Proper investigation to identify the R&M works to be carried out and preparation of technical bid documents based on the investigation was not done. This resulted in unsystematic and

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additional work during execution phase and uncertainty about costs resulting in excessive implementation time, long shutdown periods of plants and cost overruns. In the absence of standard commercial rules and policies, suppliers showed little interest in R&M work. Therefore a strong need was felt for providing standardized bidding procedures as well as model contracts, formats and specifications etc. to the utilities. Standardization will harmonize the requirements of all the stakeholders and will lead to their increased participation.

The Indo-German Energy Forum (IGEF)

The Indo-German Energy Forum (IGEF), inaugurated in 2006, provides a platform to discuss energy related issues of mutual interest. The first meeting of the ad-hoc sub-group on "energy efficiency in thermal power stations", constituted as per decision of meeting of IGEF in December 2007, was held under the chairmanship of Joint Secretary (Thermal), Ministry of Power on 12th March, 2008 in which preparation of standard tendering document for the purpose of R&M activities was, inter-alia, identified as an area of the activities. The scope of the assignment was divided in two parts as under:-

Phase-I Activity:

Phase-I activity comprised an assessment of tendering procedures currently being followed by public utilities in India and a review of documents used for standard R&M projects and the documents which have already been developed for energy efficient R&M projects financed by particularly World Bank. This activity was carried out by M/s Evonik (India) under the grant provided by GTZ. M/s Evonik (India) submitted the report in September 2009.

Phase-II Activity

Phase-II activity comprised the preparation of the model documents / templates in consultation with Task Force, power utilities & financing agencies.

In the 3rd meeting of Indo-German Energy Forum (IGEF) convened in Berlin on 4th November 2009, KfW proposed to finance and carryout the work programme of phase-II Activity, on behalf of CEA & in consultation with the Task Force. In a meeting held in MOP on 17th December 2009, chaired by Joint Secretary (Thermal), MOP, the representative of KfW suggested that CEA may act as "Project Executing Agency" for the phase-II activity. Accordingly Ministry of Power, Govt. of India have entrusted the task of "Project Executing Agency" to CEA for implementing Phase-II activity. Under Indo-German Energy Forum (IGEF) assisted programme, M/s Lahmeyer International (India) was appointed on 16th March 2012 to provide the consultancy services for 'Development of tendering procedures and model contract document for R&M of Fossil Fuel Based Power Plants in India.' The scope of consultancy services included the preparation of the following model documents:

- I) Standard Bidding Procedure for engagement of Consultants and R&M Works Contractor.
- II) Residual Life Assessment (RLA) / Condition Assessment (CA) Report.

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III) Energy Audit (EA) Report.

IV) Feasibility Report.

V) Detailed Project Report.

VI) Request for Qualification (RFQ) & (RFP) Documents for R&M Consultants and R&M Contractors.

VII) Technical Specifications.

Due Diligence done by LII of the R&M Documents of other Projects

Before the preparation of this model document, LII did a thorough review of the R&M Documents of the following Power Plants:

Documents Provided by CEA

- Remaining Life Assessment / Condition Assessment Report- Nasik Unit-3 of MAHAGENCO.
- Energy Audit Report- Nasik Unit- 3 of MAHAGENCO.
- Detailed Feasibility Report- Nasik Unit-3 of MAHAGENCO.
- Draft Detailed Project Report -Kolaghat Unit-3 of WBPDCCL.
- Service Contract- R&M of Unit-1 Panipat TPS of HPGCL.
- Tender document for Supply, Erection, Testing and Commissioning of Air Preheater for Unit 5 & 6 Koradi TPS, MAHAGENCO.
- Tender document for replacement of 6.6 KV station transformer incoming breaker & Tie- breaker of Koradi TPS, MAHAGENCO.
- Tender specification for Design, Engineering, Supply, Erection, Testing and Commissioning of Rotary Air Preheater for Units 4 & 5, Nasik TPS of MAHAGENCO.

Documents Provided by WBPDCCL

- Energy Audit Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Detailed Project Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Project Design Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Technical Specifications. (Vol. II of RFP Document for R&M Contractor).
- RLA for Boiler for Bandel Unit -5.
- RFP for R&M Consultant for Bandel Unit -5.
- Commercial Volume-I of RFP for Bandel Unit -5 for R&M Contractor.

KfW Documents

- Model Contract Document issued by KfW.
- Guidelines issued by KfW for the assignment of Consultants.

World Bank Documents

- Standard Bidding Document for Procurement of Plant, Design, Supply and Installation.
- Standard Request for Proposal for the Selection of Consultants

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This Detailed Project Report has been prepared to conceptualize the systematic methods and procedures to be implemented for carrying out R&M works for the Thermal Power Plants, taking into account the different practices followed in the past, the practices and methodologies being adopted by KfW and World Bank, as indicated in the various documents indicated above. Detailed standard documents like RFP & RFQ documents to carry out R&M works for the Thermal Power Plants shall be prepared based on this Detailed Project Report.

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NOTES & GUIDELINES FOR USING THE MODEL DETAILED PROJECT REPORT

Central Electricity Authority (CEA), the Project Executing Agency / Employer has appointed Lahmeyer International India Pvt. Ltd. (LII), the Consultant to Develop Standard Procedures and Model Documents for the Renovation and Modernization (R&M) of Fossil Fuel based Power Plants in India. The above assignment is being financed by KfW Entwicklungsbank. Accordingly, this Model Detailed Project Report (DPR) has been prepared for the guidance of Project Authorities who may decide to carryout R&M of their old Coal based Power Plants so as to extend the life of their plants and make them energy efficient and reduce emissions.

The purpose of this model document is to standardize the format of the DPR for R&M works. Since majority of 200/210 MW units are potential candidates for consideration of Renovation as they have crossed 20 to 25 years of useful life, the enclosed format has been prepared keeping those 200 MW/210 MW units in view. However, within a few years, some of the 500 MW Units will also become due for R&M. The utilities are therefore advised to suitably modify this model document, as applicable, before adopting the same for 500 MW Units.

This format of DPR (Detailed Project Report) contains two kinds of texts written in black and in blue colours. The text in blue italics and enclosed in square bracket ([...]) represents variable information which may differ from project to project. The text and numbers in blue colour are written for the sake of citing an example. The Utilities and their Consultants are advised to check the relevance of the same and replace these texts and numbers with the ones as may be applicable to their specific Project. A few guidelines have also been provided in blue italics enclosed within red curly brackets ({...}), wherever applicable.

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MODEL DETAILED PROJECT REPORT

FOR

RENOVATION & MODERNISATION

OF

FOSSIL FUEL BASED POWER PLANTS IN INDIA

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ABBREVIATIONS TO BE USED

{The utilities are advised to use the following standard abbreviations while preparing Detailed Project Report for their power plant.}

AAQ	Ambient Air Quality
ACB	Air Circuit Breaker
ACG	Automatic Control Gear
AHP	Ash Handling Plant
AHU	Air Handling Unit
ATRS	Automatic Turbine Run up System
ATT	Automatic Turbine Testing
AVR	Automatic Voltage Regulator
BFP	Boiler Feed Water Pump
BOP	Balance of Plant
CAVT	Cold Air Velocity Air Flow Test
CBD	Continuous Blow Down
CCTV	Closed Circuit Television
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CER	Certified Emission Reduction
CERC	Central Electricity Regulatory Commission
CFBC	Circulating Fluidized Bed Combustion
CHP	Coal Handling Plant
CRH	Cold Re-Heat
CLCS	Closed Loop Control System

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COG	Cost of Generation
CT	Cooling Tower
CV	Control Valve
CW	Cooling Water
CWIP	Capitalized Work in Progress
DCDB	Direct Current Distribution Board
DDCMIS	Digital Distributed Control Monitoring Information System
DG	Diesel Generator
DGA	Dissolved Gas Analyser
DM	Demineralization
DX	Direct Expansion Type of Air Conditioning Plant
EA	Energy Audit
ECO	Economizer
EEP	Energy Efficiency Programme
EHC	Electro-Hydraulic Control
ELCID	Electromagnetic Core Imperfection Detection
EOT	Electrically Operated Travelling Crane
ESP	Electro Static Precipitator
ESV	Emergency Stop Valve
EWS	Engineer's Work Station
FO	Fuel Oil
FSSS	Furnace Safeguard Supervisory System
GC	Gland Condenser

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GCV	Gross Calorific Value
GT	Generator Transformer
HCA	Host Country Approval
HEA	High Energy Pulsed Arc
HP	High Pressure
HRH	Hot Re-Heat
HT	High Tension
HVAC	Heating, Ventilation and Air Conditioning
HVWS	High Velocity Water Spray System
IBD	Intermittent Blow Down
ICB	International Competitive Bidding
IFI	International Financing Institution
IGV	Inlet Guide Vane
IPT	Intermediate Pressure Turbine
IPR	Inter Posing Relay
IRR	Internal Rate of Return
ISMB	Indian Standard Medium Beam
IV	Interceptive Valve
LDO	Light Diesel Oil
LE	Life Extension
LMZ	Leningradsky Metallichesky Zavod
LPT	Low Pressure Turbine
LRSB	Long Retractable Soot Blower

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LT	Low Tension
LTSH	Low Temperature Super Heater
LVS	Large Video Screen
MCCB	Module Case Circuit Breaker
MOCB	Minimum Oil Circuit Breaker
MoEF	Ministry of Environment and Forest
MS	Main Steam
MSSV	Main Stream Safety Valve
NOx	Oxides of Nitrogen
OPC	Object linked embedded Process Control
OWS	Operator Working Station
PA	Primary Air
PF	Pulverized Fuel
PCN	Project Concept Note
PDD	Project Design Document
PLF	Plant Load Factor
PRDS	Pressure Reducing De-superheating Station
PLC	Programmable Logic Controller
R&M	Renovation & Modernization
RFP	Request for Proposal
RFQ	Request for Qualification
RH	Reheater
RLA	Residual Life Assessment

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RO	Reverse Osmosis
RPM	Revolution Per Minute
RSO	Recurrent Surge Oscillograph
SADC	Secondary Air Damper Control
SH	Super Heater
SOC	Secondary Oil Consumption
SPM	Solid Particulate Matter
SOx	Oxides of Sulphur
SS	Stainless Steel
SWAS	Steam and Water Analysis System
TPH/T/hr	Tonnes per Hour
TFT	Thin Film Transistor (Monitor)
TPS	Thermal Power Station
TR	Tons of Refrigeration
TC	Thermocouple
TSE	Turbine Stress Evaluator
UPS	Uninterruptible Power Supply
VVVF	Variable Voltage and Variable Frequency Drive
WACC	Weighted Average Cost of Capital

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MEASUREMENT UNITS

{The utilities are advised to use the following abbreviations of measuring units while preparing Detailed Project Report for their power plant.}

°C	:	Degree Celsius
cm ²	:	Square Centimeter
dB (A)	:	Decibels Absolute
hr	:	Hour
Hz	:	Hertz
kCal	:	Kilo Calorie
kg	:	Kilogram
kl	:	Kilo Liter
km	:	kilo meter
kV	:	kilo Volt
kVA	:	kilo Volt Ampere
kW	:	kilo Watt
kWh	:	Kilo Watt hour
m	:	Meter
m ²	:	Square Meter
m ³	:	cubic meter
mg	:	Milligram
MJ	:	Millions of Joule
mm	:	Millimeter
cm	:	centimeter
MVA	:	Mega Volt Ampere
MW	:	Mega Watt
ppm	:	Parts per million
rpm	:	Revolutions per minute
TPH / T/h	:	Tonnes Per Hour
mg/Nm ³	:	Milligram per Normal cubic meter
µg/m ³	:	Micrograms per cubic meter

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1

EXECUTIVE SUMMARY

This Detailed Project Report has been prepared for carrying out the Renovation & Modernization (R&M)/ Life Extension (LE) of Unit No [...] of [...]. Thermal Power Plant, located at [...], in District [...] in the state of [...] and having a configuration of [...x...MW].

The unit no. [...] was first commissioned in the year [...]. After [...] years of operation, the performance of the unit has gradually deteriorated resulting in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. It is proposed to carry out required refurbishments and replacements in the plant so as to restore the unit's performance parameters and to extend its life of by at least [...] years. This report is based on the outcome of the Feasibility Report in which various options of renovating the plant were discussed through corresponding financial cost benefit analysis, to arrive at the most appropriate option.

The cost of the R&M Project is estimated as Rs. [...] crores. The Payback Period is estimated as [...] years. The R&M activity is expected to bring out the improvements as indicated in the following table:

[Improvements Expected after R&M of the Unit]

S.No.	Parameters	Units	Before R&M	After R&M
1.	Residual Plant Life	Years	[.....]	[.....]
2.	Capacity	MW	[.....]	[.....]
3.	Plant Load Factor	%	[.....]	[.....]
4.	Heat Rate	kCal/ kWh	[.....]	[.....]
5.	Auxiliary Power Consumption	%	[.....]	[.....]
6.	Specific Oil Consumption	ml/kWh	[.....]	[.....]
7	Specific Coal Consumption	kg/kWh	[.....]	[.....]
8.	Emission of Solid Particulate Matter	mg/Nm ³	[.....]	[.....]

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S.No.	Parameters	Units	Before R&M	After R&M
9.	SO _x - (Ground Concentration) Level	µg/m ³	[.....]	[.....]
10.	NO _x - (Ground Concentration) Level	µg/m ³	[.....]	[.....]
11.	Noise Level during day time at plant boundary.	dB (A)	[.....]	[.....]
12	Noise Level during night time at plant boundary	dB (A)	[.....]	[.....]

2 INTRODUCTION

2.1 Description

The Power Plant, having a configuration of [...]MW is located at [...], in District [...] in the state of [...]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The boiler is provided with [front & rear/corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [... substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...] coal mines. The consumptive water for the power plant is being sourced from [...river/...sea].

2.2 Operational Background

After the first commissioning during the year [...], the unit was giving a stable operation with [...] MW of Gross Power Output at an average PLF of [...] % and a Gross Heat Rate of [...]kCal/kWh]. The Auxiliary Power Consumption after the first commissioning was [...%]. [Based upon the recommendations of RLA / CA and EA Studies conducted during the year major replacements were made during the year..... comprising.....and]. The unit is presently performing with a maximum Gross Power Output of [...] MW with an average PLF of [...%] and a Gross Heat Rate of [...]kCal/kWh]. The present Auxiliary Power Consumption is [...%].

2.3 Objective of undertaking Renovation & Modernisation

Renovation and Modernisation of the unit is proposed for refurbishing the unit in a cost effective manner so as to extend its life, increase its output and efficiency and to ensure that its performance is in compliance with the revised statutory standards prescribed by the environmental authorities.

A detailed Feasibility Study consisting of the following sub-studies has already been carried out to arrive at the most cost effective and feasible solution.

- a. [Cold Walk-down and Hot Walk-down Survey.
- b. Discussion with the Plant Engineers.

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- c. Review of the operational history of the power plant, reports of Condition Assessment (CA) and Residual Life Assessment (RLA) studies carried out earlier and major replacements done in the past, prior to taking up this study.*
- d. Review of reports of Condition assessment (CA) and Residual Life Assessment (RLA) of major equipment and systems of the power plant carried out recently.*
- e. Review of reports of Energy Audit of main equipments and auxiliary systems carried out recently to identify the reasons and sources of excess power consumption.*
- f. Review of recommendations of R&M Consultant for carrying out R&M measures for increasing the useful life, efficiency and output of the plant as well as for meeting the latest environment standards prescribed by the regulating agencies at the national and state level.*
- g. Study of the financial impact of the R&M Measures proposed.*
- h. Financial analysis based on internal rate of return and cost benefit ratio.]*

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3 SALIENT FEATURES OF POWER PLANT

{Describe in this chapter, the Design Parameters and Salient Features of all the important Equipment and Systems of the Power Plant as mentioned below}

3.1 Boiler & Auxiliaries

a) Boiler

[The Boiler is of natural circulation, pulverized fuel fired, dry bottom, balanced draft using direct firing system. The design parameters of the Boiler are furnished below]

Description	Units	Design Parameters
Steam Flow at Final SH outlet	T / hr	[....]
Steam Pressure at SH outlet	kg/cm ²	[....]
Steam Temperature at SH outlet	°C	[....]
Re-heater Flow	T / hr	[....]
Steam Pressure at RH outlet	kg/cm ²	[....]
Steam Temperature at RH outlet	°C	[....]
Feed Water Flow	T / hr	[....]
Feed Water Pressure at inlet of Economiser	kg/cm ²	[....]
Feed Water Temperature at inlet of Economiser.	°C	[....]

b) Furnace

[The boiler is equipped with a water cooled furnace of balanced draft and fusion welded membrane wall construction. It is equipped with.....numbers of coal burners and.....numbers of oil burners located at numbers of elevations. The design parameters of the Furnace are furnished below.]

Description	Units	Design Parameters
Type of Firing	[.....]

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Description	Units	Design Parameters
Combustion Chamber Volume	m ³	[.....]
Furnace Dimensions (Width x Depth x Height)	m	[.....]
Heating Surface Areas		[.....]
i) Water Walls	m ²	[.....]
ii) Superheaters	m ²	[.....]
iii) Reheaters	m ²	[.....]
iv) Economiser	m ²	[.....]
v) Air Heater	m ²	[.....]
vi) Steam Coil Air Heater	m ²	[.....]
vii) Temperature Measurement of Super-heater tubes	Yes / No	[.....]
viii) Temperature Measurement of Re-heater tubes	Yes / No	[.....]

c) Super Heaters and Re-Heater

[The super heaters are composed of four sections, a platen section, a pendant section, a rear low temperature section and a steam cooled wall & roof section. The Re-heater consists of two sections, the front pendant and the rear pendant sections. The details are given below:]

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Low	[.....]	[.....]	[.....]	[.....]	[.....]

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Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Temperature Super Heater					
Platen Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Pendant Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Ceiling and Enclosure Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Front Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Rear Assembly	[.....]	[.....]	[.....]	[.....]	[.....]

d) Economiser

[The Economizer is of a single stage, continuous plain tube and horizontal, mixed flow type, located in the second pass of the boiler]

e) Air Pre-Heater

[The air pre-heater is of regenerative rotary type. Special sealing arrangements have been provided in the air pre-heater to prevent leakage between air and gas sides. Adjustable sector plates have also been provided to prevent the leakage during expansion. The heating surfaces of the air pre-heater have been provided with two types of cleaning systems, soot blowing and water washing system.]

f) Raw Coal Bunkers

[Each boiler is provided with [...] raw coal bunkers. The total capacity of the bunkers is to meet [...] hour's requirement at maximum mills capacity of the unit. The upper portion of the bunkers is of cylindrical shape made of carbon

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steel plate, while the conical portion is made of stainless steel plate. Each outlet of the bunker is provided with an isolation gate which is motor operated. In addition to the isolation gates, rod gates have been provided to control the flow of coal from the bunkers]

g) Raw Coal Feeders

[One gravimetric type of raw coal feeder has been provided for each coal mill. The coal feeders have been provided with micro-processor based controls with variable frequency drive. The feeders have been provided with dual independently measuring load cells. All parts of the feeders coming in contact with coal, except the belt, are made of stainless steel]

h) Fuel Firing System

[The boiler is working on a direct firing system. The pulverized coal is being dried and transported to the coal burners by means of hot primary air being supplied by two primary air fans. The boiler is having [front and rear/corner/down shot] firing system. There are [...] pulverized coal burners and [...] oil burners. The burners are located at [...] floors.

i) Coal Mills

[The unit is provided with numbers of [BHEL] make [XRP-783] bowl type mills, out of which mills are designed to work with designed coal andnumbers of mills are standby . The rated capacity of each mill isT/hr]

Description	Units	Design Parameters
Make and Model of Mills	.....	[....]
Capacity of Mills	T/hr	[....]
Total Number of Mills per boiler	Nos.	[....]
Number of Mills to work per boiler with design coal quality	Nos.	[....]
Motor Rating	kW	[....]

j) Primary Air Fans

[Two Primary Air (PA) Fans have been provided for each boiler. Each PA Fan is designed to meet 60% MCR condition of the boiler. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Type of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Hot Air	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]

k) Forced Draft Fans

[Two Forced Draft (FD) Fans have been provided for each boiler. Each FD Fan is designed to meet 60% MCR condition of the boiler. The FD Fans supply combustion air to the boiler, mill air through PA Fans and tempering air to control the classifier temperature of the mills. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Type of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Air	°C	[...]

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Description	Units	Design Parameters
Motor Rating	kW	[...]
Method of Regulation	[...]

I) Induced Draft Fans

[Two Induced Draft (ID) Fans have been provided for each boiler. Each ID Fan is designed to meet 60% MCR condition of the boiler. Each ID Fan evacuates flue gases through two parallel paths of ESP and discharge them into stack through separate ducting. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[...]
Type of Fans	.....	[...]
Number of Fans per Boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Flue Gases	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]

m) Wall Blowers and Long Retractable Soot Blowers (LRSBs)

[Wall Blowers [...numbers] and Long Retractable Soot Blowers (LRSBs) [...numbers] are being used for cleaning the soot deposited on the heating surfaces of the water walls and super heaters respectively. Manual soot blowing system has been provided. Details are given below:]

Description	Units	Design Parameters
Wall Blowers		
Make and Model of Wall Blowers	[...]

Description	Units	Design Parameters
No. of Wall Blowers per boiler at water walls	Nos.	[...]
Medium of soot blowing at water walls	.....	[...]
LRSBs		
Make and Model of LRSBs	.....	[...]
No. of LRSBs per boiler at pendant surfaces of pressure parts	Nos.	[...]
Medium of soot blowing at pendant surfaces of pressure parts	.....	[...]
No. of LRSBs per boiler at convection pass tube banks	Nos.	[...]
Medium of soot blowing at convection pass tube banks	.....	[...]

n) ESP

[An Electrostatic Precipitator (ESP) has been installed on the cold end side of the Air Pre-heater to remove the particulate matter from the flue gases. The ESP has been provided with Gas Distribution System, Collecting Electrodes, Discharge Electrodes, Transformer Rectifier Sets and [electrically/mechanically] operated rapping system. The hoppers of ESP have been provided with [capacitance] type level indicators and thermostatically controlled heating elements. Details are given below:]

Description	Units	Design Parameters
Make and Model of ESP	.....	[...]
Number of Passes per ESP	Nos.	[...]
Number of fields per pass	Nos.	[...]
Number of ESP Hoppers	Nos.	[...]

Description	Units	Design Parameters
Dust concentration at outlet	mg/Nm ³	[...]
Type of Control	.....	[...]
Gas Velocity in ESP	m/sec	[...]
Specific Collection Area	m ² /m ³ /sec	[...]
Aspect Ratio	.....	[...]
Particle Migration Velocity	cm/sec	[...]
Numbers of TR Sets	.....	[...]
Rating of TR Sets	.....	[...]
Plate Area/TR Set	m ² /TR Set	[...]
Storage Capacity of ESP Hoppers	hrs	[...]
Pressure Drop	mmwc	[...]
Dust Collection Efficiency with (N-1) fields in operation	%	[...]

3.2 Turbine & Auxiliaries

a) Steam Turbine

[The steam turbine is of three cylinder, 3000rpm, tandem compound, condensing type designed to operate on a re-heat and re-generative feed water cycle. The LP stage of turbine is designed with Bauman exhaust. The turbine is provided with HP/LP bypass system of 60% capacity of Boiler MCR. The turbine is provided with an electro - hydraulic control system, automatic turbine run up system and turbo supervisory instrumentation. The condensing system consists of a surface condenser of single shell and two pass, divided water box construction. Cooling water being supplied to the condenser is of raw water/ clarified water quality. The design parameters of the steam turbine are furnished below]

Description	Units	Design Parameters
Pressure of Steam at inlet of ESV of HPT	kg/cm ²	[...]

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Description	Units	Design Parameters
Temperature of Steam at inlet of ESV of HPT	°C	[...]
Pressure of Cold Reheat (CRH) Steam	kg/cm ²	[...]
Temperature of Cold Reheat (CRH) Steam	°C	[...]
Pressure of Hot Reheat (HRH) Steam	kg/cm ²	[...]
Temperature of Hot Reheat (HRH) Steam	°C	[...]
Pressure at the inlet of LP Turbine	kg/cm ²	[...]
Temperature at the inlet of LP Turbine	°C	[...]

b) **Condenser**

[The condenser is a [single/double] pass, horizontal, surface type with integral air cooling section designed to maintain a pressure of 76 mm of Hg at turbine exhaust with a cooling water temperature of [...] deg C and an outlet temp of [...] deg C. The condenser is capable of operation with [...] tubes plugged and has hot well storage capacity of [...] minutes]

Description	Units	Design Parameters
Make and Model	.....	[...]
Type of Condenser	.....	[...]
Total Cooling Surface	m ²	[...]
Number of Cooling Water Tubes	.....	[...]
Material of Tubes	.....	[...]
Diameter and thickness of tubes	mmxmm	[...]
Cooling Water Quantity through Condenser	m ³ /h	[...]
Cooling Water Temperature at the inlet to Condenser	°C	[...]

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Description	Units	Design Parameters
Condenser Vacuum	mm Hg	[....]

c) Ejectors

[The Condenser is provided with two quick starting ejectors which operate in parallel to remove large volumes of air for raising the initial vacuum during the starting of the Unit. Two main ejectors of 100% capacity each have been provided remove air and non condensable gases from the condenser to maintain the required vacuum in the condenser during the normal operation of the unit.]

d) Condensate Extraction Pumps

[Condensate extraction pumps are of vertical, multistage, centrifugal pumps of canister type.]

Description	Units	Design Parameters
Make and Model	.....	[....]
Type	.....	[....]
Capacity	m ³ /h	[....]
TDH	mwc	[....]
Speed	rpm	[....]
Motor Rating	kW	[....]

e) Gland Steam Cooler

[A Gland Steam Cooler has been provided to condensate the leak-off steam from intermediate chambers of end sealings of HP and IP turbine, thereby heating the main condensate water. The Gland Steam Cooler consists of shell, tube bundle and removable water box.]

f) LP Heaters and Drain Coolers

[Each steam turbine is provided with four numbers of low pressure heaters to increase the temperature of the condensate in stages. LP Heater -1 consists of two halves and is installed in neck of the condenser. The remaining LP Heaters are of shell and tube design and have been placed vertically. An

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integral drain cooling section is provided in each LP Heater. The design details of LP Heaters are furnished in the table below.]

Heater No.	1	2	3	4
Extraction Steam taken from	[...] stage of IP turbine	[...] stage of IP turbine	[...] stage of IP turbine	[...] stage of IP turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]	[...]

g) Deaerator

[The deaerator is of [horizontal spray cum tray type]. It is designed to remove dissolved oxygen from the condensate in excess of 0.005 cc per liter. The feed water storage tank has a capacity of [...] minutes feed water requirement of the boiler corresponding to TMCR Heat Balance]

h) Boiler Feed Pumps

[The boiler feed pumps are horizontal, multi stage centrifugal pumps of barrel type, motor driven pumps with hydraulic coupling taking the suction from the deaerator. The boiler feed pumps discharge feed water through HP heaters to the economizer of the boiler.]

Description	Units	Design Parameters
Make and Model	[....]
Type	[....]
No of stages	Nos.	[....]
Capacity	m ³ /h	[....]
Head	mwc	[....]
Feed water temp	°C	[....]

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Description	Units	Design Parameters
Gland sealing arrangement	[...]
Minimum flow	m ³ /h	[...]
Method of Speed Regulation	.....	[...]
Type of Hydraulic Coupling	.....	[...]
NPSH required at design condition	mwc	[...]
Motor Rating	kW	[...]

i) HP Heaters

[Each steam turbine is provided with three numbers of high pressure heaters to increase the temperature of the feed water in stages. The Heaters are of shell and tube design and have been placed vertically. The design details of HP Heaters are furnished in the table below.]

Heater No.	1	2	3
Extraction Steam taken from	[...] stage of HP turbine	[...] stage of HP turbine	[...] stage of HP turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]

j) HP/ LP Bypass

[HP/LP bypass system has a capacity of 60% of BMCR (Boiler Maximum Continuous Rating). HP bypass system has been provided between the Main Steam Line and Cold Reheat Line. LP bypass system has been provided between the Hot Reheat Line and the Condenser. HP bypass water spray has been taken from the discharge of Boiler Feed Pumps. LP bypass water spray has been provided from the discharge of Condensate Extraction Pumps.]

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k) Turbine Governing System

[The turbine is equipped with an electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. The system is designed to sustain full load dump from the generator. The system is provided with a quick closing Emergency Stop Valve (ESV), to interrupt the supply of steam from the boiler and stop the turbine under emergency conditions. The turbine governing system includes, speed governor,]

l) Lube Oil System

[The lube oil system consists of Main Oil Tank, Turbine driven main oil pump, AC driven bearing oil pump, DC driven emergency oil pump, AC driven jacking oil pump and oil coolers of 3x50% capacity, Lube oil is being purified by means of a centrifuge. Oil storage tanks consisting of Clean Oil Tank and Dirty Oil Tank have been provided.]

3.3

Electrical System

a) Generator

[The Generator is a 15.75 kV, 50 Hz, 0.85 power factor machine, directly coupled with steam turbine operating at 3000 rpm, with.....type of excitation system and digital programmable voltage regulator. The Generator has direct water cooled stator winding and direct hydrogen cooled rotor winding. The stator winding cooling water is cooled in a closed cycle cooling system using DM water, while the hydrogen in the machine is cooled in gas to water hydrogen coolers mounted inside the machine. The Parameters of the Generator are briefly mentioned below.]

Description	Units	Design Parameters
Rated MW Capacity	MW	[....]
Rated MVA Capacity	MVA	[....]
Rated Terminal Voltage	kV	[....]
Rated Power Factor	[....]
Rated Stator Current	kA	[....]
Rated Speed	rpm	[....]

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Description	Units	Design Parameters
Rated Frequency	Hz	[...]
Efficiency at Rated Power Output and Rated Power Factor	%	[...]
Excitation Current	kA	[...]
Excitation Voltage at Rated Power Output and Rated Power Factor	kV	[...]
Short Circuit Ratio	.....	[...]
Negative Sequence Current	Amp	[...]
Phase Connection	.....	[...]
Type of Excitation	.....	[...]
Method of Cooling the Rotor	.....	[...]
Method of Cooling the Stator	.....	[...]
Rated Hydrogen Pressure	kg/cm ²	[...]

b) Station Transformer

[Two Station Transformers have been provided to meet the station [common] auxiliary loads of the power plant. The Station Transformers have been provided with on-load tap changers to keep the station 6.6 kV voltage constant. Cooling of this transformer is ONAN/ONAF/OFAF and has 2x50 % separately mounted radiators and 2x50% oil pumps. The Parameters of the Station Transformers are briefly mentioned below]

Description	Units	Design Parameters
Make	[...]
Capacity / Rating	MVA	[...]
Voltage Ratio	[...]
Type of Cooling	[...]
Quantity	Nos.	[...]

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c) Generator Transformer

[The power output from each Generator is being stepped up to 220/400 kV through a 240 MVA step up Generator Transformer. It has 3x50% coolers and 3x50% oil pumps. The Parameters of the Generator Transformer are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[...]
Capacity	MVA	[...]
Voltage Ratio	.....	[...]
Type of Cooling	.....	[...]

d) Unit Auxiliary Transformer

[Two unit auxiliary transformers have been provided for each unit for meeting all unit auxiliary loads. These transformers have been provided on-load tap changers. The Parameters of unit auxiliary transformers are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[...]
Capacity	MVA	[...]
Voltage Ratio	.....	[...]
Type of Cooling	.....	[...]
Quantity	Nos.	[...]

e) Electrical Auxiliary Power Distribution System

[Unit auxiliaries receive their normal power supplies at 6.6 kV through two (2) nos. unit transformers. For lower rating drives, 6.6 kV is further stepped down to 415 V by two (2) nos. unit service transformers. The 415 V distribution system feeds a number of Motor Control Centers (MCCs) for running 415 V drives. 6.6 kV unit switchgears are connected to station switchgear for start up and emergency power supply. The details are mentioned below]

Description	Units	Design Parameters
Voltage Level	kV	[...]
Type of Breakers	.....	[...]
Type of Grounding	.....	[...]
Type of Protection	.....	[...]

f) DC System

[Each unit has its own DC system located in the BC bay at ground floor of the Power House. Separate DC systems have been provided in switchyard control room, intake pump house and DM plant for controlling the systems. Each DC system comprises of the Storage Battery, the Battery charger and the distribution boards. The details are mentioned below]

Description	Units	Design Parameters
Make	[...]
Capacity / Rating	[...]
Voltage	V	[...]
Type of Charger	[...]
Area of Application	[...]

g) Emergency Power Supply System

[Diesel generating sets are installed for meeting the power requirements of essential auxiliaries (viz. jacking oil pumps, AC lube oil pump, hydrogen seal oil pump, float charger for DC battery, emergency lighting, scanner air fan and stator cooling water pump) during total failure of AC Power Supply in the power station. Diesel generating sets are located in the CD bay at the ground floor. The details are mentioned below]

Description	Units	Design Parameters
Make of DG Sets	[...]
Rating of DG Sets	kVA	[...]

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Description	Units	Design Parameters
Quantity	Nos.	[...]

h) Public Address System

[The unit is provided with paging and party channels comprising handset stations with amplifiers, transmitters, receivers and loud speakers. The system facilitates paging, communication and also private conversation as on conventional telephone.]

i) Illumination System

[For indoor application, fluorescent/ energy saving compact fluorescent fixtures have been provided. For high bay areas and outdoor application, suitable high intensity discharge Mercury Vapour/ Sodium Vapour lighting fixtures have been installed. Aviation type fixtures have been installed at the Chimney]

3.4 Control & Instrumentation

[The existing control and instrumentation system generally is an old analogue based system and requires large scale replacement owing to obsolescence of the existing equipments. Furnace Supervisory Safeguard System (FSSS) is of obsolete design for which, no spares are available. Soot blowers are of manual type. No online Boiler Tube Leakage detection system has been provided. The turbine is equipped with an electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. Turbine Supervisory system is of electromagnetic type. No continuous monitoring system has been provided for observing the health of the turbine. HP- LP bypass system is in the form of standalone control panel. Integrated microprocessor based closed loop control, open loop control, sequential control and bulk data acquisition system for SG & auxiliaries, TG & auxiliaries, station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level are therefore to be envisaged for the plant.]

3.5 Balance of Plant

a) Coal Handling Plant

[Coal Handling Plant is a common facility which is feeding all the units of the power plant having a total installed capacity of...x.....MW. Coal to the power plant is brought through railways by 'Box N' /'BOBR' wagons and is unloaded by wagon tipplers / track hoppers. One crusher has been provided

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for crushing the coal from 250 mm size to 25 mm size. The plant is provided with one stacker reclaimer to stock the crushed coal. The coal stock yard has a storage capacity of 20 days. For feeding the coal to the bunkers of all the units, two streams of conveyors having a capacity ofTPH have been provided. The coal handling plant operates for 16 hrs a day.]

Description	Units	Design Parameters
No. of Wagon Tiplers	Nos.	[...]
Rating of Wagon Tiplers	T/hr	[...]
Length of Track Hopper	m	[...]
No. of streams of conveyor	Nos.	[...]
Capacity of each conveyor	T/hr	[...]
Type of Crushers	....	[...]
Number of Crushers	Nos.	[...]
Capacity of Crushers	T/ hr	[...]
No. of Stacker Reclaimers	Nos.	[...]
Stacking Capacity	TPH	[...]
Reclaiming Capacity	TPH	[...]
Storage Capacity of Stock Yard	days	[...]

b) Ash Handling Plant

[Ash Handling System is of continuous type. The bottom ash from the furnace falls into bottom ash hopper having a storage capacity of [...] hrs. The ash is removed with the help of submerged Scraper Chain Conveyors. The ash from the air pre-heater and economizer hoppers is being disposed off along with bottom ash. The ash in the form of ash slurry is conveyed through sluice channels to the ash slurry pump house with the help of high pressure jets, from where, it is pumped to the ash pond located the distance of [...] km. [...] The ash slurry pump house is provided with [...] numbers of ash slurry pumps of rating [...], out of which [...] pumps are normally working. The ash slurry disposal system is having [...].numbers of identical streamlines of ash slurry pumps connected to [...] numbers of ash slurry pipelines going to the ash pond. Fly ash is collected in dry form below the

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ESP hoppers and the same is then conveyed by vacuum system to surge hoppers from where it is either conveyed through pressurized system to dry fly ash silos or is sent to ash pond in the form of slurry. From the dry fly ash silos, the ash is disposed off through the covered trucks.]

c) Raw Water System

[The consumptive water for the plant is sourced from [...] river/sea located at a distance of [...] km from the plant boundary. The intake water pump house is installed with [...] intake pumps of capacity [...] m³/hr, out of which [...] pumps are normally working and the remaining [...] pumps are standby. The raw water is pumped from the intake water pump house to the in-plant raw water reservoir, which has a storage capacity of [...] days.]

d) CW / ACW System and Cooling Towers

[CW system for the power plant works on re-circulating system with induced draft cooling towers. The CW system uses raw/clarified quality of water and is working on [...] cycles of concentration. CW pump house is a common facility for all the units of the power plant. There are two CW pumps of capacity [...] m³/hr provided for each unit. In addition, there are two standby CW pumps common to all the units. The requirement of ACW system is being tapped from the cold CW header feeding the condenser. The hot return ACW water after cooling the auxiliaries of boiler and turbine joins the hot CW header and is sent to the cooling towers for cooling. The cold water from the cooling water flows to the fore bay of CW Pump House for recirculation into the system. One induced draft cooling tower (IDCT) has been provided for each unit. The cooling tower cools the water from [...] deg C to [...] deg C. The cooling tower has been designed for an inlet wet bulb temperature of [...] deg C].

e) Water Pre-Treatment Plant

[Water Pre-Treatment Plant is a common facility for all the units of the power plant. Pre-treatment plant supplies clarified water to DM plant, cooling water to the auxiliaries of BOP system, coal handling plant dust suppression and to the drinking water system. There are two numbers of clarifiers of [...].m³/hr capacity to meet all the clarified water requirements of the whole plant, except DM plant. The clarified water requirement for DM plant is met by a separate clarifier of capacity [...] m³/hr.]

f) DM Plant

[DM plant consists of three streams, each of [...] m³/hr capacity. There are two DM water tanks of [...].m³ capacity. A common regeneration system has been provided for all the three streams.]

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G) Air-Conditioning and Ventilation System

[The central control room, switchyard control room, ESP controls room and selected areas of service building have been provided with centralized air-conditioning system. The central air-conditioning system of chilled water type has been provided for various control rooms and DX type of plant has been provided for ESP control room, switchyard control room and other areas in the service building. Packaged type of air-conditioners has been provided for water treatment plant control room. Evaporative ventilation system has been provided for TG building along with roof extractors. Other areas are ventilated by a combination of exhaust and supply air fans].

h) Fire Fighting System

[Fire fighting system is a common facility provided for all the units. This consists of pressured hydrant system for all the auxiliary buildings, pump houses and administrative building. Automatic high velocity sprinklers system has been provided for power transformers, turbine oil tanks and lube oil system equipments. Medium velocity sprinkler system has been provided for cable galleries and coal conveyor galleries. Portable types of fire extinguishers have been provided throughout the plant for fighting small and localized fires.]

i) Plant and Instrument Air System

[Plant and instrument air system is a common facility for all the units of the plant. For meeting the instrument air requirement, [...] number of oil free screw compressors [...] working and [...] standby, each of [...] m³/hr capacity and discharge pressure of [...] kg/cm (g) have been provided along with dryers. Equal number of air compressors of similar rating has been provided to meet the requirement of plant air system. The air drying plant for the instrument air has been provided to achieve a dew point of (-) 40°C at atmospheric pressure.]

j) Fuel Oil System

[The fuel oil system has been designed for the use of Light Diesel Oil (LDO) for start- up and Heavy Fuel Oil (HFO) for load carrying and flame stabilization purposes. Two tanks of [...] kl each have been provided for the storage of HFO and two tanks of [...] kl each have been provided for the storage of LDO. The system has been provided with unloading, transferring and pressurization pumps along with necessary filters. Fuel oil system has been provided with steam / electric tracing.]

k) Cranes/Hoists

[For the maintenance of various equipments, manually /electrically operated cranes and hoists have been provided.]

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3.6 Civil Works

Major civil work facilities consist of the following:

(a) **Main Power House Building:**

[A common Power House Building has been provided to house [3x200 MW] units which are placed side by side. Centre to centre placing of units is [67.5 m.] The railway entry has been provided from the rear side of Power House Building. Turbine Generator (TG) Sets have been placed between AB rows of columns are laid out longitudinally. The TG bay, also houses, the Boiler Feed Pumps, Regenerative Heaters, Lube Oil System and other TG accessories. The total length of TG bay for 3x210 MW units is [276 m] and width [30 m]. The spacing of the column is at [7.5 m]. TG bay is provided with 2 Nos. of overhead EOT Cranes. In order to make the handling facilities of the cranes available to the heat exchangers, boiler feed pumps and other equipments, removable chequered plates have been provided at appropriate locations.

A sub zero floor has been avoided except for the localized pits required for Condensate Pump, pipe channels and HP Heaters etc. This sub zero pits are suitably connected and provided with a common sump for drainage purposes.

Three stairs for approaching the operating floor level at [+10 m] have been provided in this bay adjacent to B row columns. In addition, there are stairs for providing access to various equipments at intermediate platforms and sub zero pits.

Switchgear and Control Room bay has been provided in the BC bay which is [12 m] wide. The length of the bay is [249.0 m]. A common Control Room for all the three units is provided at [10 m] floor. In BC bay at [16 m] elevation, equipments for chemical dosing, air handling and MCC for soot blowers etc have been located. The deaerator is placed at an elevation of [23.0 m]. Air washer units and cooling water tanks are also located at [23.0 m] floor.

Mill Bunker Bay, designated as CD bay, has a span of [10.5 m] which accommodates coal bunkers, coal feeders and coal mills. CD bay houses the vertical mills at Zero m and has space for collection of disposal of mill rejects at sub zero levels adjacent to 'D' row. A stair to connect operating floor at [16.0 & 23.0 m] of BC & CD bay has been provided.]

(b) **Boiler Area**

[In boiler area, the boiler with its auxiliaries like PA fan, FD fan, ID fan as well as Electrostatic Precipitator has been located.]

(c) **Chimney**

[A common multi-flue Chimney of 220 m height has been constructed in which, flue cans of [3x200 MW] have been erected.]

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(d) Transformer Yard

[A [60] m wide yard has been provided outside the 'A' row columns. The transformer yard houses station transformer, unit auxiliary transformers and generator transformers along with oil pits etc. To facilitating erection and maintenance of transformers, the area has been provided with rail tracks parallel to 'A' row at a distance of [45 m] from 'A' row which is further connected through cross tracks. In addition, space has been provided for laying the CW pipelines and locating the butterfly valve chambers.]

(e) Service building

[A common four storey building has been provided near the main plant building and it is connected with the operating floor of TG bay at [10 m] level.]

(f) Miscellaneous buildings

[Besides the above, miscellaneous buildings like administrative building, CW Pump House, Fire Water Pump House, CHP Control Room, ESP Control Room, DM Plant Building, Chemical House and Ash Silos have been provided.]

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4 OPERATIONAL HISTORY OF THE UNIT

4.1 Performance Parameters of the Unit

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ/KWU] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The deterioration experienced over the years in Plant's performance parameters is shown in Table 4.1.

Table 4.1- Unit's Performance Parameters over the life

Years after Installation	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
5	[...]	[...]	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Table 4.2 indicated below, illustrates variations over the last five years in the performance parameters.

{Furnish in the Table 4.2 below, the Average Values for the last three years, Maximum & Minimum values for Current year and the readings on the last day.}

**Table 4.2
Unit's Performance Parameters during the Last Three Years**

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
Average value for the last Three Years	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
Average value for the last Two Years	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Average value for the last one Year.	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Maximum & Minimum values for Current year.	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Reading as on the last day.	[...]	[...]	[...]	[...]	[...]	[...]	[...]

4.2 Stack Emissions, Ambient Air Quality and Process Effluents

The Project has been regularly monitoring the environmental parameters such as stack monitoring, ambient air quality (AAQ), noise pollution and liquid waste pollution by employing an agency approved by State Pollution Control Board and in accordance with applicable norms.

{Indicate the environmental data of the unit for the past three years against the limits specified for different pollutants. Furnish the information for each year as per the table 4.3 below. Also provide the map(s) showing the locations for various measurements as Annexure to the Detailed Project Report.}

Table 4.3
Status of Stack Emissions, Ambient Air Quality and Process Effluents

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)	Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)			Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
Stack Emissions	SPM (mg/Nm³)	Not to exceed [...]		[...]		[...]	[...]
Ambient Air Quality		On 24 Hrs Basis	On Annual Basis	On 24 Hrs Basis	On Annual Basis	[...]	[...]
	SPM (µg/m³)	[...]	[...]	[...]	[...]		
	RPM (µg/m³)	[...]	[...]	[...]	[...]		
	SO ₂ (µg/m³)	[...]	[...]	[...]	[...]		
	NO _x (µg/m³)	[...]	[...]	[...]	[...]		
Process Effluent Leaving the Plant Boundary	ETP Treated Water Quality					[...]	[...]
	pH	[...]		[...]			
	Colour	[...]		[...]			
	Odour	[...]		[...]			
	Tempera ture	[...]		[...]			
	TSS (mg/l)	[...]		[...]			
	Oil & grease (mg/l)	[...]		[...]			
	COD (mg/l)	[...]		[...]			

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)	Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
	(mg/l)			
	BOD (mg/l)	...		
	Chloride (mg/l)	...		
	Sulphate (mg/l)	...		
	TDS (mg/l)	...		
	Zinc (mg/l)	...		
	Fluoride (mg/l)	...		
	Mercury (mg/l)	...		

4.3 Tripping and Maintenance Record

{Indicate in the table below the tripping and maintenance record for the past three years.}

Table 4.4
Tripping and Maintenance Record

Year	Total Trippings	No. of Trippings due to Boiler Tube Leakages	Other Major Causes of Trippings	Maintenance Carried Out
Two Years Back
One Year Back

Year	Total Trippings	No. of Trippings due to Boiler Tube Leakages	Other Major Causes of Trippings	Maintenance Carried Out
Current Year	[.....]	[.....]		[.....]

4.4 Maximum Achievable Load Due To Performance Constraint of ESP

[Due to ESP's performance constraint, the maximum generation from the unit is restricted to [...] MW, in order to keep SPM emission within the statutory limit of 50 mg/Nm³. The operational data at the above maximum load is indicated in the table below.]

Table 4.5
Maximum Achievable Load due to Performance Constraint of ESP

Nature of constraint	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]

4.5 Record of Reportable Accidents

[The record of reportable accidents for the past three years, is mentioned in the Table below]

Table 4.6
Record of Reportable Accidents

Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current	[.....]	[.....]	[.....]	[.....]

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Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Year				

4.6 Operation & Maintenance Difficulties Due To Plant Limitations

[Difficulties are being experienced in day to day maintenance of the plant due to design deficiency, layout of the plant, obsolescence of equipment and non availability of spare parts etc. These are mentioned in the Table below]

Table 4.7
Nature of Difficulties in O&M of the Unit

S.No.	NATURE OF DIFFICULTY	SPECIFIC REASON (Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

4.7 Operating Data Collected During Hot Walk Down Survey

Major Operating Parameters of the Plant as noted during the Hot Walk Down Survey are indicated in the Table 4.8 below:

Table 4.8
Operating Parameters of the Plant as per Hot Walk Down Survey

Description	Units	Design Parameters	Operating Parameters
Load	MW	[.....]	[.....]
GCV	kCal/kg	[.....]	[.....]
Water & Steam Parameters			

Description	Units	Design Parameters	Operating Parameters
Main Steam Flow	T/h	[.....]	[.....]
Main Steam Temp.	Deg C	[.....]	[.....]
Main Steam Pressure	kg/cm ²	[.....]	[.....]
Cold Reheat Steam Pressure	kg/cm ²	[.....]	[.....]
Hot Reheat Steam Pressure	kg/cm ²	[.....]	[.....]
Hot Reheat Steam Temp (Left and Right)	Deg C	[.....]	[.....]
Cold Reheat Steam Temp (Left and Right)	Deg C	[.....]	[.....]
IP Turbine Exhaust Steam Temp (Left and Right)	Deg C	[.....]	[.....]
IP Turbine Exhaust Pressure	kg/cm ²	[.....]	[.....]
Turbine Exhaust Hood Temperature.	Deg C	[.....]	[.....]
Hot Well T Temperature.	Deg C	[.....]	[.....]
Condenser Vacuum	mmHg	[.....]	[.....]
C.W. Water flow	T/h	[.....]	[.....]
C.W. Inlet Temperature (L and R)	Deg C	[.....]	[.....]
C.W. Outlet Temperature (L and R)	Deg C	[.....]	[.....]
Drum pressure	kg/cm ²	[.....]	[.....]
Feed water flow	T/h	[.....]	[.....]
Feed water inlet temp to ECO	Deg C	[.....]	[.....]
Feed Water Pressure	kg/cm ²	[.....]	[.....]
Super Heater Spray	T/h	[.....]	[.....]

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Description	Units	Design Parameters	Operating Parameters
Reheater Spray	T/h	[.....]	[.....]
Air and Flue Gas Parameters			
Air temperature at Air Pre-Heater Inlet.	Deg C	[.....]	[.....]
Primary Air temperature at Air Pre-Heater Outlet.	Deg C	[.....]	[.....]
Secondary Air temperature at Air Pre-Heater Outlet.	Deg C	[.....]	[.....]
Total Quantity of Air	T/h	[.....]	[.....]
Flue Gas temperature at Air Pre-Heater Inlet.	Deg C	[.....]	[.....]
Flue Gas temperature at Air Pre-Heater Outlet.	Deg C	[.....]	[.....]
CO ₂ in Flue Gas	%	[.....]	[.....]
CO ₂ at Inlet of Air Pre-Heater	%	[.....]	[.....]
CO ₂ at Air Pre-Heater Outlet	%	[.....]	[.....]
CO ₂ in Flue Gas – Air Pre-Heater Outlet	%	[.....]	[.....]
CO ₂ in Flue Gas – Air Pre-Heater Inlet	%	[.....]	[.....]
% of Excess Air in Flue Gas at ID fan Outlet	%	[.....]	[.....]
No. of Mills in operation for full load.	Nos	[.....]	[.....]
Wind box Differential Pressure (Left and Right)	mmwc	[.....]	[.....]
Air Temperature	Deg C	[.....]	[.....]
Furnace Draft	mmwc	[.....]	[.....]
ID Fan margin	%	[.....]	[.....]

Description	Units	Design Parameters	Operating Parameters
HP Heaters Parameters			
Extraction Steam Pressure HP Heater (HPH) No.7 at Heater End	kg/cm ²	[.....]	[.....]
Extraction Steam Pressure HPH No.6 at Heater End	kg/cm ²	[.....]	[.....]
Extraction Steam Pressure HPH No.5 at Heater End	kg/cm ²	[.....]	[.....]
Feed Water (FW) Pressure Entering HPH-5	kg/cm ²	[.....]	[.....]
F.W. Pressure Entering HPH-6	kg/cm ²	[.....]	[.....]
F.W. Pressure Entering HPH-7	kg/cm ²	[.....]	[.....]
F.W. Pressure Common Outlet of HPH	kg/cm ²	[.....]	[.....]
F.W. Temperature Entering HPH-5	Deg C	[.....]	[.....]
F.W. Temperature Leaving HPH-5	Deg C	[.....]	[.....]
F.W. Temperature Entering HPH-6	Deg C	[.....]	[.....]
F.W. Temperature Leaving HPH-6	Deg C	[.....]	[.....]
F.W. Temperature Leaving HPH-7	Deg C	[.....]	[.....]
F.W. Temperature Common Outlet of HPH	Deg C	[.....]	[.....]
Drain Temperature Heater No.5	Deg C	[.....]	[.....]
Drain Temperature Heater No.6	Deg C	[.....]	[.....]
Drain Temperature Heater No.7	Deg C	[.....]	[.....]
Extraction Steam Temperature HPH-5 (Heater end)	Deg C	[.....]	[.....]

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Description	Units	Design Parameters	Operating Parameters
Extn. Steam Temp. HPH-6 (Heater end)	Deg C	[.....]	[.....]
Extraction Steam Temp. HPH-7 (Heater end)	Deg C	[.....]	[.....]
Deaerator Pressure	kg/cm ²	[.....]	[.....]
Gauge Glass on HPH-5, 6 and 7	mmwc	[.....]	[.....]
Level indication in UCB for HPH-5, 6 and 7	mmwc	[.....]	[.....]
Other Information			
Relative humidity	%	[.....]	[.....]
Oxygen in fuel	%	[.....]	[.....]
Distribution of fly ash	%	[.....]	[.....]
Distribution of bottom ash	%	[.....]	[.....]
Distribution of duct ash	%	[.....]	[.....]
Distribution of air heater ash	%	[.....]	[.....]
Secondary Fuel Oil Consumption	ml/ kWh	[.....]	[.....]
Currents Drawn by Auxiliary Equipments			
Boiler Feed Pump Current	Amp	[.....]	[.....]
Mills Motor Current	Amp	[.....]	[.....]
ID Fan Motor Current	Amp	[.....]	[.....]
FD Fan Motor Current	Amp	[.....]	[.....]
PA Fan Motor Current	Amp	[.....]	[.....]
CEP Motor Current	Amp	[.....]	[.....]
CW Pumps Motor Current	Amp	[.....]	[.....]

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5 SELECTION OF R&M OPTION TO BE IMPLEMENTED

5.1 Formulation of R&M Options

[A detailed Feasibility Study was carried out to arrive at the most cost effective and feasible solution for implementing the Renovation & Modernization activities of the unit. Existing conditions of the unit were assessed on the basis of the results of RLA/CA & EA Studies. Based on the recommendations of RLA/CA & EA Studies, review of the performance data and discussions with the plant engineers, five R&M options were formulated. All the R&M options were aimed at achieving the following minimum objectives:

- i) Redesigning the boiler to suit the average coal quality likely to be available for the next 20 years.*
- ii) Restoring the performance parameters to the original design values.*
- iii) Extending the life of the unit by a minimum of 20 years.*
- iv) Replacing the existing obsolete technology.*
- v) Meeting the revised statutory emission standards.*
- vi) Increasing Efficiency.*
- vii) Reducing Auxiliary Power Consumption*

The first option considered for R&M was for the case, in which the objectives were restricted to the bare minimum for restoring design output, design heat rate and Auxiliary Power Consumption of the unit and to extend the unit life by 20 years. Other options were formulated for not only the life extension of the unit but also for further improving its output, heat rate and auxiliary power consumption from the original design values, as discussed in the Table 5.1 below.]

Table 5.1- R&M Options Considered for Cost Benefit Analysis

Option	Objectives to be achieved by carrying out R&M	Shut Down Period	Major Performance Parameters
I	<i>i) [Designing boiler to suit average coal quality likely to be available for the next 20 Years.]</i> <i>ii) [Increasing the output of the unit to 215 MW from (200/210MW) by retrofitting the LP turbine without retrofitting Generator. Improving heat rate beyond the original design heat rate and restoring the Auxiliary Power Consumption to the original design</i>	[...]	<i>[Life Extension Years]</i> <i>[OutputMW]</i> <i>[Heat Rate ...</i>

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Option	Objectives to be achieved by carrying out R&M	Shut Down Period	Major Performance Parameters
	<p>values.]</p> <p>iii) [Replacing the existing obsolete technology.]</p> <p>iv) [Meeting the revised statutory emission standards].</p> <p>v) [Extending the life of the unit by a minimum of 20 years].</p>		<p>kCal/kWh]</p> <p>[Aux. Power Consumption%]</p>
II	<p>i) [Designing boiler to suit average coal quality likely to be available for the next 20 Years].</p> <p>ii) [Increasing the output of the unit to 215 MW from (200/210MW) by retrofitting the LP and HP turbines without retrofitting Generator. Improving heat rate beyond the original design heat rate and restoring the Auxiliary Power Consumption to the original design values.]</p> <p>iii) [Replacing the existing obsolete technology.]</p> <p>iv) [Meeting the revised statutory emission standards.]</p> <p>v) [Extending the life of the unit by a minimum of 20 years.]</p>	[...]	<p>[Life Extension Years]</p> <p>[Output ..... ..MW]</p> <p>[Heat Rate ... kCal/kWh]</p> <p>[Aux. Power Consumption%]</p>
III	<p>i) [Designing boiler to suit average coal quality likely to be available for the next 20 Years].</p> <p>ii) [Increasing the output of the unit to 215 MW by retrofitting complete new energy efficient turbine without retrofitting Generator. Improving heat rate beyond the heat rate of option 'II' and restoring the Auxiliary Power Consumption to the original design values.]</p> <p>iii) [Replacing the existing obsolete</p>	[...]	<p>[Life Extension Years]</p> <p>OutputMW]</p> <p>[Heat Rate ... kCal/kWh]</p>

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Option	Objectives to be achieved by carrying out R&M	Shut Down Period	Major Performance Parameters
	<p>technology.]</p> <p>iv) [Meeting the revised statutory emission standards.]</p> <p>v) [Extending the life of the unit by a minimum of 20 years.]</p>		<p>Aux. Power Consumption%]</p>
IV	<p>i) [Designing boiler to suit average coal quality likely to be available for the next 20 Years.]</p> <p>ii) [Increasing the Output to 220 MW by retrofitting complete new energy efficient turbine along with new Generator, Generator Transformer and new static Excitation System. Improving heat rate better than the level of option 'III' and restoring the Auxiliary Power Consumption to the original design values.]</p> <p>iii) [Replacing the existing obsolete technology.]</p> <p>iv) [Meeting the revised statutory emission standards.]</p> <p>v) [Extending the life of the unit by a minimum of 20 years.]</p>	[...]	<p>[Life Extension Years]</p> <p>Output ..........MW]</p> <p>[Heat Rate ... kCal/kWh]</p> <p>Aux. Power Consumption%]</p>
V	<p>i) [In situ major replacement of boiler on the existing foundations, retrofitting complete new energy efficient turbine along with new Generator, Generator Transformer and new static Excitation System. Designing the boiler to suit the average coal quality likely to be available for the next 25 years.]</p> <p>ii) [Increasing the Output to 250/300 MW. Achieving heat rate' and Auxiliary Power Consumption better than Options</p>	[...]	<p>[Life Extension Years]</p> <p>Output ..........MW]</p> <p>[Heat Rate ... kCal/kWh]</p>

Option	Objectives to be achieved by carrying out R&M	Shut Down Period	Major Performance Parameters
	<p>'III' & 'IV'.]</p> <p>iii) [Replacing the existing obsolete technology.]</p> <p>iv) [Meeting the revised statutory emission standards.]</p> <p>v) [Extending the life of the unit by a minimum of 25 years.]</p> <p>{This option is advised only when the unit to be renovated is either the first or last unit of the power plant, since intermediate units are likely to have space constraint for installation of new Boiler and TG.}</p>		<p>Aux. Power Consumption</p> <p>.....%]</p>

{While evaluating the options, the utilities are advised to also check the residual life of the switchyard, the Balance of Plant and the Material Handling System. Further, the utilities should note that if the proposed calorific value of coal is inferior to the original calorific value for which the boiler was designed, then the boiler will require re-engineering.}

Estimated cost for each option was worked out after taking into account the scope of R&M measures to be implemented for each option. Cost Benefit analysis of each option was then performed. After cost-benefit analysis of [Five] options mentioned above, option [...] has been identified as most appropriate option for implementation. Cost-benefit analysis of all options is discussed in Section 6.0.

5.2

R&M option identified for Implementation

Based upon the cost benefit exercise carried out and details furnished in the Feasibility Report for various R&M options, Option [...] has been selected for implementation. This is expected to bring out the following improvements:

Table 5.2
Improvements Expected after R&M of the Unit

S.No.	Parameters	Units	Before R&M	After R&M
1.	Residual Plant Life	Years	[.....]	[.....]
2.	Capacity	MW	[.....]	[.....]
3.	Plant Load Factor	%	[.....]	[.....]

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S.No.	Parameters	Units	Before R&M	After R&M
4.	Heat Rate	kCal/ kWh	[.....]	[.....]
5.	Auxiliary Power Consumption	%	[.....]	[.....]
6.	Specific Oil Consumption	ml/kwh	[.....]	[.....]
7.	Specific Coal Consumption	kg/kWh	[.....]	[.....]
8.	Emission of SPM fro stack	mg/Nm ³	[.....]	[.....]
9.	Sox- (Ground Level Concentration)	µg/m ³	[.....]	[.....]
10.	Nox- (Ground Level Concentration)	µg/m ³	[.....]	[.....]
11.	Noise Level during day time at plant boundary.	dB (A)	[.....]	[.....]
12	Noise Level during night time at plant boundary	dB (A)	[.....]	[.....]

6 DETAILED SCOPE OF R&M WORK

Detailed scope and quantum of work to be carried out for the R&M of the unit has been worked out on the basis of the R&M option finally selected for implementation. Detailed scope of work, system and equipment wise, is furnished in the tables below.

6.1 Boiler and Auxiliaries

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Drum	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Water Walls	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Low Temperature Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Platen Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Pendant Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Ceiling Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Steam Header	[.....]	[.....]	[.....]	[.....]	[.....]
Steam Pipes	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-	[.....]	[.....]	[.....]	[.....]	[.....]

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Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Front Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Rear Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Economiser	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Air Pre-Heater	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Oil Burners	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
RC Header	[.....]	[.....]	[.....]	[.....]	[.....]
Coal Burners	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Igniters	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Refractory	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Insulation	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

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Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Buckstays	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Ducting	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Wall Blowers / LRSBs	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Pent House	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Coal Mills	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Attemperato rs	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Bottom Ash Hoppers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
PA Fans	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
ID Fans	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
FD Fans	[.....]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
	[.....]	[.....]	[.....]	[.....]	[.....]
ESP	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Fly Ash Hoppers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Replacement and Retrofitting of Valves	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Replacement and Retrofitting of Water Headers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Replacement and Retrofitting of Dampers/ Expansion Joints	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Replacement and Retrofitting of Motors	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Replacement and Retrofitting of Pipe Hangers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Equipment Cooling Water System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Misc. valves	[.....]	[.....]	[.....]	[.....]	[.....]
Any other systems	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

6.2 Steam Turbine and Auxiliaries

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Steam Turbine	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Lube Oil System	[.....]				[.....]
	[.....]				[.....]
Condenser	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Condensate Extraction	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Pumps	[.....]	[.....]	[.....]	[.....]	[.....]
Deaerator	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Boiler Feed Pumps	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heaters	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
HP Heaters	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Critical Piping	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Control Valves	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Replacement and Retrofitting of Pipe Hangers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Equipment Cooling Water System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Misc. valves	[.....]	[.....]	[.....]	[.....]	[.....]
Any other equipment	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

6.3 Balance of Plant

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Coal Handling Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Handling Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

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Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Raw Water System & Pre-treatment Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
DM Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
CW System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Cooling Tower	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Fire Fighting System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Fuel Oil Handling System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Compressed Air System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Air Conditioning & Ventilation	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
System					
Effluent Treatment Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Any other system/ equipment	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

6.4 Electrical System

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Generator Sator	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Generator Rotor	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Generator Cooling Water System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Hydrogen Coolers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Excitation System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Automatic /	[.....]	[.....]	[.....]	[.....]	[.....]

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Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Digital Voltage Regulator	[.....]	[.....]	[.....]	[.....]	[.....]
Seal Oil System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Generator Transformer	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Unit Auxiliary Transformer	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Station Transformer	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
HT Switchgear	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
6.6 kV System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
415 V System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
HT & LT motors	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
DC System	[.....]	[.....]	[.....]	[.....]	[.....]

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	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Public Address System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Illumination System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
DG Sets	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Any other System or Equipment	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

6.5 Instrumentation and Control

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
DDCMIS	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
SOOT BLOWER	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Burner Tilt	[.....]	[.....]	[.....]	[.....]	[.....]

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	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Boiler Temperature MI Thermocouple (K-Type)	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Boiler Protections	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Turbine Protection	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Turbine Controls - EHC	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Turbine - ATRS	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Turbine Supervisory System	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Machine	[.....]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Condition Monitoring System	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
Automatic Turbine Testing	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
Turbine Stress Evaluator (TSE)	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
HP LP Bypass , PRDS	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
Gland Steam Pressure Control	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
Control Valves/ Dampers	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
Furnace Draft	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
Total Air Flow	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
Mill Temperature Indications	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]
	[../]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Super Heater Steam Temperature	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Re-Heater Steam Temperature	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
DRUM Level	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
BFP Scoop Tube	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Deaerator level	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Deaerator Pressure	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Hot well level	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
HP Heaters Levels	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
LP heaters Levels	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
BFP Recirculation valve	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Feed Water Control Valve	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Transmitters	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Pressure / DP Gauges	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Temperature Gauges	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Pressure / DP Switches	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Temperature Switches	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
RTD / TC 's	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Thermowells	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Flow Measurement & Primary Flow Sensors	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Fuel Flow	[.....]	[.....]	[.....]	[.....]	[.....]

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Measurement	[.....]	[.....]	[.....]	[.....]	[.....]
Analyzers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
UPS	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Impulse Pipeline	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Any other systems	[.....]	[.....]	[.....]	[.....]	[.....]

6.6 Civil Works

Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
Boiler	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
TG Building	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Chimney	[.....]	[.....]	[.....]	[.....]	[.....]

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Equipment	Unique Tag Number	Scope of Work	Tentative Quantity	Justification	Estimated Cost
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Coal Handling Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Handling Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Water Treatment Plant	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
CW Pump House	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Cooling Towers	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Miscellaneous Works	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]
Any other Systems	[.....]	[.....]	[.....]	[.....]	[.....]
	[.....]	[.....]	[.....]	[.....]	[.....]

7 PROJECT COST AND COST BENEFIT ANALYSIS

7.1 Introduction

The objective of the financial analysis during feasibility study was to make a comparative analysis of the financial implications of the *[five R&M options]* as well as the base case option of not undertaking any R&M project at all. On the basis of the financial analysis of the R&M options, R&M option [...] was chosen for implementation. In this chapter, a detailed cost-benefit analysis of the selected R&M option is carried out.

7.2 Capital Expenditure for the selected R&M option

The estimate of capital expenditure likely to be incurred for the selected R&M option comprises dismantling cost, supply cost, construction /erection /commissioning cost, taxes/duties, interest during construction, financing cost and contingency. As a discussed in Chapter-6, the detailed scope of Renovation & Modernization work for the different systems and subsystems of the power plant was decided. The cost for different constituent parts of the project (i.e. systems and subsystems) was estimated on the basis of past cost data for similar work wherever available and/or budgetary quotes.

The R&M project work is split into *[six]* packages to be executed through *[six]* different contracts. The Engineering, Procurement and Construction cost of each of the packages is determined by summing up the cost of the constituent works covered in the scope of work of the package. The total Cost of the R&M project is sum of the Engineering, Procurement and Construction cost of individual packages and other costs such as taxes/duties, Pre-commissioning costs, interest during construction, financing cost and contingency.

The estimated capital cost of the selected R&M option is summarized at **Annexure 7.1**.

7.3 Cost Estimate for R&M Contract Packages

Package wise Cost Estimate is summarized at **Annexure 7.2**.

7.4 Impact on Tariff

[The tariff for electricity sent out from this power plant is determined by Tariff Norms of appropriate Electricity Regulator]. Capitalization of capital expenditure incurred for the project will affect cost of generation. Capitalization increases Capacity Charge (Fixed Charge) whereas improvement in plant heat rate brings down Energy Charge (Variable Charge). Owner will have to take up with the regulatory commission for acceptance of the revised tariff. The estimated Cost of Generation for selected R&M options is shown in **Annexure 7.3**.

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7.5 Financial Impact

Net Present Value (NPV) and Internal Rate of Return (IRR) have been used to assess the financial merit of selected R&M option. Net Present Value is the sum of present value of all the project cash outflows and inflows using an appropriate discount rate. All the future cash flows are discounted suitably to arrive at their present day value considering time value of money. IRR is another metric used to assess the financial attractiveness of the selected R&M option. IRR is the discount rate that makes the project NPV zero. It is the discount rate at which the present value of all future cash flows becomes equal to the initial investment. IRR is used in capital budgeting to compare the profitability of different investment options. The higher the IRR, the more profitable an investment is. For a project to create value for the proponent, the IRR should be higher than the cost of fund.

The revenue stream of the selected R&M options has been calculated on the basis of a single indicative tariff per kWh of electricity for each year. The indicative tariff is the same as that used for comparing different R&M options during feasibility study. Assuming that the regulator will prefer minimum tariff, the indicative tariff per unit of electricity for a year has been taken to be the minimum value among the calculated Costs of Generation (COG) as per Regulatory Norms for Tariff of Thermal Power Projects for the different R&M options and base case tariff for that year. The estimated capital cost of each R&M option is used for calculation of Return on Equity and Depreciation. Normative Debt Equity ratio and depreciation rates are as per Tariff Regulation of appropriate Electricity Regulator. The revenue from electricity generation during a year in which plant is shut down is calculated considering normative availability/plant load factor. The loss of generation due to shut down for R&M is accounted for by considering that equivalent amount of electricity will have to be procured from the grid/market at the prevailing tariff. Therefore, the tariff at which power will be procured during shut down also affects the financial analysis. The negative cash flow due to shut down is calculated as the product of loss of generation and average tariff at which power will be procured from the grid net of variable cost .

7.6 Assumptions for Financial Comparison

- Cost of Generation calculation is done as per Tariff norms of appropriate Electricity Regulator
- O&M cost is taken as per Tariff norms of appropriate Electricity Regulator
- Average annual Availability/PLF of [85%] is considered for financial analysis. This is in line with Normative Availability Factor prescribed by Electricity Regulator.
- In line with the approach followed in Tariff Norms of Electricity Regulators, single value is considered for Plant Gross Heat Rate for financial analysis over the plant life after R&M. This single value of Heat

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Rate includes suitable operating margin over Design Heat Rate. Similarly, single value of auxiliary power consumption and specific oil consumption is considered over the entire plant life after R&M for financial analysis.

- [For calculating the financial quantities, the design/guaranteed heat rate with operating margin of [6.5%] is considered the plant Heat Rate for all the years during the economic life after Renovation & Modernization.]
- Specific oil consumption is considered [1 ml/kWh] after R&M.
- Present coal price and fuel oil prices are considered to be equal to the actual coal price and fuel oil prices for the unit.
- The discount factor and coal price escalation rate are taken to be [that notified by appropriate Electricity Regulator].

The main factors for financial analysis are given in Table 7.1.

Table- 7.1
Factors for Financial Analysis

Description	Value of Factors
Escalation rate for domestic coal	[....]
Discount Rate	[....]
Return on Equity	[....]
Interest Rate on Rupee Term Loan	[....]
Interest Rate on Forex Loan plus cost of Forex Rate Coverage	[....]

{The value of factors indicated in the above table is to be taken from Norms of Regulator applicable as on the date of analysis. The values indicated in the table are for illustration only.}

7.7

Inputs for Financial Analysis

Table – 7.2
Inputs for Options

Description	Value for Selected R&M Option
Capacity (MW)	[....]
Operating Life (Years)	[....]

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Description	Value for Selected R&M Option
Shutdown for R&M(Months)	[...]
Project Implementation Period (Months)	[...]
Gross Heat Rate (kCal/kWh)	[.....]
Operating Margin on Heat Rate	[6.5%]
Annual Degradation of Heat Rate	-
Auxiliary Consumption	[...]
Project Cost	[...]

7.8 Financial Impact of Selected R&M Option

The NPV, IRR and Payback Period calculation for selected R&M options is placed at **Annexure-7.4**. The economic impacts are summarized at Table 7.3.

Table – 7.3
Financial Evaluation of Selected R&M Options

Levelized COG (Rs/kWh)	IRR (%)	NPV (Rs Million)	Payback Period (Years)
[...]	[...]	[...]	[...]

7.9 Other Benefits

The economic benefit of Renovation & Modernization has been described above. Apart from the direct economic benefits, R&M of old coal fired thermal power plants has many other benefits. Some of such benefits are briefly discussed below:

- R&M increases the residual life of ageing power plants and restores/enhances their capacity. This is a low cost and quicker method of increasing India's electricity generation capacity. This is very important in the present precarious demand-supply scenario of India marked by both energy shortage and peak shortage.
- R&M reduces the downtime of the power plant and increase the plant availability. This enhances the reliability of electricity supply from the plant.

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- R&M of coal fired power plants is the low hanging fruit for rapidly ramping up the electricity generation capacity. Not only R&M adds capacity with at lower capital expenditure and shorter gestation period, but also enables us to sidetrack complex project implementation challenges such as land acquisition, resettlement & Rehabilitation, environmental clearance etc.
- As the environmental norms for thermal power plants gets stricter, R&M is the only way for old power plants to meet the evolving environmental norms. This is particularly relevant for SPM emissions as many old coal fired power plants have SPM emission levels far in excess of what is acceptable my present day environmental regulation.
- Renovation and Modernization is necessary to restore design output level of power plants receiving coal with calorific values much poorer than coal considered for boiler design.
- R&M leads to lower plant heat rate and lower auxiliary power consumption thereby reducing specific coal consumption for each unit of electricity sent out of the power plant. This helps to reduce CO₂ emission and emission of other polluting gases. Further, lower coal and oil consumption helps to decelerate the depletion of fossil fuel reserves.
- R&M may increase the plant rated capacity beyond the original design capacity and reduce plant heat rate below original design heat rate.

7.10 Impact of Adverse Scenarios

R&M projects are complex in nature and are associated with many uncertainties. The cost and time for execution of the project may overshoot estimates and the project may fall short of achieving its objectives. The financial viability of the selected R&M option should have some level of tolerance for such uncertainties.

Renovation & Modernization projects are associated with high risk of Time overrun and cost overrun due to unique nature of each project and also due to the complexities and uncertainties associated with retrofitting work. The reasons for Time/Cost overrun are discussed in the Chapter on Risks (Chapter-14). Time overrun itself is a reason for Cost Overrun due escalation of hard cost, increase in overheads and increase in interest during construction. Therefore, R&M projects very often run into time overrun and cost overrun simultaneously. Time and/or cost overrun adversely affect the financial viability/attractiveness of R&M projects by negatively affecting Net Present Value and Internal Rate of Return of the project.

The three prime objectives of any R&M project are Heat Rate improvement, Electricity Output restoration/up rating and Plant Availability/Reliability enhancement with concomitant adverse impact on project financials . R&M projects are associated with the risk of partially or fully failing to achieve these objectives. Failure to achieve the desired Heat Rate may itself contribute to less than targeted electrical output. Therefore, in many cases,

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R&M projects are likely to miss Heat Rate and Output objectives simultaneously.

The financial impact of certain level of cost overrun, time overrun and shortfall in performance is depicted in Table-7.4.

Table – 7.4
Impact of Adverse Scenarios on Selected R&M Option

Scenario	Levelized COG (Rs/kWh)	IRR (%)	NPV (Rs Million)	Differential NPV w.r.t Base Case (Rs Million)
Cost Overrun (+ 10%)	[...]	[...]	[...]	[...]
Cost Overrun (+ 15%)	[...]	[...]	[...]	[...]
Cost Overrun (+ 20%)				
Time overrun (+ 6 months)	[...]	[...]	[...]	[...]
Time overrun (+ 12months)	[...]	[...]	[...]	[...]
Time overrun (+ 18months)	[...]	[...]	[...]	[...]
Cost Overrun (+ 10%) and Time overrun (+ 6 months)	[...]	[...]	[...]	[...]
Cost Overrun (+ 15%) and Time overrun (+ 12 months)	[...]	[...]	[...]	[...]
Cost Overrun (+ 20%) and Time overrun (+ 18 months)	[...]	[...]	[...]	[...]

Scenario	Levelized COG (Rs/kWh)	IRR (%)	NPV (Rs Million)	Differential NPV w.r.t Base Case (Rs Million)
Capacity shortfall(-2 MW)	[...]	[...]	[...]	[...]
Capacity shortfall(-4 MW)	[...]	[...]	[...]	[...]
Capacity shortfall(-8 MW)	[...]	[...]	[...]	[...]
Heat Rate Increase (+ 1 %)	[...]	[...]	[...]	[...]
Heat Rate Increase (+ 2 %)	[...]	[...]	[...]	[...]
Heat Rate Increase (+ 4 %)	[...]	[...]	[...]	[...]
Capacity shortfall (-2 MW) and Heat Rate Increase (+ 1 %)	[...]	[...]	[...]	[...]
Capacity shortfall (-4 MW) and Heat Rate Increase (+ 2 %)	[...]	[...]	[...]	[...]
Capacity shortfall (-8 MW) and Heat Rate Increase (+ 4 %)	[...]	[...]	[...]	[...]
Availability variation (-3%)	[...]	[...]	[...]	[...]
Availability variation (-5%)	[...]	[...]	[...]	[...]

{Note: Identify the scenarios for which the NPV of chosen R&M option becomes negative and analyze them in detail. Discuss the likelihood of

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occurrence of each such negative NPV scenarios. If a negative NPV scenario appears to be highly unlikely or remote possibility, then it may be neglected. However, in case a negative NPV scenario has a fair chance of becoming a reality, the impact of such a scenario on the owner utility may be deliberated upon and accordingly decide whether to go ahead with the implementation of the chosen R&M option.}

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8

CARBON CREDIT AND ENERGY EFFICIENCY CREDIT

[With growing worldwide concern regarding carbon emission and depletion of energy resources, governments and international bodies are trying to put in place incentive mechanisms to encourage reduction in carbon intensity of economic activities and promote energy efficiencies. The various initiatives in this regard are evolving both nationally and internationally. Projects that lead to carbon emission reduction and energy efficiency improvement have the potential to earn carbon credit and energy efficiency credit that can be sold and serve as an additional revenue stream.]

The R&M project will increase plant efficiency and reduce plant heat rate and specific coal consumption. This in turn, will result in reduction of emissions of Green House Gas carbon dioxide (CO₂) per unit of electricity generated. The selected R&M option envisages change in plant design (particularly change in turbine) so as to increase its efficiency beyond the original design efficiency and involves additional investment on this account. This R&M project may qualify for carbon credit benefits. Further, implementation of this energy efficient R&M project involves overcoming technological barriers as infrastructure for this kind of project implementation is not well established in India. Carbon Credit benefit will help make this project viable which is as such a challenging project from financial and technological stand point.]

{There are various mechanisms such as Clean Development Mechanism under Kyoto Protocol, Verified Carbon Standard, National Action Plan on Climate Change(PAT mechanism under National Mission on Enhanced Energy Efficiency) etc. that can be explored to have financial benefit on account of reduction in carbon emission and enhancement of energy efficiency. Improvement in combustion process and burners due to R&M may reduce NO_x emission as well. However, success in securing any benefit under these schemes will be project specific.}

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9 FINANCING OF R&M PROJECT

9.1 Financial Performance of Utility

The balance sheet and income statement information of Utility for the last 3 financial years is summarized below:

Table 9.1
Balance Sheet and Income Statement

Profit and Loss Statement Particulars	FY Amount in Rs Crores	FY Amount in Rs Crores	FY Amount in Rs Crores
Income from Sale of Power	[...]	[...]	[...]
Other Income	[...]	[...]	[...]
Total Income	[...]	[...]	[...]
Fuel Cost	[...]	[...]	[...]
Employee Expenses	[...]	[...]	[...]
Other Expense	[...]	[...]	[...]
PBDIT (Profit Before Depreciation, Interest and Tax)	[...]	[...]	[...]
Depreciation and Amortization	[...]	[...]	[...]
PBIT (Profit Before Interest and Tax)	[...]	[...]	[...]
Interest Expense	[...]	[...]	[...]
PBT (Profit Before Tax)	[...]	[...]	[...]
Tax	[...]	[...]	[...]
PAT (Profit After Tax)	[...]	[...]	[...]
Balance Sheet Particulars			
Fixed Asset/Capital Work in	[...]	[...]	[...]

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Progress			
Less Accumulated Depreciation
Net Fixed Asset
Investments
Current Assets excluding cash
Cash	....	....	....
Total Asset	....	....	....
Long Term Loan	....	....	....
Working capital Loan	....	....	....
Equity Share Capital	....	....	....
Reserves and Surplus	....	....	....
Total Liability	....	....	....

9.2 Means of Finance

[Utility is funding the R&M project by a combination of equity and debt. The cost of the Project is estimated to be Rs. [...] million. Utility plans to fund it at a debt-equity ratio of 70:30, which is same as the normative debt equity ratio for financing of generation projects specified by Regulator in Tariff Regulation. The debt and equity requirement for the Project works out to approximately Rs. [...] million and Rs. [...] million respectively.

Utility plans to fund the equity component from internal accruals/fresh equity infusion. Utility needs to infuse fresh equity of [Rs. Crore] to meet the equity requirement of the R&M Project. Utility is planning to raise the necessary debt for the R&M project by leveraging its balance sheet. At present the Company has a debt equity ratio of ..., which is being leveraged further to finance various projects including this R&M project.

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Utility plans to raise the debt component of the Project cost through a combination of rupee term loan and foreign currency loan as given in Table 9.2]:

Table 9.2
Means of Financing

Means of Financing	Amount
Equity	[...]
Debt:	[...]
Rupee Term Loan	[...]
Foreign Currency Loan	[...]
Total	[...]

[Given the balance sheet, the utility can support this kind of financing arrangement.]

The likely year wise phasing of the debt and equity requirement for this R&M project is as follows:

Table 9.3
Year Wise Debt & Equity Requirement

Year No	-2	-1	0	1	2
Capex (Rs Cr)	[...]	[...]	[...]	[...]	[...]
Equity (Rs Cr)	[...]	[...]	[...]	[...]	[...]
Debt (Rs Cr)	[...]	[...]	[...]	[...]	[...]

Note: Year 1 is the year in which plant is shut down and R&M work is implemented.

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10 IMPLEMENTATION OF R&M PROJECT

[The scope of R&M works was decided on the basis of the most attractive option which was selected after the cost-benefit analysis and detailed study of various options recommended by R&M Consultant. For implementing the R&M Project, the total work will be divided in suitable number of packages. A PERT Chart is attached with this Report highlighting the various timelines, parallel activities and critical paths for the implementation of the R&M project. For the selection of R&M Contractors, the tendering procedure and bidding norms will be designed to ensure a fair and transparent competition.]

10.1 Project Team

*[.....
.....
.....]*

{Explain the organization structure of the Project Team along with the Organization Chart}

10.2 Project Schedule

*[.....
.....
.....]*

{Discuss the project completion schedule along with the schedule of completion of critical activities including planning for shutdowns. Refer Annexure 9.1}

10.3 Project Management

*[.....
.....
.....]*

{Discuss the various aspects of Project Management like, Contracting, Engineering, Procurement, Construction, Erection and Commissioning so as to ensure that the quality of work conforms to relevant codes / standards and statutory requirements.}

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10.4 Project Monitoring

[.....]
[.....]
[.....]

{Discuss the methods to be used for regular monitoring the progress of R&M activities, holding of progress review meetings etc to ensure the timely and successful completion of Project.}

10.5 Role of R&M Consultant

[.....]
[.....]
[.....]

{Discuss the role of the R&M Consultant to carry out the activities from initial study stage up to the stage of finalizing the R&M contract and to facilitate approval from regulatory agencies if required.}

10.6 Role of the Implementation Support Consultant

[.....]
[.....]
[.....]

{Discuss the role of the Implementation Support Consultant for the review of design documents & drawings to ensure compliance with the spirit, intent & contents of the EPC contract, inspection & testing, site supervision and witnessing of Performance Guarantee tests of the equipments.}

10.7 Quality Management

[.....]
[.....]
[.....]

{Discuss the aspects of field quality plans to ensure that the work performed by the contractor is as per the relevant codes / standards and statutory requirements.}

10.8 Performance Guarantee Test

After the commissioning of the unit post completion of R&M works, the unit shall be tested to demonstrate the following Guaranteed Parameters as per the provisions of the R&M Contract.

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Table 10.1
Performance Guarantee Parameters

S. No.	Performance Guarantee Parameter	Value
1.0	Gross Output for the unit at Generator terminals at 100% TMCR	[...]
2.0	Steam Turbine Heat Rate for the unit at 100% TMCR conditions with 0% makeup.	[...]
3.0	Boiler Efficiency at 100% TMCR conditions while firing design coal	[...]
4.0	Auxiliary Power Consumption@ 100% TMCR while firing design coal	[...]
5.0	Emissions of SPM @ 100% TMCR while firing worst coal	[...]
6.0	Noise Level during day time at plant boundary.	[...]
7.0	Noise Level during night time at plant boundary.	[...]

The tests shall be conducted according to the applicable codes and agreed procedure.

10.9 Liquidated Damages

The R&M Contract shall have provisions of levying Liquidated Damages (LD) for:

- Delay in Completion of the Project and
- Shortfall in Performance.

LD for delay in shall accrue at a rate of Rs. [...] per MW per day for each day of delay up to [...] days of delay and Rs. [...] per MW per day for each day of delay beyond [...] days of delay. LD for shortfall in performance of the Unit shall be as per the values given in the following table.

Table 10.2
LD for shortfall in performance

Sl. No.	Parameter	Condition	LD Amount
1.0	Gross Output	For each kW of shortfall.	[...]
2.0	Turbine Heat Rate	For each 1 kCal/kWh of increase	[...]
3.0	Boiler Efficiency	For every 0.1% short fall in efficiency	[...]
4.0	Auxiliary Power Consumption	For each 1 kW of increase	[...]

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10.10 Health, Safety and Environment (HSE)

[.....
.....
.....]

{Discuss the steps to be taken for the maintenance of healthy and safe working environment with the aim to complete the project without any accident and any adverse effect on the health of manpower. Discuss also the implementation of HSE Plan by the EPC contractor.}

10.11 Supply of Spares and Special tools and tackles

[.....
.....
.....]

{Discuss the R&M Contractor's scope to include the supply of spares and special tools & tackles.}

10.12 Training

[.....
.....
.....]

{Discuss the R&M Contractor's scope to impart training to the O&M staff of the utility for the required up-gradation in their skills.}

10.13 O&M Manuals

[.....
.....]

{Discuss the R&M Contractor's scope to prepare and submit sufficient number of O&M Manuals, technical diaries indicating various equipment specifications, process parameters and key schematic diagrams.}

10.14 Operation and Maintenance

[.....
.....
.....]

{Discuss the O&M Philosophy of the utility to carry out safe, efficient and reliable plant operation of the plant in compliance with environmental legislation.}

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11 SELECTION OF R&M CONTRACTOR

11.1 Introduction

[The salient features of the tendering procedure for selecting R&M Contractor have been discussed in this chapter. It is proposed to carry out a pre-qualification process to identify qualified bidders. The RFP document/ Tender Document will be issued to only those interested bidders that are found to be qualified in the pre-qualification process. The bidders will be asked to submit Techno-commercial proposal and price bid in separate envelopes. First the techno-commercial proposal will be opened and evaluated for techno-commercial responsiveness. Price bid of only those bidders, whose techno-commercial proposal is found to be responsive, will be opened.]

{The utilities may refer the Standard Document on Tendering Procedure for R&M Contractor, which is being issued separately.}

11.2 Bidding Process

11.2.1 Qualification of Bidders

[The R&M work is technologically complex and challenging in terms of execution. It is important to ascertain the availability and willingness of capable and qualified bidders through a pre qualification process before inviting tenders. Further, evaluating tenders from large number of bidders, both qualified and unqualified, will make the tendering process time consuming. Therefore, only parties qualified in a pre-qualification process will be issued Tender Documents and will be allowed to participate in the Tendering process. For all the packages, bids will be invited after conducting a pre-qualification process to shortlist qualified bidders.]

11.2.2 Stages of Bidding Process

[Each R&M project is unique and associated with many complexities regarding assessment of the quantum and nature of retrofit and replacement to be carried out. It is important to firm up the technical contours of the contract before opening price quotations so that all the bidders and the owner have agreement and clarity about the nature and scope of the work on which the price bids are based. Therefore, it is envisaged to invite bid in two parts. The bidder will submit Part-I and Part-II of the bid together. The Part-I bid will comprise the techno-commercial bid and the Part-II bid will comprise quotations for price and performance guarantee parameters. First the Part-I bid (techno – commercial offer without price) will be opened and evaluated for techno commercial responsiveness. Part-II bid (price bid along with guaranteed parameters) of only parties whose techno-commercial offers are found to be responsive to tender documents and conditions during

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evaluation of Part-I bids will be opened. The rationale behind asking bidders to submit Part-II bid along with Part-I bid is that bidders will make their quotes before the number of responsive techno commercial bids is known. This will encourage competitive price quotes. However in case a bidder is asked to make changes in its techno commercial offer that have price implications, the bidder may be allowed to submit supplementary price against such changes before opening of Part-II bid (price bid). The broad sequence and tentative timelines for the tendering procedure is described in the Table-10.1.]

Table-11.1
Broad Outline of Tendering Procedure

	Activity	<i>Tentative Timeline</i>
1	Request for Qualification	
(a)	Publication of RFQ and start of issue of RFQ document	<i>Zero Date</i>
(b)	Last date for issue of RFQ document	<i>15th Day from zero date</i>
(c)	Last date for submission of response to RFQ	<i>45th Day from zero date</i>
(d)	Short listing based on response to RFQ	<i>75th Day from zero date</i>
2	Request for Proposal	
(a)	Issue of RFP	<i>90th Day from zero date</i>
(b)	Site Visit and O&M Document Review	<i>Before Pre-Bid Discussion</i>
(b)	Pre - Bid Discussion	<i>135th Day from zero date</i>
(c)	Last date for submission of Both Part –I and Part – II Bid and Opening of Part-I (Techno-commercial) Bid	<i>180th Day from zero date</i>
(d)	Techno – Commercial Discussion	<i>210th Day from zero date</i>
(e)	Completion of Evaluation of Techno-Commercial Bids	<i>240th Day from zero date</i>
(f)	Date of Opening of Price Bids	<i>255th Day from zero date</i>
(g)	Selection of Successful Bidder and Placement of Lol	<i>285th Day from zero date</i>

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11.3 Pre-Qualification

11.3.1 Objective

[The objective of the pre-qualification is to allow only capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process. The pre-qualification document will specify the qualification criteria to be met by the prospective bidders to be eligible to participate in the tendering process. The prequalification is not intended to limit competition to a predetermined number of potential bidders. All the interested parties meeting the specified criteria will be issued tender documents and allowed to submit bid.]

11.3.2 Qualification Requirement

[The Qualification Requirement will include Technical Qualification Requirement, Financial Qualification Requirement and Reasons for Exclusion if any. The Technical Qualification Requirement will include technological and execution capabilities and experience in the execution of comparable projects. Financial Qualification Requirement will include evidence of financial soundness; past experience in executing projects of similar magnitude and ability to mobilize financial resources for executing the project. The reasons of exclusion are aimed at excluding parties that may have unfair advantage over other parties or that have past record of wrongdoing. Any bidder who is or was involved as a consultant in the preparation or implementation of the project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of the project is to be excluded. Any bidder who is legally barred from the procurement process in India on the grounds of previous violations of regulations on fraud and corruption is to be excluded.]

The specified Technical and Financial Qualification Requirement will balance the twin objectives of restricting participation in the tendering process to capable and experience bidders with ability to successfully undertake the Renovation & Modernization work and ensuring participation by adequate number of interested parties to encourage competitive bids.

Bidders may meet the Qualification Requirements jointly with associates or consortium partners. In such cases, bidders and his associates and/or consortium partners will have to furnish joint undertaking in the prescribed format to discharge their obligations. The bidder can be a Joint Venture Company as well. In all cases of qualification through Consortium/Associate/JV, all the parties will be jointly and severally liable to the employer to discharge all contractual obligations.]

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11.3.3 Documentary Evidence for Qualification

[The intending Bidders will be required to furnish documentary evidence and performance certificates in support of their qualification credentials along with their response to Request for Qualification. The documentary evidence will include inter alia list of orders executed along with copies of orders, Performance Certificates indicating date of completion, documents of company profile incorporating information about technical man power, financial strength, resources, organization and experience to undertake such jobs, copy of audited accounts for last three years along with copy of latest income tax return etc.]

11.4 Request for Proposal and Selection of Successful Bidder

[The bids for the Renovation and modernization work will be submitted in two parts. Both the parts will be submitted together.]

11.4.1 Techno-Commercial Bid (Stage-I)

[The Part-I bid will comprise the techno-commercial bid without prices. The main components of the techno-commercial bid will be Bid Guarantee, scope, technical descriptions/details, technical data sheets, list of Tools & Tackles, deviations to technical and commercial specifications/conditions, overall time schedule & L-1 Network Schedule, resource deployment schedule, detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, spares list, Quality Assurance Programme, Details of the present commitments of the bidder & details of contracts in hand, Indices and Coefficients for Price Variation etc. After evaluation of the techno-commercial (Part-I) bids, each bidder who has submitted a broadly responsive Part-I bid will be invited for techno-commercial discussion, during which all the required amendments, additions, deletions and other adjustments will be noted and recorded in a Memorandum. Part-II bid (Price Bid) of only those bidders whose Part-I bid is found to be responsive to tender specifications and conditions will be opened.]

11.4.2 Price Bid (Part-II)

[The Part-II bid will comprise quote for Prices and the Performance Guarantee parameters. The bidders will be asked to submit filled up Schedule of Prices and Schedule of Performance Guarantees. After evaluation of Part-I bid (techno-commercial bid) and before opening of Part-II (Price Bid), However in case a bidder is asked to make changes in its techno commercial offer that have price implications, the bidder may be allowed to submit supplementary price against such changes before opening of Part-II bid (price bid) A comparative evaluation of the price bids will be carried out to identify the techno-commercial responsive and qualified bidder with Lowest Overall

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Evaluated Price after taking into account adjustment for differential quote for Performance Guarantee parameters using adjustment factors specified in the Tender Documents (adjustment to price of bids with quoted Performance Guarantee figure inferior to the value quoted in the responsive bid with most competitive quote for that Performance Guarantee parameter) and cost compensation if any arising from evaluation of techno-commercial bids. However, bids with quote for any Performance Guarantee Parameter inferior to the minimum or maximum value for the parameter specified in the tender conditions will be rejected.

The qualified and techno-commercially responsive bidder with the lowest evaluated price will be selected as contractor for carrying out the R&M work. In case the lowest price quoted is higher or lower than the estimated reasonable cost for the work by a very large amount, further investigation will be made regarding the reasonableness of the quoted price.]

11.5 Packaging and Contracting Concept

11.5.1 Packaging

[Implementing the Renovation and Modernization of the entire plant as a single package by a single contractor makes the tendering and execution process simple for the owner as it obviates the need to split the work into different packages, to ensure interface between different packages during design and execution, and to properly align the completion schedule of different packages. Further, single package allows owner to fix single point responsibility and avoids contractual disputes arising out of acts of omission of one contractor affecting other contractors. However, Renovation and Modernization of different systems of the plant need different expertise and experience. There will be very few contractors, if any, who have in house expertise and experience to carry out the R&M of all areas of a coal fired power plant. A single EPC bid for R&M work will thus restrict number of qualified bidders, which will also increase the cost of R&M. In order to balance the conflicting needs of minimizing project/contract management complexities and having adequate number of eligible and willing bidders having relevant expertise and experience to carry out the R&M work under a package, it is proposed to split the R&M work into the following packages:

- 1. Boiler & Auxiliaries (including but not limited to Pulverizes, Feeders, PA Fans, FD Fans, ID Fans), ESP, Auxiliary Steam system and MS, HRH, CRH, HPBP & LPBP piping and associated Electrical, C&I and civil works.*
- 2. Turbo-Generator & Auxiliaries (including but not limited to Heaters, Deaerator, Condenser, BFP, CEP), TG Cycle piping including Boiler Feed piping and associated Electrical, C&I and civil works. . This package will also including R&M of C&I system common to both SG and TG.*

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3. Coal Handling Plant and associated Electrical, C&I and civil works.
4. Ash Handling system and associated Electrical, C&I and civil works.
5. Mechanical Balance of Plant (BOP) systems which includes Plant Water System (Raw water treatment system, CW System, ACW system and other water systems), Compressed Air system, Fuel Oil system, Fire Fighting system and Miscellaneous balance mechanical systems.
6. Electrical BoP including inter alia switchyard, power transformers.]

11.5.2 Contracting

[R&M of BTG, BTG auxiliaries, Power Transformers and switchyard are likely to be technologically complex & involve higher value contracts and hence likely to evoke response from many reputed international bidders. Hence packages covering these systems will be tendered on International Competitive Bidding basis. However, R&M of other BoP packages are not likely to see participation by many reputed international bidders and hence will be tendered on Domestic Competitive Bidding basis.]

Table-11.2
Nature of Bidding

SI No	Package	Nature of Bidding
1	[Boiler & Auxiliaries (including but not limited to Pulverizes, Feeders, PA Fans, FD Fans, ID Fans), ESP, Auxiliary Steam system and MS, HRH, CRH, HPBP & LPBP piping and associated Electrical, C&I and civil works.]	[ICB]
2	[Turbo-Generator & Auxiliaries (including but not limited to Heaters, Deaerator, Condenser, BFP, CEP), TG Cycle piping including Boiler Feed piping and associated Electrical, C&I, and civil works. This package will also including R&M of C&I system common to both SG and TG.]	[ICB]
3	[Coal Handling Plant and associated Electrical, C&I, and civil works.]	[DCB]
4	[Ash Handling System and associated Electrical, C&I and civil works.]	[DCB]
5	[Mechanical Balance of Plant (BOP) systems which includes Plant Water System (Raw water treatment system, CW System, ACW system and other water systems),	[DCB]

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SI No	Package	Nature of Bidding
	<i>Compressed Air system, Fuel Oil system, Fire Fighting system and Miscellaneous balance mechanical systems]</i>	
6	<i>[Electrical BoP including inter alia switchyard, power transformers]</i>	<i>[ICB]</i>

[Each package will be awarded on lump sum EPC contract basis. The scope of work for each package will consists of design, engineering, manufacture, supply, inspection & testing at supplier's works, packing, forwarding to site, transportation, unloading, storage, handling at site, steel structures, civil works, insurance, erection, painting, start-up, trial operation, testing, commissioning and performance guarantee testing, guarantee & warranty and handing over on turnkey contract basis.

The price of the contract will be on lump sum price basis for the entire scope covered in the contract. The contract price will be subject to adjustment during the contract period to reflect change in labour and material price levels as per price variation formula specified in the tender document. The adjustment in price to reflect in change in labour and material price levels as per price variation formula will be subject to limits specified in the tender specification.

Appropriate change order clause will be built into the contract to deal with the need to change the scope of the contract due to surprises encountered during the execution of the R&M work

The selected contractor will be required to furnish Contract Performance Bank Guarantee equivalent to 10% (ten percent) of contract price. The contractor will be required to furnish Advance Payment Bank Guarantee equivalent to the advance payment made to it. Progressive payment will be made to the contractor against supply and erection/construction. Last 10% of the payment will be made on completion of the facilities by the contractor.

The contractor will be required to pay Liquidated Damages for delay in completion of R&M work. The aggregate liability for delay will be limited to 10% of contract price.

The contractor will be required to pay Liquidated Damages for shortfall in achieving guaranteed performance parameters. The aggregate liability for shortfall in performance guarantee parameters will be limited to 10% of contract price.]

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12 RISKS

Renovation and Modernization projects are very complex in nature and associated with high level of uncertainty. The various risk factors along with mitigation measures are discussed below.

12.1 Limitation of CA, RLA and LE Studies

[Information and inference flowing from Condition Assessment, Residual Life Assessment and Life Extension studies forms the basis of planning, designing, costing and tendering of R&M projects. However, these reports may not give the accurate idea about actual state of the plant and equipment. Similarly, the rehabilitation and retrofitting programme may not lead to the intended life, reliability and performance of the plant. In some cases serious damage might be detected for plant and equipment during the implementation stage which could not be detected during the CA studies. Such surprises may send the cost estimate and schedule for a toss.

The probability and impact of such risks may be moderated by designing proper condition assessment plans. Further, contingencies may be built into cost estimates and contractual clauses may be suitably designed to take care of such surprises.]

12.2 Regulatory Risk

[The capital expenditure incurred for the R&M project has to be serviced by suitable electricity tariff. If the concerned Electricity Regulatory Commission does not allow adequate tariff to cover the expenses incurred, it will adversely affect the cash flow and net worth of the owner.

The regulatory risk may be mitigated by designing and implementing the R&M Project in compliance and in sync with the extant regulatory regime.]

12.3 Risk of R&M Contractor and Personnel

[There is limited availability of competent contractors and personnel for carrying out R&M works. There is dearth of contractors and personnel with expertise and experience in implementation of energy efficient R&M works.

Government and industry bodies can play big role in mitigating this risk by taking initiative expands contractor base and talent pool. Owner on its part can somewhat mitigate this risk by designing tendering process and contracts that encourages better participation by available contractors.]

12.4 Risk of too weak or too stringent QR for R&M Contractor

[Too weak qualification requirements may lead to entry of incompetent bidders with lower price quotes. Awarding the R&M Contract to an incapable Contractor may severely jeopardize the R&M programme. Similarly, too stringent qualification requirement may restrict the number of eligible bidders

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to a few thereby restricting competition and this may lead to higher price quotes.

Due care should be taken to frame appropriate qualification requirement (QR) to ensure adequate participation of competent bidders. While framing the QR, information should be collected from prospective bidders regarding their experience and capability.]

12.5 Risk of Non-availability of Spares

[As the unit is very old, there may be difficulty in sourcing many spare parts. This risk may be obviated in some cases by devising suitable sourcing strategy or design modifications or reverse engineering.]

12.6 Risk of Getting Shutdown for Implementation

[As R&M of the complete plant calls for shutdown for considerable time and there is acute shortage of electricity, the grid condition may not permit shutdown period. This risk may be mitigated by proper planning and taking all stakeholders into confidence during the planning phase and adhering to the planned schedule.]

12.7 Financing Risk

[The owner may find it difficult to arrange equity and debt financing for the R&M project. This risk may be mitigated by proper financial planning. Similarly, the R&M contractor may face cash flow problem. This risk may be mitigated by specifying suitable financial qualification criteria in tender specification and incorporating suitable payment term in the contract.]

12.8 Implementation Risk

[Poor implementation of project may lead to cost and/or time overrun and deficiency in quality. This risk may be mitigated by efficient Project Management set up and selection of reliable R&M contractor.

Aligning the timeline of tendering and execution of different packages and interfacing among different packages when R&M is being implemented in multiple packages is essential for smooth and timely execution of the R&M project. This risk may be mitigated by proper planning of tendering and execution of R&M project and employing suitable Project Management / Coordination team.]

12.9 Equipment Underperformance Risk

[The renovated plant and equipment may not perform as envisaged due to deficiency in design, manufacturing and O&M practices. The risk of underperformance due to design and manufacturing shortcomings may be managed by selecting reliable contractor and incorporating appropriate LD clause in the contract. The risk of O&M deficiency can be mitigated by proper training of O&M personnel.]

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13 CONFORMITY TO STATUTORY ENVIRONMENTAL NORMS

{Discuss in this chapter, the need of compliance to the conditions prescribed by MOEF and State Pollution Control Board (SPCB)}

13.1 Environmental Monitoring Cell

[.....]
[.....]
[.....]

{Discuss the role of Environment Monitoring Cell established at the project. Discuss the steps to be taken for strengthening the above cell to monitor and control the environmental impacts from the renovated plant, as per the revised stringent norms prescribed by the regulating authorities.}

13.2 Stack Emissions

[.....]
[.....]
[.....]

{Discuss the present levels of emissions of SPM, SO₂, NO_x and NH₃ from the stack, levels of Ground Level concentrations and the pollutants in the liquid effluents with respect to the statutory norms vis a vis the levels of emissions after the implementation of R&M Project. Discuss the methods and frequency to be adopted by the utility for monitoring and controlling these emissions as per the revised conditions prescribed by the regulating authorities.}

13.3 Ambient Air Quality (AAQ)

[.....]
[.....]
[.....]

{Discuss the National Ambient Air Quality Standards prescribed by MOEF and SPCB. Discuss the methods and frequency to be adopted by the utility for monitoring and controlling the Ground Level Concentrations (GLC).}

13.4 Liquid Effluents

[.....]
[.....]
[.....]

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{Discuss the quality of liquid effluents permitted by SPCB from different systems of the plant like, effluent from Water Treatment Plant, Boiler Blow down, Cooling Tower Blow down, recycled water from ash pond and sewage disposal from plant and colony. Discuss the recycling of ash water from ash pond and reuse of Cooling Tower Blow down for ash handling and coal dust suppression. Discuss the proposal of zero discharge, if applicable to your project.}

13.5 Ambient Noise

[.....
.....
.....]

{Discuss the noise level permitted during day and night and methods proposed to contain the noise level produced from power plant equipment within the limits imposed.}

13.6 Ash Utilization

[.....
.....
.....]

{Discuss the norms for the utilization of ash from the thermal power plants as per the latest notification from MOEF. Discuss the quantum of fly ash & bottom ash to be produced from the plant and implementation of ash utilization plan by the utility, after the completion of R&M project. Please note that as per MoEF notification dated 3rd November 2009, all the coal and lignite based thermal power stations operating before the date of the above notification are required to achieve the target of 100% utilization of fly ash before the expiry of a period of five years from the date of issue of the said notification.}

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ANNEXURE-7.1

SUMMARY OF CAPITAL COST FOR SELECTED R&M OPTION

Sl. No.	Item	FC	IC	Total
		Equiv. Rs.	Rs.	Rs.
1.0	Plant & Equipment			
1.1	Mechanical Equipment	...	...	...
1.2	Electrical Equipment	...	...	...
1.3	C&I Equipment	...	...	...
1.4	Miscellaneous Equipment	...	...	...
	Sub-Total (1.0)	...	...	...
2.0	Civil Works	...	...	...
3.0	Pre Commissioning Expenses	...	...	...
4.0	Project Engineering and Management	...	...	...
5.0	Taxes and Duties	...	...	...
	Project Cost excluding IDC and FC (1.0 to 5.0)	...	...	...
6.0	Financing Charges	...	...	...
7.0	Interest During Construction (IDC)	...	...	...
	IDC + Financing Charges	...	...	...
8.0	Contingency	...	...	...
	Project Cost incl. IDC &FC and Contingency (1.0 to 8.0)	...	...	...

Detailed Project Report For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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ANNEXURE-7.2

SUMMARY OF COST ESTIMATE FOR EACH R&M PACKAGE

Name of the Package:

Sl. No.	Item	FC	IC	Total
		Equiv. Rs.	Rs.	Rs.
1.0	Onshore Supply	[...]	[...]	[...]
2.0	Offshore Supply	[...]	[...]	[...]
3.0	Civil and Structural Works	[...]	[...]	[...]
4.0	Installation, Transportation and other Services	[...]	[...]	[...]
5.0	Taxes and Duties	[...]	[...]	[...]
5.1	Taxes and Duties on Onshore Supply			
5.2	Taxes and Duties on Offshore Supply	[...]	[...]	[...]
5.3	Taxes and Duties on Civil and Structural Works	[...]	[...]	[...]
5.4	Taxes and Duties on Installation, Transportation and Other Services	[...]	[...]	[...]
	Sub-Total (5.0)	[...]	[...]	[...]
6.0	Total Package Cost (Sum of 1.0 to 5.0)	[...]	[...]	[...]

{Note: Cost Estimate Summary for each of the R&M package is to be attached.}

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ANNEXURE – 7.3

COST OF GENERATION (COG) CALCULATION FOR PROPOSED R&M OPTIONS

Year	1	2	3	4	5	16	17	18	19	20
Capacity (MW)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
PLF (%)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Heat Rate (kCal/kWh)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Secondary Fuel (Oil) Consumption (ml/kWh)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Landed Cost of Coal (Rs/tonne)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Landed Cost of Secondary Fuel (Oil) (Rs/kl)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Auxiliary Power Consumption (%)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Energy Generated (MU)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Energy Sent Out	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]

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Year	1	2	3	4	5	16	17	18	19	20
(MU)															
Energy Charges:											[...]	[...]	[...]	[...]	[...]
Annual Energy Charge (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Energy Charge per Unit (Rs/kWh)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Capacity Charge:	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Return on Equity (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Interest on Loan Capital (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Interest on Working Capital (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Depreciation (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
O&M Charge (Rs	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]

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Detailed Project Report For R&M of Unit No.[...] Capacity [...]of [Name of the Power Plant]	<i>[Logo of Utility]</i>
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Year	1	2	3	4	5	16	17	18	19	20
Million)															
Secondary Fuel (Oil) Charge (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Annual Capacity Charge (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Capacity Charge per Unit (Rs/kWh)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Cost of Generation (Rs/kWh)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Discounting Factor	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Levelized Cost of Generation (Rs/kWh)															

Note: Year 1 is the year in which plant is shut down and R&M work is implemented

{Note: The number of years in the above table is indicative only. The CoG calculation will be done for the number of years spanning the economic plant life after R&M.}

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ANNEXURE-7.4

CASH FLOW AND RETURN ANALYSIS FOR PROPOSED R&M OPTIONS

Year	-2	-1	0	1	2	3	4	5	16	17	18	19	20
PLF (%)			
(Normative PLF)																		
Average Heat Rate (kCal/kWh)			
Auxiliary Consumption (%)			
Normative Energy Generated (MU)			
Energy Sent Out (MU)			
Loss of generation due to shut down for R&M (MU)																
Landed Cost of Coal (Rs/tonne)			
Landed Cost of Secondary Fuel			

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Year	-2	-1	0	1	2	3	4	5	16	17	18	19	20
(Rs/kl)																		
Indicative Tariff (Rs/kWh)				[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Cost of Purchasing Power from Grid net of variable charge (Rs/kWh)				[...]	[...]													
Cash Inflow:																		
Annual Revenue (Rs Million)				[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Cash Outflow																		
Annual Coal Cost (Rs Million)				[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Annual Oil Cost (Rs Million)				[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Annual O&M Cost (Rs Million)				[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Cost of Loss of Generation due to shut down for				[...]	[...]													

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Detailed Project Report For R&M of Unit No.[...] Capacity [...]of [Name of the Power Plant]	[Logo of Utility]
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Year	-2	-1	0	1	2	3	4	5	16	17	18	19	20
R&M (Rs Million)																		
Capex (Rs Million)	[...]	[...]	[...]	[...]	[...]													
Interest Payment (Rs Million)				[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Principal Repayment (Rs Million)				[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Net Cash Flow (Rs Million)	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Discount Factor	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Net Present Value of Cash Flows (Rs Million)																		
IRR (%)																		
Payback Period (Years)																		

Note: Year 1 is the year in which plant is shut down and R&M work is implemented

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{Note: Cash Flow and Return analysis for each of the R&M option and base case to be attached.

The number of years in the above table is indicative only. The analysis will be done for the number of years spanning the economic plant life after R&M.}

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ANNEXURE – 10.1

PROJECT MILESTONE SCHEDULE FOR R&M CONTRACT

Milestones	Scheduled Start Date	Scheduled Finish Date
Zero Date	[.....]	[.....]
Site Office Development	[.....]	[.....]
Site visit and assessment of Equipment & System	[.....]	[.....]
Re-Engineering and Development	[.....]	[.....]
Supply of Equipment	[.....]	[.....]
Unit Shut-down	[.....]	[.....]
Dismantling Activities	[.....]	[.....]
Erection activities	[.....]	[.....]
Boiler Erection	[.....]	[.....]
Turbine Erection	[.....]	[.....]

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Milestones	Scheduled Start Date	Scheduled Finish Date
Erection of Balance of Plant	<i>[.....]</i>	<i>[.....]</i>
Erection of Electrical Equipment	<i>[.....]</i>	<i>[.....]</i>
Erection of C&I Equipment	<i>[.....]</i>	<i>[.....]</i>
Testing & Commissioning	<i>[.....]</i>	<i>[.....]</i>
Commercial Operation	<i>[.....]</i>	<i>[.....]</i>



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

MODEL ENERGY AUDIT REPORT

PREPARED BY

LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.

(CONSULTING ENGINEERS)
(AN ISO: 9001:2008 CERTIFIED COMPANY)

Model Energy Audit Report For R&M of Unit No.[..] of <i>[Name of the Power Plant]</i>	<i>[LOGO OF UTILITY]</i>
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History of Revisions

Revision No.	Date	Prepared /Revised by	Description
R00	15.03.2013	R.K.Soni (RKS)	First edition Issued (Draft Report).
R01	03.07.2013	RKS	Report finalized based on the comments of the Task Force received on 14 th May 2013 and the meeting held in CEA on 11 th June 2013.
R02	26.09.2013	RKS	Revisions carried out as per discussions held in CEA on 24 th July 2013.

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BACKGROUND

What is R&M (Renovation & Modernization) of Thermal Power Plants?

Coal based power stations contribute more than 70% share of total power generation in India. Thermal Power Stations are designed for an economical and stable life span of 25 years, after which, the level of performance starts deteriorating as a result of degradation of its equipments, components and materials. Deterioration may also take place before the completion of useful life of 25 years, if the units are not operated and maintained properly. Deterioration in performance is reflected in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. This results in costly repair and loss of revenue. Renovations & Modernization (R&M) and Life Extension (LE) Programme of thermal power station is an activity of carrying out repairs, refurbishments and replacement of defective equipments & components so as to extend the life of the power plant by at least 20 years and to restore the performance parameters to equal or better than the original design parameters.

Need of R&M

In spite of new capacity additions, India continues to face shortages of varying degree in the supply of energy and peaking power. Implementation of fresh capacity additions for bridging the demand supply gap involves huge investments and long gestation periods primarily due to the process of land acquisition and getting the required fuel and water allocations, permits & clearances, particularly, the environmental clearance.

On the other hand, R&M activity of existing old power plants which requires less investment and can be completed in shorter duration has been recognized as a techno-economically viable option to supplement the fresh capacity addition for maximizing the energy generation. Also it helps in reducing the emissions by adopting upgraded modern technologies.

Objectives of R&M and R&M/LE Programme

As per the Guidelines issued by Central Electricity Authority (CEA) the following should be the objectives of R&M and R&M/LE Programmes.

Objectives of R&M Programme:

- To restore rated capacity and design parameters such as Heat Rate, Auxiliary Power Consumption and Secondary Oil Consumption etc.
- To make the operating units well equipped with modified/ augmented latest technology.
- To overcome technological obsolescence and non-availability of spares.
- To improve the performance parameters in terms of Plant Load Factor, Efficiency, Forced Outages, Availability and Reliability.
- To reduce maintenance requirements and enhance the ease in maintenance.
- Compliance of stringent environmental norms, safety and other statutory requirements.

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Objectives of R&M/LE Programme:

- Extension of useful economic life of generating units by another 20 years.
- To focus on full load operation of the unit beyond their original design life.
- To restore rated capacity and design parameters such as heat rate,
- Improvement in Auxiliary Power Consumption Secondary Oil Consumption etc
- Up-rating of Generating Unit.
- Improvement beyond design parameters.

Criteria for the Consideration of R&M and R&M/LE Programmes

As per the Guidelines issued by Central Electricity Authority (CEA) the following criteria is to be adopted for considering the R&M and R&M/LE Programmes.

- Estimated cost of unit for complete R&M/ LE works should be limited to 50% of cost of new unit.
- Cost of Main Plant (BTG) should be limited to 50% cost of new BTG unit.
- Plant Life should be extended by about 20 years.
- The Pay Back Period should be from 5 to 7 years.

Need of Preparation of Model R&M Documents

The countrywide R&M programme was first initiated in 1980 when Government of India approved the scheme of Central Loan Assistance (CLA) of Rs. 500 crores benefitting 34 power stations mostly of 50/60/100/110/120/140 MW capacities. R&M in a structured manner was initiated as a centrally sponsored programme during the 7th Five Year Plan. The momentum of carrying out R&M works was continued through 8th and 9th Plans but the same could not be sustained during the 10th Plan.

Based on the discussions held with Ministry of Power, various utilities, PFC and BHEL, CEA prepared a document on “National Perspective Plan for Renovation & Modernization and Life Extension and Up-rating (LE&U) of thermal power stations up to the year 2016-17”. This document which also includes revised guidelines for Renovation & Modernization / Life Extension works on coal/lignite based thermal power stations was released by Honourable Minister of Power on 14th December 2009. Plan-wise Achievements of R&M and R&M/LE Programmes starting from 7th Five Year Plan till 11th Five Year Plan is furnished below:

Plan–Wise Achievements

S.No.	Plan	Year	No. of TPS / No. of Units	Capacity (MW)	Additional Generation Achieved MU/ Annum	Equivalent MW
1	7 th Plan and Two Annual Plans	85-86 to 89- 90 & 90-91, 91-92	34 / 163	13570	10000	2000

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S.No.	Plan	Year	No. of TPS / No. of Units	Capacity (MW)	Additional Generation Achieved MU/ Annum	Equivalent MW
2	8 th Plan (R&M) (LEP)	92-93 to 96-97	44 / 198 43/(194) 1/ (4)	20869 (20569) (300)	5085	763
3	9 th Plan (R&M) (LEP)	97-98 to 2001-02	37 / 152 29/ (127) 8/ (25)	18991 (17306) (1685)	14500	2200
4	10 th Plan (R&M) (LEP)	2002-03 to 2006-07	9/ 25 (14 out of 57 planned) (11 out of 106)	3445 (2460) (985)	2000	300

11th Plan R&M Programme & Achievements (2007-12)

	Programme (MW)	Achievement (MW)
Life Extension Programme (LEP)	7318 (53 units)	1291 (13 Units)
R&M Programme	18965 (76 units)	14855 (59 units)
Total	26383 (129 units)	16146 (72 units)

In the past, R&M measures were hampered due to lack of proper planning. Proper investigation to identify the R&M works to be carried out and preparation of technical bid documents based on the investigation was not done. This resulted in unsystematic and additional work during execution phase and uncertainty about costs resulting in excessive implementation time, long shutdown periods of plants and cost overruns. In the absence of standard commercial rules and policies, suppliers showed little interest in R&M work. Therefore a strong need was felt for providing standardized bidding procedures as well as model contracts, formats and specifications etc. to the utilities. Standardization will harmonize the requirements of all the stakeholders and will lead to their increased participation.

The Indo-German Energy Forum (IGEF)

The Indo-German Energy Forum (IGEF), inaugurated in 2006, provides a platform to discuss energy related issues of mutual interest. The first meeting of the ad-hoc sub-group on “energy efficiency in thermal power stations”, constituted as per decision of meeting of IGEF in December 2007, was held under the chairmanship of Joint Secretary (Thermal), Ministry of Power on 12th March, 2008 in which preparation of standard tendering document for the purpose of R&M activities was, inter-alia, identified as an area of the activities. The scope of the assignment was divided in two parts as under:-

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Phase-I Activity:

Phase-I activity comprised an assessment of tendering procedures currently being followed by public utilities in India and a review of documents used for standard R&M projects and the documents which have already been developed for energy efficient R&M projects financed by particularly World Bank. This activity was carried out by M/s Evonik (India) under the grant provided by GTZ. M/s Evonik (India) submitted the report in September 2009.

Phase-II Activity

Phase-II activity comprised the preparation of the model documents / templates in consultation with Task Force, power utilities & financing agencies.

In the 3rd meeting of Indo-German Energy Forum (IGEF) convened in Berlin on 4th November 2009, KfW proposed to finance and carryout the work programme of phase-II Activity, on behalf of CEA & in consultation with the Task Force. In a meeting held in MOP on 17th December 2009, chaired by Joint Secretary (Thermal), MOP, the representative of KfW suggested that CEA may act as "Project Executing Agency" for the phase-II activity. Accordingly Ministry of Power, Govt. of India have entrusted the task of "Project Executing Agency" to CEA for implementing Phase-II activity. Under Indo-German Energy Forum (IGEF) assisted programme, M/s Lahmeyer International (India) was appointed on 16th March 2012 to provide the consultancy services for 'Development of tendering procedures and model contract document for R&M of Fossil Fuel Based Power Plants in India.' The scope of consultancy services included the preparation of the following model documents:

- I) Standard Bidding Procedure for engagement of Consultants and R&M Works Contractor.
- II) Residual Life Assessment (RLA) / Condition Assessment (CA) Report.
- III) Energy Audit (EA) Report.
- IV) Feasibility Report.
- V) Detailed Project Report.
- VI) Request for Qualification (RFQ) & (RFP) Documents for R&M Consultants and R&M Contractors.
- VII) Technical Specifications.

Due Diligence done by LII of the R&M Documents of other Projects

Before the preparation of this model document, LII did a thorough review of the R&M Documents of the following Power Plants:

Documents Provided by CEA

- Remaining Life Assessment / Condition Assessment Report- Nasik Unit-3 of MAHAGENCO.
- Energy Audit Report- Nasik Unit- 3 of MAHAGENCO.
- Detailed Feasibility Report- Nasik Unit-3 of MAHAGENCO.
- Draft Detailed Project Report -Kolaghat Unit-3 of WBPDC.
- Service Contract- R&M of Unit-1 Panipat TPS of HPGCL.

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- Tender document for Supply, Erection, Testing and Commissioning of Air Preheater for Unit 5 & 6 Koradi TPS, MAHAGENCO.
- Tender document for replacement of 6.6 KV station transformer incoming breaker & Tie- breaker of Koradi TPS, MAHAGENCO.
- Tender specification for Design, Engineering, Supply, Erection, Testing and Commissioning of Rotary Air Preheater for Units 4 & 5, Nasik TPS of MAHAGENCO.

Documents Provided by WBPDCCL

- Energy Audit Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Detailed Project Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Project Design Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Technical Specifications. (Vol. II of RFP Document for R&M Contractor).
- RLA for Boiler for Bandel Unit -5.
- RFP for R&M Consultant for Bandel Unit -5.
- Commercial Volume-I of RFP for Bandel Unit -5 for R&M Contractor.

KfW Documents

- Model Contract Document issued by KfW.
- Guidelines issued by KfW for the assignment of Consultants.

World Bank Documents

- Standard Bidding Document for Procurement of Plant, Design, Supply and Installation.
- Standard Request for Proposal for the Selection of Consultants

This Energy Audit Report has been prepared to conceptualize the systematic methods and procedures to be implemented for carrying out R&M works for the Thermal Power Plants, taking into account the different practices followed in the past, the practices and methodologies being adopted in the Industry including the Projects funded by KfW and World Bank, as indicated in the various documents indicated above. Detailed standard documents like DPR, RFP & RFQ documents to carry out R&M works for the Thermal Power Plants shall take into account the findings of Energy Audit of the Project.

The utilities are advised to refer to the guidelines of the standard documents for the preparation of the project specific documents for their project.

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NOTES & GUIDELINES FOR USING THE MODEL ENERGY AUDIT REPORT

Central Electricity Authority (CEA), the Project Executing Agency / Employer has appointed Lahmeyer International India Pvt. Ltd. (LII), the Consultant to Develop Standard Procedures and Model Documents for the Renovation and Modernization (R&M) of Fossil Fuel based Power Plants in India. The above assignment is being financed by KfW Entwicklungsbank. Accordingly, this Model Energy Audit Report has been prepared for the guidance of Project Authorities, who may decide to carryout R&M of their old Coal based Power Plants so as to extend the life of their plants and make them energy efficient, while ensuring that the plants are in compliance with the revised statutory emission standards.

The purpose of this model document is to standardize the style and contents of the Energy Audit Report for R&M works. Since a large fleet of 200/210 MW units are potential candidates for consideration of Renovation as they have crossed 20 to 25 years of useful life, the Model Energy Audit Report has been prepared keeping those 200 MW/210 MW units in view. Since in due course of time, many 500 MW units will also become due for R&M, the Utilities are advised to suitably modify this document for its application to 500 MW units.

The Model Energy Audit Report contains two kinds of texts written in black and in blue colours. The text in blue colour written in italics and enclosed in square bracket represents variable information which may vary from project to project. The data in blue colour indicates typical data and values for typical coal fired power plants. The Project Authorities and their Consultants, carrying out R&M and LE of a particular plant/project, should review this data in respect of their plant/project and modify these data with the ones as may be applicable to their specific Project. A few guidelines for carrying out the energy audit of the power plant equipment have also been provided in blue italics enclosed within red curly brackets ({...}), wherever applicable.

A variety of performance tests and energy measurement tests are required to be carried out for arriving at decisions for the retrofitting/replacement of the equipments. While discussing the need, importance and methodology of conducting these tests and measuring the energy consumption, the Model Energy Audit Report also provides the templates for the formats for reporting the results of such tests and measurements. Formats for reporting the results of Energy Audit have been appended at the end of this Model Document. The Formats provided for a particular kind of test described for any equipment may be used for similar remaining Equipments.

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MODEL ENERGY AUDIT REPORT

FOR

RENOVATION & MODERNISATION

OF

FOSSIL FUEL BASED POWER PLANTS IN INDIA

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LIST OF ABBREVIATIONS

{The utilities are advised to use the following standard abbreviations while preparing Energy Audit Report for their power plant.}

AHP	Ash Handling Plant
AHU	Air Handling Unit
BFP	Boiler Feed Water Pump
BOP	Balance of Plant
CA	Condition Assessment
CEA	Central Electricity Authority
CFBC	Circulating Fluidized Bed Consumption
CHP	Coal Handling Plant
DM	Demineralization
EA	Energy Audit
ECO	Economizer
ESP	Electro Static Precipitator
FO	Fuel Oil
GCV	Gross Calorific Value
GT	Generator Transformer
HP	High Pressure
HT	High Tension
HVAC	Heating Ventilation Air Conditioning
IPT	Intermediate Pressure Turbine
LDO	Light Diesel Oil
LE	Life Extension
LPT	Low Pressure Turbine

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LT	Low Tension
LTSH	Low Temperature Super Heater
PA	Primary Air
PF	Pulverised Fuel
RLA	Residual Life Assessment
PLF	Plant Load Factor
R&M	Renovation & Modernization
RH	Reheater
SH	Super Heater
TPH; T/h	Tons per hour
TPS	Thermal Power Station
TR	Tons of Refrigeration

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LIST OF ANNEXURE TO BE ATTACHED WITH THE ENERGY AUDIT REPORT

{The utilities are advised to attach the following Annexure with their Energy Audit Report}

S.No.	Description
1	Schematic Diagram of the Boiler indicating the locations of measuring instruments.
2	Schematic Diagram of the Steam Turbine Generator indicating the locations of measuring instruments.
3	Schematic Diagrams for Coal Handling Plant, Ash Handling Plant, CW & ACW System, Pre-treatment Plant, DM Plant, Compressed Air System, Fuel Oil Handling System, HVAC System etc.
4	List of Measuring Instruments used in testing along with their latest Calibration Certificates.
5	Energy Audit Reports in the prescribed formats for all the Systems and Major Equipments.
6	Calculations for the Cost Benefit Analysis for all the Systems and Major Equipments.

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Model Energy Audit Report For R&M of Unit No.[...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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1 EXECUTIVE SUMMARY

This Energy Audit Report has been prepared for carrying out the Renovation & Modernization (R&M) / Life Extension (LE) of Unit No [...] of [...] Thermal Power Plant, located at [...], in District [...] in the State of [...] and having a configuration of [...x...MW].

The unit no. [...] was first commissioned in the year [...]. After [...] years of operation, the performance of the unit has gradually deteriorated resulting in reduced outputs, decreased efficiency and increased cost of generation. To verify the actual energy consumption of the power plant equipments and to work out action plans for improving the efficiency of the unit, an energy audit was carried out during the period [...].

To determine the operating efficiency and energy consumption of various components and systems of the plant, performance tests were carried out on all continuously operating equipments of Boiler & Auxiliaries, Steam Turbine & Auxiliaries and Balance of Plant. The actual values of operating efficiency and power consumption were compared with the corresponding design values and reasons for deterioration in efficiency or excess power consumption were established.

In addition, energy losses due to poor condition of thermal insulation of the equipments and the excess energy consumption by the lighting & illuminating fixtures were also analyzed.

The recommendations made in this energy audit report are based upon the analysis of the operation data of the unit, evaluation of the of the performance test results of various equipments, as well as, the detailed discussions held with the project authorities and operating personnel.

After the overall analysis, suitable solutions and energy saving measures have been recommended which are also found to be attractive from the perspective of cost benefit analysis. Summary of these recommendations are furnished below:

Equipment/ Systems	Summary of the Recommended Action Plans	Cost Impact
Boiler and Auxiliaries	[.....]	[.....]
Steam Turbine Generator and Auxiliaries	[.....]	[.....]
Balance of Plant and Systems	[.....]	[.....]
Thermal Insulation	[.....]	[.....]
Illumination System	[.....]	[.....]

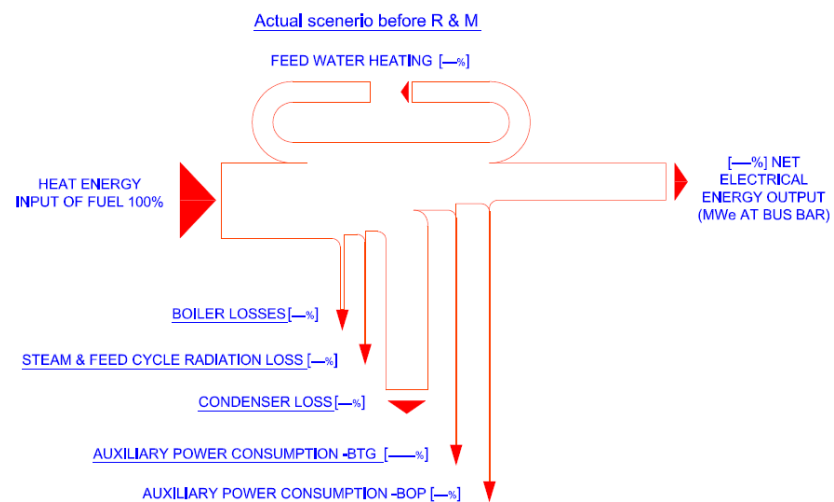
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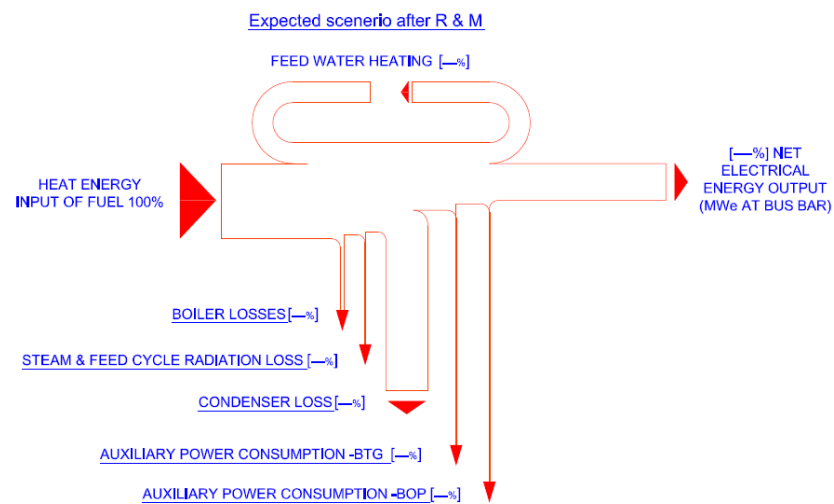
Equipment/ Systems	Summary of the Recommended Action Plans	Cost Impact
Any other System	[.....]	[.....]
Total Cost Impact		[.....]

Sankey Diagrams indicating the scenarios for the heat energy input, break-up of various losses and net electrical output from the unit before R&M and as expected after R&M are shown below.

SANKEY DIAGRAMS OF ENERGY FLOW



SANKEY DIAGRAMS OF ENERGY FLOW



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These recommendations are being hereby submitted to the Project Authorities for minimizing the energy consumption and reducing the cost of generation. These recommendations should be considered along with the recommendations of RLA/CA studies while evolving various options for Renovation and Modernization of the Unit.

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2

INTRODUCTION

[Unit No.....of..... Thermal Power Station was first synchronized on [.....]. The Unit has been operating for more than [...] and its performance has deteriorated gradually over the years. Extending the life of the unit and increasing its efficiency and output appears feasible by carrying out Renovation and Modernization of the Unit. This Energy Audit (EA) Report has identified those equipment and components of the Unit which need to be rehabilitated to prevent excess power consumption, improve efficiency and enable the unit to produce power according to prevailing norms of operation and the current statutory environmental regulations in force.

This report is based upon the analysis of the operation data of the unit, evaluation of the of the performance test results of various equipment of the power plant, as well as, detailed discussions held with the project authorities and operating personnel.

The recommendations of the energy audit have been discussed in detail in Sections 5.0 to 9.0. These recommendations are being hereby submitted to the Project Authorities for minimizing the energy consumption and reducing the cost of generation. These recommendations should be considered along with the recommendations of RLA/CA studies while evolving various options for Renovation and Modernization of the Unit.

As per the Energy Conservation Act of 2001 (BEE 2008), an energy audit is defined as:

"The verification, monitoring and analysis of the use of energy and submission of technical report containing recommendations for improving energy efficiency with cost-benefit analysis and an action plan to reduce energy consumption."

The Energy Audit Report has been prepared keeping in view the above spirit of Energy Conservation Act.

2.1

Objectives of Energy Audit

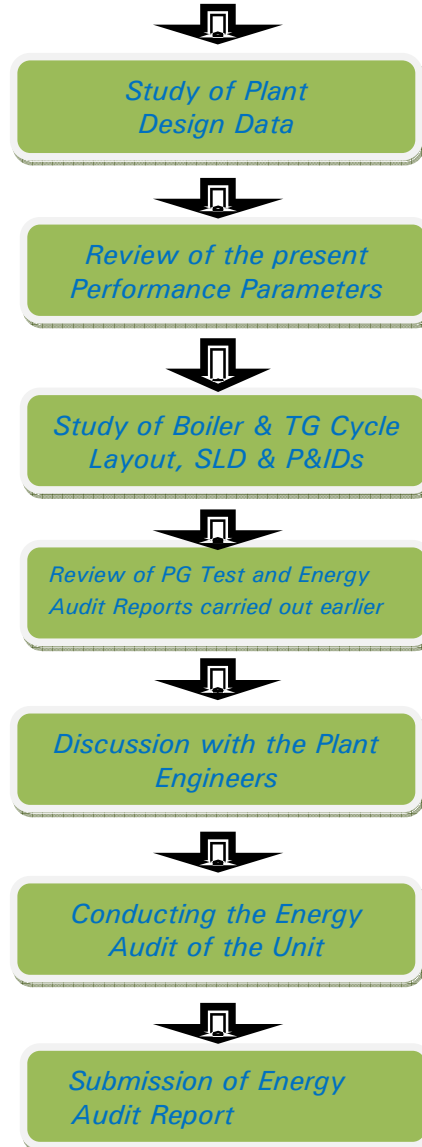
[The purpose of Energy Audit is to provide recommendation for achieving the following objectives.

- *Increasing the Boiler Efficiency by effective utilization of Heat Energy of fuel through its effective combustion in the Boiler.*
- *Decreasing the Turbine Heat Rate by increasing the effective utilization of Heat Energy of Steam through Steam Turbine.*
- *Enhancing the performance parameters of power plant equipment and their auxiliaries.*
- *Minimizing the auxiliary power consumption of electrically driven equipment.*
- *Increasing the quantum of power generation.*
- *Reducing the cost of generation.*
- *Achieving reduction in the release of green house gases.]*

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2.2 Methodology adopted for Energy Audit

[Following steps were followed for carrying out the Energy Audit.]



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3 DESCRIPTION AND SALIENT FEATURES OF THE UNIT

3.1 General

The Power Plant, having a configuration of [...x...MW] is located at [...], in District [...] in the state of [...]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator respectively. The boiler is of [natural circulation, two pass, reheat, dry bottom, balance draft, tangentially fired furnace having PF/CFBC design]. The boiler is provided with [front/front & rear/corner/down shot firing] system. The Steam Turbine consists of HP Turbine having [...] stages, IP Turbine having [...] stages and LP Turbine having [...] stages. [LP stage of Turbine is designed with [bauman exhaust]. Condenser cooling system of the unit is designed on [once through / re-circulation system] with [NDCT/IDCT] Cooling Towers. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [...] substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...&.....] coal mines. The consumptive water for the power plant is being sourced from [.....river /.....sea].

3.2 Salient Features and Details of the Unit

{Indicate in the paragraphs below the salient features and other specific technical details of the Project. The description given below is of indicative nature only.}

3.2.1 Boiler & Auxiliaries

a) Boiler

[The Boiler is of natural circulation, pulverized fuel fired, dry bottom, balanced draft using direct firing system. The design parameters of the Boiler are furnished below]

Description	Units	Design Parameters
Steam Flow at Final SH outlet	T / hr	[....]
Steam Pressure at SH outlet	kg/cm ²	[....]
Steam Temperature at SH outlet	°C	[....]
Re-heater Flow	T / hr	[....]
Steam Pressure at RH outlet	kg/cm ²	[....]
Steam Temperature at RH outlet	°C	[....]

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Description	Units	Design Parameters
Feed Water Flow	T / hr	[...]
Feed Water Pressure at inlet of Economiser	kg/cm ²	[...]
Feed Water Temperature at inlet of Economiser.	°C	[...]

b) Furnace

[The boiler is equipped with a water cooled furnace of balanced draft and fusion welded membrane wall construction. It is equipped with.....numbers of coal burners and.....numbers of oil burners located at numbers of elevations. The design parameters of the Furnace are furnished below.]

Description	Units	Design Parameters
Type of Firing	.....	[.....]
Combustion Chamber Volume	m ³	[.....]
Furnace Dimensions (Width x Depth x Height)	m	[.....]
Heating Surface Areas		[.....]
i) Water Walls	m ²	[.....]
ii) Superheaters	m ²	[.....]
iii) Reheaters	m ²	[.....]
iv) Economiser	m ²	[.....]
v) Air Heater	m ²	[.....]
vi) Steam Coil Air Heater	m ²	[.....]
vii) Temperature Measurement of Super-heater tubes	Yes / No	[.....]
viii) Temperature Measurement of Re-heater tubes	Yes / No	[.....]

c) Super Heaters and Re-Heater

[The super heaters are composed of four sections, a platen section, a pendant section, a rear low temperature section and a steam cooled wall

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& roof section. The Re-heater consists of two sections, the front pendant and the rear pendant sections. The details are given below:]

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Low Temperature Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Platen Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Pendant Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Ceiling and Enclosure Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Front Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Rear Assembly	[.....]	[.....]	[.....]	[.....]	[.....]

d) Economiser

[The Economizer is of a single stage, continuous plane tube and horizontal, mixed flow type, located in the second pass of the boiler]

e) Air Pre-Heater

[The air pre-heater is of regenerative rotary type. Special sealing arrangements have been provided in the air pre-heater to prevent leakage between air and gas sides. Adjustable sector plates have also been provided to prevent the leakage during expansion. The heating surfaces of the air pre-heater have been provided with two types of cleaning systems, soot blowing and water washing system.]

f) Raw Coal Bunkers

[Each boiler is provided with [...] raw coal bunkers. The total capacity of the bunkers is to meet [...] hour's requirement at maximum mills capacity of the unit. The upper portion of the bunkers is of cylindrical shape made of carbon steel plate, while the conical portion is made of stainless steel plate. Each outlet of the bunker is provided with an isolation gate which is motor operated. In addition to the isolation gates, rod gates have been provided to control the flow of coal from the bunkers]

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g) Raw Coal Feeders

[One gravimetric type of raw coal feeder has been provided for each coal mill. The coal feeders have been provided with micro-processor based controls with variable frequency drive. The feeders have been provided with dual independently measuring load cells. All parts of the feeders coming in contact with coal, except the belt, are made of stainless steel]

h) Fuel Firing System

[The boiler is working on a direct firing system. The pulverized coal is being dried and transported to the coal burners by means of hot primary air being supplied by two primary air fans. The boiler is having [front and rear/corner/down shot] firing system. There are [...] pulverized coal burners and [...] oil burners. The burners are located at [...] floors.]

i) Coal Mills

[The unit is provided with numbers of [BHEL] Make [XRP-783] bowl type mills, out of which mills are designed to work with designed coal andnumbers of mills are standby .The rated capacity of each mill isT/h.]

Description	Units	Design Parameters
Make and Model of Mills	.....	[....]
Type of Mills	.....	[....]
Capacity of Mills	T/h	[....]
Total Number of Mills per boiler	Nos.	[....]
Number of Mills to work per boiler with design coal quality	Nos.	[....]
Motor Rating	kW	[....]

j) Primary Air Fans

[Two Primary Air (PA) Fans have been provided for each boiler. Each PA Fan is designed to meet 60% MCR condition of the boiler. The PA Fans are Hot PA Fans. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	[....]
Type of Fans	[....]
Number of fans per boiler	Nos.	[....]

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Description	Units	Design Parameters
Capacity	m ³ /sec	[....]
Discharge Pressure	mmwc	[....]
Temperature of Hot Air	°C	[....]
Motor Rating	kW	[....]
Method of Regulation	....	[....]

k) Forced Draft Fans

[Two Forced Draft (FD) Fans have been provided for each boiler. Each FD Fan is designed to meet 60% MCR condition of the boiler. The FD Fans supply combustion air to the boiler, mill air through PA Fans and tempering air to control the classifier temperature of the mills. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	.....	[....]
Type of Fans	.....	[....]
Number of fans per boiler	Nos.	[....]
Capacity	m ³ /sec	[....]
Discharge Pressure	mmwc	[....]
Temperature of Air	°C	[....]
Motor Rating	kW	[....]
Method of Regulation	....	[....]

l) Induced Draft Fans

[Two Induced Draft (ID) Fans have been provided for each boiler. Each ID Fan is designed to meet 60% MCR condition of the boiler. Each ID Fan evacuates flue gases through two parallel paths of ESP and discharge them into stack through separate ducting. Details are given below:]

Description	Units	Design Parameters
Make and Model of Fans	[....]

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Description	Units	Design Parameters
Type of Fans	[....]
Number of Fans per Boiler	Nos.	[....]
Capacity	m ³ /sec	[....]
Discharge Pressure	mmwc	[....]
Temperature of Flue Gases	°C	[....]
Motor Rating	kW	[....]
Method of Regulation	....	[....]

m) Wall Blowers and Long Retractable Soot Blowers (LRSBs)

[Adequate number of Wall Blowers and Long Retractable Soot Blowers (LRSBs) are being used for cleaning the soot deposited on the heating surfaces of the water walls and super heaters respectively. Manually operated soot blowing system has been provided. Details are given below:]

Description	Units	Design Parameters
Wall Blowers		
Make and Model of Wall Blowers	.....	[...]
No. of Wall Blowers per boiler at water walls	Nos.	[....]
Medium of soot blowing at water walls	.....	[....]
LRSBs		
Make and Model of LRSBs	.....	[....]
No. of LRSBs per boiler at pendant surfaces of pressure parts	Nos.	[....]
Medium of soot blowing at pendant surfaces of pressure parts	[....]
No. of LRSBs per boiler at convection pass tube banks	Nos.	[....]

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Description	Units	Design Parameters
Medium of soot blowing at convection pass tube banks	[....]

n) ESP

[An Electrostatic Precipitator (ESP) has been installed on the cold end side of the Air Pre-heater to remove the particulate matter from the flue gases. The ESP has been provided with Gas Distribution System, Collecting Electrodes, Discharge Electrodes, Transformer Rectifier Sets and [electrically/mechanically] operated rapping system. The hoppers of ESP have been provided with [capacitance] type level indicators and thermostatically controlled heating elements. Details are given below:]

Description	Units	Design Parameters
Make and Model of ESP	.....	[....]
Number of Passes per ESP	Nos.	[....]
Number of fields per pass	Nos.	[....]
Dust concentration at outlet	mg/Nm ³	[....]
Type of Control	.....	[....]
Gas Velocity in ESP	m/sec	[....]
Specific Collection Area	m ² /m ³ /sec	[....]
Aspect Ratio	.....	[....]
Particle Migration Velocity	cm/sec	[....]
Numbers of TR Sets	.....	[....]
Rating of TR Sets	.....	[....]
Plate Area/TR Set	m ² /TR Set	[....]
Storage Capacity of ESP Hoppers	hrs	[....]
Pressure Drop	mmwc	[....]
Dust Collection Efficiency with (N-1) fields in operation	%	[....]

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3.2.2 Steam Turbine & Auxiliaries

a) Steam Turbine

[The steam turbine is of three cylinder, 3000rpm, tandem compound, condensing type designed to operate on a re-heat and re-generative feed water cycle. The LP stage of turbine is designed with Bauman exhaust. The turbine is provided with HP/LP bypass system of 60% capacity of Boiler MCR. The turbine is provided with an electro - hydraulic control system, automatic turbine run up system and turbo supervisory instrumentation. The condensing system consists of a surface condenser of single shell and two pass, divided water box construction. Cooling water being supplied to the condenser is of raw water/ clarified water quality. The design parameters of the steam turbine are furnished below]

Description	Units	Design Parameters
Pressure of Steam at inlet of ESV of HPT	kg/cm ²	[....]
Temperature of Steam at inlet of ESV of HPT	°C	[....]
Pressure of Cold Reheat (CRH) Steam	kg/cm ²	[....]
Temperature of Cold Reheat (CRH) Steam	°C	[....]
Pressure of Hot Reheat (HRH) Steam	kg/cm ²	[....]
Temperature of Hot Reheat (HRH) Steam	°C	[....]
Pressure at the inlet of LP Turbine	kg/cm ²	[....]
Temperature at the inlet of LP Turbine	°C	[....]

b) Condenser

[The condenser is a [single/double] pass, horizontal, surface type with integral air cooling section designed to maintain a pressure of 76 mm of Hg at turbine exhaust with a cooling water temperature of [...] deg C and an outlet temp of [...] deg C. The condenser is capable of operation with [...] tubes plugged and has hot well storage capacity of [...] minutes]

Description	Units	Design Parameters
Make and Model	[....]
Type of Condenser	[....]

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Description	Units	Design Parameters
Total Cooling Surface	m ²	[....]
Number of Cooling Water Tubes	[....]
Material of Tubes	.....	[....]
Diameter and thickness of tubes	mmxmm	[....]
Cooling Water Quantity through Condenser	m ³ /h	[....]
Cooling Water Temperature at the inlet to Condenser	°C	[....]
Condenser Vacuum	mm Hg	[....]

c) **Ejectors**

[The Condenser is provided with two quick starting ejectors which operate in parallel to remove large volumes of air for raising the initial vacuum during the starting of the Unit. Two main ejectors of 100% capacity each have been provided remove air and non condensable gases from the condenser to maintain the required vacuum in the condenser during the normal operation of the unit.]

d) **Condensate Extraction Pumps**

[Condensate extraction pumps are of vertical, multistage, centrifugal pumps of canister type.]

Description	Units	Design Parameters
Make and Model	.....	[....]
Type	.....	[....]
Capacity	m ³ /h	[....]
TDH	mwc	[....]
Speed	rpm	[....]
Motor Rating	kW	[....]

e) **Gland Steam Cooler**

[A Gland Steam Cooler has been provided to condensate the leak-off steam from intermediate chambers of end sealings of HP and IP turbine, thereby heating the main condensate water. The Gland Steam Cooler consists of shell, tube bundle and removable water box.]

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f) LP Heaters and Drain Coolers

[Each steam turbine is provided with four numbers of low pressure heaters to increase the temperature of the condensate in stages. LP Heater -1 consists of two halves and is installed in neck of the condenser. The remaining LP Heaters are of shell and tube design and have been placed vertically. An integral drain cooling section is provided in each LP Heater. The design details of LP Heaters are furnished in the table below.]

Heater No.	1	2	3	4
Extraction Steam taken from	[...] stage of IP turbine	[...] stage of IP turbine	[...] stage of IP turbine	[...] stage of IP turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]	[...]

g) Deaerator

[The deaerator is of [horizontal spray cum tray type]. It is designed to remove dissolved oxygen from the condensate in excess of 0.005 cc per liter. The feed water storage tank has a capacity of [...] minutes feed water requirement of the boiler corresponding to TMCR Heat Balance]

h) Boiler Feed Pumps

[The boiler feed pumps are horizontal, multi stage centrifugal pumps of barrel type, motor driven pumps coupled with hydraulic coupling, taking the suction from the deaerator. The boiler feed pumps discharge feed water through HP heaters to the economizer of the boiler.]

Description	Units	Design Parameters
Make and Model	[....]
Type	[....]
No of stages	Nos.	[....]
Capacity	m ³ /h	[....]
Head	mwc	[....]

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Description	Units	Design Parameters
Feed water temp	°C	[...]
Gland sealing arrangement	[...]
Minimum flow	m ³ /h	[...]
Method of Speed Regulation	.....	[...]
Type of Hydraulic Coupling	.....	[...]
NPSH required at design condition	mwc	[...]
Motor Rating	kW	[...]

i) HP Heaters

[Each steam turbine is provided with three numbers of high pressure heaters to increase the temperature of the feed water in stages. The Heaters are of shell and tube design and have been placed vertically. The design details of HP Heaters are furnished in the table below.]

Heater No.	1	2	3
Extraction Steam taken from	[...] stage of HP turbine	[...] stage of HP turbine	[...] stage of HP turbine
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]
Bled Steam Temperature (deg C)	[...]	[...]	[...]

j) HP/ LP Bypass

[HP/LP bypass system has a capacity of 60% of BMCR (Boiler Maximum Continuous Rating). HP bypass system has been provided between the Main Steam Line and Cold Reheat Line. LP bypass system has been provided between the Hot Reheat Line and the Condenser. HP bypass water spray has been taken from the discharge of Boiler Feed Pumps. LP bypass water spray has been provided from the discharge of Condensate Extraction Pumps.]

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k) Turbine Governing System

[The turbine is equipped with an electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. The system is designed to sustain full load dump from the generator. The system is provided with a quick closing Emergency Stop Valve (ESV), to interrupt the supply of steam from the boiler and stop the turbine under emergency conditions. The turbine governing system includes, speed governor.]

l) Lube Oil System

[The lube oil system consists of Main Oil Tank, Turbine driven main oil pump, AC driven bearing oil pump, DC driven emergency oil pump, AC driven jacking oil pump and oil coolers of 3x50% capacity, Lube oil is being purified by means of a centrifuge. Oil storage tanks consisting of Clean Oil Tank and Dirty Oil Tank have been provided.]

3.2.3**Electrical System****a) Generator**

[The Generator is a 15.75 kV, 50 Hz, 0.85 power factor machine, directly coupled with steam turbine operating at 3000 rpm, with.....type of excitation system and digital programmable voltage regulator. The Generator has direct water cooled stator winding and direct hydrogen cooled rotor winding. The stator winding cooling water is cooled in a closed cycle cooling system using DM water, while the hydrogen in the machine is cooled in gas to water hydrogen coolers mounted inside the machine. The Parameters of the Generator are briefly mentioned below.]

Description	Units	Design Parameters
Rated MW Capacity	MW	[....]
Rated MVA Capacity	MVA	[....]
Rated Terminal Voltage	kV	[....]
Rated Power Factor	.....	[....]
Rated Stator Current	kA	[....]
Rated Speed	rpm	[....]
Rated Frequency	Hz	[....]
Efficiency at Rated Power Output and Rated Power Factor	%	[....]
Excitation Current	kA	[....]

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Description	Units	Design Parameters
Excitation Voltage at Rated Power Output and Rated Power Factor	kV	[....]
Short Circuit Ratio	.....	[....]
Negative Sequence Current	Amp	[....]
Phase Connection	.....	[....]
Type of Excitation	.....	[....]
Method of Cooling the Rotor	.....	[....]
Method of Cooling the Stator	.....	[....]
Rated Hydrogen Pressure	kg/cm ²	[....]

b) Station Transformer

[Two Station Transformers have been provided to meet the station [common] auxiliary loads of the power plant. The Station Transformers have been provided with on-load tap changers to keep the station 6.6 kV voltage constant. Cooling of this transformer is ONAN/ONAF/OFAF and has 2x50 % separately mounted radiators and 2x50% oil pumps. The Parameters of the Station Transformers are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[....]
Capacity / Rating	MVA	[....]
Voltage Ratio	.....	[....]
Type of Cooling	.....	[....]
Quantity	Nos.	[....]

c) Generator Transformer

[The power output from each Generator is being stepped up to 220/400 kV through a 240 MVA step up Generator Transformer. It has 3x50% coolers and 3x50% oil pumps. The Parameters of the Generator Transformer are briefly mentioned below]

Description	Units	Design Parameters
Make	[....]

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Capacity	MVA	[...]
Voltage Ratio	[...]
Type of Cooling	[...]

d) Unit Auxiliary Transformer

[Two unit auxiliary transformers have been provided for each unit for meeting all unit auxiliary loads. These transformers have been provided on-load tap changers. The Parameters of unit auxiliary transformers are briefly mentioned below]

Description	Units	Design Parameters
Make	.....	[...]
Capacity	MVA	[...]
Voltage Ratio	.....	[...]
Type of Cooling	.....	[...]
Quantity	Nos.	[...]

e) Electrical Auxiliary Power Distribution System

[Unit auxiliaries receive their normal power supplies at 6.6 kV through two (2) nos. unit transformers. For lower rating drives, 6.6 kV is further stepped down to 415 V by two (2) nos. unit service transformers. The 415 V distribution system feeds a number of Motor Control Centers (MCCs) for running 415 V drives. 6.6 kV unit switchgears are connected to station switchgear for start up and emergency power supply. The details are mentioned below]

Description	Units	Design Parameters
Voltage Level	kV	[...]
Type of Breaker	.....	[...]
Type of Grounding	.....	[...]
Type of Protection	.....	[...]

f) DC System

[Each unit has its own DC system located in the BC bay at ground floor of the Power House. Separate DC systems have been provided in switchyard control room, intake pump house and DM plant for controlling the systems. Each DC system comprises of the Storage Battery, the

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Battery charger and the distribution boards. The details are mentioned below]

Description	Units	Design Parameters
Make	<i>[....]</i>
Capacity /Rating	<i>[....]</i>
Voltage	V	<i>[....]</i>
Type of Charger	<i>[....]</i>
Area of Application	<i>[....]</i>

g) Emergency Power Supply System

[Diesel generating sets are installed for meeting the power requirements of essential auxiliaries (viz. jacking oil pumps, AC lube oil pump, hydrogen seal oil pump, float charger for DC battery, emergency lighting, scanner air fan and stator cooling water pump) during total failure of AC Power Supply in the power station. Diesel generating sets are located in the CD bay at the ground floor. The details are mentioned below]

Description	Units	Design Parameters
Make of DG Sets	.....	<i>[....]</i>
Rating of DG Sets	kVA	<i>[....]</i>
Quantity	Nos.	<i>[....]</i>

h) Public Address System

[The unit is provided with paging and party channels comprising handset stations with amplifiers, transmitters, receivers and loud speakers. The system facilitates paging, communication and also private conversation as on conventional telephone.]

i) Illumination System

[For indoor application, fluorescent/ energy saving compact fluorescent fixtures have been provided. For high bay areas and outdoor application, suitable high intensity discharge Mercury Vapour/ Sodium Vapour lighting fixtures have been installed. Aviation type fixtures have been installed at the Chimney]

3.2.4 Control & Instrumentation

[The existing control and instrumentation system generally is an old analogue based system and requires large scale replacement owing to obsolescence of the existing equipments. Furnace Supervisory Safeguard System (FSSS) is of obsolete design for which, no spares are available.

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Soot blowers are of manual type. No online Boiler Tube Leakage detection system has been provided. The turbine is equipped with an electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. Turbine Supervisory system is of electromagnetic type. No continuous monitoring system has been provided for observing the health of the turbine. HP- LP bypass system is in the form of standalone control panel. Integrated microprocessor based closed loop control, open loop control, sequential control and bulk data acquisition system for SG & auxiliaries, TG & auxiliaries, station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level are therefore to be envisaged for the plant.]

3.2.5 Balance of Plant

a) Coal Handling Plant

[Coal Handling Plant is a common facility which is feeding all the units of the power plant having a total installed capacity of...x.....MW. Coal to the power plant is brought through railways by 'Box N' /'BOBR' wagons and is unloaded by wagon tipplers/ track hopper. One crusher has been provided for crushing the coal from 250 mm size to 25 mm size. The plant is provided with one stacker reclaimer to stock the crushed coal. The coal stock yard has a storage capacity of 20 days. For feeding the coal to the bunkers of all the units, two streams of conveyors having a capacity ofTPH have been provided. The coal handling plant operates for 16 hrs a day.]

Description	Units	Design Parameters
No. of Wagon Tipplers	Nos.	[...]
Rating of Wagon Tipplers	T/h	[...]
Length of the Track Hopper	m	[...]
No. of streams of conveyor	Nos.	[...]
Capacity of each conveyor	T/h	[...]
Type of Crushers	Nos.	[...]
Number of Crushers	Nos.	[...]
Capacity of Crushers	T/ hr	[...]
No. of Stacker Reclaimers	Nos.	[...]
Stacking Capacity	TPH	[...]
Reclaiming Capacity	TPH	[...]

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Description	Units	Design Parameters
Storage Capacity of Stock Yard	days	[....]

b) Ash Handling Plant

[Ash Handling System is of continuous type. The bottom ash from the furnace falls into bottom ash hopper having a storage capacity of [...] hrs. The ash is removed with the help of submerged Scrapper Chain Conveyors. The ash from the air pre-heater and economizer hoppers is being disposed off along with bottom ash. The ash in the form of ash slurry is conveyed through sluice channels to the ash slurry pump house with the help of high pressure jets, from where, it is pumped to the ash pond located the distance of [...] km. [...] The ash slurry pump house is provided with [...] numbers of ash slurry pumps of rating [...], out of which [...] pumps are normally working. The ash slurry disposal system is having [...].numbers of identical streams of ash slurry pumps connected to [...] numbers of ash slurry pipelines going to the ash pond. Fly ash is collected in dry form below the ESP hoppers and the same is then conveyed by vacuum system to surge hoppers from where it is either conveyed through pressurized system to dry fly ash silos or is sent to ash pond in the form of slurry. From the dry fly ash silos, the ash is disposed off through the covered trucks.]

c) Raw Water System

[The consumptive water for the plant is sourced from [...] river/sea located at a distance of [...] km from the plant boundary. The intake water pump house is installed with [...] intake pumps of capacity [...] m³/hr, out of which [...] pumps are normally working and the remaining [...] pumps are standby. The raw water is pumped from the intake water pump house to the in-plant raw water reservoir, which has a storage capacity of [...] days.]

d) CW / ACW System and Cooling Towers

[CW system for the power plant works on re-circulating system with induced draft cooling towers. The CW system uses raw/clarified quality of water and is working on [...] cycles of concentration. CW pump house is a common facility for all the units of the power plant. There are two CW pumps of capacity [...] m³/hr provided for each unit. In addition, there are two standby CW pumps common to all the units. The requirement of ACW system is being tapped from the cold CW header feeding the condenser. The hot return ACW water after cooling the auxiliaries of boiler and turbine joins the hot CW header and is sent to the cooling towers for cooling. The cold water from the cooling water flows to the fore bay of CW Pump House for recirculation into the system. One induced draft cooling tower (IDCT) has been provided for each unit. The cooling tower cools the water from [...] deg C to [...] deg C. The cooling tower has been designed for an inlet wet bulb temperature of [...] deg C].

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e) Water Pre-Treatment Plant

[Water Pre-Treatment Plant is a common facility for all the units of the power plant. Pre-treatment plant supplies clarified water to DM plant, cooling water to the auxiliaries of BOP system, coal handling plant dust suppression and to the drinking water system. There are two numbers of clarifiers of [...].m³/hr capacity to meet all the clarified water requirements of the whole plant, except DM plant. The clarified water requirement for DM plant is met by a separate clarifier of capacity [...] m³/hr.]

f) DM Plant

[DM plant consists of three streams, each of [...] m³/hr capacity. There are two DM water tanks of [...].m³ capacity. A common regeneration system has been provided for all the three streams. DM plant operates on semi-automatic system with PLC controls.]

g) Air-Conditioning and Ventilation System

[The central control room, switchyard control room, ESP controls room and selected areas of service building have been provided with centralized air-conditioning system. The central air-conditioning system of chilled water type has been provided for various control rooms and DX type of plant has been provided for ESP control room, switchyard control room and other areas in the service building. Packaged type of air-conditioners has been provided for water treatment plant control room. Evaporative ventilation system has been provided for TG building along with roof extractors. Other areas are ventilated by a combination of exhaust and supply air fans].

h) Fire Fighting System

[Fire fighting system is a common facility provided for all the units. This consists of pressured hydrant system for all the auxiliary buildings, pump houses and administrative building. Automatic high velocity sprinklers system has been provided for power transformers, turbine oil tanks and lube oil system equipments. Medium velocity sprinkler system has been provided for cable galleries and coal conveyor galleries. Portable types of fire extinguishers have been provided throughout the plant for fighting small and localized fires.]

i) Plant and Instrument Air System

[Plant and instrument air system is a common facility for all the units of the plant. For meeting the instrument air requirement, [...] number of oil free screw compressors [...] working and [...] standby, each of [...] m³/hr capacity and discharge pressure of [...] kg/cm (g) have been provided along with dryers. Equal number of air compressors of similar rating has been provided to meet the requirement of plant air system. The air drying plant for the instrument air has been provided to achieve a dew point of (-) 40°C at atmospheric pressure.]

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j) Fuel Oil System

[The fuel oil system has been designed for the use of Light Diesel Oil (LDO) for start- up and Heavy Fuel Oil (HFO) for load carrying and flame stabilization purposes. Two tanks of [...] kl each have been provided for the storage of HFO and two tanks of [...] kl each have been provided for the storage of LDO. The system has been provided with unloading, transferring and pressurization pumps along with necessary filters and heating arrangement.]

k) Cranes/Hoists

[For the maintenance of various equipments, manually /electrically operated cranes and hoists have been provided.]

3.2.6

Civil Works

Major civil works of the unit consist of the following:

(a) Main Power House Building:

[A common Power House Building has been provided to house [3x200 MW] units which are placed side by side. Centre to centre placing of units is [67.5 m.] The railway entry has been provided from the rear side of Power House Building. Turbine Generator (TG) Sets have been placed between AB rows of columns are laid out longitudinally. The TG bay, also houses, the Boiler Feed Pumps, Regenerative Heaters, Lube Oil System and other TG accessories. The total length of TG bay for 3x210 MW units is [276 m] and width [30 m]. The spacing of the column is at [7.5 m]. TG bay is provided with 2 Nos. of overhead EOT Cranes. In order to make the handling facilities of the cranes available to the heat exchangers, boiler feed pumps and other equipments, removable chequered plates have been provided at appropriate locations.

A sub zero floor has been avoided except for the localized pits required for Condensate Pump, pipe channels and HP Heaters etc. This sub zero pits are suitably connected and provided with a common sump for drainage purposes.

Three stairs for approaching the operating floor level at [+ 10 m] have been provided in this bay adjacent to B row columns. In addition, there are stairs for providing access to various equipments at intermediate platforms and sub zero pits.

Switchgear and Control Room bay has been provided in the BC bay which is [12 m] wide. The length of the bay is [249.0 m]. A common Control Room for all the three units is provided at [10 m] floor. In BC bay at [16 m] elevation, equipments for chemical dosing, air handling and MCC for soot blowers etc have been located. The deaerator is placed at an elevation of [23.0 m]. Air washer units and cooling water tanks are also located at [23.0 m] floor.

Mill Bunker Bay, designated as CD bay, has a span of [10.5 m] which accommodates coal bunkers, coal feeders and coal mills. CD bay houses

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the vertical mills at Zero m and has space for collection of disposal of mill rejects at sub zero levels adjacent to 'D' row. A stair to connect operating floor at [16.0 & 23.0 m] of BC & CD bay has been provided.]

(b) Boiler Area

[In boiler area, the boiler with its auxiliaries like PA fan, FD fan, ID fan as well as Electrostatic Precipitator has been located.]

(c) Chimney

[A common multi-flue Chimney of 220 m height has been constructed in which, flue cans of [3x200 MW] have been erected.]

(d) Transformer Yard

[A [60] m wide yard has been provided outside the 'A' row columns. The transformer yard houses station transformer, unit auxiliary transformers and generator transformers along with oil pits etc. To facilitating erection and maintenance of transformers, the area has been provided with rail tracks parallel to 'A' row at a distance of [45 m] from 'A' row which is further connected through cross tracks. In addition, space has been provided for laying the CW pipelines and locating the butterfly valve chambers.]

(e) Service building

[A common four storey building has been provided near the main plant building and it is connected with the operating floor of TG bay at [10 m] level.]

(f) Miscellaneous buildings

[Besides the above, miscellaneous buildings like administrative building, CW Pump House, Fire Water Pump House, CHP Control Room, ESP Control Room, Chimney, DM Plant Building, Chemical House and Ash Silos have been provided.]

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4 OPERATIONAL HISTORY OF THE PLANT

4.1 General

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The Average Performance Parameters of the unit over the past 25 years are shown in Table 4.1.

Table 4.1
Unit's Average Performance Parameters over the life

Years after Installation	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
5	[...]	[...]	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Table 4.2 indicated below, illustrates variations over the last five years in the performance parameters.

{Furnish in the Table 4.2 below, the Average Values for the last five years. However, for the Parameters in respect of 'One Year back' and 'Current Year', furnish the Maximum, the Minimum and the Average Values.}

Table 4.2
Unit's Performance Parameters during the Last Five Years

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
Four Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Three Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]

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Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
Two Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
One Year back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Current year	[...]	[...]	[...]	[...]	[...]	[...]	[...]

4.2 Stack Emissions, Ambient Air Quality and Process Effluents

The Project has been regularly monitoring the environmental parameters such as stack monitoring, ambient air quality (AAQ), noise pollution and liquid waste pollution in accordance with applicable norms by employing *[M/s....., an agency approved by State Pollution Control Board]*.

The existing environmental data and the limits specified for different pollutants, the locations of their measurements and the frequency of monitoring are given in the table below.

Table 4.3
Status of Stack Emissions, Ambient Air Quality and Process Effluents

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
Stack Emissions	SPM (mg/Nm ³)	<i>Not to exceed [...]</i>	[...]		[...]	[...]
Ambient Air Quality		<i>On 24 Hrs Basis</i>	<i>On Annual Basis</i>	<i>On 24 Hrs Basis</i>	<i>On Annual Basis</i>	[...]
	SPM (µg/m ³)	[...]	[...]	[...]	[...]	
	RPM (µg/m ³)	[...]	[...]	[...]	[...]	
	SO ₂	[...]	[...]	[...]	[...]	

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)			Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
	(µg/m³)						
	NOx	[...]	[...]	[...]	[...]		
	(µg/m³)						
Process Effluent	Boiler Blow Down					[...]	[...]
	SS (mg/l)	[...]		[...]			
	Oil & grease (mg/l)	[...]		[...]			
	Cu (mg/l)	[...]		[...]			
	Fe (mg/l)	[...]		[...]			
	Cooling Tower Blow Down						
	Free Cl ₂ (mg/l)	[...]		[...]			
	Zn (mg/l)	[...]		[...]			
	Cr (mg/l)	[...]		[...]			
	PO ₄ (mg/l)	[...]		[...]			
	pH	[...]		[...]			
	Oil & grease (mg/l)	[...]		[...]			
	BOD (mg/l)	[...]		[...]			

4.3 Major Replacements in the last ten years

[Major replacements of equipment and systems in the Power Project and capital expenditures in the last 10 years from.....toare indicated in the table 4.4 below]

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Table 4.4
Major Replacements & Capital Expenditure done during the last 10 years

S.No.	Name of the Equipment	Reason for replacement	Capital Expenditure
1	[.....]	[.....]	[.....]
2	[.....]	[.....]	[.....]
3	[.....]	[.....]	[.....]
4	[.....]	[.....]	[.....]
5	[.....]	[.....]	[.....]
6	[.....]	[.....]	[.....]
7	[.....]	[.....]	[.....]
8	[.....]	[.....]	[.....]
9	[.....]	[.....]	[.....]
10	[.....]	[.....]	[.....]

5 BOILER AND AUXILIARIES

5.1 General

{Discuss in this section, the actual operating parameters with respect to the design parameters and the action plan recommended to reduce the energy consumption of the Boiler and its Auxiliaries based upon the findings of Performance and Efficiency Test. Discuss the recommendations based upon the Cost Benefit Analysis and the results of the Energy Audit carried out on the Boiler, Air Pre-Heater, Mills, ID/FD/PA Fans and ESP etc.}

Guidelines for carrying out the Energy Audit for various equipments are appended at the end of this model document, for general reference.}

5.2 Operating Parameters of Boiler and Auxiliaries

{Discuss below the Design Parameters and Actual Operating Parameters of the Boiler}.

5.2.1 Operating Parameters of the Boiler

Design and Actual Operating Parameters of the Boiler are given in the Tables below:

Table 5.1
Design and Operating Parameters of the Boiler

Description	Units	Design Parameter	Actual Operating Parameter
Main Steam flow	tph	[.....]	[.....]
Main steam pressure	kg/cm ²	[.....]	[.....]
Main steam temperature	°C	[.....]	[.....]
Reheater outlet flow	tph	[.....]	[.....]
Steam temperature at re- heater inlet	°C	[.....]	[.....]
Steam temperature at re- heater outlet	°C	[.....]	[.....]
Steam pressure at re -heater inlet	kg/cm ²	[.....]	[.....]
Steam pressure at re -heater outlet	kg/cm ²	[.....]	[.....]
Steam temperature at LTSH outlet	°C	[.....]	[.....]
Saturated steam temperature in drum	°C	[.....]	[.....]
Super heater platen outlet temperature	°C	[.....]	[.....]

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Description	Units	Design Parameter	Actual Operating Parameter
Pressure drop in re- heater	kg/cm ²	[.....]	[.....]
Economizer inlet temperature	°C	[.....]	[.....]
Super heater spray	tph	[.....]	[.....]
Re heater spray	tph	[.....]	[.....]
Ambient temperature	°C	[.....]	[.....]
Coal consumption	tph	[.....]	[.....]
GCV of Coal	kCal/kg	[.....]	[.....]

5.2.2 Operating Parameters of Economiser

Design and Actual Operating Parameters of the Economiser are given in the Tables below:

Table 5.2
Design and Operating Parameters of Economiser

Description	Unit	Design Parameter	Actual Operating Parameter
Feed water pressure at the inlet	kg/cm ²	[.....]	[.....]
Feed water pressure at the outlet	kg/cm ²	[.....]	[.....]
Feed water flow	tph	[.....]	[.....]
Feed water temperature at the inlet	°C	[.....]	[.....]
Feed water temperature at the outlet	°C	[.....]	[.....]
Oxygen content in flue gas before economizer	%	[.....]	[.....]
Excess air % in flue gas before economizer	%	[.....]	[.....]
Flue gas inlet temperature	°C	[.....]	[.....]
Flue gas outlet temperature	°C	[.....]	[.....]

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5.2.3 Operational Parameters of Air Pre-heater

Design and operational parameters of Air Pre-heater are given in the table below:

Table 5.3
Design and Operating Parameters of AIR Pre-heater

Description	Units	Design Parameter	Actual Operating Parameter
Air quantity at APH outlet (Primary)	tph	[.....]	[.....]
Air Quantity at APH outlet (Secondary)	tph	[.....]	[.....]
Air temperature at APH inlet	°C	[.....]	[.....]
Air outlet temperature of APH - primary	°C	[.....]	[.....]
Air outlet temperature of APH – secondary	°C	[.....]	[.....]
Oxygen content in flue gas before APH	%	[.....]	[.....]
Oxygen content in flue gas before APH	%	[.....]	[.....]
Excess air % in flue gas before APH	%	[.....]	[.....]
Flue gas inlet temperature	°C	[.....]	[.....]
Flue gas outlet temperature	°C	[.....]	[.....]
Flue gas quantity	tph	[.....]	[.....]
Others	---	[.....]	[.....]

5.2.4 Temperature Profile of Flue Gas

Design and actual profile of flue gas is given in the table below:

Table 5.4
Design and Actual Profile of Flue Gas

Description	Units	Design Value	Actual Value
Super heater platen outlet	°C	[.....]	[.....]
Front RH inlet	°C	[.....]	[.....]
Rear RH inlet	°C	[.....]	[.....]
Final SH inlet	°C	[.....]	[.....]

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Description	Units	Design Value	Actual Value
LTSH inlet	°C	[.....]	[.....]
Economizer inlet	°C	[.....]	[.....]
APH inlet	°C	[.....]	[.....]
APH outlet	°C	[.....]	[.....]
ID fan inlet	°C	[.....]	[.....]
ID fan outlet	°C	[.....]	[.....]

5.2.5 Feed Water and Boiler Water Quality

Design and actual quality of the Boiler Water and Feed Water is given below:

Table 5.5
Design and Actual values of Boiler Water and Feed Water

Description	Unit	Feed Water		Boilers Water	
		Design	Actual	Design	Actual
Hardness	ppm	[.....]	[.....]	[.....]	[.....]
pH at 25°C	pH	[.....]	[.....]	[.....]	[.....]
Oxygen – maximum	ppm	[.....]	[.....]	[.....]	[.....]
Total iron – maximum	ppm	[.....]	[.....]	[.....]	[.....]
Total silica - maximum	ppm	[.....]	[.....]	[.....]	[.....]
Conductivity at 25°C	$\mu\Omega/\text{cm}$	[.....]	[.....]	[.....]	[.....]
Hydrazine residual	ppm	[.....]	[.....]	[.....]	[.....]
Total solids – maximum	ppb	[.....]	[.....]	[.....]	[.....]
Chlorides	ppm	[.....]	[.....]	[.....]	[.....]
Copper – maximum	ppm	[.....]	[.....]	[.....]	[.....]
Oil	ppm	[.....]	[.....]	[.....]	[.....]

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5.2.6 Mill Performance Data

Design and Actual Performance Data of the Mills is furnished below:

Table 5.6
Design and Actual Performance Data of Mills

Description	Design Value	Actual Operating Value					
		Mill-1	Mill-2	Mill-3	Mill-4	Mill-5	Mill-6
Mill inlet coal flow (tph)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Mill inlet temp. (°C)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Mill outlet temp. (°C)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Mill differential pressure. (mmwc)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Air flow to mill (tph)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
PA common header pressure (mmwc)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Coal Fineness Passing through 200 mesh(%)	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Mill reject, kg/hr.	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Specific energy consumption kWh/ton of Coal.	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

5.2.7 Heat Losses and Efficiency of the Boiler

Break up of Heat Losses as well as Design and Actual Values of Boiler Efficiency are given below:

Table 5.7
Heat Balance of the Boiler

Description	Symbol	Unit	Design Value	Actual Value
Ambient Temp	--	°C	[.....]	[.....]
Excess Air	--	%	[.....]	[.....]
Unburnt Carbon Loss	Z1	%	[.....]	[.....]

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Description	Symbol	Unit	Design Value	Actual Value
Dry Gas Loss	Z2	%	[.....]	[.....]
Loss due to Moisture in Fuel	Z3	%	[.....]	[.....]
Loss due to Hydrogen in Fuel	Z4	%	[.....]	[.....]
Loss due to Moisture in Air	Z5	%	[.....]	[.....]
Loss due to Carbon Monoxide	Z6	%	[.....]	[.....]
Sensible heat loss in fly ash	Z7	%	[.....]	[.....]
Sensible heat loss in bottom ash	Z8	%	[.....]	[.....]
Radiation loss	Z9	%	[.....]	[.....]
Total losses $Z = Z1 + Z2 + Z3 + Z4 + Z5 + Z6 + Z7 + Z8 + Z9$	Z	%	[.....]	[.....]
Actual Boiler Efficiency	Eff _a	%	[.....]	[.....]
Design Boiler Efficiency	Eff _d	%	[.....]	[.....]

5.3

Action Plan for Reducing the Energy Consumption

{Discuss in the Table below, one by one, all the equipment for which the action is recommended to be taken for improving the efficiency and reducing the power consumption in the light of energy audit and cost benefit analysis of the recommendations. Discuss the presently operating parameters/ efficiency / power consumption of the equipment at rated performance parameters in comparison to the corresponding values as per design. Target values indicated in the table should be equal or better than the design values. Also attach the results of Energy Audit for the equipments in the form of Annexure. Formats for reporting the results of Energy Audit have been appended at the end of this Model Document for reference. The Formats provided for a particular kind of equipment may be used for similar remaining Equipment.}

Table-5.8
Summary of Action Plan for Boiler and Auxiliaries

Description	Design Value	Operating Value	Target Value	Recommended Action Plan	Cost Impact
Efficiency of Boiler	[.....]	[.....]	[.....]	[.....]	[.....]

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Description	Design Value	Operating Value	Target Value	Recommended Action Plan	Cost Impact
Air Pre Heater – Cold end Temperature	[.....]	[.....]	[.....]	[.....]	[.....]
Air Pre Heater - Air Leakage	[.....]	[.....]	[.....]	[.....]	[.....]
Air Pre Heater - Gas Side Efficiency	[.....]	[.....]	[.....]	[.....]	[.....]
Power Consumption of Mill A (as per full loading of the mill)	[.....]	[.....]	[.....]	[.....]	[.....]
Power Consumption of Mill B (as per full loading of the mill)	[.....]	[.....]	[.....]	[.....]	[.....]
Power Consumption of Mill C (as per full loading of the mill)	[.....]	[.....]	[.....]	[.....]	[.....]
Power Consumption of Mill D (as per full loading of the mill)	[.....]	[.....]	[.....]	[.....]	[.....]
Power Consumption of Mill E (as per full loading of the mill)	[.....]	[.....]	[.....]	[.....]	[.....]
Power Consumption of Mill F (as per full loading of the mill)	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of ID Fan A	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of ID	[.....]	[.....]	[.....]	[.....]	[.....]

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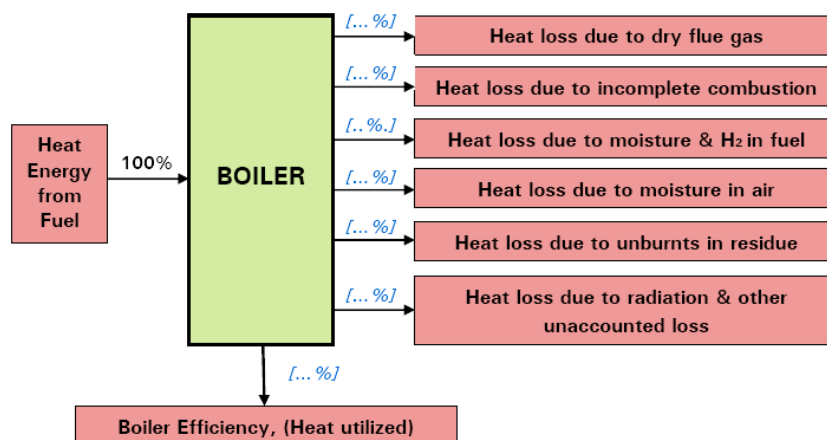
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Description	Design Value	Operating Value	Target Value	Recommended Action Plan	Cost Impact
Fan B					
Efficiency of FD Fan A	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of FD Fan B	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of PA Fan A	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of PA Fan B	[.....]	[.....]	[.....]	[.....]	[.....]
ESP Efficiency	[.....]	[.....]	[.....]	[.....]	[.....]
ESP- Emission of SPM	[.....]	[.....]	[.....]	[.....]	[.....]
<i>Total Cost Impact</i>					[.....]

Energy Audit Results of Boiler and Auxiliaries are attached at Annexure [...] to [...] of the Report.

5.4 Sankey Diagram for the Efficiency of the Boiler

{Insert a Sankey diagram for the energy input, output and different losses with range of values being presently achieved, as well as, those expected after the implementation of recommendations for R&M. A suggestive diagram is given below.}



5.5 Schematic Diagrams of the Boiler & Auxiliaries

Schematic Diagrams of the Boiler & Auxiliaries indicating the locations of measuring instruments used during the test are attached at Annexure [.....].

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6 STEAM TURBINE GENERATOR AND AUXILIARIES

6.1 General

{Discuss in this section, the actual operating parameters with respect to the design parameters and the action plan recommended to reduce the energy consumption of Steam Turbine Generator and its Auxiliaries, based upon the findings of Turbine Heat Rate. Discuss the recommendations based upon the Cost Benefit Analysis and the results of the Energy Audit carried out on Steam Turbine Generator, Condenser, CEPs, BFPs and Water Heaters.

Guidelines for carrying out the Energy Audit for various equipments are

6.1.1 Operating Parameters of Steam Turbine

S.No.	Parameters	Units	Design Value	Operating Value	Deviation
1	Load	MW	[.....]	[.....]	[.....]
2	Auxiliary Consumption	MW	[.....]	[.....]	[.....]
3	Main Steam Pressure Before ESV	kg/cm ²	[.....]	[.....]	[.....]
4	Main Steam Temp. Before ESV	°C	[.....]	[.....]	[.....]
5	CRH Pressure	°C	[.....]	[.....]	[.....]
6	CRH Temperature	°C	[.....]	[.....]	[.....]
7	HRH Pressure	kg/cm ²	[.....]	[.....]	[.....]
8	HRH Temperature	°C	[.....]	[.....]	[.....]
9	IPT exhaust Temp.	°C	[.....]	[.....]	[.....]
10	Turbine exhaust Temp.	°C	[.....]	[.....]	[.....]
11	Condenser back pressure	kg/cm ²	[.....]	[.....]	[.....]
12	SH Spray Flow	TPH	[.....]	[.....]	[.....]
13	RH Spray Flow	TPH	[.....]	[.....]	[.....]
14	Feed water flow	TPH	[.....]	[.....]	[.....]
15	Feed water Temp.	°C	[.....]	[.....]	[.....]

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S.No.	Parameters	Units	Design Value	Operating Value	Deviation
16	Soot Blowing Steam Flow	TPH	[.....]	[.....]	[.....]
17	HP Turbine Efficiency	%	[.....]	[.....]	[.....]
18	IP Turbine Efficiency	%	[.....]	[.....]	[.....]
19	LP Turbine Efficiency	%	[.....]	[.....]	[.....]
20	Turbine Heat Rate	kcal/kWh	[.....]	[.....]	[.....]
21	Gross Heat Rate	kcal/kWh	[.....]	[.....]	[.....]

6.1.2 Operating Parameters of Condenser

S.No.	Description	Unit	Design Value	Operating Value	Deviation
1	CW inlet temp	°C	[.....]	[.....]	[.....]
2	CW outlet temp (L)	°C	[.....]	[.....]	[.....]
3	CW outlet temp (R)	°C	[.....]	[.....]	[.....]
4	Condenser back pressure	kg/cm ²	[.....]	[.....]	[.....]
5	Saturation temp	°C	[.....]	[.....]	[.....]
6	TTD	°C	[.....]	[.....]	[.....]
7	Rise in temp of cooling water	°C	[.....]	[.....]	[.....]
8	Condenser heat load	kW	[.....]	[.....]	[.....]
9	Condenser LMTD	°C	[.....]	[.....]	[.....]
10	Condenser efficiency	%	[.....]	[.....]	[.....]
11	DP across condenser	mmwc	[.....]	[.....]	[.....]

6.1.3 Operating Parameters of LP Heaters

Parameters	Units	LPH1		LPH2		LPH3		LPH4	
		Design Value	Actual Value	Design Value	Actual Value	Design Value	Actual Value	Design Value	Actual Value
Feed water inlet temp.	°C								
Feed water outlet temp.	°C								
Feed water	kg/cm ²								

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Parameters	Units	LPH1		LPH2		LPH3		LPH4	
		Design Value	Actual Value	Design Value	Actual Value	Design Value	Actual Value	Design Value	Actual Value
inlet pressure									
Feed water outlet pressure	kg/cm ²								
Extraction steam temp.	°C								
Extraction steam pressure	kg/cm ²								
Drip temp.	°C								
Saturation temp. at heater shell pressure.	°C								
Shell pressure.	kg/cm ²								
TTD	°C								
DCA	°C								
LMTD	°C								

6.1.4 Operating Parameters of HP Heaters

	Units	HPH 5		HPH 6		HPH 7	
		Design	Actual	Design	Actual	Design	Actual
Load	MW	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Feed water inlet temp.	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Feed water outlet temp.	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Feed water inlet pressure	kg/cm ²	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Feed water outlet pressure	kg/cm ²	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Extraction steam temp.	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Extraction steam pressure	kg/cm ²	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

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	Units	HPH 5		HPH 6		HPH 7	
		Design	Actual	Design	Actual	Design	Actual
Drip temp.	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Saturation temp. at heater shell pressure	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
Shell p ressure	kg/cm ²	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
TTD	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
DCA	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]
LMTD	°C	[.....]	[.....]	[.....]	[.....]	[.....]	[.....]

6.2 Action Plan to Reduce Energy Consumption

{Discuss in the Table below, one by one, all the equipment for which the action is recommended to be taken for improving the efficiency and reducing the power consumption as per the cost benefit analysis of energy audit carried out. Discuss the presently operating Heat Rate / efficiency / power consumption and other parameters of the equipment at rated performance parameters in comparison to the corresponding values as per design. Target values indicated in the table should be equal or better than the design values. Also attach the results of Energy Audit for the equipments in the form of Annexure.

Formats for reporting the results of Energy Audit have been appended at the end of this Model Document for reference. The Formats provided for a particular kind of equipment may be used for similar remaining Equipment.}

Table-6.1
Summary of Action Plan for Steam Turbine Generator and Auxiliaries

Description	Design Value	Operating Value	Target Value	Recommended Action Plan	Cost Impact
Turbine Heat Rate	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of HP Cylinder	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of IP Cylinder	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of LP Cylinder	[.....]	[.....]	[.....]	[.....]	[.....]

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Description	Design Value	Operating Value	Target Value	Recommended Action Plan	Cost Impact
Condenser TTD	[.....]	[.....]	[.....]	[.....]	[.....]
Condenser Efficiency	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of CEP-A	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of CEP-B	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of CEP-C	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-1 TTD	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-2 TTD	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-3 TTD	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-4 TTD	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-1 DCA	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-2 DCA	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-3 DCA	[.....]	[.....]	[.....]	[.....]	[.....]
LP Heater-4 DCA	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of BFP-A	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of BFP-B	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of BFP-C	[.....]	[.....]	[.....]	[.....]	[.....]
HP Heater-1 TTD	[.....]	[.....]	[.....]	[.....]	[.....]
HP Heater-2 TTD	[.....]	[.....]	[.....]	[.....]	[.....]
HP Heater-3 TTD	[.....]	[.....]	[.....]	[.....]	[.....]

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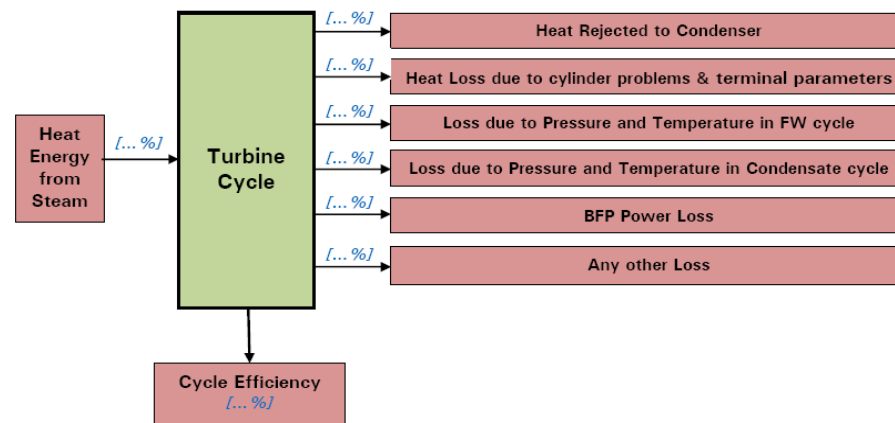
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Description	Design Value	Operating Value	Target Value	Recommended Action Plan	Cost Impact
HP Heater-1 DCA	[.....]	[.....]	[.....]	[.....]	[.....]
HP Heater-2 DCA	[.....]	[.....]	[.....]	[.....]	[.....]
HP Heater-3 DCA	[.....]	[.....]	[.....]	[.....]	[.....]
Efficiency of Generator	[.....]	[.....]	[.....]	[.....]	[.....]
	Total Cost Impact				[.....]

Energy Audit Results of Steam Turbine and Auxiliaries are attached at Annexure [...] to [...] of the Report.

6.3 Sankey diagram for the Efficiency of Turbine & Auxiliaries

{Insert a Sankey diagram for the energy input, output and different losses with range of values being presently achieved, as well as, those expected after the implementation of recommendations for R&M. A suggestive diagram is given below.}



6.4 Schematic Diagram of the Steam Turbine Generator

Schematic Diagram of the Steam Turbine Generator indicating the locations of measuring instruments is attached at Annexure [.....].

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7 BALANCE OF PLANT SYSTEMS

7.1 General

{Discuss in this section, the action plan recommended to reduce the energy consumption of Balance of Plant, based upon the findings of Performance Test and Measurement of Energy Consumption of Intake Water Pumps, CW & ACW Pumps, Ash Handling Systems and Pumps, Induced Draft Cooling Towers, Pre-Treatment and DM Plant, Coal Handling Plant Equipment, Fuel Oil Handling Pumps, Compressed Air System, HVAC System etc. Discuss the recommendations based upon the Cost Benefit Analysis.

Guidelines for carrying out the Energy Audit for various equipments are appended at the end of this document for general reference.}

7.2 Action Plan for Reducing the Energy Consumption

{Discuss in the Table below, one by one all the equipment for which the action is recommended to be taken for improving the efficiency and reducing the power consumption as per the cost benefit analysis of energy audit carried out. Discuss the presently operating parameters/efficiency / power consumption of the equipment at rated performance parameters in comparison to the corresponding parameters as per design. Target parameters indicated in the table should be equal or better than the design parameters. Also attach the results of Energy Audit for the equipment in the form of Annexure.

Formats for reporting the results of Energy Audit have been appended at the end of this Model Document for reference. The Formats provided for a particular kind of equipment may be used for similar remaining Equipment.}

Table- 7.1
Summary of Action Plan for Balance of Plant and Auxiliaries

Description	Design Parameters	Operating Parameters	Target Parameters	Recommended Action Plan	Cost Impact
Water Intake Pumps	[.....]	[.....]	[.....]	[.....]	[.....]
CW Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
CW Pump-2	[.....]	[.....]	[.....]	[.....]	[.....]
CW Pump-3	[.....]	[.....]	[.....]	[.....]	[.....]
ACW Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
ACW Pump-2	[.....]	[.....]	[.....]	[.....]	[.....]
ACW Pump-3	[.....]	[.....]	[.....]	[.....]	[.....]

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Description	Design Parameters	Operating Parameters	Target Parameters	Recommended Action Plan	Cost Impact
Clariflocculator -1	[.....]	[.....]	[.....]	[.....]	[.....]
Clariflocculator -2	[.....]	[.....]	[.....]	[.....]	[.....]
Clarified Water Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
Clarified Water Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
DM Water Make up Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
DM Water Make up Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
Cooling Tower Fans	[.....]	[.....]	[.....]	[.....]	[.....]
Clinker Grinder-1	[.....]	[.....]	[.....]	[.....]	[.....]
Clinker Grinder-2	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Water Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Water Pump-2	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Water Pump-3	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Slurry Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Slurry Pump-2	[.....]	[.....]	[.....]	[.....]	[.....]
Ash Slurry Pump-3	[.....]	[.....]	[.....]	[.....]	[.....]
Wagon Tippler	[.....]	[.....]	[.....]	[.....]	[.....]
Apron Feeder-1	[.....]	[.....]	[.....]	[.....]	[.....]
Apron Feeder-2	[.....]	[.....]	[.....]	[.....]	[.....]

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Description	Design Parameters	Operating Parameters	Target Parameters	Recommended Action Plan	Cost Impact
Primary Crusher-1	[.....]	[.....]	[.....]	[.....]	[.....]
Primary Crusher-2	[.....]	[.....]	[.....]	[.....]	[.....]
Secondary Crusher-1	[.....]	[.....]	[.....]	[.....]	[.....]
Secondary Crusher-1	[.....]	[.....]	[.....]	[.....]	[.....]
Heavy Duty Conveyor-1	[.....]	[.....]	[.....]	[.....]	[.....]
Heavy Duty Conveyor-2	[.....]	[.....]	[.....]	[.....]	[.....]
Plant Air Compressor-1	[.....]	[.....]	[.....]	[.....]	[.....]
Plant Air Compressor-2	[.....]	[.....]	[.....]	[.....]	[.....]
Instrument Air Compressor -1	[.....]	[.....]	[.....]	[.....]	[.....]
Instrument Air Compressor -2	[.....]	[.....]	[.....]	[.....]	[.....]
Fuel Oil Forwarding Pump-1	[.....]	[.....]	[.....]	[.....]	[.....]
Fuel Oil Forwarding Pump-2	[.....]	[.....]	[.....]	[.....]	[.....]
HVAC System	[.....]	[.....]	[.....]	[.....]	[.....]
Any other Equipment consuming more than 50 kW	[.....]	[.....]	[.....]	[.....]	[.....]
Total Cost Impact					[.....]

Audit Results of Balance of Plant Equipments are attached at Annexure [...] to [...] of the Report.

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{Numbers of equipment indicated in Table above are indicative only. The number of different equipment should be based on actual number of equipment of the Power Project, for which Energy Audit is to be carried out.}

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8 THERMAL INSULATION

8.1 General

{Discuss in this section, the action plan recommended to reduce the heat loss due to poor or damaged condition of thermal insulation based upon the findings of Energy Audit. Guidelines for carrying out the Energy Audit for various equipments are appended at the end of this model document for general reference.}

8.2 Action Plan for Reducing the Heat Loss

{Discuss in the Table below, one by one, all the equipment for which the action is recommended to be taken to reduce the heat loss due to poor or damaged condition of thermal insulation, as per the cost benefit analysis of energy audit carried out. A few important locations are given below for reference Discuss the present heat loss, the estimated cost impact of the action plan against the expected saving in the fuel cost and payback period. Also attach the results of Energy Audit for the equipments in the form of Annexure.}

Formats for reporting the results of Energy Audit have been appended at the end of this Model Document for reference.}

Table 8.1

Description of Piping/ Body of Equipment	Location	Status of Insulation	Recommended Action Plan	Cost Impact
[Main Steam Piping]	[Near Boiler Safety Valve]	[.....]	[.....]	[.....]
	[Top of the down comer from boiler]	[.....]	[.....]	[.....]
	[Entry to Turbine ESV]	[.....]	[.....]	[.....]
[Cold Re-heat Pipe]	[Adjoining NRV]	[.....]	[.....]	[.....]
[Hot Re-heat Pipe]	[Near Safety Valve]	[.....]	[.....]	[.....]
	[Near LP Bypass]	[.....]	[.....]	[.....]
[Man Hole]	[Deaerator]	[.....]	[.....]	[.....]

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Description of Piping/ Body of Equipment	Location	Status of Insulation	Recommended Action Plan	Cost Impact
[Covers]	[HP Heaters]	[.....]	[.....]	[.....]
	[LP Heaters]	[.....]	[.....]	[.....]
[Outdoor Steam Piping]	[Between Boiler and Turbine House]	[.....]	[.....]	[.....]
	[Deaerator Floor]	[.....]	[.....]	[.....]
[Hanger locations on steam piping]	[.....]	[.....]	[.....]	[.....]
[Insulation of Boiler Shell]	[All burner floors]	[.....]	[.....]	[.....]
[Auxiliary Steam Headers]	[22 ata]	[.....]	[.....]	[.....]
	[16 ata]	[.....]	[.....]	[.....]
	[3 ata]	[.....]	[.....]	[.....]
HP/LP Heaters	[Level gauge connections]	[.....]	[.....]	[.....]
	[Drain connections]			
[Boiler Feed Discharge Piping]	Control Station			
[Steam Turbine]	Lower Half Casing			
[HFO System]	Tank Shells			
	Heat tracing of pipes			
Total Cost Impact				[.....]

Energy Audit Results of Thermal Insulation are attached at Annexure [...] to [...] of the Report.

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9 ILLUMINATION SYSTEM

9.1 General

{Discuss the methodology adopted for conducting the illumination survey and for identifying the illumination deficient areas and the areas where energy loss is taking place due to the inefficient luminaries and lighting fixtures presently installed.

Recommended lux levels for various areas of the power plant and the Guidelines for carrying out the Energy Audit and working out the energy loss are appended at the end of this model document for reference.}

9.2 Action Plan for Reducing the Energy Loss

{Discuss in the Table below, one by one, all the areas where inefficient luminaries and lighting fixtures are recommended to be replaced with the efficient ones as per the cost benefit analysis of energy audit carried out. Some areas have been indicated for reference. Discuss the cost impact of implementing the improvements recommended and the energy loss which can be prevented on annual basis. Support your recommendation with the details of the illumination survey and Cost Benefit Analysis carried out.

Formats for reporting the results of Energy Audit have been appended at the end of this Model Document for reference.}

Table 9.1

Specific Location of Power Plant	Description of lighting fixture to be replaced	Description of lighting fixture to be installed	Reason for Replacement	Cost Impact
[Control Room]	[.....]	[.....]	[.....]	[.....]
[Administrative Office]	[.....]	[.....]	[.....]	[.....]
[Conference Rooms]	[.....]	[.....]	[.....]	[.....]
[Crusher House]	[.....]	[.....]	[.....]	[.....]
[Coal Stock areas]	[.....]	[.....]	[.....]	[.....]
[Switch Yard area]	[.....]	[.....]	[.....]	[.....]
[Hazardous	[.....]	[.....]	[.....]	[.....]

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Specific Location of Power Plant	Description of lighting fixture to be replaced	Description of lighting fixture to be installed	Reason for Replacement	Cost Impact
Area within Fuel Oil Storage Dyke]				
[Ash Slurry Pump House]	[.....]	[.....]	[.....]	[.....]
[Passages inside the buildings]	[.....]	[.....]	[.....]	[.....]
[Periphery lighting around the buildings]	[.....]	[.....]	[.....]	[.....]
[Indoor stair cases]	[.....]	[.....]	[.....]	[.....]
[Roads in side boundary walls]	[.....]	[.....]	[.....]	[.....]
[Open- Water Reservoirs]	[.....]	[.....]	[.....]	[.....]
[Toilets]	[.....]	[.....]	[.....]	[.....]
Total Cost Impact				[.....]

Energy Audit Results of Illumination System are attached at Annexure [...] to [...] of the Report.

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10 COST BENEFIT ANALYSIS

[During the Energy Audit, the Performance Test was conducted on all the continuous operating equipments to first verify the actual operating efficiency/power consumption of each equipment and compare the same with the corresponding value as per design. The reason for deterioration in the efficiency/excess power consumption, if any, was identified.

Recommendations made by R&M Consultant to refurbish the power consuming equipments for increasing efficiency/reducing the energy consumption were examined with respect to the actual expenditure involved for replacing/refurbishing such equipments including cost of training if any, vis-à-vis the expected benefits in power consumption.

Cost benefit calculation were made on the basis of simple payback period as per illustrations given below. The payback period of 5 to 7 years was considered good criteria for deciding to implement the recommendation of R&M Consultant.]

10.1 Illustration-1 on the basis of efficiency monitoring.

[(Let us say Boiler Efficiency).]

Let

IC be the Installed Capacity in MW,

η_a , the Actual Boiler Efficiency before R&M and

η_e , the Expected Boiler Efficiency after R&M. Then,

$$\text{Annual fuel consumption before R\&M} = \frac{IC * 8760 * PLF * TGHR * 1000}{\eta_a} \quad \text{kCal/annum}$$

Where,

PLF = Plant Load Factor

TGHR = Turbine Heat Rate

$$\text{Annual fuel consumption after R\&M} = \frac{IC * 8760 * PLF * TGHR * 1000}{\eta_e} \quad \text{kCal/annum}$$

Expected annual saving in fuel (in kCal/annum) is therefore,

$$\text{Expected annual saving in fuel} = IC * 8760 * PLF * TGHR * 1000 \left\{ \frac{1}{\eta_a} - \frac{1}{\eta_e} \right\}$$

*Annual fuel cost saving = Annual saving in Fuel * Fuel Cost*

$$\text{Pay Back Period in Years} = \frac{\text{Capital Expenditure}}{\text{Annual fuel cost saving}}$$

10.2 Illustration-2 on the basis of power consumption for any equipment

[(Let us Say - a Motor Driven Boiler Feed Pump)]

Let, IC be the Installed Capacity in MW,

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Pa, the actual power consumption of the equipment in kilowatt before R&M and

Pe, the Expected power consumption of the equipment in kilowatt after R&M

Then Saving in power consumption = $P_e - P_a$

*Annual cost of power saving = Power saving (kW) * 8760 * DF * COG*

Where,

DF = Duty factor for equipment in percentage (%).

COG = Cost of Generation (Rs/kWh)

Pay Back Period in Years = $\frac{\text{Capital Expenditure}}{\text{Annual Cost of Power Saving}}$

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11

SUMMARY OF THE RECOMMENDATION OF ENERGY AUDIT

Based upon the recommendations of energy audit reports of various systems, the action plans for improving the efficiency and reducing the power consumption of various plants and equipments have been discussed in sections 5.0 to 9.0. An overall summary of the recommended action plans is furnished in the table below.

Table11.1
Summary of the Recommended Action Plans

Equipment/ Systems	Summary of the Recommended Action Plans	Cost Impact
Boiler and Auxiliaries	[.....]	[.....]
Steam Turbine Generator and Auxiliaries	[.....]	[.....]
Balance of Plant and Systems	[.....]	[.....]
Thermal Insulation	[.....]	[.....]
Illumination System	[.....]	[.....]
Any other System	[.....]	[.....]
Total Cost Impact		[.....]

{GUIDELINES FOR ENERGY AUDIT OF BOILER AND AUXILIARIES}**DETERMINATION OF BOILER EFFICIENCY**

Efficiency of the Boiler should be determined by Heat Loss Method. Guidelines as per the ASME Code PTC– 4 provide a more detailed method of determining the heat losses, whereas Bureau of Energy Efficiency (BEE) Guidelines provide a relatively simple method of determining the heat losses. Both the Guidelines are discussed below.

ASME Code PTC – 4 Guidelines

As per the above code, Net Heat Loss should be worked out by deducting the total heat credits from the total heat loss, i.e,

$$\text{Net Heat Loss} = \text{Total Heat Loss} - \text{Total Heat Credits}$$

As per the above Code, Total Heat Loss consists of the following items:

- i) Heat Loss due to dry flue gases.
- ii) Heat Loss due to evaporation of moisture in fuel.
- iii) Heat Loss due to hydrogen in fuel.
- iv) Heat Loss due to moisture in Air.
- v) Heat Loss due to incomplete combustion to CO.
- vi) Heat Loss due to un-burnt carbon.
- vii) Heat Loss due to mill (pulveriser) rejects.
- viii) Heat Loss due to Radiation and convection (Difficult to evaluate. Hence Design Value [normally 0.18%] should be considered.)

Total Heat Credit consists of the following items:

- i) Heat Credit due to entering dry air.
- ii) Heat Credit due to moisture in entering air.
- iii) Heat Credit due to sensible heat in fuel.
- iv) Energy Credit due to Auxiliary Equipment within the Boiler Envelope as per ASME Code PTC - 4.

As per ASME Code PTC – 4, Efficiency of Boiler is to be worked out by the following equation.

$$\text{Efficiency} = 100 - \% \text{ Net Losses of Heat Input.}$$

Where,

$$\text{Net Losses of Heat Input} = \text{Total Heat Losses} - \text{Total Heat Credits}$$

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BEE Guidelines

As per BEE Guidelines, both (i) the heat credits and (ii) the losses due to mill rejects are neglected. As per BEE Guidelines, the following formulae are to be used for estimating the losses for calculating the efficiency :

i) Heat loss due to dry flue gases L_{dfg} :

$$\text{Stoichiometric air, kg / kg of fuel} = \frac{(11.6 * C)}{100} + \frac{34.8 * H_2 - O_2/8}{100} + \frac{4.35 * S}{100}$$

$$\text{Excess Air Supplied, EA \%} = \frac{O_2\%}{21 - O_2\%} * 100$$

Whereas O_2 = Oxygen Component measured in Flue Gas

$$\text{Actual Air Supplied (AAS), kg of air/kg of fuel} = \frac{1 + EA\%}{100} * \text{Stoichiometric air}$$

Dry flue gas quantity (Wd), kg/kg of fuel =

$$\frac{100}{12 * (CO_2\% + CO\%)} * \left[\frac{\%C}{100} + \frac{\%S}{267} - \frac{\%C \text{ of BA} * Bash}{100} - \frac{C\% FA * Fash}{100} \right]$$

$$\text{Dry flue gas } L_{dfg} \% = \frac{\text{Dry flue gas quantity Kg/kg of fuel} * \text{Specific heat kCal/kg } ^\circ\text{C} * (FGT ^\circ\text{C} - ABT ^\circ\text{C})}{\text{GCV of Fuel kCal/kg}} * 100$$

Where,

C % BA = % of carbon in bottom ash

C % FA = % of carbon in fly ash

Bash = Bottom ash quantity in kg/kg

Fash = Fly ash quantity in kg/kg

FGT = Flue gas temperature at APH outlet in $^\circ\text{C}$

ABT = Ambient dry bulb temperature in $^\circ\text{C}$

Cp = Specific heat of flue gas in kCal/kg $^\circ\text{C}$ = 0.23

ii) Heat Loss due to evaporation of moisture in fuel, L_{mf}

$$\text{Loss due to moisture in fuel, } L_{mf} = \frac{M * [(0.45 * (FGT - ABT) + 584)] * 100}{\text{GCV}}$$

Where, M is kg of Moisture in 1 kg of fuel

iii) Heat Loss due to Hydrogen in fuel, L_{hf}

$$\text{Loss due to hydrogen in fuel, } L_{hf} = \frac{9 * H_2 * [(0.45 * (FGT - ABT) + 584)] * 100}{\text{GCV}}$$

Where, H_2 is kg of H_2 in 1 kg of fuel

iv) Heat Loss due to moisture in air, L_{ma}

$$\text{Loss due to moisture in air, } L_{ma} = \text{AAS} * \text{humidity} * 0.45 * (FGT - ABT) * \frac{100}{\text{GCV}}$$

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Where, AAS = Actual mass of air supplied

Humidity = humidity of air in kg/kg of dry air

v) Heat Loss due to incomplete combustion to carbon monoxide, L_{co}

$$\text{Loss due to carbon monoxide, } L_{co} = \frac{CO\% \cdot C}{CO\% + CO_2\%} * \frac{5744 \cdot 100}{GCV}$$

During the flue gas analysis when CO is obtained in ppm, then losses can be obtained

Loss due to carbon monoxide, L_{co}

$$= CO \text{ in ppm} * 10^{-6} * \text{fuel consumption in kg/h} * 28 * 5744 * 100 / GCV$$

vi) Heat Loss due to un-burnt carbon in ash, L_{uca}

Loss due to un-burnt carbon in ash, $L_{uca} =$

$$\frac{\text{Calorific value of carbon in kCal/kg}}{GCV \text{ of fuel kCal/kg}} * [(C\%FA * F_{ash} + (C\%BA * B_{ash})]$$

vii) Heat Loss due to Radiation and convection.

These losses are taken as per design documents. As per BEE Guidelines, typical value for 210-500 MW is 0.4%-1.0% of GCV.

As per BEE Guidelines,

Boiler Efficiency = 100 – % Sum of Losses mentioned above.

Locations of Measuring Instruments:

For conducting the Boiler Efficiency Test, following locations should be used for installing the measuring instruments and for collecting the samples:

- Flue Gas Analyzers / Orsat Apparatus at the inlet and outlet of Air Pre-Heater for measuring O₂, CO & CO₂.
- Thermocouples for measuring the temperature of flue gas at Air Pre-Heater inlet and outlet.
- Fly ash sampling at Economiser outlet and ESP Hoppers for unburnt carbon in fly ash.
- Dry Bulb and Wet Bulb Thermometer.
- Sampling of bottom ash from hopper or scrapper.
- Sampling of raw coal from RC feeder of the mill for proximate and ultimate analysis of fuel and finding its Gross Calorific Value (GCV).
- Pulverised coal samples from each mill for sieve analysis.
- Sampling of mill rejects for finding GCV.

Notes:

- (i) Before the Efficiency Test is conducted, the contractor will submit a detailed procedure for conducting the test which will be subject

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to the approval of the owner. Among other things, the procedure will also include the type of instruments to be used and the locations of various measuring instruments and sampling points.

- (ii) During the Efficiency Test, the Boiler blow downs and the use of auxiliary steam for purposes like soot blowing should be stopped, since, accurate evaluation of heat loss due to these items is difficult.*
- (iii) Test Instruments should have 0.5% accuracy. Calibration of the instruments should not be more than six months old. Instruments calibration should be certified by Govt. Accredited Laboratories i.e. NABL approved laboratories.*
- (iv) During the test, the operating parameters should be kept stable and close to design parameters.*
- (v) During the Boiler Efficiency Test, quality of fuel to be used should be as close as possible of the design quality.*
- (vi) All loss components should be thoroughly examined for the deviations, since in most of the plants, the actual GCV of the fuel and composition of the fuel does not match with design specifications and the above losses need to be corrected for the actual quality of fuel.*

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{PERFORMANCE TEST OF AIR PRE-HEATERS (APH)}

Air Pre-heater is the last heat exchanger in the path of flue gases. Extracting maximum heat from the outgoing gases helps in improving the efficiency of the Boiler by reducing the heat loss due to dry flue gas. It also helps in limiting the cold end temperature of the Air Pre-Heater as well as the stack temperature.

APH leakage and APH gas side efficiency has to be checked to assess the performance of APH.

Determination of APH Leakage

The static air pressure on the side of incoming air is much higher than that of the flue gas side. Unfortunately, this leads to significant air bypass to flue gas side and consumes unnecessary fan power. When the incoming air bypasses to the flue gas side, the flue gas temperature decreases. The lower stack temperature due to air leakage gives a false indication that the Boiler is operating efficiently. The air leakage therefore needs to be measured and minimized by improving the sealing arrangement.

Air heater leakage in APH is the weight of air passing from the air side to the gas side of the APH. This is an indicator of the condition of the air heater's seals. As the air heater seals wear, air heater leakage increases. The increase in the air heater leakage increases the power requirement of the draft fans, increasing the unit heat rate and possibly limiting the unit loading.

The air leakage can be determined by measuring the O₂ component in the flue gases before and after the APH. Isokinetic Sampling (Grid Measurement) should be taken before and after the APH for measuring the O₂ component and Flue Gas temperature.

$$\text{Air Leakage AL \%} = \frac{\text{O}_2\% \text{ in the gas leaving APH} - \text{O}_2\% \text{ in the gas entering APH}}{21 - \text{O}_2\% \text{ in the gas leaving APH}} * 100$$

Determination of APH Efficiency

The performance of APH can also be checked by finding the operating gas side efficiency. Gas side efficiency is the ratio of gas temperature drop (at no leakage) to the temperature Head expressed as a percentage.. Temperature Head is the gas inlet temperature minus the air inlet temperature.

$$\text{Gas Side Efficiency} = (T_{gnl} - T_{ge}) / (T_{ae} - T_{ge}).$$

The corrected gas outlet temperature T_{gnl} is defined as the outlet gas temperature for no air leakage and is given by the following formula:

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$$T_{gnl} = \frac{AL * C_{pa} (T_{gl} - T_{ae})}{100 * C_{pg}} + T_{gl}$$

Where,

AL : Air leakage into APH system, in %

T_{gnl} : Gas outlet temperature corrected for no leakage, in °C

C_{pa} : Mean specific heat of air between *T_{ac}* and *T_{gl}*, in kCal/kg/ °C

T_{ae} : Temperature of the air entering the APH, in °C

T_{al} : Temperature of the air leaving the APH, in °C

T_{gl} : Temperature of the gas leaving the APH, in °C

C_{pg} : Mean specific heat of gas between *T_{gl}* and *T_{gnl}*, in kCal/kg/ °C

T_{ge} : Temperature of gas entering the APH, in °C

{PERFORMANCE TEST OF MILLS}

The energy audit of coal mills has to be conducted after obtaining an overview of system which includes mills, RC feeders, PA fans, seal air fans, mill reject handling system and associated ducts, piping, valves and dampers, lubrication system, thermal insulation status of mills/PA fans ducts/piping etc. While monitoring the general health of various installations, noticeable leakages of coal, air, oil and condition of thermal insulation should be checked.

Coal Mills are designed with a particular fuel grinding capacity or throughput at a certain Hardgrove Grindability Index (HGI) based on a definite raw coal size, moisture content and desired fineness level. Since these factors are significant, the coal to be used for testing the performance of mills should preferably be close to the design coal quality.

Testing Methods

For checking the performance of mills, following two tests should be done.

i) Clean Air Pitot Tube Test.

ii) Dirty Pitot Tube Test.

In clean air pitot tube test, no coal is injected into the mills and only primary air from the PA Fans is supplied to the mills to check any unbalance of flow of primary air in the coal lines. Flow of air is checked by measuring the velocity of air with the help of pitot tubes.

In dirty pitot tube test, mills are operated by injecting coal and measurements are taken on all pulverized coal lines to check any unbalance of flow of pulverized coal in coal lines / choking of the lines etc. Samples are taken from each coal line to determine the coal fineness of each supply conduit of the mills. During the test, coal integrator readings of individual raw coal feeder should be compared with the overall coal integrator reading. Quantity and GCV of rejects produced by each mill should be measured.

As explained above, Performance of all the mills should be checked with respect to the following design parameters:

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- (i) Throughput (tons/hour),
- (ii) Fineness for each supply conduit (% passing through 200 mesh)
- (iii) Air to coal ratio of mills (tons of air per ton of coal)
- (iv) Calorific value of Mill rejects and
- (v) Power Consumption (kWh/ton of coal).

Measuring instruments to be used

- (i) Calibrated Pitot tubes.
- (ii) Gravimetric Feeders.
- (iii) Standard Sieves.
- (iv) Stroboscope.
- (v) Power Analyzers for measuring electrical parameters like kW, kVA, pf, V, A and Hz.

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{Performance Test of ID Fans, FD Fans and PA Fans}

ID, FD and PA Fans generate pressure to move air or flue gases against air or gases against a resistance caused by ducts, elbows and dampers etc in the system. Fans being constant volume machines, volume of air or gases moved through the fans remain constant regardless of density. Pressure and power requirements however change proportionately with density.

For doing the energy audit of the ID Fans, FD Fans and PA Fans, Performance parameters of these fans should be checked with respect to the design parameters of total pressure developed, the volume of air / flue gas discharged, power consumption and efficiency of the fans.

Total pressure developed by a fan is the sum of static pressure and the average velocity pressure. Measurements of static and velocity pressure are done both at the suction and discharge of the fans by using a combination of pitot tube and manometer.

Since the velocity pressure in a duct or pipe varies across its cross section, its measurements are taken at various points by traversing the pitot tube across the cross-section. Average velocity of air/flue gas in a duct is determined from the average value of the velocity pressures measured across the cross-section of the duct. Flow through the duct is then determined by the product of the average velocity and the area of cross-section.

Measuring Instruments to be used:

- Pitot tubes.
- Manometer of suitable range.
- Power Analyzer for measuring electrical parameters such as kW, kVA, PF, V, A and Hz.
- Stroboscope for measuring the speed.
- Temperature indicator and probe
- Hygrometer for measuring the relative humidity.

Evaluation of Results:

Following equations may be used for evaluating the performance and efficiency of Fans.

Total pressure developed by a fan = Sum of static pressure and the average velocity pressure.

Static pressure developed by the fan. = Difference of static pressure at discharge and static pressure at suction.

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Velocity pressure developed by the fan. = Difference of velocity pressure at discharge and velocity pressure at suction.

Total pressure developed by the fan. = Difference of total pressure at discharge and total pressure at suction.

$$\text{Velocity (m/sec)} = \frac{C_p \cdot \sqrt{(2 \cdot 9.81 \cdot \text{velocity pressure developed (mm wc)} \cdot \rho)}}{\rho}$$

Where,

C_p = Pitot tube constant, as given by the manufacturer

ρ = Density of air or gas at test condition in kg/m³

Flow Rate (m³/sec) = Area of Cross-section (m²) * Velocity (m/sec)

$$\text{PA/FD Fan total kW} = \frac{Q \text{ in m}^3/\text{s} \cdot \text{total pressure developed by fan (mmwc)}}{102}$$

$$\text{PA/FD Fan Mechanical Efficiency (\%)} = \frac{\text{Fan total kW} \cdot 100}{\text{Input kW to motor} \cdot \eta_m}$$

Where Fan total kW = Total power consumption of the fan in kW

Input kW to motor = Measured power consumption of the motor in kW

η_m = Motor Efficiency

$$\text{Corrected air density} = \frac{273 \cdot 1.293}{273 + \text{Air temperature (}^\circ\text{C)}}$$

$$\text{ID Fan total kW} = \frac{Q \text{ in m}^3/\text{s} \cdot \text{total pressure developed by fan (mmwc)} \cdot \rho_{fg}}{102 \cdot 1.293}$$

$$\text{ID Fan Mechanical Efficiency (\%)} = \frac{\text{Fan total kW} \cdot 100 \cdot \rho_{fg}}{1.293 \cdot \text{Input kW to motor} \cdot \eta_m}$$

Where ρ_{fg} - Density of flue gas at test condition in kg/m³

As per the basic principles, the combined efficiency of fan and motor can be determined by the following formula

$$\text{Combined Efficiency (Fan \& Motor)} = \frac{P_i}{P} = \frac{dp \cdot q}{P}$$

Where, P_i = Ideal Power Consumption in Watts.

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P = *Actual Power Consumption in Watts.*
 dp = *Total pressure developed by the Fan (N/m² or P_a)*
 q = *Flow of air/ flue gas (m³/sec)*

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{PERFORMANCE TESTS OF ELECTROSTATIC PRECIPITATOR}**Determination of Efficiency of Electrostatic Precipitator**

For measuring the efficiency of Electrostatic Precipitator (ESP), the volume of the gas flowing through ESP is measured as well as samples of the dust burden are collected and weighed, both at the inlet as well as the outlet of all the streams / passes of the ESP.

Measuring Instruments to be used:

- (i) Stack Monitoring Kit (For Gas Flow and Dust Loading).
- (ii) On-line Instruments.
- (iii) Power Analyzers for measuring electrical parameters like kW, kVA, pf, V, A and Hz.
- (iv) Temperature Indicator.

The Efficiency of ESP is then calculated as per the following formula:

$$Em = \frac{(Di-Do)}{Di} * 100\%$$

Where,

Em = The measured test efficiency.

Di = Weighted mean of dust burdens at the inlet of ESP (mg/NM³)

Do = Weighted mean of dust burdens at the outlet of ESP (mg/NM³)

$$Di = \frac{\{(Vm_1 * Di_1) + (Vm_2 * Di_2) + (Vm_3 * Di_3) + (Vm_4 * Di_4)\}}{(Vm_1 + Vm_2 + Vm_3 + Vm_4)}$$

$$Do = \frac{\{(Vm_1 * Do_1) + (Vm_2 * Do_2) + (Vm_3 * Do_3) + (Vm_4 * Do_4)\}}{(Vm_1 + Vm_2 + Vm_3 + Vm_4)}$$

Vm = Volume of Gas flow Measured at various passes/streams of ESP.
(Suffix 1, 2, 3 & 4 represents four gas streams.)

Measurement of Solid Particulate Matter (SPM):

The test is done by method 17 of Environment Protection Agency (EPA) of US. This involves determination of mass concentration and volumetric flows. The method involves collection of a representative sample of flue gas from all the streams / passes at the ESP's outlet and finding out mass concentration of particulates from this sample.

In sampling, it is to be ensured that a representative sample of flue gas is obtained. To ensure this, isokinetic sampling is done by grid method such that velocity and direction of the gas entering the probe is the same as the gas in the duct at the sampling point. The test is done for a period of at least one hour and sampling from each grid point is done for two

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minutes. The dust particulates are collected on the filters. The filters are dried in the oven and the weight of the dust particulates is found by deducting the weight of net filter from the gross filter weight. The actual sampling volume of dry gas is measured by the gas meter which is converted into volume at standard conditions of temperature and pressure. The solid particulate emission is then worked out by dividing the dried mass of solids by the corresponding volume of gas at standard temperature and pressure.

$$SPM = \frac{Do}{Vs} * 100\%$$

Where,

Do = Weighted mean of dust burdens at the outlet of ESP (mg/NM³)

Vs = Volume of Dry Flue Gas at standard temperature and pressure.

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{GUIDELINES FOR ENERGY AUDIT OF STEAM TURBINE GENERATOR AND AUXILIARIES}

Performance Testing of Steam Turbine Generator

Performance Test of a Steam Turbine Generator (STG) should be conducted in accordance with Standard Test Codes ASME PTC-6.

The performance of a STG is judged by the Net Heat Rate which is a ratio of 'Heat given to the STG cycle' to 'The Gross Electrical Output'. Turbine Heat Rate (HR) is expressed by the following equation:

$$\text{Turbine Heat Rate} = \text{Heat Given to the Cycle} / \text{Gross Electrical Output}$$

Heat given to the cycle is calculated by adding the Enthalpy additions made to the feed water as well as to the Cold Reheat Steam and by making correction due to the enthalpy of de-superheating water injected to the super heated/ re- heated steam. Net Electrical Output is measured at the terminals of Generator.

Turbine Heat Rate is given by:

$$\text{Turbine Heat Rate (kCal/kWh)} = \frac{Q_1 * (H_1 - h_2) + Q_2 * (H_3 - H_2)}{\text{Gross Generator Output}}$$

Where:

Units

Q_1	Main steam flow	kg/ hr
H_1	Main steam enthalpy	kCal/kg
h_2	Feed water enthalpy	kCal/kg
H_3	Hot reheat enthalpy	kCal/kg
H_2	Cold reheat enthalpy	kCal/kg
Q_2	Reheat steam flow	kg/ hr

$$\text{Turbine Cycle Efficiency \%} = \frac{860}{\text{Turbine Heat Rate}} * 100$$

Measurement of Steam Flow Rate:-

The installation and calibration of flow measuring devices for determining the steam flow rate to higher pressure, high temperature turbines is inherently difficult. ASME Code PTC-6 therefore recommends the use of flow measuring devices in the low temperature portion of the water cycle, i.e. either for the condensate flow or the feed water flow.

The measurement of condensate or feed water flow should be done by measuring the differential pressure across the calibrated flow nozzle built to the design and dimensions given in the ASME code.

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Main Steam flow rate can be worked out from the measured value of condensate flow by adding the flow from the HP Water Heaters calculated through Heat Mass Balance, by adjusting to the equivalent flow corresponding to the level changes in the deaerator, by subtracting un-accounted leakage of maximum allowable value 0.1% and by deducting the amount of water taken for sampling. A typical example of calculating the Main Steam Flow and Reheat Flows is discussed below.

However, it is to be noted that the method of computation for any project will actually depend upon the project specific scheme of the Steam Turbine and its auxiliaries.

EXAMPLE:

Let,

MF1 be the Condensate flow to deaerator,

MF4 be the Ejector steam flow from deaerator,

M_{fw} be the feed water at the out of deaerator,

H7, H6, H5, H4 be the enthalpies of water after HP Heaters, HP7, HP6, HP5 & LP heater LP4 respectively,

H_{fw} be the enthalpy of Feed Water at deaerator outlet and

Mext7, Mext6, Mext5, Mext4 be the extraction steam flow of Ext 7, 6, 5 & 4 respectively.

Then, from Heat Balance of HPH - 7, HPH-6 and HPH-5, we have,

$$M_{fw} * (H7 - H6) = Mext7 * (Hex7 - H_{drip7}) - Eq. (1)$$

$$M_{fw} * (H6 - H5) = Mext6 * (Hex6 - H_{drip6}) + Mext7 * (H_{drip7} - H_{drip6}) - Eq.(2)$$

$$M_{fw} (H5 - H_{fw}) = Mext5 (Hex5 - H_{drip5}) + [(Mext7 + Mext6) * (H_{drip6} - H_{drip5})] - Eq.(3)$$

Similarly from Heat Balance and Mass Balance of Deaerator, we have,

$$M_{fw} * H_{fw} = Mext4 * Hex4 + MF1 * H4 + (Mext7 + Mext6 + Mext5) * H_{drip5} - MF4 * H_{drip5} \text{ ---} \\ \text{----Eq.(4)}$$

$$M_{fw} = Mext7 + Mext6 + Mext5 + Mext4 + MF1 - Mej - Eq. (5)$$

After four unknown quantities of Mext7, Mext6, Mext5 and Mext4 from above five equations are determined by solving above equations, then Feed water flow at the outlet of Deaerator can be worked out from equation-5 above. Main Steam Flow (Q1) can then be established as explained below.

$$Q1 = M_{fw} + M_{dl} - M_s - M_{lk}$$

Where,

M_{dl} = Equivalent flow corresponding to decrease in the level of deaerator.

M_s = Amount of water taken for sampling if any.

M_{lk} = Un-accounted leakage. (Maximum allowable value is 0.1%)

Reheat steam flow Q2 is evaluated by subtracting steam extraction to last two HP Heaters (as per the heat balance across these heaters) & HP Turbine Leak off flows from the main steam flow Q1 and by adding sprays

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for the attemptations. Leak off flows shall either be taken as per the design values or evaluated from the collected data.

Thus $Q_2 = Q_1 - \text{Extraction from last 2 HP Heaters} - (\text{HPT leaks})$
As already stated, Turbine Heat Rate can be worked out as follows.

$$\text{Turbine Heat Rate (kCal/kWh)} = \frac{Q_1 * (H_1 - h_2) + Q_2 * (H_3 - H_2)}{\text{Gross Generator Output}}$$

Measuring Instruments to be used:

- (i) Temperature Indicators and Sensors.
- (ii) Pressure Gauges.
- (iii) Water Flow Measuring Instruments (Calibrated Flow Nozzles, Ultrasonic Devices)
- (iv) Helium Leak Detectors for Condensers.

Notes:

- (I) To ensure the accuracy of the test, extraneous flows like, Make up to the cycle, bypass lines and drain lines are isolated from the cycle.
- (II) Test Instruments should have 0.5% accuracy. Calibration of the instruments should not be more than six months old. Instruments calibration should be certified by Govt. Accredited Laboratories i.e. NABL approved laboratories.
- (III) At the beginning of the test, Deaerator and Hot well levels should be kept at high water level.
- (IV) During the test, the operating parameters should be kept stable and close to design parameters.

Determination of Efficiency of Individual Turbine Cylinders

Efficiency of Individual HP, IP and LP Turbine Cylinders can be determined by first calculating the energy extracted from each kg of steam passing through a particular cylinder (HP, IP or LP) by subtracting the exhaust enthalpy ($H_{out \text{ act}}$) from the inlet enthalpy ($H_{in \text{ act}}$). Dividing this quantity by the amount of energy that would have been extracted, if the process was isentropic or ideal, gives the efficiency of the particular Turbine Cylinder. The energy extraction through isentropic process can be determined from the Mollier Chart:

$$\text{Efficiency (\%)} = \frac{(H_{in \text{ act}} - H_{out \text{ act}})}{(H_{in \text{ act}} - H_{out \text{ ideal}})} \times 100$$

Where, $H_{in \text{ act}}$ = The actual inlet enthalpy of the steam.

$H_{out \text{ act}}$ = The actual exhaust enthalpy of the steam.

$H_{out \text{ ideal}}$ = The ideal exhaust enthalpy of the steam.

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{PERFORMANCE TEST OF CONDENSERS}

Since the performance of the condenser depends upon the cooling water flow and inlet cooling water temperature, it is often cost effective to conduct the performance test of the condenser along with the testing of CW Pumps and Cooling Tower.

Objective of the condenser performance test is to find out whether condenser is performing as per the design expectations or not. Analysis of the condenser performance is based on the following parameters:

- CW Inlet Temperature.
- CW Outlet Temperature.
- Flow Quantity of Cooling Water.
- Turbine exhausts hood temperature.
- Terminal temperature difference (TTD.)
- Log Mean Temperature Difference (LMTD)
- Back Pressure.

The above parameters most importantly the TTD, (LMTD) and Back Pressure are compared with the design /expected parameters and actions are required to be planned to correct the deviations.

Notes:

Before conducting the test, it should be ensured that,

- (i) The condenser tubes are cleaned and
- (ii) Air leakage into the condenser has been tested with the help of Helium leak detection system.

Parameters to be checked

The following parameters need to be checked:

(i) Condenser heat load

$$\text{Condenser heat load (kCal/h)} = Q \times T \times C_p$$

Where,

Q = Water flow rate in (kg/h)

T = Average CW temperature rise in °C

C_p = Specific heat in kCal/kg °C

(ii) Condenser Vacuum

Expected condenser vacuum can be calculated from the performance curves of condenser as given by the manufacturer.

Calculated condenser vacuum

Calculated condenser vacuum = atmospheric pressure – Condenser back pr.

Deviation in condenser vacuum

Deviation in vacuum = Expected condenser vacuum – Measured condenser vacuum

(iii) Condenser TTD

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Condenser TTD = Saturation temperature – Cooling water outlet temperature

(iv) Condenser Effectiveness

$$\text{Condenser effectiveness} = \frac{\text{Rise in cooling water temperature}}{\text{Saturation temperature – Cooling water inlet temperature}}$$

(v) Determination of actual LMTD

Actual LMTD is given by:

$$LMTD = \frac{T_{out} - T_{in}}{\ln \frac{T_{sat} - T_{in}}{T_{sat} - T_{out}}}$$

Where

LMTD = Log Mean Temperature Difference

T_{sat} = Saturation temperature (°C) corresponding to back pressure.

T_{in} = Cooling water inlet temperature (°C)

T_{out} = Cooling water outlet let temperature (°C)

Establishing the reasons for loss/gain in condenser vacuum:

After diagnosis, the loss/gain in condenser vacuum should be categorized into the following factors in order to find optimum solutions:

- i) Due to CW inlet Temp.:
- ii) Due to CW inlet flow:
- iii) Due to air ingress:
- iv) Due to dirty tubes :

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{PERFORMANCE TEST OF LP & HP FEED WATER HEATERS}

Performance of the LP & HP feed Water heaters is to be checked from the following indices:

- Terminal Temperature Difference (TTD)
- Drain Cooler Approach (DCA)
- Temperature Rise across the heaters.(TR)

Formulae to be used are given below

Terminal temperature difference, $TTD = t_{sat} - t_{fw\ out}$

Where,

TTD = Terminal temperature difference ($^{\circ}C$)

T_{sat} = Saturation temperature taken at the heater shell pressure ($^{\circ}C$)

$T_{fw\ out}$ = Temperature of feed water leaving the heater ($^{\circ}C$)

Drain Cooler Approach temperature, $DCA = T_{drains} - T_{fw\ in}$

Where,

DCA = Drain cooler approach temperature ($^{\circ}C$)

T_{drains} = Temperature of the drains leaving the heater ($^{\circ}C$)

$T_{fw\ in}$ = Temperature of feed water entering the heater ($^{\circ}C$)

Temperature Rise, $TR = T_{fw\ out} - T_{fw\ in}$

Where,

TR = Feed water temperature rise across the heater ($^{\circ}C$)

$T_{fw\ in}$ = Temperature of feed water entering the heater($^{\circ}C$)

$T_{fw\ out}$ = Temperature of feed water leaving the heater ($^{\circ}C$)

The above parameters are compared with the design /expected parameters and actions are required to be planned to correct the deviations.

{PERFORMANCE TEST OF CEPs AND BFPs}

For the performance test of CEPs and BFPs, please refer to the 'Guidelines for Testing Centrifugal Pumps' appended after the section on Balance of Plant.

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{GUIDELINES FOR ENERGY AUDIT OF BALANCE OF PLANT SYSTEMS}**Performance Testing of Centrifugal Pumps**

All kinds of centrifugal pumps namely the Boiler Feed Pumps, Condensate Extraction Pumps, CW Pumps, ACW Pumps, Raw Water Intake Pumps, Ash Water Pumps, DM Water Pumps, Ash Slurry Pumps and Miscellaneous pumps can be tested by the method explained below.

The primary factors affecting the operation of the pumps are the inlet condition at suction side, outlet condition on the discharge side and the operating speed of the pump. The secondary factors are physical and climatic variables, such as the temperature, viscosity, specific weight and turbidity of the liquid being pumped and the elevation of the pumping system above the sea level.

Measuring Instruments to be used:

During the test, the following instruments are required.

- (i) Venturi meters / flow nozzles / orifice meters / pitot tubes for measuring the Discharge,
- (ii) Bourden type pressure gauges for measuring suction and discharge Head
- (iii) Stroboscope for measuring Operating Speed.
- (iv) Power Analyzers for measuring electrical parameters like kW, kVA, pf, V, A and Hz.

Measurement of Discharge:-

Discharge or flow can be measured by installing calibrated devices like venturi meters, flow nozzles, orifice meters and pitot tubes etc.

When the flow is measured by the venturi meter, the flow nozzle or orifice meter, its quantity can be calculated by the following equation:

$$Q = \frac{CA_2\sqrt{2gh}}{\sqrt{1-R^4}}$$

Where,

- Q = Rate of flow (m^3/sec)
- C = Coefficient of discharge for venturi meter, flow nozzle or orifice meter as the case may be.
- A_2 = Area of throat in case of venturi meter /flow nozzle or area of orifice in case of orifice meter, as the case may be (m^2).
- g = Acceleration due to gravity ($9.81 m/sec^2$)
- h = Differential head of liquid between meter inlet and throat in case of venture meter or head across the flow nozzle or orifice meter as the case may be.(m)
- R = Ratio of throat to inlet diameter in case of venturi meter/ flow nozzle or orifice meter as the case may be.

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When the Discharge or Flow is measured by the pitot tube, its quantity can be calculated by the following equation:

$$Q = A \times \sqrt{2gh}$$

Where,

Q = Flow in m^3/sec

A = Area of cross section of flow, where pilot tube is installed (m^2)

g = Acceleration due to gravity ($9.81 m/sec^2$)

h = Height of rise of water column above the surface of water (m)

Measurement of Total Dynamic Head (TDH):-

For measuring the TDH, measurements are required to be taken both on the suction as well as Discharge side of the pumps. Instruments to be used could be either the direct reading liquid manometers, converted mercury manometers or calibrated bourden pressure gauges.

The TDH is given by the algebraic difference of the total discharge head (hd) and the total suction head (hs) i.e.

$$H = hd - hs$$

The values of hd and hs are calculated by the following equations:

$$hd = hgd + Zd + \frac{V_d^2}{2g}$$

and

$$hs = hgs + Zs + \frac{V_s^2}{2g}$$

Where,

hgd = discharge gauge reading in metres of liquid.

hgs = suction gauge reading in metres of liquid.

Zd = elevation of discharge gauge above datum elevation.

Zs = elevation of suction gauge above datum elevation.

V_d = Velocity in discharge pipe (m/s)

V_s = Velocity in suction pipe (m/s)

Measurement of Power Consumption:-

The power consumption (kW) should be measured at the terminals of the drive motor (in case of motor driven pumps) to exclude any line losses that may occur between the switchboard and the driver.

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Measurement of Speed:-

The speed of the pump can be measured by revolution counter (manual or automatic), tachometer, stroboscopic device or an electronic counter.

Power Output of Pump:-

Power output of the pump in kW can be determined by the following relationship:

$$\text{Liquid Power Output (kW)} = \frac{Q * H * \rho * g}{1000}$$

Where,

Q = Flow rate of liquid (m^3/sec)

H = Total Dynamic Head (m)

ρ = Density of Liquid / Ash Slurry (kg/m^3)

g = Acceleration due to gravity ($9.81 \text{ m}/\text{sec}^2$)

Pump Efficiency:-

Mechanical Efficiency of the Pump is given by the following relationship:

$$\text{Mechanical Efficiency \%} = \frac{\text{Liquid Power Output (kW)}}{\text{Power Input to the shaft (kW)}} \times 100$$

Overall Efficiency of the Motor Driven Pump including motor is given by the following equation:

$$\text{Overall Efficiency (\%)} = \frac{\text{Liquid Power Output}}{\text{Electrical Power Input}} \times 100$$

Adjustments due to change in pump speed:-

If the frequency of electrical supply of power is other than 50 Hz, the actual speed of the pump during the test will be somewhat different from the rated speed. Adjustments are therefore required to be made in the measured values of Discharge, TDH and Electric Power Consumption, to convert these parameters corresponding to the rated speed of the pump. This can be done by using the following equations:

$$Q_r = \frac{N_r}{N_t} \times Q_t$$

$$H_r = \left(\frac{N_r}{N_t} \right)^2 \times H_t$$

$$P_r = \left(\frac{N_r}{N_t} \right)^3 \times P_t$$

Where,

Q_r = Discharge Capacity at Rated speed

Q_t = Discharge Capacity at Tested Speed

H_r = TDH at Rated Speed

H_t = TDH at Tested Speed

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Pr = *Power Consumption at Rated Speed*
Pt = *Power Consumption at Tested Speed*
Nr = *Rated Speed*
Nt = *Test Speed*

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{COOLING TOWER PERFORMANCE TEST}

There are a number of variables, which influence the performance of cooling towers. The various test codes namely CTI Code ATC-105, ASME Code PTC-23 and BS 4485 Part 2 prescribe certain permissible limits for these variables. The permissible limits recommended by CTI Code ATC-105 are given below:-

S.No.	Parameter	Permissible Variation from the Design value
1	Water Rate	$\pm 10\%$
2	Cooling Range	$\pm 20\%$
3	Heat Load	$\pm 20\%$
4	Wet Bulb Temperature	$\pm 10^{\circ} F$
5	Dry Bulb Temperature	$\pm 20^{\circ} F$
6	Wind velocity	$\pm 10\%$
7	Fan Power	$\pm 10\%$

The Wet Bulb Temperature in case of Induced Draft Towers and Wet & Dry Bulb Temperatures in case of Natural Draft Towers are the basic weather conditions on which the cooling towers are designed. The date of conducting the performance test of the Cooling Towers should therefore be chosen considering the trend of the weather conditions so that the above temperatures are as close as possible to the design values.

Testing Method:

The test is conducted for a minimum period of one hour during which time, readings for all the following parameters are taken at an interval of 5 minutes.

- (i) Wind Velocity.
- (ii) Ambient Wet & Dry Bulb Temperatures.
- (iii) Inlet Wet Bulb Temperature.
- (iv) Hot Water Flow to the Cooling Tower.
- (v) Temperature of Hot Water.
- (vi) Re-cooled Water Temperature.
- (vii) Fan Power Consumption in case of Induced Draft Cooling Towers.

Instruments Required

- (i) Mechanically aspirated psychrometer for measuring Wet Bulb Temperature.
- (ii) Dry Bulb Thermometers.
- (iii) Anemometer for measuring wind speed and Cooling Tower Air Flow.
- (iv) Pitot Tube for measuring water velocity to determine Water flow.

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(v) Mercury in Glass Thermometers or RTD's for measuring hot and cold water temperatures.

(vi) Watt meter for measuring power consumed by the Fan Motor.

Following relationships are used for determining important parameters:

Cooling Range = Hot Water Temperature at Inlet – Cold Water Temperature at Outlet.

Cooling Tower Approach = Cold Water Temperature at Outlet – Wet Bulb Temperature.

$$\text{Effectiveness \%} = \frac{\text{Range}}{\text{Range} + \text{Approach}} \times 100$$

$$\text{Fan Air Flow Actual (NM}^3\text{/h) Per Cell} = \frac{\text{Rated Fan Flow (Nm}^3\text{/h)} \times (\text{Fan Input kW Actual})^{1/3}}{(\text{Fan Input Rated})^{1/3}}$$

$$\text{Air Mass Flow Per Cell} = \text{Air Flow} \times \text{Density of Air}$$

$$\text{L/G Ratio} = \frac{\text{Water Flow in kg/h}}{\text{Air Flow in kg/h}}$$

$$\text{Evaporation Loss} = \frac{\text{Cooling Water Flow (m}^3\text{/h)} \times \text{Cooling Tower Range in } ^\circ\text{C}}{675}$$

Based upon the actual test data, the predicted re-cooled water temperature is determined from the performance curves provided by the manufacturer. The deviation is analyzed and corrective action is planned to remove the deviation.

Note:

To simplify the evaluation of test results and to minimize the chances of errors, blow down and make up is stopped during the time of testing.

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{PERFORMANCE TEST OF COMPRESSED AIR SYSTEM}

Performance of air compressors and compressed air system deteriorates with the passage of time. During the Energy Audit, the capacity of the air compressor as well as the leakages in the system should be checked.

FREE AIR DELIVERY (FAD) TEST

This test is to be conducted to assess the actual output of the compressor. The procedure of conducting the test is as follows:

- Isolate the compressor along with its individual receiver being taken for test from main compressed air system by tightly closing the isolation valve or blanking the receiver outlet. Ensure that the valves are closed completely.
- Check the pressure gauge and the temperature gauge installed for the air receiver for calibration and working status.
- Open water trap drain outlet and empty the receiver and the pipeline. Make sure that water trap line is tightly closed once again to start the test.
- Start the compressor and activate the stopwatch
- Note the time to attain the normal generated pressure P_2 (in the receiver) from initial pressure P_1 .
- Measure the temperature of ambient and compressed air (receiver)

Calculate the capacity as per the formula given below:

Actual Free Air Discharge:

$$Q = \frac{(P_2 - P_1)}{P_0} * \frac{V}{T}$$

Where,

- Q : Actual free air discharge (m^3/min)
 P_2 : Final pressure after filling ($\text{kg}/\text{cm}^2\text{a}$)
 P_1 : Initial pressure ($\text{kg}/\text{cm}^2\text{a}$) after bleeding
 P_0 : Atmospheric pressure ($\text{kg}/\text{cm}^2\text{a}$)
 V : Receiver and connected pipe volume in m^3
 T : Time taken to build up pressure to P_2 in minutes

The above equation is relevant where the compressed air temperature is same as the ambient air temperature, i.e. perfect isothermal compression.

In case the actual compressed air temperature at discharge, say t_2 °C is higher than ambient air temperature say t_1 °C (as is the usual case), the FAD is to be corrected by a factor $(273 + t_1) / (273 + t_2)$.

Once the actual output is assessed, then it should be compared with rated output. If any deviation is found then the various factors causing deviation should be investigated to arrive at the remedial measures to improve the performance.

Efficiency Calculation

Calculate the ideal kW as per formula given below:

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$$\text{Ideal Power kW} = \left[\frac{NK}{K-1} \right] \left[\frac{Q * P_s}{0.612} \right] \left[\frac{P_d}{P_s} \right]^{\frac{K}{(K-1)/NK}} - 1$$

Where,

N : No. of stages

K : Ratio of Specific Heat (1.35 for air)

P_s : Suction Pressure in kg / cm²g

P_d : Discharge pressure in kg / cm²g

Q : Actual fir flow (m³/min)

Measure the actual kW during steady state load condition.

Calculate the actual efficiency

$$\eta = \frac{\text{Ideal kW}}{\text{Actual kW}}$$

Compare the actual with the design efficiency. If any deviation is found then the various factors causing deviation should be investigated to arrive at the remedial measures to improve the efficiency.

Method of checking the leakages in the System:

Loud leaks can be spotted without the aid of an ultrasonic leak detector while walking across the route of compressed air pipelines. Check the rags placed over the pipes to reduce the noise level of large scale leaks. Check all the drain traps. Small leaks can be traced with the help of ultrasonic leak detector.

For checking the rate of leakage in a given system, all the isolating valves at supply points and the drain traps should be closed. The normal operating pressure should be established in the air receiver and the compressor should be stopped. The fall in the air pressure of the receiver should be monitored over a period of time. The rate of leakage in the system can be worked out by the following formula.

$$\text{Leakage Rate (Nm}^3/\text{min)} Q = \frac{\text{Pressure loss (kg/cm}^2\text{a)}}{\text{Atmospheric Pr. (kg/cm}^2\text{a)}} * \frac{\text{System volume (m}^3\text{)}}{\text{Time Measured (minutes)}}$$

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{Performance Test of Air Conditioning System}**Evaluation of net refrigeration capacity and specific energy consumption**

The test shall include a measurement of the net heat removed from the water as it passes through the evaporator by determination of the following:

1. Water flow rate
2. Temperature difference between entering and leaving water

The heat removed from the chilled water is equal to the product of the chilled water flow rate, the water temperature difference, and the specific heat of the water.

The net refrigeration capacity in tons shall be obtained by the following equation:

$$\text{Net refrigeration capacity (TR)} = \frac{m \times c_p \times (T_{in} - T_{out})}{3024}$$

Where

m - Mass flow rate of chilled water, m^3/hr

C_p - Specific heat, $kcal/kg\ ^\circ C$

T_{in} - Chilled water temperature at evaporator inlet $^\circ C$

T_{out} - Chilled water temperature at evaporator outlet $^\circ C$

The accurate temperature measurement is very vital in refrigeration and air conditioning and therefore least count of temperature measured should be at least to one decimal place.

After arriving at net refrigerating capacity, the specific energy consumption can be arrived at by measuring power consumption.

$$\text{Specific power consumption, kW/TR} = \frac{\text{kW input to the motor}}{\text{Net refrigeration effect in TR}}$$

The compressor power can be measured by a portable power analyzer, which would give reading directly in kW.

Other specific energy parameter is,

$$\text{Co-efficient of Performance COP} = \frac{\text{Refrigeration effect in kW}}{\text{Motor input power}}$$

Performance evaluation of Air Handling Units (AHU)

Performance of air handling units needs to be evaluated for the following:

- TR of AHU (Heat load)
- No of air changes of fresh air supply
- Air flow rate

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- Operating parameters

For centralized air conditioning systems the airflow at the air-handling unit (AHU) can be measured with an anemometer. The dry bulb and RH can be measured at the AHU inlet and outlet by using thermal hygrometer. The data can be used along with a psychrometric chart (now a software is available) to determine the enthalpy (heat content of air at the AHU inlet and outlet).

$$\text{Heat load (TR)} = \frac{m \times (h_{in} - h_{out})}{4.18 \times 3024}$$

Where:

- m - Mass flow rate of air, kg/hr
- h_{in} - Enthalpy of inlet air at AHU, kJ/kg
- h_{out} - Enthalpy of outlet air at AHU, kJ/kg

Power Consumption of Auxiliaries:

- Measure all electrical parameters of air conditioning auxiliaries such as pumps, fans and blowers.
- Tabulate the measured parameters
- Evaluate specific energy consumption
- Compare above measurement with respective design / best achieved values.

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{AUDIT OF WATER CONSUMPTION}

In thermal power stations, monitoring and auditing of specific water consumption (litres/kwh) should also be done similar to the monitoring of specific coal consumption or specific oil consumption.

Requirement of water in a thermal power station is mainly for the following areas:-

- i) Water requirement for Boiler make up.*
- ii) Cooling water for Condenser and Heat Exchangers etc.*
- iii) Make up water for evaporation and blow down loss from cooling tower.*
- iv) Water requirement for ash disposal.*
- v) Water requirement for coal dust suppression.*
- vi) Service water for washing and cleaning purposes.*
- vii) Drinking water supply.*

Auditing of Water Consumption

Auditing of water consumption should be carried out periodically and as frequently as possible for each of the systems covered in the water balance diagram. Effort should be made to conserve the usage of water.

Guidelines for conserving water

A few guidelines are mentioned below for minimizing specific water consumption in the power plants:

- i) Increasing the Cycle of Concentration (COC) in Condenser cooling water system in closed cycle.*
- ii) Increasing the ash concentration in the wet ash disposal system.*
- iii) Recycling of water from the wet ash disposal system.*
- iv) Adopting of dry fog dust suppression system for coal handling plant.*
- v) Checking of leakages from water pipe joints and water taps.*
- vi) Treatment and recycling of waste water.*
- vii) Rain water harvesting*
- viii) Adopting zero discharge system.*

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{Guidelines for the Energy Audit of Thermal Insulation}

In thermal power plants, thermal insulation is provided for the following purposes;

- To minimize the heat loss to environment from the hot surfaces of pipes and equipment specially carrying steam and hot water.*
- To minimize heat gain from environment to the cold surfaces of Air Conditioning System.*
- To protect the working personnel.*

Thermal insulation is normally provided for the following systems in the thermal power plants:

- Piping and equipment carrying steam and hot water e.g. Boiler & Auxiliaries, Steam Turbine & Auxiliaries and Feed Water System.*
- Heat tracings for Fuel Oil Systems.*
- Chimney.*
- Air Conditioning System.*

Generally, it is the avoidable heat loss from the damaged insulation of hot surfaces, which matters most in the thermal power plants. For carrying out energy audit for the thermal insulation system, the condition of the insulation should be inspected and surface temperatures of hot spot areas having damaged insulation, should be measured with the help of infrared temperature indicator. Where the surface temperature is more than 60° C, the estimated heat loss should be calculated. The formula for calculating the Heat Loss or gain from the bare and un-insulated surfaces is indicated below.

$$H = h \times A \times (T_h - T_a)$$

Where,

H = Heat loss/ Heat gain in Watts.

A = Outside Area in m².

h = Heat transfer coefficient, W/m²-K

T_h = Hot surface temperature (for hot fluid piping) & Cold surface temperature for cold fluids piping in °C.

T_a = Average ambient temperature, °C

For horizontal pipes, heat transfer coefficient can be calculated by:

$$h = (B + 0.005 (T_h - T_a)) \times 10 \text{ W/m}^2\text{-K}$$

For vertical pipes, heat transfer coefficient can be calculated by:

$$h = (C + 0.009 (T_h - T_a)) \times 10 \text{ W/m}^2\text{-K}$$

The values of the coefficients B & C are given in the table below.

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Surface	B	C
Aluminum, Bright Rolled.	0.25	0.27
Aluminum, Oxidized.	0.31	0.33
Steel	0.32	0.34
Galvanized Sheet Metal	0.53	0.55
Non Metallic Surfaces	0.85	0.87

The material and thickness of appropriate Insulation material has to be worked out so that after the application of insulation, the surface temperature does not exceed 60°C.

The potential saving in heat loss can be worked out by calculating the heat loss with surface temperature as 60°C and subtracting it from the Heat Loss from the bare and un-insulated surface calculated above.

The cost of replacing the damaged insulation should then be compared with the expected savings in the cost of fuel, to work out the payback period

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{Guidelines for the Energy Audit of illumination System}

The illumination System is provided in various areas of the Power Plant for rendering comfortable working environment. The primary objective should be to provide the required intensity of lighting at the lowest power consumption.

Annexure -A indicates the recommended average illumination levels (lux level) for different areas of the power plant as well as the suggested type of luminaries to be used.

The purpose of energy audit of any illumination system, therefore, is to identify the illumination deficient areas and the areas where energy loss is taking place due to the usage of inefficient luminaries and to recommend the improvement option.

Measuring Instruments Required

- Power Analyzer for measuring electrical parameters such as kW, kVA, pf, V, A and Hz .
- LUX meters.
- Measuring tape.
- On line energy metering instruments (calibrated)

Method of Energy Audit

For the determination of the number of measurement points and their locations, first of all Room Index (RI) is calculated for each area, by using the expression:

$$RI = \frac{L \times W}{Hm (L + W)}$$

Where,

L = length of interior;

W = width of interior;

Hm = the mounting height of the lighting fittings above the horizontal working plane.

Depending upon the Room Index (RI), the number of measuring points in the given area is determined from the values given in the Table-1 below.

Table-1

Room Index (RI)	Number of Measuring Points
Below 1	9
Between 1&2	16

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Between 2&3	25
3 and above	36

Depending upon the number of measuring points, the interior is divided into a number of equal areas, which should be as square as possible. The illumination at the centre of each area is measured with lux meter and the mean value is calculated. By also measuring the power consumed, Installed Load Efficacy (ILE) of the system can be worked out in terms of lux/watt/m². This gives an estimate of the actual illumination on the horizontal working plane. The working plane is usually assumed to be 0.75m above the floor in the offices and at 0.85m above floor level in equipment areas.

The ratio of ILE to the target value of lux/watt/m² is defined as the Installed Load Efficacy Ratio (ILER).

$$\text{i.e. ILER} = \frac{\text{Actual lux/watt/m}^2}{\text{Target lux/watt/m}^2}$$

The target values of lux/watt/m² may be taken from the values given in the Table - 2 which are based on the advanced type of luminaries being used in the industry.

Table - 2

Room Index (RI)	Target lux/watt/m ²
5	53
4	52
3	50
2.5	48
2	46
1.5	43
1.25	40
1	36

Annual energy loss of any illumination system can then be worked out by the following expression.

$$\text{Annual energy loss (kWh)} = \frac{(1 - \text{ILER}) \times \text{watts consumed} \times \text{no. of operating hrs / year}}{1000}$$

The above method is summarized below in the form of steps.

STEP -1: Measure the floor area of the interior in m².

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- STEP- 2: Calculate the Room Index (RI)*
- STEP-3: Determine the total circuit watts of the installation by a power meter if a separate feeder for lighting is available. If a separate feeder for lighting is not available, a reasonable approximation can be obtained by totaling up the lamp wattages including the ballasts.*
- STEP-4: Calculate 'Watts consumed per square metres (W/m²)' by dividing the Value of Step 3 by the value of Step 1.*
- STEP -5: Ascertain the average maintained lux level, by using lux meter.*
- STEP-6: Divide the Value of step 5 by the Value of step 4 to calculate Actual value of Lux/W/m².*
- STEP-7: Obtain Target value of Lux/W/m² for the given RI from the values given in the Table-2 above.*
- STEP-8: Calculate Installed Load Efficacy Ratio (ILER) by Dividing the Value of step 6 by the value of step 7.*
- STEP -9: Calculate the Annual Energy Loss.*

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ANNEXURE-A

THE AREA-WISE AVERAGE ILLUMINATION LEVELS AND TYPE OF LUMINARIES

S. NO.	LOCATION	LIGHTING FIXTURE TYPE	AVERAGE LUX LEVEL
1.	Control Rooms / Conference Room	Energy Efficient FTL in Decorative fittings with wide angle mirror optic antiglare reflector. OR Decorative Compact fluorescent tube (CFL) fitting with internal mirror reflector with mounting bracket suitable for 1x18W/ 1 x 22W/ 1x25W lamps.	500
2.	Office / Conference room	Decorative recessed type energy efficient 2 x 40 FTL with mirror reflector. OR Decorative Compact fluorescent tube (CFL) fitting with internal mirror reflector with mounting bracket suitable for 1x18W/ 1 x 22W/ 1x25W lamps. For rooms without false ceiling, surface mounted fixtures shall be used.	300
3.	Testing Laboratories	Energy Efficient FTL in Decorative fittings with wide angle mirror optic antiglare reflector. OR Decorative Compact fluorescent tube (CFL) fitting with internal mirror reflector with mounting bracket suitable for 1x18W/ 1 x 22W/ 1x25W lamps.	400
4.	Work shop Building	High fittings – 150W/250W HPSV	300
5.	Transformer area, Switchyard area, outdoor yard area	Dust & weather proof 70 W HPSV well glass fitting with reflector and integral mounted control gear.	50
6.	Indoor GIS Buildings	High Bay fittings – 400W/250W HPSV	300
7.	Air Compressor	Energy efficient 2x40 W FTL industrial	200

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S. NO.	LOCATION	LIGHTING FIXTURE TYPE	AVERAGE LUX LEVEL
	Plant	type with vitreous enamel finish (pendant / bracket mounting	
8.	Silo surrounding areas, Silo Platforms	Dust and weather proof 70W HPSV well glass fitting with reflector and integral mounted control gear.	100
9.	Pump Houses	High / medium Bay fittings - 250/400W HPSV	200
10.	Battery Room	Energy efficient 2X40 W FTL industrial type Corrosion proof with vitreous enamel finish (pendant / bracket mounting (Explosion Protected)	150
11.	Air Conditioning Plant Room	Energy efficient 2x40 W FTL industrial type with vitreous enamel finish (pendant / bracket mounting	200
12.	AHU Room	Energy efficient 2x40 W FTL industrial type with vitreous enamel finish (pendant / bracket mounting	200
13.	Switchgear/MCC/Electrical & Electronic equipment Rooms	Energy efficient 2x40 W FTL industrial type with vitreous enamel finish (pendant / bracket mounting	200
14.	Elevator M/C Room	Energy efficient 2x40 W FTL industrial type with vitreous enamel finish (pendant / bracket mounting	100
15.	Cable spreader Area	Energy efficient 2x40 W FTL industrial type with vitreous enamel finish	100
16.	Chlorination Building / Chlorinator Room	Acid/ Corrosion proof CFL light fixture	200
17.	Chemical storage Room	Acid/ Corrosion proof CFL light fixture	150
18.	Conveyors (exposed)	70 W HPSV lamps Dust & Vapour proof increased safety well glass with reflector wire guard, integral mounted control gear	50
19.	Conveyors (enclosed)	150 W HPSV lamps Dust & Vapour proof increased safety well glass with reflector	100

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S. NO.	LOCATION	LIGHTING FIXTURE TYPE	AVERAGE LUX LEVEL
		wire guard, integral mounted control gear	
20.	Crusher House Screen Houses Junction towers	70 / 150W HPSV - Dust & Vapour proof increased safety well glass with reflector wire guard, integral mounted control gear	200
21.	Coal / Lignite stock Yard (open Area)	1 X 400W HPSV - General Purpose Flood Light	20
22.	Coal / Lignite stock yard (covered Area), stacker and reclaimer	1 X 400W HPSV - MH General Purpose Flood light – Medium beam	25-50
23.	Oil Room and indoor hazardous areas	1 x 70 W HPMV Flame proof well glass fixture	150
24.	Passage, Indoor Stair case , Toilet etc	Energy efficient 2x20/40 W FTL industrial type with vitreous enamel finish	100-150
25.	Outdoor/Semi outdoor stairs	Dust & weather proof 70 W HPSV well glass fitting with reflector and integral mounted control gear.	70
26.	Street / roads & periphery lighting	150W/250W HPSV street / roads light fittings	20
27.	Building periphery lighting	150W/250W HPSV Outdoor/building periphery light fitting with integral mounted control gear/industrial bulk head with integral mounted control gear/ flood light fittings	100
28.	Approach roads	150 W HPSV Street / roads light fitting with clear acrylic cut off type with integral mounted control gear	50
29.	Hydrogen Plant Indoor hazardous areas	1 x 70 W HPMV Flame proof well glass fixture	150

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Appendix-1

ENERGY AUDIT REPORT FOR BOILER

Plant Name *[.....]*
 Work Order Number *[.....]*
 Test Report Number *[.....]*
 Owner *[.....]*
 Unit Number *[.....]*
 Unit Capacity *[.....]*
 Date *[.....]*
 Make *[.....]*
 Type *[.....]*

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Unit Load	MW	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
2	Main Steam Pressure	kg/cm ²	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
3.	Main Steam Temperature	°C	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
4.	Re-heat Temperature	°C	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
5.	Oxygen in flue gas	%	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
6	Air preheater flue gas outlet temperature	°C	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
7	Main Steam Flow	TPH	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
8	Economizer Inlet Feed Water Temperature	°C	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
9	Calorific Value – GCV	kCal/Kg	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
10	Number of Mills in Operation	Nos	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
11	ID Fan Margin	%	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
12	Furnace Draft	mmwc	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
13	Superheater Spray	TPH	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>

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S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
14	Reheater Spray	TPH	[.....]	[.....]	[.....]
15	Type of Mills	[.....]	.....	.....	.....
16	Type of Feeder	[.....]	.....	.....	.....
17	No.of ESP fields working	[.....]	.....	.....	.....
18	Dry Flue Gas Loss	%	[.....]	[.....]	[.....]
19	Loss due to Hydrogen in Fuel	%	[.....]	[.....]	[.....]
20	Loss due to Moisture in Fuel	%	[.....]	[.....]	[.....]
21	Loss Due to Un-burnt Carbon	%	[.....]	[.....]	[.....]
22	Radiation Loss	%	[.....]	[.....]	[.....]
23	Total Loss	%	[.....]	[.....]	[.....]
24	Efficiency	%	[.....]	[.....]	[.....]

Observations:

[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[93]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-2

ENERGY AUDIT REPORT FOR AIR PREHEATER (A/B)

Plant Name [.....]

Work Order Number [.....]

Test Report Number [.....]

Owner [.....]

Unit Number [.....]

Unit Capacity [.....]

Date [.....]

Make [.....]

Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Ambient Temperature	°C	[.....]	[.....]	[.....]
2	Temperature of Air entering the air heater	°C	[.....]	[.....]	[.....]
3	Temperature of gas entering the air heater	°C	[.....]	[.....]	[.....]
4	Temperature of gas leaving the air heater	°C	[.....]	[.....]	[.....]
5	Percent O ₂ in flue gas entering air heater	%	[.....]	[.....]	[.....]
6	Percent O ₂ in flue gas leaving air heater	%	[.....]	[.....]	[.....]
7	Air preheater Leakage	%	[.....]	[.....]	[.....]
8	Gas Side Efficiency	%	[.....]	[.....]	[.....]

Observations:

[.....]

[.....]

[.....]

Recommendations:

[.....]

[.....]

Cost Benefit Analysis:

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[94]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[95]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-3

ENERGY AUDIT REPORT FOR PA FAN (A/B)

Plant Name [.....]

Work Order Number [.....]

Test Report Number [.....]

Owner [.....]

Unit Number [.....]

Unit Capacity [.....]

Date [.....]

Make [.....]

Control [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Load	MW	[.....]	[.....]	[.....]
2	Flow Rate	m ³ /sec	[.....]	[.....]	[.....]
3	Discharge Pressure	Pa	[.....]	[.....]	[.....]
4	Current	Amps	[.....]	[.....]	[.....]
5	Speed	RPM	[.....]	[.....]	[.....]
6	Power consumption	KW	[.....]	[.....]	[.....]
7	Mechanical Efficiency	%	[.....]	[.....]	[.....]
8	Combined Efficiency of Fan & Motor	%	[.....]	[.....]	[.....]

Observations:

[.....]

[.....]

[.....]

Recommendations:

[.....]

[.....]

[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[96]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[97]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of <i>[Name of the Power Plant]</i>	<i>[LOGO OF UTILITY]</i>
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Appendix-4

ENERGY AUDIT REPORT FOR FD FAN (A/B)

Plant Name
 Work Order Number
 Test Report Number
 Owner
 Unit Number
 Unit Capacity
 Date
 Make
 Control

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Load	MW	.....	.....	.....
2	Furnace Draft	Pa	.....	.....	.....
3	Flow	m ³ /sec	.....	.....	.....
4	Suction Pressure	Pa	.....	.....	.....
5	Discharge Pressure	Pa	.....	.....	.....
6	Total Head Developed	Pa	.....	.....	.....
7	Discharge Air Temperature	°C	.....	.....	.....
8	Current	Amps	.....	.....	.....
9	Speed	RPM	.....	.....	.....
10	Power consumption	kW	.....	.....	.....
11	Efficiency	%	.....	.....	.....

Observations:

.....

Recommendations:

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[98]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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[.....]
[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[99]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of <i>[Name of the Power Plant]</i>	<i>[LOGO OF UTILITY]</i>
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Appendix-5

ENERGY AUDIT REPORT FOR ID FAN (A/B/C)

Plant Name *[.....]*
 Work Order Number *[.....]*
 Test Report Number *[.....]*
 Owner *[.....]*
 Unit Number *[.....]*
 Unit Capacity *[.....]*
 Date *[.....]*
 Make *[.....]*
 Control *[.....]*

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Load	MW	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
2	Furnace Draft	Pa	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
3	Flow	m ³ /sec	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
4	Suction Pressure	Pa	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
5	Discharge Pressure	Pa	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
6	Discharge Flue Gas Temperature	°C	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
7	Current	Amps	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
8	Speed	RPM	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
9	Power consumption	kW	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
10	Efficiency	%	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>

Observations:

[.....]
[.....]
[.....]
[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[100]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Recommendations:

[.....
.....
.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[101]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-6

ENERGY AUDIT REPORT FOR MILL (A/B/C/D/E/F/G/H)

Plant Name [.....]

Work Order Number [.....]

Test Report Number [.....]

Owner [.....]

Unit Number [.....]

Unit Capacity [.....]

Date [.....]

Make [.....]

Type (Ball, Bowl, Ball&Race)[.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Unit Load	MW	[.....]	[.....]	[.....]
2	Frequency	Hz	[.....]	[.....]	[.....]
3	Mill Capacity/ Throughput	TPH	[.....]	[.....]	[.....]
4	Furnace Draft	mmwc	[.....]	[.....]	[.....]
5	Mill Motor Speed	RPM	[.....]	[.....]	[.....]
6	Mill Differential Pressure	mmwc	[.....]	[.....]	[.....]
7	Mill Current	Amps	[.....]	[.....]	[.....]
8	Mill Power Consumption / ton of coal	kW/ton	[.....]	[.....]	[.....]
9	Calorific Value of Mill reject	kCal/kg	[.....]	[.....]	[.....]
10	Classifier Position	%	[.....]	[.....]	[.....]
11	Air to Coal ratio	Tons/Tons			

Fineness Analysis	Delivery Port-1	Delivery Port-2	Delivery Port-3	Delivery Port-4
+ 50 Mesh				

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[102]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
--	-------------------

Fineness Analysis	Delivery Port-1	Delivery Port-2	Delivery Port-3	Delivery Port-4
200 Mesh				

Observations:

[.....
.....
.....]

Recommendations:

[.....
.....
.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[103]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-7

ENERGY AUDIT REPORT FOR TURBINE

Plant Name [.....]
 Work Order Number [.....]
 Test Report Number [.....]
 Owner [.....]
 Unit Number [.....]
 Unit Capacity [.....]
 Date [.....]
 Make [.....]
 Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Load	MW	[.....]	[.....]	[.....]
2	Auxiliary Consumption	MW	[.....]	[.....]	[.....]
3	Main Steam Pressure Before ESV	kg/cm ²	[.....]	[.....]	[.....]
4	Main Steam Temperature before ESV	°C	[.....]	[.....]	[.....]
5	CRH Pressure	kg/cm ²	[.....]	[.....]	[.....]
6	CRH Temperature	°C	[.....]	[.....]	[.....]
7	HRH Pressure	kg/cm ²	[.....]	[.....]	[.....]
8	HRH Temperature	°C	[.....]	[.....]	[.....]
9	IPT Exhaust Temperature	°C	[.....]	[.....]	[.....]
10	Turbine Exhaust Temperature	°C	[.....]	[.....]	[.....]
11	Condenser back pressure	kg/cm ²	[.....]	[.....]	[.....]
12	SH Spray Flow	TPH	[.....]	[.....]	[.....]
13	RH Spray Flow	TPH	[.....]	[.....]	[.....]
14	Feed Water Flow	TPH	[.....]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[104]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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15	Feed Water Temperature	°C	[.....]	[.....]	[.....]
16	Soot Blowing Steam Flow	TPH	[.....]	[.....]	[.....]
17	HP Turbine Efficiency	%	[.....]	[.....]	[.....]
18	IP Turbine Efficiency	%	[.....]	[.....]	[.....]
19	LP Turbine Efficiency	%	[.....]	[.....]	[.....]
20	Turbine Heat Rate	kCal/Kwh	[.....]	[.....]	[.....]
21	Gross Heat Rate	kCal/Kwh	[.....]	[.....]	[.....]

Observations:

[.....]
[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]
[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[105]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[...] of [Name of the Power Plant]	[LOGO OF UTILITY]
---	-------------------

Appendix-8

ENERGY AUDIT REPORT FOR CONDENSER (A/B)

Plant Name [.....]
 Work Order Number [.....]
 Test Report Number [.....]
 Owner [.....]
 Unit Number [.....]
 Unit Capacity [.....]
 Date [.....]
 Make [.....]
 Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Number of cooling tubes	Nos	[.....]	[.....]	[.....]
2	Cooling surface area	M ²	[.....]	[.....]	[.....]
3	Cooling water flow	TPH	[.....]	[.....]	[.....]
4	CW I/L temperature	°C	[.....]	[.....]	[.....]
5	CW O/L temperature	°C	[.....]	[.....]	[.....]
6	Back Pressure	kg/cm ²	[.....]	[.....]	[.....]
7	Hot well Temperature	°C	[.....]	[.....]	[.....]
8	Length of cooling tubes	MM	[.....]	[.....]	[.....]
9	Diameter of cooling tubes	MM	[.....]	[.....]	[.....]
10	Turbine exhaust hood temperature	°C	[.....]	[.....]	[.....]
11	Condenser TTD	°C	[.....]	[.....]	[.....]
12	LMTD	°C	[.....]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[106]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
--	-------------------

Observations:

[.....
.....
.....]

Recommendations:

[.....
.....
.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[107]	26.09.2013

Appendix-9

ENERGY AUDIT REPORT FOR LP HEATERS (No.1/2/3/4/5)

Plant Name [.....]

Work Order Number [.....]

Test Report Number [.....]

Owner [.....]

Unit Number [.....]

Unit Capacity [.....]

Date [.....]

Make [.....]

Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Saturation temperature of extraction steam	°C	[.....]	[.....]	[.....]
2	Temp of feed water at Heater Outlet	°C	[.....]	[.....]	[.....]
3	Temperature of heater drip	°C	[.....]	[.....]	[.....]
4	Temp of feed water at Heater Inlet	°C	[.....]	[.....]	[.....]
5	TTD of heater	°C	[.....]	[.....]	[.....]
6	DCA of heater	°C	[.....]	[.....]	[.....]

Observations:

[.....]

[.....]

[.....]

Recommendations:

[.....]

[.....]

[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[108]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
--	-------------------

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[109]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-10

ENERGY AUDIT REPORT FOR HP HEATERS (No.5/6/7)

Plant Name [.....]

Work Order Number [.....]

Test Report Number [.....]

Owner [.....]

Unit Number [.....]

Unit Capacity [.....]

Date [.....]

Make [.....]

Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Saturation temperature of extraction steam	°C	[.....]	[.....]	[.....]
2	Temp of feed water at Heater Outlet	°C	[.....]	[.....]	[.....]
3	Temperature of heater drip	°C	[.....]	[.....]	[.....]
4	Temp of feed water at Heater Inlet	°C	[.....]	[.....]	[.....]
5	TTD of heater	°C	[.....]	[.....]	[.....]
6	DCA of heater	°C	[.....]	[.....]	[.....]

Observations:

[.....]

[.....]

[.....]

Recommendations:

[.....]

[.....]

[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[110]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
--	-------------------

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[111]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-11

ENERGY AUDIT REPORT FOR BOILER FEED PUMP (No.1/2/3)

Plant Name [.....]
 Work Order Number [.....]
 Test Report Number [.....]
 Owner [.....]
 Unit Number [.....]
 Unit Capacity [.....]
 Date [.....]
 Make [.....]
 Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Load	MW	[.....]	[.....]	[.....]
2	Feed water temperature to BFP Inlet	°C	[.....]	[.....]	[.....]
3	Feed water temperature to BFP Outlet	°C	[.....]	[.....]	[.....]
4	Feed water pressure to BFP inlet	kg/cm ²	[.....]	[.....]	[.....]
5	Feed water pressure to BFP outlet	kg/cm ²	[.....]	[.....]	[.....]
6	Speed	RPM	[.....]	[.....]	[.....]
7	Current	Amps	[.....]	[.....]	[.....]
8	Power	kW	[.....]	[.....]	[.....]
9	Capacity	TPH	[.....]	[.....]	[.....]
10	Efficiency	%	[.....]	[.....]	[.....]

Observations:

[.....]
 [.....]
 [.....]
 [.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[112]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
--	-------------------

Recommendations:

[.....

]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[113]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
--	-------------------

Appendix-12

ENERGY AUDIT REPORT FOR CONDENSATE EXTRACTION PUMP (No.1/2/3)

Plant Name [.....]
 Work Order Number [.....]
 Test Report Number [.....]
 Owner [.....]
 Unit Number [.....]
 Unit Capacity [.....]
 Date [.....]
 Make [.....]
 Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Load	MW	[.....]	[.....]	[.....]
2	Feed water temperature to CEP Inlet	°C	[.....]	[.....]	[.....]
3	Feed water temperature to CEP Outlet	°C	[.....]	[.....]	[.....]
4	Feed water pressure to CEP inlet	kg/cm ²	[.....]	[.....]	[.....]
5	Feed water pressure to CEP outlet	kg/cm ²	[.....]	[.....]	[.....]
7	RPM	RPM	[.....]	[.....]	[.....]
8	Current	Amps	[.....]	[.....]	[.....]
9	Power	kW	[.....]	[.....]	[.....]
12	Capacity	TPH	[.....]	[.....]	[.....]
13	Minimum flow recommended	TPH	[.....]	[.....]	[.....]
15	Efficiency	%	[.....]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[114]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Observations:

[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]
[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[115]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-13

ENERGY AUDIT REPORT FOR CW PUMP (No.1/2/3)

Equipment [.....]
Plant Name [.....]
Capacity [.....]
Owner [.....]
Date [.....]
Time [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Capacity	TPH	[.....]	[.....]	[.....]
2	Total dynamic head	mwc	[.....]	[.....]	[.....]
3	Speed	RPM	[.....]	[.....]	[.....]
4	Current	Amps	[.....]	[.....]	[.....]
5	Power	kW	[.....]	[.....]	[.....]
6	Efficiency	%	[.....]	[.....]	[.....]

Observations:

[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended / not recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[116]	26.09.2013

Appendix-14

ENERGY AUDIT REPORT FOR COOLING TOWER

Plant Name [.....]

Work Order Number [.....]

Test Report Number [.....]

Owner [.....]

Unit Number [.....]

Unit Capacity [.....]

Date [.....]

Make [.....]

Type [.....]

S.No.	Description	Unit	Design Value	Operating Value	Deviation (%)
1	Ambient Wet Bulb Temp	°C	[.....]	[.....]	[.....]
2	Ambient Dry Bulb Temp	°C	[.....]	[.....]	[.....]
3	Inlet Wet Bulb Temp	°C	[.....]	[.....]	[.....]
4	Flow	m ³ /hr	[.....]	[.....]	[.....]
5	Hot Water Temp	°C	[.....]	[.....]	[.....]
6	Recooled Water Temp	°C	[.....]	[.....]	[.....]
7	Power Consumption	kW	[.....]	[.....]	[.....]
8	Efficiency	%	[.....]	[.....]	[.....]

Observations:

[.....]

[.....]

[.....]

Recommendations:

[.....]

[.....]

[.....]

Cost Benefit Analysis:

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[117]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

<i>Estimated Investment (Rs.)</i>	<i>Estimated Increase in Efficiency (%)</i>	<i>Payback Period (Years)</i>
<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[118]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-15

ENERGY AUDIT REPORT FOR PLANT AIR COMPRESSOR (No.1/2/3)

Plant Name [.....]

Work Order Number [.....]

Test Report Number [.....]

Owner [.....]

Unit Number [.....]

Unit Capacity [.....]

Date [.....]

Make [.....]

Type [.....]

S.No.	Description	Units	Design Values	Operating Value	Deviation (%)
1	Atmospheric pressure	Bar	[.....]	[.....]	[.....]
2	Relative humidity	%	[.....]	[.....]	[.....]
3	Dry bulb temperature	° K	[.....]	[.....]	[.....]
4	Saturated vapour pressure	kg/cm ²	[.....]	[.....]	[.....]
5	Partial vapour pressure	kg/cm ²	[.....]	[.....]	[.....]
6	Suction pressure	kg/cm ²	[.....]	[.....]	[.....]
7	Pressure reading at start	kg/cm ²	[.....]	[.....]	[.....]
8	Pressure reading at finish	kg/cm ²	[.....]	[.....]	[.....]
9	Final temperature	°K	[.....]	[.....]	[.....]
10	Volume of receiver	m ³	[.....]	[.....]	[.....]
11	Volume of pipes	m ³	[.....]	[.....]	[.....]
12	Total volume	m ³	[.....]	[.....]	[.....]
13	Time of filling	Sec	[.....]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[119]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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S.No.	Description	Units	Design Values	Operating Value	Deviation (%)
14	Free air delivery	m ³ /hr	[.....]	[.....]	[.....]
15	Measured capacity	Nm ³ /hr	[.....]	[.....]	[.....]
16	Power consumption	kW	[.....]	[.....]	[.....]
17	KW rating	kW	[.....]	[.....]	[.....]

Observations:

[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[120]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-16

ENERGY AUDIT REPORT FOR INSTRUMENT AIR COMPRESSOR (No.1/2/3)

Plant Name [.....]
 Work Order Number [.....]
 Test Report Number [.....]
 Owner [.....]
 Unit Number [.....]
 Unit Capacity [.....]
 Date [.....]
 Make [.....]
 Type [.....]

S.No.	Description	Units	Design Values	Operating Value	Deviation (%)
1	Atmospheric pressure	Bar	[.....]	[.....]	[.....]
2	Relative humidity	%	[.....]	[.....]	[.....]
3	Dry bulb temperature	° K	[.....]	[.....]	[.....]
4	Saturated vapour pressure	kg/cm ²	[.....]	[.....]	[.....]
5	Partial vapour pressure	kg/cm ²	[.....]	[.....]	[.....]
6	Suction pressure	kg/cm ²	[.....]	[.....]	[.....]
7	Pressure reading at start	kg/cm ²	[.....]	[.....]	[.....]
8	Pressure reading at finish	kg/cm ²	[.....]	[.....]	[.....]
9	Final temperature	° K	[.....]	[.....]	[.....]
10	Volume of receiver	m ³	[.....]	[.....]	[.....]
11	Volume of pipes	m ³	[.....]	[.....]	[.....]
12	Total volume	m ³	[.....]	[.....]	[.....]
13	Time of filling	Sec	[.....]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[121]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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S.No.	Description	Units	Design Values	Operating Value	Deviation (%)
14	Free air delivery	m ³ /hr	[.....]	[.....]	[.....]
15	Measured capacity	Nm ³ /hr	[.....]	[.....]	[.....]
16	Power consumption	kW	[.....]	[.....]	[.....]
17	kW rating	kW	[.....]	[.....]	[.....]

Observations:

[.....]
[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]
[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis are attached. The results of analysis are furnished in the table below.]

Estimated Investment (Rs.)	Estimated Increase in Efficiency (%)	Payback Period (Years)
[.....]	[.....]	[.....]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[122]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of <i>[Name of the Power Plant]</i>	<i>[LOGO OF UTILITY]</i>
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Appendix-17

ENERGY AUDIT REPORT FOR THERMAL INSULATION

Plant Name *[.....]*

Work Order Number *[.....]*

Test Report Number *[.....]*

Owner *[.....]*

Unit Number *[.....]*

Unit Capacity *[.....]*

Date *[.....]*

<i>S.No.</i>	<i>Description of Piping/ Equipment Body</i>	<i>Surface Temperature (°C)</i>	<i>Heat Saving Potential (Watts/m²)</i>	<i>Cost Impact</i>	<i>Payback Period</i>
<i>1</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>2</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>3</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>4</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>5</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>6</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>7</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>8</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>9</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>10</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>11</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>12</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>13</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>14</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>15</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>16</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>	<i>[.....]</i>

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[123]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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S.No.	Description of Piping/ Equipment Body	Surface Temperature (°C)	Heat Saving Potential (Watts/m ²)	Cost Impact	Payback Period
17	[.....]	[.....]	[.....]	[.....]	[.....]
18	[.....]	[.....]	[.....]	[.....]	[.....]
19	[.....]	[.....]	[.....]	[.....]	[.....]
20	[.....]	[.....]	[.....]	[.....]	[.....]

Observations:

[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]
[.....]

Cost Benefit Analysis:

[Calculations for the cost benefit analysis for each of the recommended improvement options are attached.]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[124]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Appendix-18

ENERGY AUDIT REPORT FOR ILLUMINATION SYSTEM

Plant Name [.....]
Work Order Number [.....]
Test Report Number [.....]
Owner [.....]
Unit Number [.....]
Unit Capacity [.....]
Date [.....]

S. No.	Location	Actual lux/W/m ²	Target lux/W/m ²	Energy Loss Saving Potential kWh/Annum	Cost Impact	Payback Period
1.	Control Room.	[.....]	[.....]	[.....]	[.....]	[.....]
2.	Conference Room	[.....]	[.....]	[.....]	[.....]	[.....]
3.	Administrative Office	[.....]	[.....]	[.....]	[.....]	[.....]
4.	Conference room	[.....]	[.....]	[.....]	[.....]	[.....]
5.	Testing Laboratory	[.....]	[.....]	[.....]	[.....]	[.....]
6.	Work shop Building	[.....]	[.....]	[.....]	[.....]	[.....]
7.	Transformer area,	[.....]	[.....]	[.....]	[.....]	[.....]
8.	Switchyard area	[.....]	[.....]	[.....]	[.....]	[.....]
9.	Outdoor yard area	[.....]	[.....]	[.....]	[.....]	[.....]
10.	Indoor GIS Buildings	[.....]	[.....]	[.....]	[.....]	[.....]
11.	Air Compressor Plant	[.....]	[.....]	[.....]	[.....]	[.....]
12.	Silo surrounding areas	[.....]	[.....]	[.....]	[.....]	[.....]
13.	Silo Platforms	[.....]	[.....]	[.....]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[125]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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S. No.	Location	Actual lux/W/m²	Target lux/W/m²	Energy Loss Saving Potential kWh/Annum	Cost Impact	Payback Period
14.	CW Pump House	[.....]	[.....]	[.....]	[.....]	[.....]
15.	Battery Room	[.....]	[.....]	[.....]	[.....]	[.....]
16.	Air Conditioning Plant Room	[.....]	[.....]	[.....]	[.....]	[.....]
17.	AHU Room	[.....]	[.....]	[.....]	[.....]	[.....]
18.	Switchgear Room	[.....]	[.....]	[.....]	[.....]	[.....]
19.	Electrical & Electronic equipment Room	[.....]	[.....]	[.....]	[.....]	[.....]
20.	Elevator M/C Room	[.....]	[.....]	[.....]	[.....]	[.....]
21.	Cable spreader Area	[.....]	[.....]	[.....]	[.....]	[.....]
22.	Chlorination Building	[.....]	[.....]	[.....]	[.....]	[.....]
23.	Chlorinator Room	[.....]	[.....]	[.....]	[.....]	[.....]
24.	Chemical storage Room	[.....]	[.....]	[.....]	[.....]	[.....]
25.	Conveyors (exposed)	[.....]	[.....]	[.....]	[.....]	[.....]
26.	Conveyors (enclosed)	[.....]	[.....]	[.....]	[.....]	[.....]
27.	Crusher House	[.....]	[.....]	[.....]	[.....]	[.....]
28.	Screen Houses	[.....]	[.....]	[.....]	[.....]	[.....]
29.	Junction Towers	[.....]	[.....]	[.....]	[.....]	[.....]
30.	Coal / Lignite Stock Yard (open Area)	[.....]	[.....]	[.....]	[.....]	[.....]
31.	Coal / Lignite stock yard (covered Area)	[.....]	[.....]	[.....]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[126]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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S. No.	Location	Actual lux/W/m ²	Target lux/W/m ²	Energy Loss Saving Potential kWh/Annum	Cost Impact	Payback Period
32.	Stacker and Reclaimer area	[.....]	[.....]	[.....]	[.....]	[.....]
33.	Fuel Oil Pump House	[.....]	[.....]	[.....]	[.....]	[.....]
34.	Hazardous Area within Fuel Oil Storage Dyke Area	[.....]	[.....]	[.....]	[.....]	[.....]
35.	Passages	[.....]	[.....]	[.....]	[.....]	[.....]
36.	Indoor Stair Cases	[.....]	[.....]	[.....]	[.....]	[.....]
37.	Outdoor Stair Cases	[.....]	[.....]	[.....]	[.....]	[.....]
38.	Semi Outdoor stairs	[.....]	[.....]	[.....]	[.....]	[.....]
39.	Toilets	[.....]	[.....]	[.....]	[.....]	[.....]
40.	Roads inside the Boundary Wall	[.....]	[.....]	[.....]	[.....]	[.....]
41.	Periphery lighting around the Buildings	[.....]	[.....]	[.....]	[.....]	[.....]
42.	Approach roads	[.....]	[.....]	[.....]	[.....]	[.....]
43.	Hydrogen Plant hazardous areas	[.....]	[.....]	[.....]	[.....]	[.....]

Observations:

[.....]
[.....]
[.....]
[.....]

Recommendations:

[.....]
[.....]
[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[127]	26.09.2013

Model Energy Audit Report For R&M of Unit No.[..] of <i>[Name of the Power Plant]</i>	<i>[LOGO OF UTILITY]</i>
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Cost Benefit Analysis:

[Calculations for the cost benefit analysis for each of the recommended improvement options are attached.]

[Based on the cost benefit analysis, it is recommended to take up the R&M Measures]

[Signature]

[Name and Designation of Inspecting Engineer]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-005	02	MODEL ENERGY AUDIT REPORT	[128]	26.09.2013



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDERING PROCEDURE FOR SELECTION OF
R&M CONTRACTORS AND CONSULTANTS**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

Model Tendering Procedure for Selection of R&M Contractors and Consultants	Logo of Utility
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BACKGROUND

What is R&M (Renovation & Modernization) of Thermal Power Plants?

Coal based power stations contribute more than 70% share of total power generation in India. Thermal Power Stations are designed for an economical and stable life span of 25 years, after which, the level of performance starts deteriorating as a result of degradation of its equipments, components and materials. Deterioration in performance is reflected in frequent forced outages, reduced outputs, decreased efficiency and increased cost of generation. This results in costly repair and loss of revenue. Renovations & Modernization (R&M) of thermal power station is an activity of carrying out repairs, refurbishments and replacement of defective equipments & components so as to extend the life of the power plant by at least 15-20 years, to restore the performance parameters to equal or better than the original design parameters and to ensure that the renovated plant complies with the revised statutory emission standards.

Need of R&M

In spite of new capacity additions, India continues to face shortages of varying degree in the supply of energy and peaking power. Implementation of fresh capacity additions for bridging the demand supply gap involves huge investments and long gestation periods primarily due to the process of land acquisition and getting the required fuel and water allocations, permits & clearances, particularly, the environmental clearance.

On the other hand, R&M activity of existing old power plants which requires less investment and can be completed in shorter duration has been recognized as a techno-economically viable option to supplement the fresh capacity addition for maximizing the energy generation. Also it helps in reducing the emissions by adopting upgraded modern technologies.

Need of preparation of Model R&M Documents

The countrywide R&M programme was first initiated in 1980 when Government of India approved the scheme of Central Loan Assistance (CLA) of Rs. 500 crores benefitting 34 power stations mostly of 50/60/100/110/120/140 MW capacities. R&M in a structured manner was initiated as a centrally sponsored programme during the 7th Five Year Plan. The momentum of carrying out R&M works was continued through 8th and 9th Plans but the same could not be sustained during the 10th Plan.

Based on the discussions held with Ministry of Power, various utilities, PFC and BHEL, CEA prepared a document on “National Perspective Plan for Renovation & Modernization and Life Extension and Up-rating (LE&U) of thermal power stations up to the year 2016-17”. This document which also includes revised guidelines for Renovation & Modernization / Life Extension works on coal/lignite based thermal power stations was released by Honourable Minister of Power on 14th December 2009. In the Perspective Plan, 53 units (7318 MW) for LE works and 76 units (18965 MW) for R&M works were identified for 11th Plan and 72 units (16532 MW) for LE works and 23 units (4871 MW) for R&M works were identified for 12th Plan.

Document Number	Rev No	Description	Page No.	Date of Issue
LII-GETS12021-G-001119-006	01	Model Tendering Procedure	[i]	25.09.2014

Model Tendering Procedure for Selection of R&M Contractors and Consultants	Logo of Utility
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In the past, R&M measures were hampered due to lack of proper planning. Proper investigation to identify the R&M works to be carried out and preparation of technical bid documents based on the investigation was not done. This resulted in unsystematic and additional work during execution phase and uncertainty about costs resulting in excessive implementation time, long shutdown periods of plants and cost overruns. In the absence of standard commercial rules and policies, suppliers showed little interest in R&M work. Therefore a strong need was felt for providing standardized bidding procedures as well as model contracts, formats and specifications etc. to the utilities. Standardization will harmonize the requirements of all the stakeholders and will lead to their increased participation.

The Indo-German Energy Forum (IGEF)

The Indo-German Energy Forum (IGEF), inaugurated in 2006, provides a platform to discuss energy related issues of mutual interest. The first meeting of the ad-hoc sub-group on “energy efficiency in thermal power stations”, constituted as per decision of meeting of IGEF in December 2007, was held under the chairmanship of Joint Secretary (Thermal), Ministry of Power on 12th March, 2008 in which preparation of standard tendering document for the purpose of R&M activities was, inter-alia, identified as an area of the activities. The scope of the assignment was divided in two parts as under:-

Phase-I Activity:

Phase-I activity comprised an assessment of tendering procedures currently being followed by public utilities in India and a review of documents used for standard R&M projects and the documents which have already been developed for energy efficient R&M projects, financed particularly by World Bank. This activity was carried out by M/s Evonik under the grant provided by GTZ.

Phase-II Activity

Phase-II activity comprised the preparation of the model documents / templates in consultation with Task Force, power utilities & financing agencies.

In the 3rd meeting of Indo-German Energy Forum (IGEF) convened in Berlin on 4th November 2009, KfW proposed to finance and carryout the work programme of phase-II Activity, on behalf of CEA & in consultation with the Task Force. In a meeting held in MOP on 17th December 2009, chaired by Joint Secretary (Thermal), MOP, the representative of KfW suggested that CEA may act as “Project Executing Agency” for the phase-II activity. Accordingly Ministry of Power, Govt. of India have entrusted the task of “Project Executing Agency” to CEA for implementing Phase-II activity. Under Indo-German Energy Forum (IGEF) assisted programme, M/s Lahmeyer International (India) was appointed on 16th March 2012 to provide the consultancy services for ‘Development of tendering procedures and model contract document for R&M of Fossil Fuel Based Power Plants in India.’

Due Diligence done by LII of the R&M Documents of other Projects

Before the preparation of this model document, LII did a thorough review of the R&M Documents of the following Power Plants:

Document Number	Rev No	Description	Page No.	Date of Issue
LII-GETS12021-G-001119-006	01	Model Tendering Procedure	[ii]	25.09.2014

Model Tendering Procedure for Selection of R&M Contractors and Consultants	Logo of Utility
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Documents of the Power Plants where LII was associated with R&M activities

- R&M and LE of Units 1 & 2 of Ukai TPS (2x120 MW) of GSECL.
- R&M of Units 1 & 2 of Kutch Lignite TPS (2x70 MW) of GSECL.
- Refurbishment & Up-gradation of 240 TPH Blast Gas Fired Boiler of Ispat Energy Ltd.
- Detailed design for the Balance of Plant for the R&M of OBRA 'A' & 'B' Thermal Power Station.
- RFP document for the R&M Unit 1, 3, & 4 (3x50 MW) of Patratu TPS of JSEB.
- R&M crash programme document for Units III & IV of Panki Thermal Power Station (2x105 MW).

Documents provided by CEA

- Remaining Life Assessment / Condition Assessment Report- Nasik Unit-3 of MAHAGENCO.
- Energy Audit Report- Nasik Unit- 3 of MAHAGENCO.
- Detailed Feasibility Report- Nasik Unit-3 of MAHAGENCO.
- Draft Detailed Project Report -Kolaghat Unit-3 of WBPDCCL.
- Service Contract- R&M of Unit-1 Panipat TPS of HPGCL.
- Tender document for Supply, Erection, Testing and Commissioning of Air Preheater for Unit 5 & 6 Koradi TPS, MAHAGENCO.
- Tender document for replacement of 6.6 KV station transformer incoming breaker & Tie- breaker of Koradi TPS, MAHAGENCO.
- Tender specification for Design, Engineering, Supply, Erection, Testing and Commissioning of Rotary Air Preheater for Units 4 & 5, Nasik TPS of MAHAGENCO.

Documents provided by WBPDCCL

- Energy Audit Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Detailed Project Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Project Design Report of Bandel Unit -5 (210 MW) of WBPDCCL.
- Technical Specifications. (Vol. II of RFP Document for R&M Contractor).
- RLA for Boiler for Bandel Unit -5.
- RFP for R&M Consultant for Bandel Unit -5.
- Commercial Volume-I of RFP for Bandel Unit -5 for R&M Contractor.

KfW Documents

- Model Contract Document issued by KfW.
- Guidelines issued by KfW for the assignment of Consultants.

World Bank Documents

- Standard Bidding Document for Procurement of Plant, Design, Supply and Installation.
- Standard Request for Proposal for the Selection of Consultants.

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OBJECTIVE OF THE MODEL TENDERING PROCEDURE DOCUMENT

Central Electricity Authority (CEA), the Project Executing Agency / Employer has appointed Lahmeyer International India Pvt. Ltd. (LII), the Consultant to Develop Standard Procedures and Model Documents for the Renovation and Modernization (R&M) of Fossil Fuel based Power Plants in India. The above assignment is being financed by KfW Entwicklungsbank. Development of Model Tendering Procedure for Selection of R&M Contractors and Consultants is one of the tasks under this assignment. Accordingly, this Tendering Procedure for Selection of R&M Contractors and CXonsultants has been prepared for the guidance of Project Authorities who may decide to carryout R&M of their old Coal based Power Plants so as to extend the life of their plants and make them energy efficient in compliance with statutory norms. The utilities are advised to refer to the guidelines of the standard documents for the preparation of the project specific documents for their project.

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1 INTRODUCTION

1.1 Guiding Principles

This Tendering Procedure has been prepared to provide the guidelines for the methodology to be adopted for selection of R&M Contractors and Consultants in a fair and transparent manner with an objective to carry out the Energy Efficient Renovation & Modernization work by adhering to acceptable standards of quality and cost competitiveness. The prescribed methodology aims at employing capable and competent contractors from any part of the world to best achieve Life Extension, Reliability improvement and Performance Restoration/Enhancement objectives of R&M Projects. While developing the procedure, the tendering practices prescribed by international development banks and practices followed by public sector undertakings of India were reviewed.

1.2 Applicability

This Tendering Procedure may be used by utilities as a guideline for designing a Tendering Process for selection of Contractors and Consultants for Renovation & Modernization work for coal fired thermal power plants in India.

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2 OVERALL TENDERING PROCESS FOR CONTRACTORS

2.1 Qualification of Bidders

2.1.1 Pre-Qualification vs. Post Qualification

Pre-qualification is carried out to assess whether or not the interested bidders are capable of properly delivering as per the contractual scope of work. The capability of the bidders is assessed on the basis of qualification documents submitted as part of the pre-qualification exercise. Only such bidders who are found qualified in the pre-qualification stage are issued the tender documents and are allowed to submit the bid for the R&M work.

In tendering process with post-qualification, the qualification documents and the actual bids are submitted simultaneously.

Advantages of pre-qualification:-

In pre-qualification route, bidders have a fair idea whether or not they are qualified to be considered as prospective contractor for the work being tendered, before spending considerable time and expenses for preparing a detailed bid. Further, prequalification gives the Owner some idea about the qualified bidders who are likely to submit the bid. In case it turns out that inadequate number of prospective bidders are qualified to bid; the owner may explore ways to increase participation of qualified bidders.

Advantages of post-qualification:-

Post-qualification route obviates the need for a separate pre-qualification exercise before submission of proposal. Further, as the qualification documents are submitted along with proposal, latest qualification data/status as on the date of submission of proposal can be used for qualification.

Recommended Qualification Procedure for R&M Work:-

Pre-qualification route is more suitable for large or complex work that involves considerable time and effort for preparation of detailed bid/proposal.

The Energy Efficient R&M work is technologically complex and challenging in terms of execution. It is important to ascertain the availability and willingness of capable and qualified bidders through a pre qualification process before inviting tenders. Further, evaluating tenders from a large number of bidders, both qualified and unqualified, will make the tendering process time consuming. Therefore, only parties qualified in a pre-qualification process should be issued Tender Documents and should be allowed to participate in the Tendering process. For all the packages, bids should be invited after conducting a pre-qualification process to shortlist qualified bidders

The objective of the pre-qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process. The pre-qualification document should specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The prequalification route is not intended to limit the competition to a predetermined number of potential bidders. While following this route, all the interested parties meeting the specified criteria will be issued tender documents and allowed to submit bid.

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2.1.2 Qualification Requirement

Due care should be taken to frame appropriate Qualification Requirement (QR) to ensure adequate participation of competent bidders. While framing the QR, detailed information should be collected from prospective bidders regarding their experience and capability.

The Qualification Requirement should include Technical Qualification Requirement, Financial Qualification Requirement and should cover Reasons for Exclusion if any. The Technical Qualification Requirement should call for technological & execution capabilities and experience in the execution of comparable projects. Financial Qualification Requirement should call for evidence of financial soundness; past experience in executing projects of similar magnitude and ability to mobilize financial resources for executing the project. The reasons of exclusion are aimed at excluding parties that may have unfair advantage over other parties or may have past record of wrongdoing. Any bidder who is or was involved as a consultant in the preparation or implementation of the project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of the project is to be excluded. Any bidder who is legally barred from the procurement process in India on the grounds of previous violations of regulations on fraud and corruption is to be excluded.

Too weak a qualification requirement may lead to the entry of incompetent bidders with lower price quotes. Awarding the R&M Contract to an incapable bidder may severely jeopardize the R&M programme. Similarly, too stringent a qualification requirement may restrict the number of eligible bidders to only a few, thereby restricting competition which may lead to higher price quotes.

The specified Technical and Financial Qualification Requirement should balance the twin objectives of restricting participation in the tendering process to capable and experience bidders with ability to successfully undertake the Renovation & Modernization work and ensuring participation by adequate number of interested parties to encourage competitive bids.

Bidders should be entitled to meet the Qualification Requirements jointly with their associates or consortium partners. In such cases, bidders and their associates and/or consortium partners should be asked to furnish a joint undertaking in the prescribed format to discharge their obligations. A bidder can be a Joint Venture Company as well. In all cases of qualification through Consortium/Associate/JV, all the parties will be jointly and severally liable to the Owner to discharge all contractual obligations.

2.1.3 Qualification Document

The intending Bidders should be asked to furnish documentary evidence and performance certificates in support of their qualification credentials along with their response to Request for Qualification. The documentary evidence should include inter alia list of orders executed along with copies of orders, Performance Certificates indicating date of completion as well as documents of company profile incorporating information about technical man power, financial strength, resources, organization, experience to undertake such jobs and certificates of audited accounts for last three years along with copies of latest income tax return etc.

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2.2 Stages of Tendering Process

The bid/proposal for the Renovation and Modernization work comprises (i) Techno-Commercial proposal/bid (without price) and (ii) Price/Financial Bid. The owner/processor has the option of inviting these two components of the bid simultaneously or in stages/in bids.

2.2.1 Single Stage Single Envelope Bidding

In this method of bidding, the bidder is asked to submit the techno-commercial bid along with price bid, which are opened simultaneously. The quoted prices of the bidders are thus known before the evaluation of techno-commercial proposals of the bidders to assess their techno-commercial responsiveness and before any discussion with the bidders regarding deviation in bids with respect to the tender conditions. The advantage with this method is that in case of large number of bids, detailed evaluation of bids can be restricted to the lowest bid and the bids with price quote close to the lowest bid. However, it has two disadvantages. Firstly, in case the bid with lowest price quote turns out to be techno-commercially non-responsive, it becomes a tough call to reject the lowest price bid and accept a bid with higher price quote. Secondly, this method has no provision of inviting supplementary price quotes, in case; the purchaser wants to introduce some changes in the specifications on the basis of post-bid discussions.

2.2.2 Single Stage Two Envelope Bidding

In this method, the bids for the Renovation and modernization work are submitted in two parts. Both the parts are submitted together.

The Part-I bid comprises the techno-commercial bid without prices. The main components of the techno-commercial bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical data sheets, List of Tools & Tackles, Deviations to technical and commercial specifications/conditions, Overall completion period & L-1 Network Schedule, Resource deployment schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part -II Bid will comprise quoted price and Performance Guarantee Parameters. Initially, only the Part-I bid is opened and Part-II bid is kept in safe custody.

After evaluation of the techno-commercial (Part-I) bids, each bidder who has submitted a broadly responsive Part-I bid, is invited for techno-commercial discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a Memorandum. Part-II bid (Price Bid) of only those bidders is opened, whose Part-I bid is found to be responsive to tender specifications and conditions.]

The Part-II bid comprises quote for Prices and the Performance Guarantee parameters in the form of filled up Schedules of Prices and Performance Guarantees.

However, after the evaluation of Part-I bids (techno-commercial bids) and before opening of Part-II bids (Price Bids), in case a particular bidder is asked to make changes in his techno commercial offer that may have price implications, then

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that bidder is allowed to submit supplementary price against such changes before the opening of Part-II bids (Price Bids).

This tendering method has the advantage that the evaluation of techno-commercial bid and techno-commercial discussion is carried out without any influence of price quotes. The price-bid of techno-commercially non-responsive bid is not opened at all. Further, in case any bidder is asked to change his proposal during techno-commercial discussions for conformance to tender conditions, the bidder is given an opportunity to submit supplementary price corresponding to that change. However, in this tendering method, techno-commercial bids of all the participating bidders need to be evaluated in detail. This may consume a lot of time and effort when quite a large number of bids are received.

2.2.3 Two Stage Bidding

In this tendering method, in the first stage, the bidders are asked to submit only the techno-commercial bid without any price quote and guaranteed performance parameters. The techno-commercial bids are evaluated to assess the techno-commercial responsiveness of the bid. Techno-commercial discussion is carried out to freeze the techno-commercial conditions of the contract. In the second stage, only the bidders whose techno-commercial bids are found to be responsive, are asked to submit price bids comprising quoted price and quoted performance guarantee parameters. The biggest advantage of this tendering method is that the bidders know the final techno-commercial contours of the tender before submitting any price bid. Therefore, they get the opportunity to base their price quotes on the final agreed techno-commercial conditions of the contract. However, the flip side is, that the bidders know who are the bidders, whose techno-commercial bids have been evaluated to be responsive, before making the price quotes. This may lead to uncompetitive price quotes in case where the number of responsive bidders is low (i.e. one/two). Further, in case only one bid is found to be responsive, the bidder is likely to quote largely inflated price to take advantage of the situation. Further, contracts/procurement norms of Government undertakings may not allow inviting price quotes from only one bidder.

2.2.4 Recommended Tendering Process

Each R&M project is unique and associated with many complexities regarding assessment of the quantum and nature of retrofit and replacement to be carried out. It is therefore important to firm up the technical contours of the contract before opening price quotations so that all the bidders and the owner have agreement and clarity about the nature and scope of the work on which the price bids are to be based. Considering the complexities of R&M Projects, it is recommended to invite the bids in two parts in single stage, as discussed in Para 2.2.2 above. The rationale behind inviting Part-II bid along with Part-I bid is that bidders will make their quotes before the number of responsive techno commercial bids is known. This will encourage competitive price quotes. However in case a bidder is asked to make changes in its techno commercial offer that may have price implications, that bidder may be allowed to submit supplementary price against such changes before opening of Part-II bids (Price Bids).

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2.3 Recommended Timeline of Tendering Process

The recommended sequence and timelines for the tendering process are described in the Table-2.1 and Figure-1 below:

Table-2.1
Broad Outline of Tendering Procedure

	Activity	Tentative Timeline
1	Request for Qualification	
(a)	Publication of RFQ and start of issue of RFQ document	Zero Date
(b)	Last date for issue of RFQ document	15 th Day from zero date
(c)	Last date for submission of response to RFQ	45 th Day from zero date
(d)	Short listing based on response to RFQ	75 th Day from zero date
2	Request for Proposal	
(a)	Issue of RFP	90 th Day from zero date
(b)	Pre - Bid Discussion	120 th Day from zero date
(c)	Last date for submission of Both Part –I and Part – II Bid and Opening of Part-I (Techno-commercial) Bid	150 th Day from zero date
(d)	Techno – Commercial Discussion	180 th Day from zero date
(e)	Completion of Evaluation of Techno-Commercial Bids	210 th Day from zero date
(f)	Date of Opening of Price Bids	225 th Day from zero date
(g)	Selection of Successful Bidder and Placement of Lol	255 th Day from zero date

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Figure-1: Tendering Procedure

PREQUALIFICATION

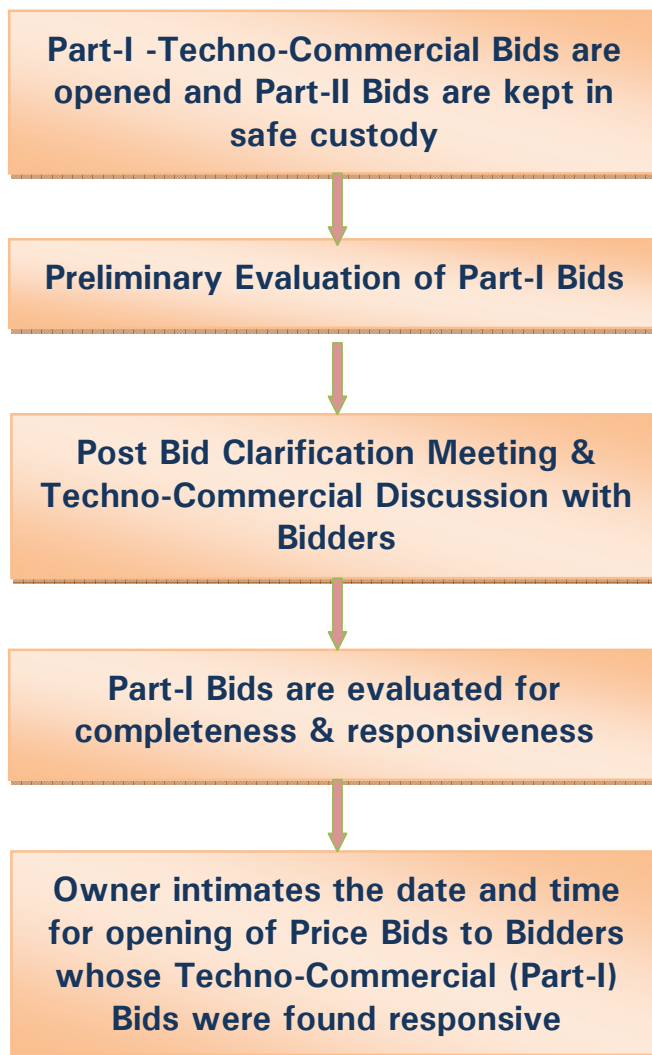


TENDERING



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EVALUATION OF PART-I BID



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EVALUATION OF PART-II BID

Price Bid of Bidders whose Part-I Bid was evaluated to be responsive



Part-II Bids are evaluated to identify Bidder with Lowest Evaluate Price as successful Bidder



Employer notifies successful Bidder. Successful Bidder submits Contract Performance Security and Contract is signed

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3 PACKAGING CONCEPT FOR R&M WORK

3.1 Single Package R&M vs Multiple Package R&M

Aligning the timeline of tendering process and execution of different packages and interfacing among different packages when R&M is being implemented in multiple packages is essential for smooth and timely execution of the R&M project. This risk may be mitigated by proper planning of tendering and execution of R&M project and employing suitable Project Management / Coordination team.

When a utility is planning to carry out renovation and modernization of the entire plant covering a number of major equipment and systems, it has the option of do it as a single package by a single contractor or split it into a number of packages each covering a major part of the plant /system and awarding these packages to separate contractors.

The advantages and disadvantages of single package R&M and multi-package R&M are listed in table 3.1.

Table 3.1
Single Package R&M Vs Multi-package R&M

Single Package	Multiple Package
<u>Advantages</u> <ul style="list-style-type: none"> ⇒ An all inclusive scope of work can minimize the need for changes in scope of work during execution and minimize disputes pertaining to scope of work. ⇒ Single point responsibility of one R&M Contractor. ⇒ For delay in any part, liquidated damages will be paid by the Contractor based on total contract value. ⇒ In case of deficiency in performance, liquidated damages will be paid by Contractor based on total contract value. ⇒ Less time and effort required in selection of contractor. 	<u>Advantages</u> <ul style="list-style-type: none"> ⇒ Lower contract price and better control on progress based payment. ⇒ Better suppliers/vendors for each package specialized in their respective area. ⇒ Owner can better monitor and control the work at more granular level.
<u>Disadvantages</u> <ul style="list-style-type: none"> ⇒ Higher contract price. ⇒ Selection of suppliers/vendors for different sub packages at the discretion of the main contractor. ⇒ Less transparency in project execution information flow. ⇒ No of competent Contractors available to execute such big R&M Contract is limited which leads to limited competition. 	<u>Disadvantages</u> <ul style="list-style-type: none"> ⇒ No single point contractor responsibility. Owner responsible for overall R&M work. ⇒ Scope of work, terminal points and interface requirements for different Contractors need to be defined properly to ensure there is no mismatch and no system/equipment is missed. ⇒ Liquidated damage for delay is paid by individual contractor linked to his contract value though delay in

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	single package may delay the whole project. ⇒ More time and effort required for selection of contractors.
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3.2 Recommended Package List

Implementing the Renovation and Modernization of the entire plant as a single package by a single contractor makes the tendering and execution process simple for the owner as it obviates the need to split the work into different packages, to ensure interface between different packages during design and execution and to properly align the completion schedule of different packages. Further, single package allows owner to fix single point responsibility and avoids contractual disputes arising out of acts of omission of one contractor affecting other contractors. However, Renovation and Modernization of different systems of the plant need different expertise and experience. There will be very few contractors, if any, who have in-house expertise and experience to carry out the R&M of all areas of a coal fired power plant. A single EPC bid for R&M work will thus restrict number of qualified bidders, which will also increase the cost of R&M. In order to balance the conflicting needs of minimizing project/contract management complexities and having adequate number of eligible and willing bidders having relevant expertise and experience to carry out the R&M work under a package, it is recommended to split the R&M work into the following packages:

1. Boiler & Auxiliaries (including but not limited to Pulverizes, Feeders, PA Fans, FD Fans, ID Fans), ESP, Auxiliary Steam system and MS, HRH, CRH, HPBP & LPBP piping and associated Electrical, C&I and Civil Works.
2. Turbo-Generator & Auxiliaries (including but not limited to Heaters, Deaerator, Condenser, BFPs, CEPs), TG Cycle piping including Boiler Feed piping and associated Electrical, C&I and Civil Works. This package will also including R&M of C&I system common to both SG and TG.
3. Coal Handling Plant and associated Electrical, C&I and Civil Works.
4. Ash Handling System and associated Electrical, C&I and civil works.
5. Mechanical Balance of Plant (BOP) System which includes Plant Water System (Raw water intake system, Pre-treatment Plant, D.M.Plant, CW System including Cooling Towers, ACW & CCW System), Compressed Air System, Fuel Oil System, Fire Fighting System and Miscellaneous balance mechanical systems.
6. Electrical BoP including inter alia Switchyard, Power Transformers and Switchgears.

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4 CONTRACTING CONCEPT FOR R&M WORK (CONTRACTORS)

The utility should adopt a fair and transparency bidding process that provides equal opportunity to all eligible bidders to participate in the tendering process. The objective of the tendering process is to select a contractor that is likely to execute the scope of renovation and modernization work satisfactorily adhering to envisaged completion schedule and acceptable quality standards at competitive prices.

4.1 International Competitive Bidding vs Domestic Competitive Bidding

International Competitive Bidding (ICB) process will be followed for high value contracts and contracts that are complex in terms of engineering and execution skills to achieve the best possible supply and services at competitive prices. R&M of BTG, BTG auxiliaries, Power Transformers and Switchyard are likely to be technologically complex & involve higher value contracts and hence likely to evoke response from many reputed international bidders. Hence packages covering these systems may be tendered on International Competitive Bidding (ICB) basis. However, R&M of other BoP packages are not likely to see participation by many reputed international bidders and hence may be tendered on Domestic Competitive Bidding (DCB) basis.

Recommended list of packages and suggested nature of bidding is given at Table 4.1 below:

Table-4.1
Nature of Bidding

S. No	Package	Nature of Bidding
1	Boiler & Auxiliaries (including but not limited to Pulverizers, Feeders, PA Fans, FD Fans, ID Fans), ESP, Auxiliary Steam system and MS, HRH, CRH, HPBP & LPBP piping and associated Electrical, C&I and Civil Works.	ICB
2	Turbo-Generator & Auxiliaries (including but not limited to Heaters, Deaerator, Condenser, BFPs, CEPs), TG Cycle piping including Boiler Feed piping and associated Electrical, C&I, and Civil Works. This package will also include R&M of C&I system common to both SG and TG.	ICB
3	Coal Handling Plant and associated Electrical, C&I, and civil works.	DCB
4	Ash Handling system and associated Electrical, C&I and civil works.	DCB
5	Mechanical Balance of Plant (BOP) systems which include Plant Water	DCB

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S. No	Package	Nature of Bidding
	System (Raw water intake system, Pre-treatment Plant, D.M.Plant, CW System including Cooling Towers, ACW & CCW System), Compressed Air System, Fuel Oil System, Fire Fighting System and Miscellaneous balance mechanical Systems	
6	Electrical BoP including inter alia switchyard, power transformers and Switchgears	ICB

4.2 Lump sum Price vs Unit Rate

In a lump sum price contract, the entire scope of supply and services is grouped into a single overall contract price for the contractors to quote their price against. During execution of work, phasing of payment is done against progress of supply and services, but the sum of total of all the payments is the contracted price and it remains unchanged irrespective of the quantity of supply and service required to complete the contracted scope of work. The payments are linked to contractual milestones.

The bidder quoting the lowest lump sum price for the overall contract scope of work is treated as the lowest price bidder.

For unit rate contract, the bidders quote the unit rates for each supply and service against an estimated bill of quantity. The bidder with lowest total price for the estimated BOQ is treated as the lowest price bidder. During execution, payment is made based on actual quantity of each item/type of supply and service.

Given the nature of renovation and modernization work, it is difficult to exhaustively identify all the types/items of supply and service required and estimate quantities for them. Therefore, unit rate contract is difficult to design for renovation and modernization work. It is more practical to contract R&M work on lump sum price basis for the entire scope of plant, equipment, machinery, material, parts and including design, engineering, procurement, supply, assembly, construction, erection, testing & commissioning.

Each package therefore should be awarded on lump sum EPC contract basis based on the Scope and Terminal Points identified in the Bid Documents of the corresponding package.

4.3 Scope Change

The scope of Renovation & Modernization is defined in the bid documents of different packages on the basis of Residual Life Assessment / Condition Assessment and Energy Audit. During execution, in case there arises a need for any change in scope of work, change order should be issued. The contract should include procedure to deal with such change order.

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Appropriate change order clause will be built into the contract to deal with the need to change the scope of the contract due to surprises encountered during the execution of the R&M work.

4.4 Price Basis & Price Variation

The Contract Price should include price of executing whole scope of work specified in the Contract. The price of the contract should be on lump sum price basis for the entire scope covered in the contract. The contract price should be subject to adjustment during the contract period to reflect change in labour and material price levels as per price variation formula specified in the tender document, which is subject to limits specified in the tender specification.

For adjustment in contract price, bidding document should specify base date for contract price and price variation formula. The price variation formula should break down the total price into components that are not adjustable and components that are adjustable by indices specified for the various components. The bidders may be asked to indicate the coefficients (in the techno-commercial bid) to distribute the adjustable price into different components.

4.4.1 Scope

The scope of work for each package should consists of design, engineering, manufacture, supply, inspection & testing at supplier's works, packing, forwarding to site, transportation, unloading, storage, handling at site, steel structures, civil works, insurance, erection, painting, start-up, trial operation, testing, commissioning and performance guarantee testing, guarantee & warranty and handing over on turnkey contract basis.

4.4.2 Taxation

The tender specification should explicitly indicate the taxes and duties that will be reimbursed to the contractor by the Owner. Usually custom duty, excise duty, VAT, sales tax, GST is reimbursed by the Owner on actual for direct transactions between Owner and Contractor. All other taxes (i.e. taxes other than specifically mentioned in the contract for reimbursement) levied on the contractor in connection with the contract work, are borne and paid by the Contractor. Such taxes are to be included by the bidders in the quoted contract price. Cost of transportation of material, equipment, tools & tackles are to be included in the quoted contract price.

4.4.3 Insurance

Bidding document should include clauses that require contractor to bear the cost of insurance. Bidding document should specify the types and terms of insurance to be bought by the contractor. Usually, all risk type of policy is specified.

4.5 Terms and Methods of Payment

The payment for the supplies and services should be made progressively as the project execution progresses. Payments should be made in currencies agreed between Owner and Contractor in the Contract. The Bidders should be asked to prepare and submit to the Owner item-wise breakup of the Contract price in the currencies of the Contract. The contract price break up should be linked to the

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detailed PERT network of the contract. Owner may pay 10% of the contract price as initial interest free amount. Major part of the payment for supply items should be linked to dispatch and receipt of item. A part of the contract price for supply and service should be linked to commissioning/completion equipment/facilities. Payment should be made through Letter of Credit and Electronic Transfer.

4.6 Splitting of Contract

For each package of the renovation & modernization work, there should be a contract encompassing the entire scope of the work and the principal bidder should be made responsible for executing the entire scope of work. However, this contract may be split into two or more independent component contracts for offshore supply, onshore supply, transportation & port clearance, erection & installation services etc. All the independent component contracts should contain a cross-fall breach clause specifying that breach of one contract will constitute breach of the other contracts.

4.7 Assignee

Any foreign bidder should have the option to propose an Assignee in its bid to execute the Indian supply & services part of the contract. The Assignee should have acquired capability and relevant experience to perform his scope of work.

4.8 Sub contractors and Sub vendors

The contractor may subcontract parts of supply and service to sub-contractor/sub-vendors approved by the Owner. However, the successful bidder should not be permitted to subcontract the entire work on back to back basis or otherwise.

4.9 Performance Guarantee

The bidding documents should specify the performance parameters, the bidder is required to guarantee. Against each specified parameter, the bidding document should specify the minimum performance level that the bidder is required to guarantee. The bidding documents should stipulate performance test procedures to measure actual value of performance parameters. If the measured performance parameters fall short of guaranteed or specified value, and the contractors fail to bring it to acceptable levels through repair and rectification within a stipulated period, the executed plant equipment may be rejected and payments already made may be recovered. For shortfall in performance parameters that have economic consequences, if the quantum of shortfall is within certain limits specified in tender specification, the plant and equipment may be accepted after levying liquidated damages. If the shortfall in performance level is beyond the limits specified in tender specification, the plant and equipment will be rejected and payments already made will be recovered. Shortfall in functional parameters pertaining to safety or statutory environmental requirements, the plant and equipment will be rejected and payments already made will be recovered.

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4.10 Liquidated Damage

The contractor should be made responsible to pay Liquidated Damages for delay in completion of R&M work. The aggregate liability for delay may be limited to 10% of contract price.

The contractor should be made responsible to pay Liquidated Damages for shortfall in achieving guaranteed performance parameters. The aggregate liability for shortfall in performance guarantee parameters may be limited to 10% of contract price.

4.11 Advance Payment Security

The contractor should be made responsible to furnish unconditional Bank Guarantee equivalent to advance payment made to him. The value of advance payment security may be reduced at regular intervals on prorata based on the value of the equipments/service/facilities received.

4.12 Contract Performance Security

The bidding document should specify contract performance security to be furnished by the contractor to protect the Owner in case of breach of contract by the contractor. The contract performance security may be of 10% of the contract price for all the contracts and may be valid till three months beyond the defect liability period.

4.13 Retention Money

10% of price of each item of supply and service should be held as retention money until final acceptance of contractor's work. After provisional acceptable, contractor may be allowed to take the retention money by furnishing retention money security guarantee of equivalent amount.

4.14 Force Majeure

The bidding document should incorporate appropriate force majeure clause to cover any event beyond the reasonable control of the Owner or Contractor and which cannot be avoided notwithstanding reasonable care by the affected party. No delay or non-performance by either party caused by an event of force majeure will constitute a default or breach of contract. The bidding document should specify procedure to deal with the consequences of an event of force majeure.

4.15 Applicable Law

The contract for renovation & modernization work should be governed and interpreted in accordance with laws in force in India.

4.16 Dispute Resolution

The bidding document should specify dispute settlement mechanisms such as Adjudication and Arbitration.

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5 TENDERING FOR SELECTION OF R&M CONTRACTORS

5.1 Invitation for Bid

Tender documents should be issued to parties qualified in pre-qualification stage. The bidding document should comprise the following main components:

- Invitation for Bid
- General Project Information
- Instruction to Bidders
- General Conditions of Contract.
- Particular Condition of Contract.
- Technical specification & tender drawings.
- Bid forms & other formats
- Bid Datasheets
- Format for Price Schedules.

5.2 Clarification and Amendment

All clarifications/corrigendum/Addendum/Amendment to the Tender Documents should notified to all the Bidders

5.3 Time frame

Adequate time should be allowed to the bidders for preparation and submission of Bid.

5.4 Language of Bid and Tender Document

The bid submitted by the bidders should be in English language. Any document / literature furnished by the Bidder in any other language should be accompanied by authentic English translation. The English translation should be used for interpretation of the bid. The tender documents issued to the bidders should be in English language.

5.5 Currency of Bid and Currency Conversion

The bidders should be allowed to quote prices of supply item in any currency. However, the number of foreign currencies used should be limited to some number specified in tender document.

Indian bidders quoting in foreign currencies should be asked to comply with relevant government regulation. The prices of local (Indian) services such as local transportation, installation, construction etc should be quoted in Indian currency.

5.6 Validity of Bid

The Techno-Commercial bid and price bid submitted by the bidders should be valid for sufficient period to allow ample time for bid evaluation, post-bid discussion, internal processing and award.

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5.7 Bid Security

Every bidder should furnish, as part of the techno-commercial bid, a Bid Security for an amount to be specified in Tender Documents. The bid security will be forfeited in case (1) the bidder withdraws or modifies the bid during validity of bid or fails to sign the contract document or deposit contract performance security when selected as the successful bidder or (2) commits any fraud.

5.8 Integrity Pact

The Tender Documents should include a format for Integrity Pact. The Owner and Bidder will enter into an integrity pact before the bidders bid is considered by the Owner.

5.9 Components of Bid

5.9.1 Techno-Commercial Bid

The Techno-Commercial Bid should comprise of the following main components:

1. Bid Security.
2. Filled up and signed form of bid.
3. Authorization in favour of a person signing the bid.
4. Overall project completion schedule.
5. Contractor's Resource Deployment schedule.
6. Requirements of the contractor at site.
7. Technical details and Quality Assurance Programme.
8. List of mandatory and recommended spares.
9. Deviation to Technical Specifications.
10. Deviation to commercial conditions.

5.9.2 Price Bid

The price bid should comprise of the following main components:

1. Filled up form of Bid.
2. Filled in schedule of Prices.
3. Filled in schedule of Guaranteed Performance Parameters.

Prices of Indian supply items should be quoted in Ex-works basis including packing and forwarding. Prices of Foreign Supply items should be quoted on CIF Indian Port basis. Cost of inland transportation and insurance should be indicated separately. Taxes & duties on all direct transaction between Owner and Contractor should be indicated separately.

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6 BID EVALUATION AND AWARD OF CONTRACT FOR R&M WORKS

A comparative evaluation of the price bids should be carried out to identify the techno-commercial responsive and qualified bidder with Lowest Overall Evaluated Price after taking into account, adjustment for differential quote for Performance Guarantee Parameters using adjustment factors specified in the Tender Documents (adjustment to price of bids with quoted Performance Guarantee Figure inferior to the value quoted in the responsive bid with most competitive quote for that Performance Guarantee Parameter) and cost compensation if any arising from evaluation of techno-commercial bids. However, bids with quote for any Performance Guarantee Parameter inferior to the minimum or maximum value for the parameter specified in the tender conditions should be rejected.

The qualified and techno-commercially responsive bidder with the lowest evaluated price should be selected as contractor for carrying out the R&M work.

In case the lowest price quoted is higher or lower than the estimated reasonable cost for the work by a very large amount, further investigation should be made regarding the reasonableness of the quoted price.

6.1 Bid Submission and Bid Opening

The date of bid opening of Part-I (Techno-Commercial) should be same as the last date of bid submission. The Techno-Commercial Bids should be opened promptly after the deadline for receipt of bids. The date and exact time of opening of Techno-Commercial Bid should be specified in the Tender Documents. The date and time of opening of Price Bid should be communicated to the bidders after evaluation of the techno-commercial bid. Bidders or their representatives should be allowed to be present during opening of Part-II and Part-I bid.

6.2 Completeness of Bid

Each of the techno-commercial bid should be first examined to ascertain whether the required bid security has been furnished, all the required components have been submitted and the bids/attached documents have been properly signed.

6.3 Evaluation of Techno-Commercial Bids

The techno commercial bids should be evaluated to ensure that:

- (1) The proposals are in line with the intended scope, quality and performance of the contract;
- (2) The proposals do not adversely affect the rights of Owner and obligations of contractor envisaged in the tender conditions;
- (3) The proposals are in line with and are complete as per technical specification and commercial conditions.
- (4) The proposals conform to completion schedule specified in the tender documents;
- (5) The proposals meet the performance guarantee requirements specified in tender documents.

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The techno-commercial bids from pre-qualified bidders meeting above criteria during evaluation should be considered techno-commercially responsive to tender conditions. The Owner may invite any bidder(s) for a meeting during the evaluation stage for the purpose of seeking some clarifications..

The Owner may issue amendments to the tender documents, if considered necessary by Owner, based upon evaluation of techno-commercial evaluation and post-bid clarification meeting.

The bidders may be asked to withdraw some deviations to tender conditions and technical specifications to make the bid compliant with the tender specifications.

If any amendment to the tender documents or any withdrawal of deviation by a bidder may have cost implication, that bidder may be allowed to furnish supplementary price quotes against such amendments /withdraw of deviations, before opening of the Part-II Bid (Price Bid).

The bidders of the techno-commercially responsive offers should be intimated the date and time of Part-II Bid (Price Bid). The price bids of such techno-commercially responsive bids should be opened on the scheduled date and time in the presence of bidders or their representatives who want to be present during opening of Price Bid. The bidders of techno-commercially non-responsive bids should be intimated about such finding and their bid security should be returned.

6.4 Evaluation of Part-II Bids

After opening, the price bids should be examined to ensure that

- (i) The bids are complete and signed. The price schedules and performance guarantee schedules are filled up. Incomplete and improperly filled bids should be rejected.
- (ii) There is no arithmetic error in price quotes.

The tender document should elaborate a method for dealing with arithmetic errors.

To facilitate comparison of quoted prices, the bid prices expressed in different currencies may be converted to a single currency. The tender documents should explicitly specify the currency and source and date of exchange note to be used for converting bid prices to a common currency.

For comparison of price bids, the following should be added to the arithmetically corrected quoted price:

- (1) Adjustments for quoted performance guarantee parameters.
- (2) Cost compensation for deviations.
- (3) Any price preference to domestic bidders as per Govt. Policy.

The prices arrived at after adding these values to quoted price will be the evaluated prices of the techno-commercially responsive qualified bids. Bidder with the lowest evaluated price bid should be selected as successful bidder for award for the R&M Contract. The evaluated price arrived at as above will be used for comparison of price bid only. The arithmetically corrected quoted price will be the contract price.

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The taxes, duties & levies that are to be reimbursed by the Owner on actual basis as per stipulation of tender documents will not be considered for comparison of price bid.

The escalation in prices due to change in material and labour index during execution will not be considered in price bid evaluation.

6.4.1 Price preference

In case Government Rules mandate any price preference to domestic bidders, the same should be clearly brought out in the tendering documents along with an unambiguous procedure for applying the price preference.

6.4.2 Cost Compensation for Deviation

In case the bidder has taken any deviation to technical specification or tender condition and after evaluation of techno-commercial deviation, Owner decides to allow the bidder to retain the deviation, the cost implication, if any, of such deviation will be added to the quoted bid price for evaluation of price bid.

6.4.3 Differential Loading for Quoted Performance Guarantee Parameters

Bidders should be asked to quote guaranteed value of performance guarantee parameters of the retrofitted plant and facilities on the prescribed performance guarantee schedule as part of the price bid. The tender documents should indicate adjustment factors or bid evaluation factors for performance guarantee parameters having financial implication. For evaluation purpose, for every such performance parameter, the most favourable quoted value for the parameter should be taken as the base value and the difference between quoted value of any other bidder and base value should be multiplied with the indicated adjustment factor for loading the price bid of the bidder with the performance parameter inferior to the base value.

6.5 Letter of Award and Signing of Contract

The successful bidder should be notified within the bid validity period in writing that his bid has been accepted. Once the successful bidder submits contract performance security, the unsuccessful bidders will be intimated that they have not been successful and their bid security will be released.

After the deposition of contract performance security and other required details/documents by the successful bidder, the contract will be signed without any delay and the bid security of successful bidder will be released.

6.6 Inadequate Participation by Bidders

To promote competitive price quotes, efforts should be made to ensure that adequate number of prospective bidders participate in the pre-qualification and subsequent bidding process. In case the number of parties qualified in pre-qualification process is less than three, the reasons of non-participation by capable/eligible entities should be analyzed. Similarly, whether the specified qualifying requirements are stringent should be examined. Preferably three or more (at least two) qualified bidders should submit the bid for the R&M work.

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6.7 Unreasonable Price Quote

If the bid price of bidder with the lowest evaluated price is too low or too high as compared to the updated cost estimate for the R&M work, all the possible reasons for the same should be analyzed. If the quoted price is too high, it should be examined whether or not the tendering process encourages competitive price quotes. If the quoted price is too low, then the seriousness/competence of the bidder should be looked into.

6.8 Rejection of all Bids and Retendering

The tender document should include a clause empowering the Owner to reject all bids, if so required. However rejection of all bids and retendering should be considered only as an extreme measure due to any or combination of the following reasons:-

1. There is lack of adequate and effective competitive competition among the bidders.
2. All the bids are found to be techno-commercially non-responsive or defective.
3. The bid price of lowest evaluated bidder is high as compared to updated estimate of the Owner.
4. Fraud and unfair practices by bidders.

Inadequate participation of bidders in prequalification process or proposal/bid process and inadequate number of techno-commercial bids should trigger review and analysis of the tendering process. However, less number of bidders is not the sole criteria for annulment of tendering process and retender. If it is established that appropriate prequalification and tendering process have been followed, the Owner may persist with the tendering process even if there is only one techno-commercially responsive bid. If the evaluated price of the sole techno-commercially responsive bid is comparable with or within the Owner's estimate and prevalent market prices, such as bidder may be selected as the successful bidder. Similarly, the qualification requirements should be changed only if they are found to be too stringent and that appears to be the reason for inadequate participation/competition among prospective bidders.

If all the bids are rejected and retendering is required to be carried out, the tender documents should be thoroughly reviewed with regard to scope, technical specification, commercial conditions, risk allocating between Owner and contractor and other influencing factors before issue of the retender.

If rejection of all the bids is due to the reason that all the bids are techno-commercially non-responsive, fresh prequalification and retendering may substantially delay R&M project and in case, new capable bidders other than already participating bidders are not likely to participate in the fresh qualification and retendering, new bids may be invited from the already qualified bidders with the original or modified tender documents. If the lowest evaluated price of the responsive bids is substantially higher than the Owner's estimate in spite of adequate participation by the potential bidders, negotiations may be carried out with the bidder with the lowest evaluated price, for reduction in contract price to a reasonable level.

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7 TENDERING PROCEDURE FOR SELECTION OF CONSULTANTS

7.1 Types of Consultant

Renovation and Modernization of old Thermal Power Projects involves in-depth study of the power plant equipment, assessment of their health condition, identification of the root causes of the equipments for deficit performance, determination of the residual life of critical components, auditing of auxiliary power consumption of various equipments, finding solutions to various operational problems in terms of Run/ Retrofit/ Replacement options etc. This requires special knowledge, skill and experience which is normally not available with the Operating and Maintenance Engineers of the Power plants. Power plants therefore require the services of consultants who are specialized in the field of conducting various investigative studies and can deliver the services of this nature.

Support of consultants is also needed to review the design and engineering work done by the R&M Contractors, to monitor the progress of R&M works at the site and to evaluate the results of the Performance Guarantee Tests etc. The job of site supervision requires adequate experience of erection and construction activities which is not always available with O&M engineers of the power plants.

Two types of Consultants have been suggested namely, 'R&M Consultants' and 'Implementation Support Consultants' (ISC). The consultancy work is initiated by the R&M Consultant who does all the investigative studies like RLA/CA and EA studies, provides the solutions to various operating problems in the form of formulation of R&M options, selects the most attractive R&M option to be implemented, prepares the DPR (Detailed Project Report), assists the utility in getting the approval of appropriate Regulatory Commission, prepares the Bidding Documents as well as appointment of R&M Contractor(s). Implementation of R&M works is finally done with the help of Implementation Support Consultant (ISC).

7.2 Role and Responsibility of Consultants

7.2.1 Role of R&M Consultant

The consultant to be selected for the role of R&M Consultant should have requisite experience of conducting the plant studies as well as for the preparation and evaluation of bidding documents. Role of R&M Consultant consists of the following activities:

- i. Conducting of Cold Walk-down and Hot Walk-down Survey.
- ii. Review of the operational history of the power plant.
- iii. Discussion with the Plant Engineers.
- iv. Carrying out of technical studies namely, the Residual Life Assessment (RLA) and Condition assessment (CA) of BTG and BOP of the power plant.
- v. Carrying out Energy Audit of BTG and BOP to identify the reasons and sources of excess power consumption.
- vi. Reviewing the results of studies mentioned at v) & vi) above.
- vii. Identification of the equipments needing retrofitting / replacement.

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- viii. Studying the variations in the present quality of coal from the quality considered at the time of original design of the plant.
- ix. Studying the average quality of coal likely to be available during the next twenty years.
- x. Studying the latest environment standards prescribed by the regulating agencies at the national and state level.
- xi. Formulating alternative options including the cost impact for the refurbishment / replacement of specific plant equipments for enhancing their performance and extending their life.
- xii. Preparing a matrix of R&M options for the plant as a whole for extending the useful life by minimum 20 years by either restoring the performance parameters to the original level or for achieving better parameters than the original design.
- xiii. Carrying out detailed economic evaluation of each of the R&M options proposed in the matrix.
- xiv. Discussions with Plant Management.
- xv. Selection of R&M option to be implemented.
- xvi. Finalizing the scope of R&M Works.
- xvii. Preparation of Detailed Project Report.
- xviii. Obtaining approval from appropriate Regulatory Commission.
- xix. Preparation of Bidding Documents for the appointment of R&M Contractors.
- xx. Evaluation of Bids of R&M Contractors.

7.2.2 Role of Implementation Support Consultant

The consultant to be selected for supporting the utilities for implementing the R&M works should have adequate experience of executing the projects of similar nature. The role of the Implementation Support Consultant consists of the following activities:

- i. Reviewing of design documents & drawings of the R&M contractors to ensure compliance of scope of works.
- ii. Site supervision and monitoring the progress of works.
- iii. Checking the quality of construction and erection.
- iv. Holding review meetings with the contractor(s).
- v. Coordination between the Plant head and the R&M Contractor.
- vi. Shop Testing at supplier's works and inspection at site.
- vii. Supervising the commissioning activities.
- viii. Witnessing and evaluation of Performance Guarantee Tests.

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7.3 Tendering for R&M Consultant & Implementation Support Consultant

The Bidding procedure for appointment of R&M Consultant has been standardized. For hiring of Consultants, a two step process comprising Request for Qualification and Request for Proposal is recommended. For the Request for Proposal for selecting R&M Consultant and Implementation Support Consultant (ISC), a Single stage Two Envelope method has been specified since the consultants to be engaged for R&M services must be specialized in their respective fields and must have requisite experience of similar nature.

Following documents were studied to analyze the process of hiring consultants:

- i. World Bank Guideline (January 2011) for Selection and Employment of Consultants
- ii. KfW Guidelines for Assignment of Consultants in Financial Cooperation with developing countries.
- iii. Model Request for Proposal for Selection of Technical Consultants published by Planning Commission, Government of India
- iv. Request for Tender for Selection of Consultant for Feasibility Study for Renovation & Modernization of Unit-4 of Nasik Thermal Power Station.

The recommended Selection Criteria for R&M Consultant and Implementation Support Consultant broadly conforms to the Quality and Cost Based selection process of World Bank guidelines and Two-Stage selection process with pre-selection as per KfW Guideline. However, it is recommended that the first stage or pre-qualification stage will be Pass / No-Pass type without any limitation on number of consultants to be pre-qualified for quality and cost based competition in second stage. The evaluation criteria are in line with the Model RFP for Technical Consultants published by Planning Commission.

Only Applicants found pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the Consultancy work and will be eligible to submit Bid Proposal. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, competence of key personnel, project execution capability and financial resources to discharge the scope of service.

Single Stage Two Part Bidding Procedure will be followed for RFP stage.

The bidders are required to submit, the bids for the Consultancy Services in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Methodology & Work Plan for discharging the consultancy services as per Terms of Reference, Details of Key Personnel along with their Curriculum Vitae, Deviations to Terms of Reference, Deviation to commercial Conditions, Overall Completion Time Period & Network Schedule, Resource Deployment Schedule, Detail of Sub-Consultants, Details of the present commitments & details of contracts in hand

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etc. Part-II Bid will comprise Quoted Price. Initially, only the Part-I Bid will be opened and Part-II Bid will be kept in safe custody.

The Part-I Bid will be checked for responsiveness to techno-commercial conditions and a detailed Technical Evaluation will be carried out to assign a Technical Score to each Bid. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions and Technical Score is above a specified level.

7.4 Request for Qualification for Consultants (R&M Consultant and ISC)

The RFQ document for selection of Consultants has been standardized. The Standard RFQ covers the following aspects:

1. The scope of works for R&M Consultant
2. The RFQ details regarding the
 - i. Participation fee
 - ii. Publication date of RFQ
 - iii. Last date for issue of RFQ document
 - iv. Last date and time for receipt of RFQ applications
 - v. Date for selection of qualified consultancy Firm
3. Qualification Requirement
4. List of Qualification Document
5. Instruction to Applicants
6. Standard Application Forms and Data Sheets

The following Forms and Data Sheets have been standardized

1. Format for the Pre – qualification Application
2. Letter of Consent to be Furnished by the Associate
3. Letter of Consent to be Furnished by the Consortium Partners
4. Sample format for Data sheet regarding Technical Qualification Requirement
5. Sample format for Data sheet regarding Financial Qualification Requirement

7.5 Pre-qualification Documents

The pre-qualification documents requirement for consultants has been standardized. These include the following:

- (i) List of orders executed by them, their Consortium Partners / Associates along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates from the previous employers in respect of such completed consultancy assignment(s) clearly indicating scope of and date of completion for each assignment.
- (iii) Names of proposed Associates or Consortium member if any, along with Letters of Consent from each Associate / Consortium Partner.
- (iv) Particulars of Key Personnel that must include inter alia their names, details regarding qualification, areas of expertise, professional experience and names of relevant projects.

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- (v) Documents of company profile incorporating details of technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity for the satisfaction of Employer.
- (vi) Firm's audited accounts for last three (3) years along with a copy of latest income tax return filed.
- (vii) Consultancy Assignments in hand / pending jobs and their status along with value.
- (viii) Pending legal cases, if any.

7.6 Request for Proposal for Consultants (R&M Consultant & ISC)

The Standard Request for Proposal for consultants comprises the sections as indicated in the Table below:

Table: 7.1
Structure of Request for Proposal for Consultants

Section	Description
Section-I	Commercial <ol style="list-style-type: none"> 1. Invitation For Bid 2. Instruction to Bidder 3. General Project Information 4. General Condition of Contract (GCC) 5. Special Condition of Contract (SCC) 6. Forms and Schedules
Section-II	Terms of Reference

General Conditions of Contract (GCC)

The GCC contains the Contracting Concept, the scope of the Contractor, the precedence of the Contract Documents, definitions and Acronyms used in the Contract Document, the severability of the Contract, the governing laws to the Contract, methods for settlement of disputes, Time of commencement and completion of the contract, Contractor's Responsibilities, Owner's Responsibilities, Taxes and Duties applicable, Confidential Clause. It also covers the Defect Liabilities, Completion Time and Liquidated damages, Conditions to Performance Guarantees, Limitations of Liability, Transfer of Ownership, Insurance, Force Majeure Conditions and Termination of the Contract.

Special Conditions of Contract (SCC)

- i. Effective date: The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. The date of this Letter of Acceptance will be the Effective Date for determining the Time for Completion of the milestones for Consultancy work as per the scope of work. The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the

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date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

- ii. Time of Commencement and Completion: The Time Schedule for the execution of the scope of work by the Consultant is to be specified.
- iii. Contract Securities
 - a) Advance Payment Security: The Contractor shall, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with validity of up to ninety (90) days beyond the date of the Scheduled Completion Date for R&M Consultancy Services.
 - b) Performance Security: The Contractor shall provide a security for the due performance of the Contract for five percent (5%) of the Contract Price with an initial validity up to ninety (90) days beyond the the Scheduled Completion Date for R&M Consultancy Services.

7.7 Evaluation Criteria for Consultants (R&M Consultant and ISC)

The selection of the successful Bidder for award of the R&M Consultancy Services Contract and Implementation Support Consultancy (ISC) contract will be based on both Quality of the Technical Proposal and Price quoted by the Bidder for the entire scope of work. The selection process will comprise the following steps:

1. First, Techno-Commercial offer will be assessed for completeness and responsiveness to commercial/contractual conditions. Bidders qualifying the criteria would be considered for further evaluation on the basis of Quality and Price.
2. The Bidder's proposed methodology and Work Plan for discharging the Consultancy Assignment, experience of the Bidder and the experience & expertise of Key Personnel will be assigned a Technical Score 'St'. Only those Bidders whose Technical Proposals get a Technical Score of 70 marks or more out of 100 shall qualify for further consideration.

The Technical score of each Bidder will be equal to the weighted sum scores on three elements with indicated weights

$$S_t = 0.2 \times S_{t-1} + 0.3 \times S_{t-2} + 0.5 \times S_{t-3}$$

Where:

- a. S_t – Technical score
- b. S_{t-1} – should be less than or equal to 100 points, depending on the clarity, completeness, soundness of methodology and scope of work. The Bidder with the best submission will be assigned a score of 100 ($S_{t-1} = 100$). Other Bidders will be assigned scores below 100 considering the relative quality of the submission with respect to the best submission.

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- c. S_{t-2} – should be less than or equal to 100 points, depending on the Bidders experience on the grounds of size, nature & complexity of scope and similarity with the subject R&M Consultancy Service / Implementation Support Consultancy Service for at least 5 projects.
- d. S_{t-3} – should be less than or equal to 100 points, depending on the experience list of at least a specified number of personnel who would be associated with the R&M Project.

- 3. The Price Proposal of each qualified Technical Bidder will be assigned a Financial Score (S_f) on the basis of its cost competitiveness.

$$S_f = 100 \times (\text{Lowest Quoted Total Price} / \text{Total Price quoted by the Bidder})$$

- 4. Each bidder will be assigned a Composite Score (S_c) equal to the weighted sum of Technical Score and Financial Score. Finally, the bidder with the highest Composite Score will be selected as R&M Consultant for the subject R&M Consultancy Services Contract or Implementation Support Consultancy (ISC) contract.

For selection of successful Bidder, the Technical Score will be a weight of 70% and Financial Score will be given a weight of 30%. For each Bidder, the Composite Score S_c will be computed as follows:

$$S_c = 0.7 \times S_t + 0.3 \times S_f$$

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**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF CONTRACTOR
FOR
RENOVATION & MODERNISATION
OF
BOILER & AUXILIARIES**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

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List of Formats & Data Sheets

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by JV Partner / Holding Company / Consortium Partner pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2
3.0	Format for Letter of Consent to be furnished by the Consortium Partners	Annexure-3
4.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (a).	Data Sheet-1
5.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (b).	Data Sheet-2
6.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-3
7.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-4
8.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding/ Partner Company meet the financial QR	Data Sheet-5
9.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-6

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1 INVITATION FOR QUALIFICATION

1.1 Introduction

[Give brief introduction about the name, location and details of the Power Plant of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of XXX MW Unit no.-XX ----- of the Power Plant]

1.2 INVITATION

[Name of The Utility], hereinafter referred to as "Employer / Owner / Purchaser", is undertaking Renovation & Modernization project of Unit No.[XXX] of the [XXX] Power Plant. Under this project, [Name of The Utility] invites sealed Pre-Qualification Tenders from experienced and interested bidders for the Renovation & Modernization Work of [Boiler & Auxiliaries] package of Unit No.[XXX] of the [XXX] Power Plant on International Competitive Bidding (ICB).

Interested bidders may collect the RFQ documents in person from [Name and Contact Details of Designated Official.....]. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....] to [.....]. Alternatively, the RFQ document can be downloaded from [Name of The Utility] website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to [Name and Contact Details of Designated Official.....] by [Date and Time].

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly and replacement of specified existing equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing & forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, carrying out of all associated civil works including supply of cement & steel etc., testing & commissioning and successful completion of trial operation & Performance guarantee tests for [Boiler & Auxiliaries] package of Unit no. [XXX] of [XXX] Power Plant.

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]/ USD [---]/ EUR [---]
(b)	Publication date of RFQ	:	[-----]
(c)	Last date for issue of RFQ document	:	[-----]

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(d)	Last Date & Time of Receipt of Pre-Qualification Bids and Date & Time for Opening of Prequalification Bids	:	[-----]
(e)	Date for identification of Qualified Bidders and Issuance of RFP	:	[-----]

If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of the Utility] is carrying out this Pre-Qualification Process to identify qualified bidders for the issuance of RFP Documents for the Tender of Renovation & Modernization work of [Boiler & Auxiliaries] package of Unit no. [XXX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process.

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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in tendering process for the subject Renovation & Modernization work for [Boiler & Auxiliaries] package, the bidder must meet the Technical Qualification Requirement specified at clause 2.1.1 and Financial Qualification Requirement specified at clause 2.1.2 below. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no 2.1.3.

2.1.1 Technical Qualification Requirement

- (a) The Bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Tenders indicated in row (d) in section 1.4 above, should have designed, engineered, manufactured, supplied, erected/ supervised erection and commissioned / supervised commissioning of one (1) unit of reheat type coal/lignite fired Boiler for a power plant unit of 200 MW or above capacity which should have completed satisfactory operation for a period of not less than One (1) years as on the date of opening of Pre-Qualification Bid.

And

- (b) The bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Tenders indicated in row (d) in section 1.4 above, should have successfully completed execution of Renovation & Modernization of one (1) unit of coal/ lignite fired Boiler for a power plant unit of 50 MW or above capacity.
- (c) The bidder can be a Joint Venture of two firms who collectively meet the Qualification Requirement specified at (a) and (b) above. Each of the JV partner must have at least 26% equity in the JV and in case of award of contract, must maintain JV arrangement till the successful completion of the R&M work. In such a case, parts and components of boiler has to be sourced from the partner who satisfies the Qualification Requirement specified at (a).
- (d) The bidder can be a Consortium of two firms who collectively meet the Qualification Requirement specified at (a) and (b) above. The Consortium members shall designate one member as the Leader of the Consortium with whom the Contract will be entered into in case the Consortium emerges as the successful bidder. In such a case, parts and components of boiler has to be sourced from the Consortium member who satisfies the Qualification Requirement specified at (a).

2.1.2 Financial Qualification Requirement

- (a) The average annual turnover of the Bidder should be at least [Indian Rupees] millions or equivalent foreign currency as per audited annual accounts during the preceding three consecutive years – [FY], [FY] and [FY] For the purpose of conversion of foreign currency to Indian Rupees, the TT Buying rate of State Bank of India as on 30 days prior to the date of submission of Bid will be

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considered. Other income will not be considered for arriving at the annual turnover.

- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year shall be positive.
- (c) The sum of bank balances (including fixed deposits) and available unutilized credit line of the bidder (including non fund based credit lines) should not be less than [INR.....] as on not more than 30 days prior to the scheduled last date of submission of Pre-qualification Bid
- (d) In case the Bidder/Consortium Leader does not satisfy the Financial Criteria stipulated in the above clauses (a) and (b) on its own and the JV Partner in case the Bidder a Joint Venture of two firms or Holding Company having controlling interest in the Bidder / Consortium Partner Company, as the case may be, meets the stipulated turn-over requirements at Clause (a), then Financial Criteria stipulated in the above clauses (a) and (b) will be deemed to have been met, provided that the Net worth of such Holding Company / Partner Company, as the case may be, as on the last day of the preceding financial year is at least equal to or more than [.....]. In such a case, the Bidder / Consortium Leader has to submit a Letter of Undertaking from the JV Partner Company/ Holding Company/ Consortium Partner company pledging unconditional and irrevocable financial support to the bidder for execution of the Contract.

To establish the financial capacity for performance of the contractual obligations, the Bidder shall furnish documentary proof of their audited annual turnover and net worth for the last three (3) financial years [FY], [FY] & [FY].

2.1.3 Other Criteria

- (a) Any firm who is or was involved as a Consultant in the preparation for this R&M Project for activities such as Feasibility Study or RLA/CA Study or Energy Audit or preparation of DPR/Tender Document or any other preparatory activity or any firm who is or was involved as a consultant for implementation of this R&M project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of this R&M project cannot participate as a bidder for this R&M Tender.
- (b) Any bidder who is legally barred from the procurement process of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as a bidder for this R&M Tender.
- (c) Any firm or its associate company or parent company cannot participate as Bidder or JV Partner or Consortium Member in more than one Bid under this tender.

2.2 Qualification Documents

2.2.1 Documents to be submitted (Pre-qualification)

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Bidders are required to furnish following documents for pre-qualification in *[five (5)]* copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them along with copies of orders to demonstrate their qualifications.
- (ii) Past Performance Certificates clearly indicating date of completion from the facility owner in respect of such completed contract(s).
- (iii) Name of any proposed JV partner or Consortium member along with details of equity participation of JV partner or letter of consent of consortium partner.
- (iv) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity to the satisfaction of Employer. Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (v) Contracts in hand / pending jobs and their status along with value.
- (vi) Major pending legal cases.

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3 INSTRUCTION TO APPLICANTS

- 3.1. Only bidders pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the R&M work of [Boiler & Auxiliaries] package and will be eligible to submit Bid Proposal for R&M work. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, project execution capability and financial resources to discharge the scope of service
- 3.2. [Name of Utility] is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Bidder or JV Partner or Consortium leader or Consortium partner is found to be factually incorrect or manipulated, the Bidder or JV Partner or Consortium leader or Consortium partner as the case may be, will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the Bidder shall be on the basis of single bidder responsibility. The contract will be entered into only with the successful Bidder / Consortium leader. Thus the bidder / Consortium leader shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder / Consortium leader and Consortium partner shall not Sub-contract the entire scope of work, back to back or otherwise, for the performance of this contract.
- 3.5. The bidder meeting the Qualifying Requirement on the strength of the JV partners should enclose details of equity holding of the JV partners. However, in the event, the bidder is found pre-qualified and issued RFP document, while submitting the techno-commercial Bid Proposal for R&M work, the bidder shall furnish a copy of the Joint Venture Agreement. Further, while submitting the techno-commercial Bid Proposal for R&M work, the JV partners shall furnish a joint undertaking towards joint and several liability to the employer for the successful performance of the Contract. The undertaking shall be furnished as per the format to be specified in the RFP document.
- 3.6. The bidder meeting the Qualifying Requirement as a Consortium should enclose the Letter of Consent (as per the prescribed format) from the consortium Partner along with the Pre-Qualification Bid signed by the Consortium Partners indicating the scope of work. However, in the event, the bidder is found pre-qualified and issued RFP document, while submitting the techno-commercial Bid Proposal for R&M work, the bidder (consortium leader) shall furnish a Consortium Agreement with the other Consortium member. No new consortium partner, (other than those qualified at Pre-qualification stage)

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will be permitted at the time of submitting the Techno commercial Bid. Further, while submitting the techno-commercial Bid Proposal for R&M work, the Consortium leader and Consortium member will furnish a joint undertaking regarding diligent performance of their respective scope of work and towards joint and several liability to the employer for the successful performance of the Contract. The undertaking shall be furnished as per the format to be specified in the RFP document.

- 3.7. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period.

If the bidder is a joint venture of two firms who collectively meet the Qualifying Requirement, in addition to the Contract Performance Guarantee (CPG) of 10% furnished by the bidder, each of the JV partner shall furnish Additional Contract Performance Guarantee equal to 1% of Contract Price.

If the bidder is a Consortium of two firms, in addition to the Contract Performance Guarantee (CPG) of 10% furnished by the Consortium Leader, the other consortium member will furnish Additional Contract Performance Guarantee equal to 2% of Contract Price

The Bidder shall provide satisfactory evidence that he and / or, where applicable, the consortium leader and consortium partners have adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid have an adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfillment of the qualifying requirements as specified are liable for rejection without assigning any reason.

- 3.8. The Bidder shall provide satisfactory evidence that he has adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid and adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfillment of the qualifying requirements as specified are liable for rejection without assigning any reason.

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- 3.9. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to confirm the bidder's / Consortium leader's & Consortium Partners' claim on experience and to assess the Bidder's / Consortium leader's & Consortium Partners' capability and capacity to perform the contract, should the circumstances warrant such an assessment in the overall interest of the project.
- 3.10. [Name of Utility] reserves the right to reject any or all Pre-Qualification Bids or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no bidder / intending bidder shall have any claim arising out of such action.
- 3.11. Participation Fee for an amount of [INR.....] or [USD.....] or [Euro.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXX]' is to be submitted along with the Pre-Qualification Bid. Pre-Qualification Bid received without the Participation Fee will be rejected. Participation Fee is non-refundable.
- 3.12. Language of Bid
The Bid submitted by the Bidder and all correspondences and documents relating to the Bid exchanged by the bidder and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.
- 3.13. Signature on Pre-Qualification Bid
The Pre-Qualification Bid must contain the name and place of business of the Bidder and each page of the EOI must be signed and sealed by the authorized person(s) of the Bidder / Consortium leader with his usual signature. The name of all persons signing should be typed or printed below the signature. Satisfactory evidences of authority of the person signing on behalf of the bidder / Consortium leader shall be furnished with the Bid.
The Bidder / Consortium leader's name stated on the Pre-Qualification Bid shall be the exact legal name of the firm.
- 3.14. Method of Submission of Pre-Qualification Bid
The Pre-Qualification Bid shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of The Pre-Qualification Bid.
The outside of the covers should indicate clearly the name of the Bidder / Consortium leader and his address. In addition, the envelope or container should indicate the "Tender No. and Name of the work for which the Pre-Qualification Bid is submitted ". Pre-Qualification Bid with no indication given on the outside of the envelope that it is a Pre-Qualification Bid which therefore gets opened before the due date shall be liable to be disqualified. All the pages of the Pre-Qualification Bid shall be serially numbered.

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The Pre-Qualification Bid, complete in all respects, must be submitted to the official and address mentioned below.

'[XXXXXX]
'[XXXXXX]'[XXXXXX]

Submission of Pre-Qualification Bid through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post either way.

Pre-Qualification Bids must reach the above office on or before '[XXXXXX] Hours (IST) on '[XXXXXX]. Any Pre-Qualification Bid received after the expiry of the time specified is liable for rejection.

3.15. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXX] on Date and at Time indicated in row (d) in section 1.4 above.

The Pre-Qualification Bids shall be opened in the presence of such bidders who may be present. The bidders are at liberty to be present or authorise their representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Accredited Agents / representatives of foreign bidders in India are also permitted to submit the Pre-Qualification Bids on behalf of the foreign bidders with due Authorisation Letter.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least [15 (Fifteen) days] before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. [Name of Utility] will issue interpretations and clarifications as it may deem fit.

3.16. Application Data Sheets and Forms

The Pre-Qualification Bid is to be submitted as per the Format at Annexure-1. The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Bid. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

SI No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by JV Partner / Holding Company / Consortium Partner pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2
3.0	Format for Letter of Consent to be furnished by the Consortium Partners	Annexure-3

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[9]	25.09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No.[..] Capacity [..] of [Name of the Power Plant]	<i>[LOGO OF UTILITY]</i>
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SI No	Description	Format/ Data Sheet No.
4.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (a).	Data Sheet-1
5.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (b).	Data Sheet-2
6.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-3
7.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-4
8.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding/ Partner Company meets the financial QR	Data Sheet-5
9.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-6

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[10]	25.09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-1

Format for Pre-Qualification Bid

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Renovation & Modernization of [.....] Package for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX].

To,

[Designated Officer XXXXX]

[Address XXXXX]

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified bidders for Renovation & Modernization of [Boiler & Auxiliaries] Package for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Bidder/Leader of Consortium with name & designation of person authorized to submit the pre-qualification bid:

Name of Bidder/ Leader of Consortium: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1 & 2.1.2 of RFQ document *on our own/ on the strength of the parent JV partner [XXXXXX] & [XXXXXX] / in association with our Consortium Partner [XXXXXX].(Bidder to strike off whichever is not applicable).*

(The bidder is required to give a detailed description indicating the specific part of the qualification requirement which is met by the Bidder/JV Partner/ Consortium Members. Bidder is also required to furnish the relationship between the Bidder & others on whose strength Qualification Requirement is met.)

4.0 We confirm that neither we nor any of our parent JV Partners/ Our Consortium Members/ Our associates/ affiliates are liable for exclusion from participation in tendering process under 'other criteria' stipulated under clause no.2.1.3 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

Document Number	Rev No.	Description	Page No.	Date of Issue
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- (i) Covering Letter
- (ii) Power of Attorney in favor of persons signing on behalf of Bidder, Consortium members, Parent JV Partner and Holding Company as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1 (a)
- (iv) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1 (b)
- (v) Data Sheet regarding turnover requirement at RFQ clause no. 2.2.1 (a)
- (vi) Data Sheet regarding net worth requirement at RFQ at clause 2.2.1 (b)
- (vii) Data Sheet regarding bank balances & available unutilized credit line.
- (viii) Letter of Undertaking pledging unconditional & irrevocable financial support to the bidder for execution of the contract.(In case of financial QR is met on the strength of Holding Company/ Partner Company.)
- (ix) Letter of Consent of Consortium partner in case of Consortium
- (x) Details of equity holding of JV partners for Joint Ventures.

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:-

- (i) List of order executed
- (ii) Copies of order
- (iii) Past performance certificate.
- (iv) Contracts in hands/pending jobs along with value
- (v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.
- (vi) Copies of last 3 year audited financial statement.
- (vii) List of major litigations/disputes.
- (viii) Any other document.

7.0 We hereby attach participation fee of [INR-----] in the form of demand draft in favor of '[XXXXX]' payable at '[XXXXX]'.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to the best of our knowledge & belief.

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LII-GETS12021-G-00100-006	02	RFQ for Contractor	[12]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Dated this '[XXXXXX]' day of '[XXXXXX] 20XX

Yours Faithfully,

Signature '[XXXXXX]

Full Name '[XXXXXX]

Designation '[XXXXXX]

Company Seal '[XXXXXX]

Business Address: '[XXXXXX]

Country & province of Incorporation '[XXXXXX]

Contact details '[XXXXXX]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[13]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-2

Format for Letter of Undertaking by Holding Company / JV Partner / Consortium Partner pledging unconditional & irrevocable support to the Bidder for the execution of R&M work.

Ref.: [XXXXXX]

Date: [XXXXXX]

To,
 /Designated Official of Utility XXXXX/
 /Name & Address XXXXX/

Dear Sir/ Madam,

*We, M/s..... (Name and Complete address of the Holding Company) hereby declare that we have controlling interest in(Name of the Bidder) who is submitting Prequalification bid for R&M of Boiler Package for Unit No. [...] of [...] Plant of [...]. M/s.....(Name of the Bidder) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document./

*We have formed a Joint Venture with (name of other JV Partner) and the Joint Venture (Name of JV) is submitting Prequalification bid for R&M of Boiler Package for Unit No. [...] of [...] Plant of [...]. M/s.....(Name of JV) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document. /

*We, M/s..... (Name and Complete address of the Consortium Partner) hereby declare that we have agreed to associate with(Name and Complete address of the Bidder/Consortium Leader) for part scope of work of for the package (Name of the package) for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX] under RFQ no..... dated and M/s.....(Name of the Bidder/Consortium Leader) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document.

We hereby undertake to pledge our unconditional & irrevocable financial support for the execution of the said package to M/s..... (Name of the Bidder), for the execution of the Contract, in case they are awarded the Contract for the said package at the end of the bidding process. We further agree that this undertaking shall be without prejudice to the various liabilities that M/s..... (Name of Bidder) would be required to undertake in terms of the Contract including the Performance Security as well as other obligations of the Bidder/Contractor.

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[14]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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This undertaking is irrevocable and unconditional, and shall remain in force till the successful execution and performance of the entire contract and/or till it is discharged by Employer.

Yours faithfully,
(Signature of Authorized
Signatory) on behalf of the
Holding Company)

Date: Name & Designation.....

Place: Name of the Holding Company.....
Seal of the Holding Company.....

1. *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[15]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-3

Letter Of Consent To Be Furnished By The Consortium Partners

We hereby declare that the undersigned firm (Name and Complete address of the Consortium Partner) hereby agrees to associate with (Name and Complete address of the Bidder/Consortium Leader) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Consortium Partner) of '[XXXXXX]' Package for the Unit no. '[XXXXXX]' of '[XXXXXX]' plant in the state of '[XXXXXX]' for '[XXXXXX]', India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of. '[XXXXXX]', fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Employer's Project site.

On award of LOA, we the Consortium Partner agrees to furnish on demand a back up bank guarantee for 2 % of Contract Price.

1. WITNESS

For Consortium Partner

Signature:	(Signature of the Authorized Signatory)
Name	Name
Designation:	Designation:
Office Address	Seal of the Company

2. WITNESS

For Bidder

Signature:	(Signature of the Authorized Signatory)
Name	Name
Designation:	Designation:
Office Address	Seal of the Company

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[16]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (a):

To,

Bidder/Consortium
Partner/JV Partner's Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

*We are submitting the Prequalification Bid for R&M of [Boiler & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...]. /
*We are associated with (Name of Consortium Leader) as Consortium Partner for R&M of Boiler Package for Unit [...] of [...] Plant of [...] / *We have formed a Joint Venture with (name of other JV Partner) and the Joint Venture (Name of JV) is submitting Prequalification bid for R&M of Boiler Package for Unit No. [...] of [...] Plant of [...].

We have designed, engineered, manufactured, supplied, erected/supervised erection and commissioned/supervised commissioning of at least one (1) unit of reheat type coal fired Boiler for a power plant unit of 200 MW or above capacity which has completed satisfactory operation for a period of not less than two (2) years as on the scheduled date of opening of Prequalification Bid as per stipulated requirement at Clause No. 2.1.1 (a) of RFQ document. The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax & Tel. No.			
	- Email ID			
	- Web site address			
3.	Name and Designation of the responsible person in Client's organization.			
4.	No. of Boiler & Auxiliaries Sets supplied to the Station			
5.	Contact No. & Date			
6.	Capacity in MW of unit			

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LII-GETS12021-G-00100-006	02	RFQ for Contractor	[17]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
7.	Starting Date of the Project			
8.	Schedule Date of Completion			
9.	Actual Date of Completion			
10.	Date of Commencement of Successful Operation			
11.	(a) Whether the Plant is coal fired thermal power station	Yes*/No*	Yes*/No*	Yes*/No*
	(b) Whether the Boiler is of reheat type	Yes*/No*	Yes*/No*	Yes*/No*
12.	Scope of Work executed for the aforesaid Boiler & Auxiliaries includes the following:			
	(i) Designed	Yes*/No*	Yes*/No*	Yes*/No*
	(ii) Engineered	Yes*/No*	Yes*/No*	Yes*/No*
	(iii) Manufactured	Yes*/No*	Yes*/No*	Yes*/No*
	(iv) *Erected / *Supervised Erection	Yes*/No*	Yes*/No*	Yes*/No*
	(v) *Commissioned / *Supervised Commissioning	Yes*/No*	Yes*/No*	Yes*/No*
13.	Details of Boiler & Auxiliaries			
	Is this Steam Generator of the similar type as per reference package	Yes*/No*	Yes*/No*	Yes*/No*
	Type of Boiler [*Drum type with *single pass (Tower type) / *Two pass arrangement or *once through type with* single pass (Tower Type) / *Two pass arrangement]			
	Boiler Superheated steam flow capacity (T/Hr)			
	Main Steam Temperature (°C)			
	Main Steam Pressure {kg/cm ² (a)}			
	Reheat Steam flow (T/Hr)			
	Reheat outlet pressure {kg/cm ² (a)} and temperature			

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[18]	25. 09.2014

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	(°C)			
	Whether balanced draft type or not			
	<u>Type of start up/ circulation system</u>			
	Details of water wall tube (i) Type of water wall tubes (Inclined, Wrap around or vertical plain, ribbed or vertical rifled) (ii) Tube outer dia & thickness (mm) (iii) Width of fins in the membrane wall (mm)			
	Mass flow through the water wall tubes in the burner zone (Kg/m ² -sec) (applicable for bidders offering drum type Steam Generator) a)Maximum b)Minimum			
	Minimum load at which separator runs dry (%) (applicable for bidders offering once through type Steam Generator Unit)			
	Type of coal used i) Max. HHV (kCal/kg) ii) Min.HHV (kCal/kg) iii) Max. Ash content (%) iv) Max. total moisture content (%) v) Volatile matter content (%)			
	Type of oil used for Start up/low load operation i) HHV (Kcal/Kg)			

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[19]	25. 09.2014

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	ii) Sulphur content (%) iii) Viscosity in centistokes at 50°C (Max.) iv) Pour point (°C) v) Flash point (°C)			
	Any other Type of fuel(s) used			
	Firing rate (T/hr.)			
	Type of firing(Corner/Wall/Downshot etc)			
	Calorific value of fuel (kCal/kg)			
	Designed Boiler efficiency and corresponding GCV			
	Tested boiler efficiency and corresponding GCV			
	Tested boiler efficiency corrected to design conditions and corresponding GCV			
	a) Whether used for two shift operation b) If yes, number of such operations it has been designed for c) No. of actual two shift cycles it has actually operated till date			
	Minimum start-up time achieved i) Cold (after 72 hrs of unit shut down) ii) Warm (after 36 hrs of unit shut down) iii) Hot (after 8 hrs of unit shut down)			
	Availability of Steam Generator for last two years			
	Maximum Total NOx emission (from thermal as well as fuel) from Steam Generator at rated			

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LII-GETS12021-G-00100-006	02	RFQ for Contractor	[20]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	load with coal firing gm / Giga joules of Heat input			
14.	Certificate(s) from the Client is/are enclosed along with the bid at Annexure.....to this Attachment			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.
2. *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[21]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet -2

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (b):

Bidder/Consortium Partner/JV Partner's Name and Address:-	To, <i>[Designated Official]</i> <i>[Name of Utility]</i> <i>[Address]</i>
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*We are submitting the Prequalification Bid for R&M of *[Boiler & Auxiliaries]* Package for Unit No. [...] of [...] Plant of [...]. /
 *We are associated with (Name of Consortium Leader) as Consortium Partner for R&M of Boiler Package for Unit [...] of [...] Plant of [...] /
 *We have formed a Joint Venture with (name of other JV Partner) and the Joint Venture (Name of JV) is submitting Prequalification bid for R&M of Boiler Package for Unit No. [...] of [...] Plant of [...].

We have successfully completed execution of Renovation & Modernization of at least one coal fired Boiler for a power plant unit of 50 MW or above capacity. The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
	- Email ID			
	- Web site address			
3.	Name and Designation of the responsible person in Client's organization.			
4.	No. of Steam Generator sets retrofitted by us for the station			
5.	Capacity in MW of Unit			
6.	Starting date of Project			
7.	Scheduled date of completion			
8.	Actual date of completion			
9.	Date of commencement of successful Operation			
10.	Whether the Plant is coal fired	Yes*/No*	Yes*/No*	Yes*/No*

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LII-GETS12021-G-00100-006	02	RFQ for Contractor	[22]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	Thermal Power Station			
11.	Details of Steam Generator for which R&M work had been done by us:			
	Brief scope of R&M work carried out			
	Scope of work executed by us for the aforesaid Steam Generator and associated/ auxiliaries includes the following :			
	Designed	Yes*/No*	Yes*/No*	Yes*/No*
	Engineered	Yes*/No*	Yes*/No*	Yes*/No*
	Manufactured	Yes*/No*	Yes*/No*	Yes*/No*
	*Erected / *Supervised Erection	Yes*/No*	Yes*/No*	Yes*/No*
	*Commissioned / *Supervised Commissioning	Yes*/No*	Yes*/No*	Yes*/No*
	List of major parts/equipment renovated / retrofitted and type of work for such parts/equipment (repair / replacement / modification etc.)			
	Is this Steam Generator of the similar type as per reference package	Yes*/No*	Yes*/No*	Yes*/No*
	Type of Steam Generator [*Drum type with *single pass (Tower type) / *Two pass arrangement or *once through type with* single pass (Tower Type) / *Two pass arrangement]			
	Steam Generator Superheated steam flow capacity (T/Hr)			
	Main Steam Temperature (°C)			
	Main Steam Pressure {Kg/cm ² (a)}			
	Reheat Steam flow (T/Hr) – if applicable			

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[23]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	Reheat outlet pressure {Kg/cm ² (a)} and temperature (°C) – if applicable			
	Whether balanced draft type or not			
	<u>Type of start up/ circulation system</u>			
	Details of water wall tube (iv) Type of water wall tubes (Inclined, Wrap around or vertical plain, ribbed or vertical rifled) (v) Tube outer dia & thickness (mm) (vi) Width of fins in the membrane wall (mm)			
	Type of coal used vi) Max. HHV (kCal/kg) vii) Min.HHV (kCal/kg) viii) Max. Ash content (%) ix) Max. total moisture content (%) x) Volatile matter content (%)			
	Type of oil used for Start up/low load operation vi) HHV (kCal/kg) vii) Sulphur content (%) viii) Viscosity in centistokes at 50°C (Max.) ix) Pour point (°C) x) Flash point (°C)			
	Any other Type of fuel(s) used			
	Firing rate (T/hr.)			

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LII-GETS12021-G-00100-006	02	RFQ for Contractor	[24]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	Type of firing (Corner/Wall/Downshot etc)			
	Calorific value of fuel (kCal/kg.)			
	Designed Boiler efficiency and corresponding GCV			
	Boiler efficiency before R&M and corresponding GCV			
	Tested boiler efficiency after R&M and corresponding GCV			
	Tested boiler efficiency after R&M corrected to design conditions and corresponding GCV			
	Boiler capacity before R&M (T/hr)			
	Boiler capacity after R&M (T/hr)			
	a) Whether used for two shift operation b) If yes, number of such operations it has been designed for c) No. of actual two shift cycles it has actually operated till date			
	Minimum start-up time achieved iv) Cold (after 72 hrs of unit shut down) v) Warm (after 36 hrs of unit shut down) vi) Hot (after 8 hrs of unit shut down)			
	Availability of Steam Generator for last two years			
	Maximum Total NOx emission (from thermal as well as fuel) from Steam Generator at rated load with coal firing gm / Giga joules of Heat input			
	Extended life after R&M (years)			

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[25]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
12.	Certificate(s) from the Client is/are enclosed along with the bid at Annexure [.....] to this Attachment			

Date :

(Signature.)

Place :

(Printed Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.

2. *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[26]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-3

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a):

To,

Bidder/Consortium
Partner/JV Partner's Name
and Address

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Boiler Auxiliaries] Package for Unit No. [.....] of [.....] Plant of [.....].

In line with RFQ Document clause 2.1.2(a) , we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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LII-GETS12021-G-00100-006	02	RFQ for Contractor	[27]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-4

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b):

To,

Bidder/Consortium
Partner/JV Partner's Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Boiler & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-006	02	RFQ for Contractor	[28]	25. 09.2014

Request for Qualification for the Selection of Contractor for R&M of Boiler of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-5

Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & JV Partner / Holding Company / Consortium Partner Company meets the financial QR:

To,

Bidder/Consortium
Partner/JV Partner's Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Boiler & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...].

Since we do not meet Financial QR on own, we give the following details of JV Partner / Holding Company/ Consortium Partner:-

Name and Address of the Holding/Partner Company:

Turnover of the JV Partner / Holding Company / Partner Company with following details:

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years as on date of Bid Opening.			
5	Net worth of Holding/ Partner Company on last day of preceding financial year			
6	We have enclosed Balance Sheets and Profit & Loss Account of Holding/ Partner Company duly certified by Chartered Accountant	*Yes/*No		

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7	We are enclosing a Letter of Undertaking from the Holding/Partner Company, pledging unconditional and irrevocable financial support for execution of the contract by the bidder in case of award is enclosed	*Yes/*No
---	--	----------

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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Data Sheet -6

Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document:

Bidder/Consortium Partner/JV Partner's Name and Address	To, [Designated Official] [Name of Utility] [Address]
---	--

We are submitting the Prequalification Bid for R&M of [Boiler & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that the sum of unutilised line of credit for fund based and non fund based limits & cash & bank balances including fixed deposits of our company, duly certified by the bankers as on not more than 30 days prior to the schedule date of bid opening, is not less than INR [XXXXXX] or in equivalent foreign currency. The details are as under:

Sl. No.	Description	Amount in Indian Rupees or equivalent in foreign currency* as on a date not earlier than 30 days prior to the date of bid opening
1	Sanctioned Line of credit	
2	Unutilized Line of credit for fund based and non-fund based limits	
4	Cash and bank balances including fixed deposits	
4	We are enclosing Certificate from the Bankers in respect of unutilized Line of credit & bank balances as on .....(date)	*Yes/*No

Date:	(Signature).....
Place:	(Full Name).....
	(Designation).....
	(Company seal).....

Note: In case certificates from more than one bank are submitted, the certified unutilized limit shall be of the same date from all such banks.

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**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF CONTRACTOR
FOR
RENOVATION & MODERNISATION
OF
TURBO GENERATOR & AUXILIARIES**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

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List of Formats & Data Sheets

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by JV Partner/Holding Company/ Consortium Partner pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2
3.0	Format for Letter of Consent to be furnished by the Consortium Partners	Annexure-3
4.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (a).	Data Sheet-1
5.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (b).	Data Sheet-2
6.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-3
7.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-4
8.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding/ Partner Company meet the financial QR	Data Sheet-5
9.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-6

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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1 INVITATION FOR QUALIFICATION

1.1 Introduction

[Give brief introduction about the name, location and details of the Power Plant of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of XXX MW Unit no.-XX ----- of the Power Plant]

1.2 INVITATION

[Name of The Utility], hereinafter referred to as "Employer / Owner / Purchaser", is undertaking Renovation & Modernization project of Unit No.[XXX] of the [XXX] Power Plant. Under this project, [Name of The Utility] invites sealed Pre-Qualification Tender from experienced and interested bidders for the Renovation & Modernization Work of [Turbo Generator & Auxiliaries] package of Unit No.[XXX] of the [XXX] Power Plant on International Competitive Bidding (ICB).

Interested bidders may collect the RFQ documents in person from [Name and Contact Details of Designated Official.....]. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....]to [.....]. Alternatively, the RFQ document can be downloaded from [Name of the Utility] website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to [Name and Contact Details of Designated Official.....] by [Date and Time].

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly and replacement/refurbishment of specified existing equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing & forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, carrying out of all associated civil works including supply of cement, steel etc., testing & commissioning and successful completion of trial operation & performance guarantee tests for [Turbo Generator & Auxiliaries] package of Unit no. [XXX] of [XXX] Power Plant.

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]/ USD [---]/ EUR [---]
(b)	Publication date of RFQ	:	[-----]

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(c)	Last date for issue of RFQ document	:	[-----]
(d)	Last Date & Time of Receipt of Pre-Qualification Bids and Date & Time of Opening of Prequalification Bids	:	[-----]
(e)	Date for identification of Qualified Bidders and Issuance of RFP	:	[-----]

If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of The Utility] is carrying out this Pre-Qualification Process to identify qualified bidders for the issuance of RFP Documents for the Tender of Renovation & Modernization work of [Turbo Generator & Auxiliaries] package of Unit no. [XXX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process.

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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in tendering process for the subject Renovation & Modernization work for [Turbo Generator & Auxiliaries] package, the bidder must meet the Technical Qualification Requirement specified at clause 2.1.1 and Financial Qualification Requirement specified at clause 2.1.2. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no. 2.1.3.

2.1.1 Technical Qualification Requirement

- (a) The Bidder during the last 10 years preceding the scheduled date for submission of Pre-Qualification Tenders indicated in row (d) in section 1.4 above, should have designed, engineered, manufactured, supplied, erected/ supervised erection and commissioned / supervised commissioning of one (1) unit of reheat type Steam Turbine Set of 200 MW or above capacity for a coal fired power plant which should have completed satisfactory operation for a period of not less than One (1) years as on the scheduled date for submission of Pre-Qualification Tenders indicated in row (d) in section 1.4 above.

And

- (b) The bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Tenders indicated in row (d) in section 1.4 above, should have successfully completed execution of Renovation & Modernization of Steam Turbine Set of 50 MW or above capacity for a coal fired power plant.
- (c) The bidder can be a Joint Venture of two firms who collectively meet the Qualification Requirement specified at (a) and (b) above. Each of the JV partner must have at least 26% equity in the JV and in case of award of contract, must maintain JV arrangement till the successful completion of the R&M work. In such a case, parts and components of turbine set has to be sourced from the partner who satisfies the Qualification Requirement specified at (a).
- (d) The bidder can be a Consortium of two firms who collectively meet the Qualification Requirement specified at (a) and (b) above. The Consortium members shall designate one member as the Leader of the Consortium with whom the Contract will be entered into in case the Consortium emerges as the successful bidder. In such a case, parts and components of turbine set has to be sourced from the Consortium member who satisfies the Qualification Requirement specified at (a).

2.1.2 Financial Qualification Requirement

- (a) The average annual turnover of the Bidder should be at least [Indian Rupees] millions or equivalent foreign currency as per audited annual accounts during the preceding three consecutive years – [FY], FY [.....] and FY [.....]. For the purpose of conversion of

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foreign currency to Indian Rupees, the TT Buying rate of State Bank of India as on 30 days prior to the date of submission of Bid will be considered. Other income will not be considered for arriving at the annual turnover.

- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year shall be positive.
- (c) The sum of bank balances (including fixed deposits) and available unutilized credit line of the bidder (including non fund based credit lines) should not be less than [INR.....] as on not more than 30 days prior to the scheduled last date of submission of Pre-qualification Bid
- (d) In case the Bidder/Consortium Leader does not satisfy the Financial Criteria stipulated in the above clauses (a) and (b) on its own and the JV Partner in case the Bidder a Joint Venture of two firms or Holding Company having controlling interest in the Bidder / Consortium Partner Company, as the case may be, meets the stipulated turn-over requirements at Clause (a), then Financial Criteria stipulated in the above clauses (a) and (b) will be deemed to have been met, provided that the Net worth of such Holding Company / Partner Company, as the case may be, as on the last day of the preceding financial year is at least equal to or more than [.....]. In such a case, the Bidder / Consortium Leader has to submit a Letter of Undertaking from the JV Partner Company/ Holding Company/ Consortium Partner company pledging unconditional and irrevocable financial support to the bidder for execution of the Contract.

To establish the financial capacity for performance of the contractual obligations, the Bidder shall furnish documentary proof of their audited annual turnover and net worth for the last three (3) financial years [FY], [FY] & [FY].

2.1.3 Other Criteria

- (a) Any firm who is or was involved as a Consultant in the preparation for this R&M Project for activities such as Feasibility Study or RLA/CA Study or Energy Audit or preparation of DPR/Tender Document or any other preparatory activity or any firm who is or was involved as a consultant for implementation of this R&M project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of this R&M project cannot participate as a bidder for this R&M Tender.
- (b) Any bidder who is legally barred from the procurement process of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as a bidder for this R&M Tender.
- (c) Any firm or its associate company or parent company cannot participate as Bidder or JV Partner or Consortium Member in more than one Bid under this tender.

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2.2 Qualification Documents

2.2.1 Documents to be submitted (Pre-qualification)

Bidders are required to furnish following documents for pre-qualification in *[five (5)]* copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates clearly indicating date of completion from the facility owner in respect of such completed contract(s).
- (iii) Name of any proposed JV partner or Consortium member along with details of equity participation of JV partner or letter of consent of consortium partner.
- (iv) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity to the satisfaction of Employer. Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (v) Contracts in hand / pending jobs and their status along with value.
- (vi) Major pending legal cases.

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3 INSTRUCTION TO APPLICANTS

- 3.1. Only bidders pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the R&M work of *[Turbo Generator & Auxiliaries]* package and will be eligible to submit Bid Proposal for R&M work. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, project execution capability and financial resources to discharge the scope of service
- 3.2. *[Name of Utility]* is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Bidder or JV Partner or Consortium leader or Consortium partner is found to be factually incorrect or manipulated, the Bidder or JV Partner or Consortium leader or Consortium partner as the case may be, will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the Bidder shall be on the basis of single bidder responsibility. The contract will be entered into only with the successful Bidder / Consortium leader. Thus the bidder / Consortium leader shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder / Consortium leader and Consortium partner shall not Sub-contract the entire scope of work, back to back or otherwise, for the performance of this contract.
- 3.5. The bidder meeting the Qualifying Requirement on the strength of the JV partners should enclose details of equity holding of the JV partners. However, in the event, the bidder is found pre-qualified and issued RFP document, while submitting the techno-commercial Bid Proposal for R&M work, the bidder shall furnish a copy of the Joint Venture Agreement. Further, while submitting the techno-commercial Bid Proposal for R&M work, the JV partners shall furnish a joint undertaking towards joint and several liability to the employer for the successful performance of the Contract. The undertaking shall be furnished as per the format to be specified in the RFP document.
- 3.6. The bidder meeting the Qualifying Requirement as a Consortium should enclose the Letter of Consent (as per the prescribed format) from the consortium Partner along with the Pre-Qualification Bid signed by the Consortium Partners indicating the scope of work. However, in the event, the bidder is found pre-qualified and issued RFP document, while submitting the techno-commercial Bid Proposal for R&M work, the bidder (consortium leader) shall furnish a Consortium Agreement with the other Consortium member. No new consortium partner, (other than those qualified at Pre-qualification stage) will be permitted at the time of submitting the Techno commercial Bid. Further, while submitting the techno-commercial Bid Proposal for R&M work,

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the Consortium leader and Consortium member will furnish a joint undertaking regarding diligent performance of their respective scope of work and towards joint and several liability to the employer for the successful performance of the Contract. The undertaking shall be furnished as per the format to be specified in the RFP document.

- 3.7. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period.

If the bidder is a joint venture of two firms who collectively meet the Qualifying Requirement, in addition to the Contract Performance Guarantee (CPG) of 10% furnished by the bidder, each of the JV partner shall furnish Additional Contract Performance Guarantee equal to 1% of Contract Price.

If the bidder is a Consortium of two firms, in addition to the Contract Performance Guarantee (CPG) of 10% furnished by the Consortium Leader, the other consortium member will furnish Additional Contract Performance Guarantee equal to 2% of Contract Price

The Bidder shall provide satisfactory evidence that he and / or, where applicable, the consortium leader and consortium partners have adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid have an adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfillment of the qualifying requirements as specified are liable for rejection without assigning any reason.

- 3.8. The Bidder shall provide satisfactory evidence that he has adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid and adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfillment of the qualifying requirements as specified are liable for rejection without assigning any reason.

- 3.9. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to confirm the

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bidder's / Consortium leader's & Consortium Partners' claim on experience and to assess the Bidder's / Consortium leader's & Consortium Partners' capability and capacity to perform the contract, should the circumstances warrant such an assessment in the overall interest of the project.

3.10. [Name of Utility] reserves the right to reject any or all Pre-Qualification Bids or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no bidder / intending bidder shall have any claim arising out of such action.

3.11. Participation Fee for an amount of [INR.....] or [USD.....] or [Euro.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXXX]' is to be submitted along with the Pre-Qualification Bid. Pre-Qualification Bid received without the Participation Fee will be rejected. Participation Fee is non-refundable.

3.12. Language of Bid

The Bid submitted by the Bidder and all correspondences and documents relating to the Bid exchanged by the bidder and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.

3.13. Signature on Pre-Qualification Bid

The Pre-Qualification Bid must contain the name and place of business of the Bidder and each page of the EOI must be signed and sealed by the authorized person(s) of the Bidder / Consortium leader with his usual signature. The name of all persons signing should be typed or printed below the signature. Satisfactory evidences of authority of the person signing on behalf of the bidder / Consortium leader shall be furnished with the Bid. The Bidder / Consortium leader's name stated on the Pre-Qualification Bid shall be the exact legal name of the firm.

3.14. Method of Submission of Pre-Qualification Bid

The Pre-Qualification Bid shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of The Pre-Qualification Bid.

The outside of the covers should indicate clearly the name of the Bidder / Consortium leader and his address. In addition, the envelope or container should indicate the "Tender No. and Name of the work for which the Pre-Qualification Bid is submitted ". Pre-Qualification Bid with no indication given on the outside of the envelope that it is a Pre-Qualification Bid which therefore gets opened before the due date shall be liable to be disqualified. All the pages of the Pre-Qualification Bid shall be serially numbered.

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The Pre-Qualification Bid, complete in all respects, must be submitted to the official and address mentioned below.

'[XXXXXX]
'[XXXXXX] '[XXXXXX]

Submission of Pre-Qualification Bid through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post either way.

Pre-Qualification Bids must reach the above office on or before '[XXXXXX] Hours (IST) on '[XXXXXX]. Any Pre-Qualification Bid received after the expiry of the time specified is liable for rejection.

3.15. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXX] on *Date* and at *Time* indicated in row (d) in section 1.4 above.

The Pre-Qualification Bids shall be opened in the presence of such bidders who may be present. The bidders are at liberty to be present or authorise their representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Accredited Agents / representatives of foreign bidders in India are also permitted to submit the Pre-Qualification Bids on behalf of the foreign bidders with due Authorisation Letter.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least [15 (Fifteen) days] before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. [Name of Utility] will issue interpretations and clarifications as it may deem fit.

3.16. Application Data Sheets and Forms

The Pre-Qualification Bid is to be submitted as per the Format at Annexure-1. The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Bid. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by JV Partner/ Holding Company/ Consortium Partner pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2

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S.No	Description	Format/ Data Sheet No.
3.0	Format for Letter of Consent to be furnished by the Consortium Partners	Annexure-3
4.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (a).	Data Sheet-1
5.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (b).	Data Sheet-2
6.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-3
7.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-4
8.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding/ Partner Company meets the financial QR	Data Sheet-5
9.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-6

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Annexure-1

Format for Pre-Qualification Bid

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Renovation & Modernization of [.....] Package for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX].

To,

/Designated Officer XXXXX/

/Address XXXXX/

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified bidders for Renovation & Modernization of [Turbo Generator & Auxiliaries] Package for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Bidder/Leader of Consortium with name & designation of person authorized to submit the pre-qualification bid:

Name of Bidder/ Leader of Consortium: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1 & 2.1.2 of RFQ document *on our own/ on the strength of the parent JV partner [XXXXXX] & [XXXXXX] / in association with our Consortium Partner [XXXXXX].(Bidder to strike off whichever is not applicable).*

(The bidder is required to give a detailed description indicating the specific part of the qualification requirement which is met by the Bidder/JV Partner/ Consortium Members meet which part of Qualification Requirement. Bidder is also required to the relationship between the Bidder & others on whose strength Qualification Requirement is met.)

4.0 We confirm that neither we nor any of our parent JV Partners/ our Consortium Members/our associates/ affiliates are liable for exclusion from participation in tendering process under 'other criteria' stipulated under clause no.2.1.3 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

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- (i) Covering Letter
- (ii) Power of Attorney in favor of persons signing on behalf of Bidder, Consortium members, Parent JV Partner and Holding Company, as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1 (a)
- (iv) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1 (b)
- (v) Data Sheet regarding turnover requirement at RFQ clause no. 2.2.1 (a)
- (vi) Data Sheet regarding net worth requirement at RFQ at clause 2.2.1 (b)
- (vii) Data Sheet regarding bank balances & available unutilized credit line.
- (viii) Letter of Undertaking pledging unconditional & irrevocable financial support to the bidder for execution of the contract. (In case of financial QR is met on the strength of Holding Company/ Partner Company).
- (ix) Letter of Consent of Consortium Partner in case of Consortium
- (x) Details of equity holding of JV partners for Joint Ventures.

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:-

- (i) List of order executed
- (ii) Copies of order
- (iii) Past performance certificate.
- (iv) Contracts in hands/pending jobs along with value
- (v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.
- (vi) Copies of last 3 year audited financial statement.
- (vii) List of major litigations/disputes.
- (viii) Any other document.

7.0 We hereby attach participation fee of [INR-----] in the form of demand draft in favor of 'XXXXXX' payable at 'XXXXXX'.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to our best of the knowledge & belief.

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Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Dated this '[XXXXXX]' day of '[XXXXXX] 20XX'

Yours Faithfully,

Signature '[XXXXXX]'

Full Name '[XXXXXX]'

Designation '[XXXXXX]'

Company Seal '[XXXXXX]'

Business Address: '[XXXXXX]'

Country & province of Incorporation '[XXXXXX]'

Contact details '[XXXXXX]'

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-007	02	RFQ for Contractor	[13]	18.09.2014

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-2

Format for Letter of Undertaking by Holding Company/ JV Partner/ Consortium Partner pledging unconditional & irrevocable support to the Bidder for the execution of R&M work.

Ref.: [XXXXXX]

Date : [XXXXXX]

To,
 /Designated Official of Utility XXXXX/
 /Name & Address XXXXX/

Dear Sir/ Madam,

*We, M/s..... (Name and Complete address of the Holding Company) hereby declare that we have controlling interest in(Name of the Bidder) who is submitting Prequalification bid for R&M of Turbo Generator Package for Unit No. [...] of [...] Plant of [...]. M/s.....(Name of the Bidder) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document./

*We have formed a Joint Venture with (name of other JV Partner) and the Joint Venture (Name of JV) is submitting Prequalification bid for R&M of Turbo Generator Package for Unit No. [...] of [...] Plant of [...]. M/s.....(Name of JV) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document. /

* We, M/s..... declare that we are the holding company of M/s..... (Name of the Bidder) and have controlling interest therein.

* We, M/s..... (Name and Complete address of the Consortium Partner) hereby declare that we have agreed to associate with (Name and Complete address of the Bidder/Consortium Leader) for part scope of work of for the package..... (Name of the package) for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX] under RFQ no..... dated and M/s.....(Name of the Bidder/Consortium Leader) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document.

We hereby undertake that we hereby pledge our unconditional & irrevocable financial support for the execution of the said package to M/s..... (Name of the Bidder), for the execution of the Contract, in case they are awarded the Contract for the said package at the end of the bidding process. We further agree that this undertaking shall be without prejudice to the various liabilities that M/s..... (Name of Bidder) would be required to undertake in terms of the Contract including the Performance Security as well as other obligations of the Bidder/Contractor.

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Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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This undertaking is irrevocable and unconditional, and shall remain in force till the successful execution and performance of the entire contract and/or till it is discharged by Employer.

Yours faithfully,
(Signature of Authorized
Signatory) on behalf of the
Holding Company)

Date: Name & Designation.....

Place: Name of the Holding Company.....
Seal of the Holding Company.....

- *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-007	02	RFQ for Contractor	[15]	18.09.2014

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-3

Letter Of Consent To Be Furnished By The Consortium Partners

We hereby declare that the undersigned firm (Name and Complete address of the Consortium Partner) hereby agrees to associate with (Name and Complete address of the Bidder/Consortium Leader) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Consortium Partner) of '[XXXXXX] Package for the Unit no. '[XXXXXX] of '[XXXXXX] plant in the state of '[XXXXXX] for '[XXXXXX], India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of. '[XXXXXX] , fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Employer's Project site.

On award of LOA, we the Consortium Partner agrees to furnish on demand back up bank guarantee for 2 % of Contract Price.

1. Witness

For Consortium Partner

Signature: (Signature of the Authorized Signatory)
Name Name
Designation: Designation:
Office Address Seal of the Company

2. Witness

For Bidder

Signature: (Signature of the Authorized Signatory)
Name Name
Designation: Designation:
Office Address Seal of the Company

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-007	02	RFQ for Contractor	[16]	18.09.2014

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (a):

Bidder/Consortium Partner/JV Partner's Name and Address:-	To, [Designated Official] [Name of Utility] [Address]
---	--

*We are submitting the Prequalification Bid for R&M of [Turbo Generator & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...]. / *We are associated with (Name of Consortium Leader) as Consortium Partner for R&M of Turbine & Generator Package for Unit [...] of [...] Plant of [...] / *We have formed a Joint Venture with (name of other JV Partner) and the Joint Venture (Name of JV) is submitting Prequalification bid for R&M of Turbine & Generator Package for Unit No. [...] of [...] Plant of [...].

We have designed, engineered, manufactured, supplied, erected/supervised erection and commissioned/supervised commissioning of at least one (1) unit of reheat type steam Turbine set of 200 MW or above capacity for a coal fired power plant which has completed satisfactory operation for a period of not less than two (2) years as on the scheduled date of opening of Prequalification Bid as per stipulated requirement at Clause No. 2.1.1 (a) of RFQ document. The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	No. of Turbine set supplied to the Thermal Power Station.			
5.	Contact No. & Date			
6.	Turbine Set Capacity in MW			
7.	Starting Date of the Project			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
8.	Schedule Date of Completion			
9.	Actual Date of Completion			
10.	Date of Commencement of Successful Operation			
11.	(a) Whether the Plant is coal fired thermal power station	Yes*/No*	Yes*/No*	Yes*/No*
	(b) Whether the Turbine Set is reheat type	Yes*/No*	Yes*/No*	Yes*/No*
12.	Scope of Work executed for the aforesaid Steam Turbine set includes the following:			
	(i) Designed	Yes*/No*	Yes*/No*	Yes*/No*
	(ii) Engineered	Yes*/No*	Yes*/No*	Yes*/No*
	(iii) Manufactured	Yes*/No*	Yes*/No*	Yes*/No*
	(iv) *Erected / *Supervised Erection	Yes*/No*	Yes*/No*	Yes*/No*
	(v) *Commissioned / *Supervised Commissioning	Yes*/No*	Yes*/No*	Yes*/No*
13.	Details of Steam Turbine			
	Steam Turbine Make			
	*Tandem Compound / *Cross Compound			
	No. of Reheat			
	<u>No. of Cylinders</u>			
	(i) HP			
	(ii) IP			
	(iii) Combined HP & IP			
	(iv) LP			
	<u>Module No.</u>			
	(i) HP Turbine			
	(ii) IP Turbine			
	(iii) LP Turbine			
	(iv) Combined HP & LP			

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	Whether HP & IP Combined or Separate			
	Initial Pressure (ata)			
	Initial Temperature (deg C)			
	Reheat Temperature (deg C)			
	Exhaust Pressure (ata)			
	Type of Turbine	*Condensing / *Non-Condensing	*Condensing / *Non-Condensing	*Condensing / *Non-Condensing
	Rated Speed (rpm) and Operating Frequency range (Hz)			
	No. of Steam Extractions for regeneration			
	Whether Steam Turbine and Generator directly coupled	Yes*/No*	Yes*/No*	Yes*/No*
	Installation	*Indoor / *Outdoor	Indoor / *Outdoor	Indoor / *Outdoor
14.	Certificate(s) from the Client is/are enclosed along with the bid at Annexure.....to this Attachment			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.
2. *Strike off whichever is not applicable

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Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet -2

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 (b):

Bidder/Consortium Partner/JV Partner's Name and Address:-	To, [Designated Official] [Name of Utility] [Address]
---	--

*We are submitting the Prequalification Bid for R&M of [Turbo Generator & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...]. / *We are associated with (Name of Consortium Leader) as Consortium Partner for R&M of Turbine & Generator Package for Unit [...] of [...] Plant of [...] / *We have formed a Joint Venture with (name of other JV Partner) and the Joint Venture (Name of JV) is submitting Prequalification bid for R&M of Turbine & Generator Package for Unit No. [...] of [...] Plant of [...].

We have successfully completed execution of Renovation & Modernization of at least one Steam Turbine set of 50 MW or above capacity for a coal fired power plant. The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
	- Email ID			
	- Web site address			
3.	Name and Designation of the responsible person in Client's organization.			
4.	No. of Turbine Generator sets retrofitted by us for the station			
5.	Capacity in MW of Unit			
6.	Starting date of Project			
7.	Scheduled date of completion			
8.	Actual date of completion			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
9.	Date of commencement of successful Operation			
10.	Whether the Plant is coal fired Thermal Power Station	Yes*/No*	Yes*/No*	Yes*/No*
11.	Details of Turbine Generators for which R&M work had been done by us:			
	Brief scope of R&M work carried out			
	Steam Turbine Make			
	*Tandem Compound / *Cross Compound			
	No. of Reheat			
	<u>No. of Cylinders</u>			
	HP			
	IP			
	Combined HP & IP			
	LP			
	<u>Module No.</u>			
	HP Turbine			
	IP Turbine			
	LP Turbine			
	Combined HP & LP			
	Whether HP & IP Combined or Separate			
	Initial Pressure (ata)			
	Initial Temperature (deg C)			
	Reheat Temperature (deg C)			
	Exhaust Pressure (ata)			
	Type of Turbine	*Condensing / *Non-Condensing	*Condensing / *Non-Condensing	*Condensing / *Non-Condensing
	Rated Speed (rpm) and Operating Frequency range (Hz)			

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	No. of Steam Extractions for regeneration			
	Whether Steam Turbine and Generator directly coupled	Yes*/No*	Yes*/No*	Yes*/No*
	Installation	*Indoor / *Outdoor	Indoor / *Outdoor	Indoor / *Outdoor
	Certificate(s) from the Client is/are enclosed along with the bid at Annexure [.....]			
	Brief scope of R&M work carried out			
	Scope of work executed by us for the aforesaid Turbine Generator and associated/ auxiliaries includes the following :			
	Designed	Yes*/No*	Yes*/No*	Yes*/No*
	Engineered	Yes*/No*	Yes*/No*	Yes*/No*
	Manufactured	Yes*/No*	Yes*/No*	Yes*/No*
	*Erected / *Supervised Erection	Yes*/No*	Yes*/No*	Yes*/No*
	*Commissioned / *Supervised Commissioning	Yes*/No*	Yes*/No*	Yes*/No*
	List of major parts/equipment renovated / retrofitted and type of work for such parts/equipment (repair / replacement / modification etc.)			
	Is this Turbine Generator of the similar type as per reference package	Yes*/No*	Yes*/No*	Yes*/No*
	Designed TG Heat rate			
	TG Heat rate before R&M			
	Tested heat rate after R&M			
	Tested heat rate after R&M corrected to design conditions			
	TG Output before R&M			
	TG Output after R&M			

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LII-GETS12021-G-00100-007	02	RFQ for Contractor	[22]	18.09.2014

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	a) Whether used for two shift operation b) If yes, number of such operations it has been designed for c) No. of actual two shift cycles it has actually operated till date			
	Minimum start-up time achieved i) Cold (after 72 hrs of unit shut down) ii) Warm (after 36 hrs of unit shut down) iii) Hot (after 8 hrs of unit shut down)			
	Availability of Turbo Generator for last two years			
	Extended life after R&M (years)			
12.	Certificate(s) from the Client is/are enclosed along with the bid at Annexure [...] to this Attachment			

Date :

(Signature.)

Place :

(Printed Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.
2. *Strike off whichever is not applicable

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LII-GETS12021-G-00100-007	02	RFQ for Contractor	[23]	18.09.2014

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-3

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a):

Bidder/Consortium
Partner/JV Partner's Name
and Address

To,
[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Turbo Generator & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...].

In line with RFQ Document clause 2.1.2(a) , we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable.

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Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-4

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b):

To,

Bidder/Consortium
Partner/JV Partner's Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Turbo Generator & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date:

(Signature).....

Place:

(Full Name).....

(Designation).....

(Company seal).....

- *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-007	02	RFQ for Contractor	[25]	18.09.2014

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-5

Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & JV Partner / Holding Company / Consortium Partner Company meets the financial QR:

Bidder/Consortium
Partner/JV Partner's Name
and Address:-

To,
[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Turbo Generator & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...].

Since we do not meet Financial QR on own, we give the following details of JV Partner Company/ Holding Company/Consortium Partner:-

Name and Address of the Holding/Partner Company:

Turnover of the Holding JV Partner/ Holding Company/ Partner Company with following details:

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years as on date of Bid Opening.			
5	Net worth of Holding/ Partner Company on last day of preceding financial year			
6	We have enclosed Balance Sheets and Profit & Loss Account of Holding/ Partner Company duly certified	*Yes/ *No		

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Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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	by Chartered Accountant	
7	We are enclosing a Letter of Undertaking from the Holding/Partner Company, pledging unconditional and irrevocable financial support for execution of the contract by the bidder in case of award is enclosed	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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LII-GETS12021-G-00100-007	02	RFQ for Contractor	[27]	18.09.2014

Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet -6

Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document:

Bidder/Consortium
Partner/JV Partner's Name
and Address

To,
[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Turbo Generator & Auxiliaries] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that the sum of unutilised line of credit for fund based and non fund based limits & cash & bank balances including fixed deposits of our company, duly certified by the bankers as on not more than 30 days prior to the schedule date of bid opening, is not less than INR [XXXXXX] or in equivalent foreign currency.

The details are as under:

Sl. No.	Description	Amount in Indian Rupees or equivalent in foreign currency* as on a date not earlier than 30 days prior to the date of bid opening
1	Sanctioned Line of credit	
2	Unutilized Line of credit for fund based and non-fund based limits	
4	Cash and bank balances including fixed deposits	
4	We are enclosing Certificate from the Bankers in respect of unutilized Line of credit & bank balances as on(date)	*Yes/*No

Date:
Place:

(Signature).....
(Full Name).....

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Request for Qualification for the Selection of Contractor for R&M of Turbo Generator of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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(Designation).....

(Company seal).....

Note: In case certificates from more than one bank are submitted, the certified unutilized limit shall be of the same date from all such banks.

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**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF CONTRACTOR
FOR
RENOVATION & MODERNISATION
OF
COAL HANDLING PLANT**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

Request for Qualification For R&M of Coal Handling Plant of Unit No.[../] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Request for Qualification For R&M of Coal Handling Plant of Unit No.[../] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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List of Formats & Data Sheets

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2
3.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1.	Data Sheet-1
4.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-2
5.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-3
6.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meets the financial QR	Data Sheet-4
7.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-5

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Request for Qualification For R&M of Coal Handling Plant of Unit No.[../] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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1 INVITATION FOR QUALIFICATION

1.1 Introduction

[Give brief introduction about the name, location and details of the Power Plant of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of XXX MW Unit no.-XX ----
---- of the Power Plant]

1.2 Invitation

[Name of The Utility], hereinafter referred to as "Employer / Owner / Purchaser", is undertaking Renovation & Modernization project of Unit No.[XXX] of the [XXX] Power Plant. Under this project, [Name of The Utility] invites sealed Pre-Qualification Tenders from experienced and interested bidders from India for the Renovation & Modernization Work of [Coal Handling Plant] package of Unit No.[XXX] of the [XXX] Power Plant on Domestic Competitive Bidding (DCB).

Interested bidders from India may collect the RFQ documents in person from [Name and Contact Details of Designated Official.....]. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....]to [.....]. Alternatively, the RFQ document can be downloaded from [Name of the Utility] website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to [Name and Contact Details of Designated Official.....] by [Date and Time].

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly and replacement/refurbishment of specified existing equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing & forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, carrying out of all associated civil works including supply of cement, steel etc., testing & commissioning and successful completion of trial operation & performance guarantee tests for [Coal Handling Plant] package of Unit no. [XXX] of [XXX] Power Plant.

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]
(b)	Publication date of RFQ	:	[-----]
(c)	Last date for issue of RFQ document	:	[-----]

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(d)	Last Date & Time of Receipt of Pre-Qualification Bids and Date & Time of Opening of Prequalification Bids	:	[-----]
(e)	Date for identification of Qualified Bidders and Issuance of RFP	:	[-----]

If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of The Utility] is carrying out this Pre-Qualification Process to identify qualified bidders for the issuance of RFP Documents for the Tender of Renovation & Modernization work of [Coal Handling Plant] package of Unit no. [XXX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process.

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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in tendering process for the subject Renovation & Modernization work for *[Coal Handling Plant]* package, the bidder must meet the Technical Qualification Requirement specified at clause 2.1.1 and Financial Qualification Requirement specified at clause 2.1.2. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no. 2.1.3.

2.1.1 Technical Qualification Requirement

[The Bidder , during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above, should have designed, engineered, manufactured, erected and commissioned [at least one coal Handling Plants of capacityTPH] comprising (Track Hopper/Wagon Tippler) Belt Conveying System, Stacker Reclaimer, Inline Magnetic Separators, Metal Detectors, Coal Crusher, Transfer Points, Traveling Trippers, Dust Extraction & Dust Suppression System complete with associated Electrical and PLC based Instrument and Control System for entire Coal Handling Plant which should have completed satisfactory operation for a period of not less than One (1) year as on the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above.]

2.1.2 Financial Qualification Requirement

- (a) The average annual turnover of the Bidder should be at least *[Indian Rupees]* millions as per audited annual accounts during the preceding three consecutive years – *[FY], FY [.....] and FY [.....]*. Other income will not be considered for arriving at the annual turnover.
- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year shall be positive.
- (c) The sum of bank balances (including fixed deposits) and available unutilized credit line of the bidder (including non fund based credit lines) should not be less than *[INR.....]* as on not more than 30 days prior to the scheduled last date of submission of Pre-qualification Bid
- (d) In case the Bidder does not satisfy the Financial Criteria stipulated in the above clauses (a) and (b) on its own and the Holding Company having controlling interest in the Bidder, meets the stipulated turn-over requirements at Clause (a), then Financial Criteria stipulated in the above clauses (a) and (b) will be deemed to have been met, provided that the Net worth of such Holding Company as on the last day of the preceding financial year is at least equal to or more than *[.....]*. In such a case, the Bidder has to submit a Letter of Undertaking from the Holding Company pledging unconditional and irrevocable financial support to the bidder for execution of the Contract.

To establish the financial capacity for performance of the contractual

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obligations, the Bidder shall furnish documentary proof of their audited annual turnover and net worth for the last three (3) financial years [FY] , [FY] & [FY].

2.1.3 Other Criteria

- (a) Any firm who is or was involved as a Consultant in the preparation for this R&M Project for activities such as Feasibility Study or RLA/CA Study or Energy Audit or preparation of DPR/Tender Document or any other preparatory activity or any firm who is or was involved as a consultant for implementation of this R&M project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of this R&M project cannot participate as a bidder for this R&M Tender.
- (b) Any bidder who is legally barred from the procurement process of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as a bidder for this R&M Tender.
- (c) Any firm or its associate company or parent company cannot participate as Bidder in more than one Bid under this tender.

2.2 Qualification Documents

2.2.1 Documents to be submitted (Pre-qualification)

Bidders are required to furnish following documents for pre-qualification in [five (5)] copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates clearly indicating date of completion from the facility owner in respect of such completed contract(s).
- (iii) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity to the satisfaction of Employer. Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (iv) Contracts in hand / pending jobs and their status along with value.
- (v) Major pending legal cases.

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3 INSTRUCTION TO APPLICANTS

- 3.1. Only bidders pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the R&M work of [Coal Handling Plant] package and will be eligible to submit Bid Proposal for R&M work. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, project execution capability and financial resources to discharge the scope of service.
- 3.2. [Name of Utility] is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Bidder is found to be factually incorrect or manipulated, the Bidder will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the Bidder shall be on the basis of single bidder responsibility. The contract will be entered into only with the successful Bidder. Thus the bidder shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder shall not Sub-contract the entire scope of work, back to back or otherwise, for the performance of this contract.
- 3.5. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus ninety (90) days grace period.
- 3.6. The Bidder shall provide satisfactory evidence that he has adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid and adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfilment of the qualifying requirements as specified are liable for rejection without assigning any reason.

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3.7. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to confirm the bidder's claim on experience and to assess the Bidder's capability and capacity to perform the contract, should the circumstances warrant such an assessment in the overall interest of the project.

3.8. [Name of Utility] reserves the right to reject any or all Pre-Qualification Bids or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no bidder / intending bidder shall have any claim arising out of such action.

3.9. Participation Fee for an amount of [INR.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXXX]' is to be submitted along with the Pre-Qualification Bid. Pre-Qualification Bid received without the Participation Fee will be rejected. Participation Fee is non-refundable.

3.10. Language of Bid
The Bid submitted by the Bidder and all correspondences and documents relating to the Bid exchanged by the bidder and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.

3.11. Signature on Pre-Qualification Bid

The Pre-Qualification Bid must contain the name and place of business of the Bidder and each page of the EOI must be signed and sealed by the authorized person(s) of the Bidder with his usual signature. The name of all persons signing should be typed or printed below the signature.
Satisfactory evidences of authority of the person signing on behalf of the bidder shall be furnished with the Bid.

The Bidder's name stated on the Pre-Qualification Bid shall be the exact legal name of the firm.

3.12. Method of Submission of Pre-Qualification Bid

The Pre-Qualification Bid shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of The Pre-Qualification Bid.

The outside of the covers should indicate clearly the name of the Bidder and his address. In addition, the envelope or container should indicate the "Tender No. and Name of the work for which the Pre-Qualification Bid is submitted ". Pre-Qualification Bid with no indication given on the outside of the envelope that it is a Pre-Qualification Bid which therefore gets opened before the due

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date shall be liable to be disqualified. All the pages of the Pre-Qualification Bid shall be serially numbered.

The Pre-Qualification Bid, complete in all respects, must be submitted to the official and address mentioned below.

'[XXXXXX]

'[XXXXXX]'[XXXXXX]

Submission of Pre-Qualification Bid through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post either way.

Pre-Qualification Bids must reach the above office on or before '[XXXXXX]' Hours (IST) on '[XXXXXX]'. Any Pre-Qualification Bid received after the expiry of the time specified is liable for rejection.

3.13. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXX]' on Date and at Time indicated in row (d) in section 1.4 above.

The Pre-Qualification Bids shall be opened in the presence of such bidders who may be present. The bidders are at liberty to be present or authorise their representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least [15 (Fifteen) days] before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. [Name of Utility] will issue interpretations and clarifications as it may deem fit.

3.14. Application Data Sheets and Forms

The Pre-Qualification Bid is to be submitted as per the Format at Annexure-1. The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Bid. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2

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S.No	Description	Format/ Data Sheet No.
3.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1.	Data Sheet-1
4.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-2
5.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-3
6.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meets the financial QR	Data Sheet-4
7.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-5

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Annexure-1

Format for Pre-Qualification Bid

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Renovation & Modernization of [.....] Package for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX].

To,

[Designated Officer XXXXX]

[Address XXXXX]

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified bidders for Renovation & Modernization of [Coal Handling Plant] Package for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Bidder with name & designation of person authorized to submit the pre-qualification bid:

Name of Bidder: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1 & 2.1.2 of RFQ document.

4.0 We confirm that neither we nor any of our associates/ affiliates are liable for exclusion from participation in tendering process under 'other criteria' stipulated under clause no.2.1.3 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

- (i) Covering Letter
- (ii) Power of Attorney in favor of persons signing on behalf of Bidder and Holding Company, as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1
- (iv) Data Sheet regarding turnover requirement at RFQ clause no. 2.1.2 (a)

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- (v) Data Sheet regarding net worth requirement at RFQ at clause 2.1.2 (b)
- (vi) Data Sheet regarding bank balances & available unutilized credit line.
- (vii) Letter of Undertaking pledging unconditional & irrevocable financial support to the bidder for execution of the contract. (In case of financial QR is met on the strength of Holding Company).

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:

- (i) List of order executed
- (ii) Copies of order
- (iii) Past performance certificate.
- (iv) Contracts in hands/pending jobs along with value
- (v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.
- (vi) Copies of last 3 years audited financial statement.
- (vii) List of major litigations/disputes.
- (viii) Any other document.

7.0 We hereby attach participation fee of [INR-----] in the form of demand draft in favor of '[XXXXXX]' payable at '[XXXXXX]'.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to the best of our knowledge & belief.

Dated this '[XXXXXX]' day of '[XXXXXX]' 20XX

Yours Faithfully,

Signature '[XXXXXX]'

Full Name '[XXXXXX]'

Designation '[XXXXXX]'

Company Seal '[XXXXXX]'

Business Address: '[XXXXXX]'

Country & province of Incorporation '[XXXXXX]'

Contact details '[XXXXXX]'

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Annexure-2

Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the Bidder for the execution of R&M work.

Ref.: [XXXXXX]

Date : [XXXXXX]

To,
/Designated Official of Utility XXXXX/
/Name & Address XXXXX/

Dear Sir/ Madam,

We, M/s..... declare that we are the holding company of M/s..... (Name of the Bidder) and have controlling interest therein.

M/s.....(Name of the Bidder) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document for the package..... (Name of the package) for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX] under RFQ no..... dated

We hereby undertake that we hereby pledge our unconditional & irrevocable financial support for the execution of the said package to M/s..... (Name of the Bidder), for the execution of the Contract, in case they are awarded the Contract for the said package at the end of the bidding process. We further agree that this undertaking shall be without prejudice to the various liabilities that M/s..... (Name of Bidder) would be required to undertake in terms of the Contract including the Performance Security as well as other obligations of the Bidder/Contractor.

This undertaking is irrevocable and unconditional, and shall remain in force till the successful execution and performance of the entire contract and/or till it is discharged by Employer.

Yours faithfully,
(Signature of Authorized
Signatory) on behalf of the
Holding Company)

Date:
Place:

Name & Designation.....

Name of the Holding Company.....
Seal of the Holding Company.....

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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1:

To,

Bidders's
Name
and Address:-

[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of *[Coal Handling Plant]* Package for Unit No. *[.....]* of *[.....]* Plant of *[.....]*.

[We have designed, engineered, manufactured, erected and commissioned [..... Coal Handling Plants of capacityTPH] comprising (Track Hopper/Wagon Tippler) Belt Conveying System, Stacker Reclaimer, Inline Magnetic Separators, Metal Detectors, Coal Crusher, Transfer Points, Traveling Trippers, Dust Extraction & Dust Suppression System complete with associated Electrical and PLC based Instrument and Control System for entire Coal Handling Plant which have completed satisfactory operation for a period of not less than two (2) years as on the date of opening of Pre-Qualification Bid.] The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Contact No. & Date			
5.	Starting Date of the Project			
6.	Schedule Date of Completion			
7.	Actual Date of Completion			
8.	Date of Commencement of Successful Operation			
9.	Scope of Work executed for the aforesaid Coal Handling Plant.			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
10.	Details of the Plant/Systems executed			
	- Capacity of Coal Handling Plant (TPH)			
	- Inlet Coal lump size at Wagon Tippler/Track Hopper (mm)			
	- Coal size at the outlet of Crusher (mm)			
	- Hours of operation per day			
	- No. of tips/hour. (in case of Wagon Tippler)			
	- Capacity of Paddle/Plough Feeders. (in case of Track Hopper)			
	Belt Conveyors			
	- Belt material			
	- Belt width (mm)			
	- Belt speed (m/sec)			
	- Troughing angle (°C)			
	- Belt Protection Switches (Pull Cord, Belt Sway & Zero Speed Switches)			
	- Type of Tensioning Arrangement provided			
	Pulleys			
	- Pulleys width			
	- Material of construction			
	- Material of lagging			
	- Type of bearings			
	Idlers			
	- Material			
	- Type of Bearing			
	Gear Boxes			
	- Type of Prime Mover			
	- Type of High Speed Coupling			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	- Type of Low Speed Coupling			
	Belt Weigher			
	- Type of sensing			
	- Type of indication			
	Magnetic Separator			
	- Type			
	- Operating gap (mm)			
	- Supply voltage			
	- Method of cooling the transformer			
	Vibrating Screens before Crusher			
	- Capacity			
	- Screening size			
	- Efficiency of screening			
	Crushers			
	- Type			
	- Capacity of Crushers (TPH)			
	- Capacity of Drive Motor (KW)			
	- Type of Coupling			
	Stacker Cum Reclaimer			
	- Type			
	- Quantity			
	- Boom length			
	- Length of Travel (m)			
	Coal Storage Bunkers			
	- Type / Shape			
	- Capacity			
	- Quantity			
	- Material of Construction			
	- Type of level indicator			
	Dust Extraction System			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	- Type of System			
	- Locations			
	- Dust level achieved during operation (mg/Nm ³)			
	Dust Suppression System			
	- Type of System			
	- Locations			
	- Dust level achieved during operation (mg/Nm ³)			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.

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Data Sheet-2

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a):

To,

Bidder's Name [Designated Official]
and Address [Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Coal Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

In line with RFQ Document clause 2.1.2(a) , we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable.

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Data Sheet-3

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b):

Bidder's Name
and Address:-

To,
[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Coal Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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Request for Qualification For R&M of Coal Handling Plant of Unit No.[...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-4

Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meet the financial QR:

To,

Bidder, Name [Designated Official]
and Address:- [Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Coal Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

Since we do not meet Financial QR on own, we give the following details of Holding Company:-

Name and Address of the Holding Company:

Turnover of the Holding Company with following details:

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years as on date of Bid Opening.			
5	Net worth of Holding Company on last day of preceding financial year			
6	We have enclosed Balance Sheets and Profit & Loss Account of Holding duly certified by Chartered Accountant	*Yes/*No		

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7	We are enclosing a Letter of Undertaking from the Holding Company, pledging unconditional and irrevocable financial support for execution of the contract by the bidder in case of award is enclosed	*Yes/*No
---	--	----------

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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Request for Qualification For R&M of Coal Handling Plant of Unit No.[...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet -5

Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document:

To,

Bidder's Name [Designated Official]
[Name of Utility]
and Address [Address]

We are submitting the Prequalification Bid for R&M of [Coal Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that the sum of unutilised line of credit for fund based and non fund based limits & cash & bank balances including fixed deposits of our company, duly certified by the bankers as on not more than 30 days prior to the schedule date of bid opening, is not less than INR [XXXXX] or in equivalent foreign currency. The details are as under:

Sl. No.	Description	Amount in Indian Rupees or equivalent in foreign currency* as on a date not earlier than 30 days prior to the date of bid opening
1	Sanctioned Line of credit	
2	Unutilized Line of credit for fund based and non-fund based limits	
4	Cash and bank balances including fixed deposits	
4	We are enclosing Certificate from the Bankers in respect of unutilized Line of credit & bank balances as on .....(date)	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

Note: In case certificates from more than one bank are submitted, the certified unutilized limit shall be of the same date from all such banks.

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**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF CONTRACTOR
FOR
RENOVATION & MODERNISATION
OF
ASH HANDLING PLANT**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

Request for Qualification For R&M of Ash Handling Plant of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
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6.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meets the financial QR	Data Sheet-4
7.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-5

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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1 INVITATION FOR QUALIFICATION

1.1 Introduction

[Give brief introduction about the name, location and details of the Power Plant of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of XXX MW Unit no.-XX ---- of the Power Plant]

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, is undertaking Renovation & Modernization project of Unit No.[XXX] of the [XXX] Power Plant. Under this project, *[Name of the Utility]* invites sealed Pre-Qualification Tenders from experienced and interested bidders from India for the Renovation & Modernization Work of *[Ash Handling Plant]* package of Unit No. [XXX] of the [XXX] Power Plant on Domestic Competitive Bidding (DCB).

Interested bidders from India may collect the RFQ documents in person from *[Name and Contact Details of Designated Official.....]*. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....] to [.....]. Alternatively, the RFQ document can be downloaded from *[Name of the Utility]* website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to *[Name and Contact Details of Designated Official.....]* by *[Date and Time]*.

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly and replacement/refurbishment of specified existing equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing & forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, carrying out of all associated civil works including supply of cement, steel etc., testing & commissioning and successful completion of trial operation & performance guarantee tests for *[Ash Handling Plant]* package of Unit no. [XXX] of [XXX] Power Plant.

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]
(b)	Publication date of RFQ	:	[-----]
(c)	Last date for issue of RFQ document	:	[-----]

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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(d)	Last Date & Time of Receipt of Pre-Qualification Bids and Date & Time of Opening of Prequalification Bids	:	[-----]
(e)	Date for identification of Qualified Bidders and Issuance of RFP	:	[-----]

If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of the Utility] is carrying out this Pre-Qualification Process to identify qualified bidders for the issuance of RFP Documents for the Tender of Renovation & Modernization work of [Ash Handling Plant] package of Unit no. [XXX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process.

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in tendering process for the subject Renovation & Modernization work for [Ash Handling Plant] package, the bidder must meet the Technical Qualification Requirement specified at clause 2.1.1 and Financial Qualification Requirement specified at clause 2.1.2. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no. 2.1.3.

2.1.1 Technical Qualification Requirement

[The Bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above, should have designed, engineered, manufactured, erected and commissioned at least One Ash Handling Plants for Thermal Power Plants of capacity 200 MW or above comprising, a) Lean Slurry/High Concentration Slurry Disposal System) for Bottom & Coarse Ash; b) Dry Handling & Disposal System for Fly Ash and c) Ash Water Recycling System, complete with associated Electrical and PLC based Instrumentation & Control Systems for the entire Ash Handling Plant which should have completed satisfactory operation for a period of not less than One (1) years as on the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above.

2.1.2 Financial Qualification Requirement

- (a) The average annual turnover of the Bidder should be at least [Indian Rupees] millions as per audited annual accounts during the preceding three consecutive years – [FY], FY [.....] and FY [.....]. Other income will not be considered for arriving at the annual turnover.
- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year shall be positive.
- (c) The sum of bank balances (including fixed deposits) and available unutilized credit line of the bidder (including non fund based credit lines) should not be less than [INR.....] as on not more than 30 days prior to the scheduled last date of submission of Pre-qualification Bid
- (d) In case the Bidder does not satisfy the Financial Criteria stipulated in the above clauses (a) and (b) on its own and the Holding Company having controlling interest in the Bidder, meets the stipulated turn-over requirements at Clause (a), then Financial Criteria stipulated in the above clauses (a) and (b) will be deemed to have been met, provided that the Net worth of such Holding Company / Partner Company, as the case may be, as on the last day of the preceding financial year is at least equal to or more than [.....]. In such a case, the Bidder has to submit a Letter of Undertaking from the Holding Company pledging unconditional and irrevocable financial support to the bidder for execution of the Contract.

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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To establish the financial capacity for performance of the contractual obligations, the Bidder shall furnish documentary proof of their audited annual turnover and net worth for the last three (3) financial years [FY] , [FY] & [FY].

2.1.3 Other Criteria

- (a) Any firm who is or was involved as a Consultant in the preparation for this R&M Project for activities such as Feasibility Study or RLA/CA Study or Energy Audit or preparation of DPR/Tender Document or any other preparatory activity or any firm who is or was involved as a consultant for implementation of this R&M project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of this R&M project cannot participate as a bidder for this R&M Tender.
- (b) Any bidder who is legally barred from the procurement process of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as a bidder for this R&M Tender.
- (c) Any firm or its associate company or parent company cannot participate as Bidder in more than one Bid under this tender.

2.2 Qualification Documents

2.2.1 Documents to be submitted (Pre-qualification)

Bidders are required to furnish following documents for pre-qualification in [five (5)] copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates clearly indicating date of completion from the facility owner in respect of such completed contract(s).
- (iii) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity to the satisfaction of Employer. Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (iv) Contracts in hand / pending jobs and their status along with value.
- (v) Major pending legal cases.

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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3 INSTRUCTION TO APPLICANTS

- 3.1. Only bidders pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the R&M work of [Ash Handling Plant] package and will be eligible to submit Bid Proposal for R&M work. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, project execution capability and financial resources to discharge the scope of service.
- 3.2. [Name of Utility] is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Bidder is found to be factually incorrect or manipulated, the Bidder will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the Bidder shall be on the basis of single bidder responsibility. The contract will be entered into only with the successful Bidder. Thus the bidder shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder shall not Sub-contract the entire scope of work, back to back or otherwise, for the performance of this contract.
- 3.5. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus ninety (90) days grace period.
- 3.6. The Bidder shall provide satisfactory evidence that he has adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid and adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfilment of the qualifying requirements as specified are liable for rejection without assigning any reason.

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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- 3.7. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to confirm the bidder's claim on experience and to assess the Bidder's capability and capacity to perform the contract, should the circumstances warrant such an assessment in the overall interest of the project.
- 3.8. [Name of Utility] reserves the right to reject any or all Pre-Qualification Bids or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no bidder / intending bidder shall have any claim arising out of such action.
- 3.9. Participation Fee for an amount of [INR.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXXX]' is to be submitted along with the Pre-Qualification Bid. Pre-Qualification Bid received without the Participation Fee will be rejected. Participation Fee is non-refundable.
- 3.10. Language of Bid
The Bid submitted by the Bidder and all correspondences and documents relating to the Bid exchanged by the bidder and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.
- 3.11. Signature on Pre-Qualification Bid
The Pre-Qualification Bid must contain the name and place of business of the Bidder and each page of the EOI must be signed and sealed by the authorized person(s) of the Bidder with his usual signature. The name of all persons signing should be typed or printed below the signature.
Satisfactory evidences of authority of the person signing on behalf of the bidder shall be furnished with the Bid.
The Bidder's name stated on the Pre-Qualification Bid shall be the exact legal name of the firm.
- 3.12. Method of Submission of Pre-Qualification Bid
The Pre-Qualification Bid shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of The Pre-Qualification Bid.
The outside of the covers should indicate clearly the name of the Bidder and his address. In addition, the envelope or container should indicate the "Tender No. and Name of the work for which the Pre-Qualification Bid is submitted ". Pre-Qualification Bid with no indication given on the outside of the envelope that it is a Pre-Qualification Bid which therefore gets opened before the due

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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date shall be liable to be disqualified. All the pages of the Pre-Qualification Bid shall be serially numbered.

The Pre-Qualification Bid, complete in all respects, must be submitted to the official and address mentioned below.

'[XXXXXX]
'[XXXXXX] '[XXXXXX]

Submission of Pre-Qualification Bid through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post either way.

Pre-Qualification Bids must reach the above office on or before '[XXXXXX] Hours (IST) on '[XXXXXX]. Any Pre-Qualification Bid received after the expiry of the time specified is liable for rejection.

3.13. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXX] on Date and at Time indicated in row (d) in section 1.4 above.

The Pre-Qualification Bids shall be opened in the presence of such bidders who may be present. The bidders are at liberty to be present or authorise their representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least [15 (Fifteen) days] before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. [Name of Utility] will issue interpretations and clarifications as it may deem fit.

3.14. Application Data Sheets and Forms

The Pre-Qualification Bid is to be submitted as per the Format at Annexure-1. The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Bid. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the bidder for	Annexure-2

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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S.No	Description	Format/ Data Sheet No.
	the execution of R&M work.	
3.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1.	Data Sheet-1
4.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-2
5.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-3
6.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meets the financial QR	Data Sheet-4
7.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-5

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-1

Format for Pre-Qualification Bid

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Renovation & Modernization of [.....] Package for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX].

To,

[Designated Officer XXXXX]

[Address XXXXX]

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified bidders for Renovation & Modernization of [Ash Handling Plant] Package for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Bidder with name & designation of person authorized to submit the pre-qualification bid:

Name of Bidder: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1 & 2.1.2 of RFQ document.

4.0 We confirm that neither we nor any of our associates/ affiliates is liable for exclusion from participation in tendering process under 'other criteria' stipulated under clause no.2.1.3 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

- (i) Covering Letter
- (ii) Power of Attorney in favor of persons signing on behalf of Bidder and Holding Company, as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1
- (iv) Data Sheet regarding turnover requirement at RFQ clause no. 2.1.2 (a)

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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- (v) Data Sheet regarding net worth requirement at RFQ at clause 2.1.2 (b)
- (vi) Data Sheet regarding bank balances & available unutilized credit line.
- (vii) Letter of undertaking pledging unconditional & irrevocable financial support to the bidder for execution of the contract. (In case of financial QR is met on the strength of Holding Company).

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:

- (i) List of order executed
- (ii) Copies of order
- (iii) Past performance certificate.
- (iv) Contracts in hands/pending jobs along with value
- (v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.
- (vi) Copies of last 3 year audited financial statement.
- (vii) List of major litigations/disputes.
- (viii) Any other document.

7.0 We hereby attach participation fee of [INR-----] in the form of demand draft in favor of '[XXXXXX]' payable at '[XXXXXX]'.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to the best of our knowledge & belief.

Dated this '[XXXXXX]' day of '[XXXXXX]' 20XX

Yours Faithfully,

Signature '[XXXXXX]'

Full Name '[XXXXXX]'

Designation '[XXXXXX]'

Company Seal '[XXXXXX]'

Business Address: '[XXXXXX]'

Country & province of Incorporation '[XXXXXX]'

Contact details '[XXXXXX]'

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-2

Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the Bidder for the execution of R&M work.

Ref.: [XXXXX]

Date : [XXXXX]

To,
 /Designated Official of Utility XXXXX/
 /Name & Address XXXXX/

Dear Sir/ Madam,

We, M/s..... declare that we are the holding company of M/s..... (Name of the Bidder) and have controlling interest therein.

M/s.....(Name of the Bidder) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document for the package..... (Name of the package) for Unit No. [XXXXX] of [XXXXX] power plant of [XXXXX] under RFQ no..... dated

We hereby undertake that we hereby pledge our unconditional & irrevocable financial support for the execution of the said package to M/s..... (Name of the Bidder), for the execution of the Contract, in case they are awarded the Contract for the said package at the end of the bidding process. We further agree that this undertaking shall be without prejudice to the various liabilities that M/s..... (Name of Bidder) would be required to undertake in terms of the Contract including the Performance Security as well as other obligations of the Bidder/Contractor.

This undertaking is irrevocable and unconditional, and shall remain in force till the successful execution and performance of the entire contract and/or till it is discharged by Employer.

Yours faithfully,
 (Signature of Authorized
 Signatory) on behalf of the
 Holding Company)

Date: _____ Name & Designation.....
 Place: _____

Name of the Holding Company.....
 Seal of the Holding Company.....

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1:

To,

Bidders's

Name

and Address:-

[Name of Utility]

[Address]

We are submitting the Prequalification Bid for R&M of [Ash Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

[We have designed, engineered, manufactured, erected and commissioned Ash Handling Plants for Thermal Power Plants of capacity 200 MW or above comprising, a) Lean Slurry/High Concentration Slurry Disposal System) for Bottom & Coarse Ash; b) Dry Handling & Disposal System for Fly Ash and c) Ash Water Recycling System, complete with associated Electrical and PLC based Instrumentation & Control Systems for the entire Ash Handling Plant which have completed satisfactory operation for a period of not less than two (2) years as on the date of opening of Pre-Qualification Bid.]

The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Contact No. & Date			
5.	Starting Date of the Project			
6.	Schedule Date of Completion			
7.	Actual Date of Completion			
8.	Date of Commencement of Successful Operation			
9.	Scope of Work executed for the aforesaid Ash Handling Plant.			
10.	Details of the Plant/Systems executed			
	Bottom Ash Handling System			
	- Type of collection system			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	(Submerged Scraper Chain Conveyor System / W-Shaped Water Impounded Hopper)			
	- Capacity (TPH)			
	- Type of wet disposal system (Lean Slurry/High Concentration Slurry Disposal System (HCSD)			
	- Ash to Water Ratio			
	Coarse Ash Handling System			
	- Type of collection system			
	- Capacity (TPH)			
	- Type of Disposal System.			
	- Ash to Water Ratio.			
	Fly Ash Handling System			
	- Type of System adopted for collection & conveying dry fly ash from ESP Hoppers to Surge Hoppers (Vacuum / Pressurized System)			
	- Type of System adopted for conveying dry fly ash from Surge Hopper to Fly Ash Storage Silos.			
	- Capacity of Fly Ash Storage Silos.			
	Ash Water Recycling System			
	- Percentage of ash water recycled.			
	- Type of treatment provided for the recycled ash water			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.

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Data Sheet-2

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a):

To,

Bidder's Name [Designated Official]
[Name of Utility]
and Address [Address]

We are submitting the Prequalification Bid for R&M of [Ash Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

In line with RFQ Document clause 2.1.2(a) , we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable.

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Request for Qualification For R&M of Ash Handling Plant of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-3

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b):

To,
 Bidder's Name [Designated Official]
 and Address:- [Name of Utility]
 [Address]

We are submitting the Prequalification Bid for R&M of [Ash Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date: (Signature).....
 Place: (Full Name).....
 (Designation).....
 (Company seal).....

1. *Strike off whichever is not applicable

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Data Sheet-4

Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meet the financial QR:

Bidder, Name
and Address:-

To,
[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Ash Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

Since we do not meet Financial QR on own, we give the following details of Holding Company:-

Name and Address of the Holding Company:

Turnover of the Holding Company with following details:

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years as on date of Bid Opening.			
5	Net worth of Holding Company on last day of preceding financial year			
6	We have enclosed Balance Sheets and Profit & Loss Account of Holding duly certified by Chartered Accountant	*Yes/*No		
7	We are enclosing a Letter of Undertaking	*Yes/*No		

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	from the Holding Company pledging unconditional and irrevocable financial support for execution of the contract by the bidder in case of award is enclosed	
--	--	--

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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Data Sheet -5

Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document:

Bidder's Name

and Address

To,

[Designated Official]

[Name of Utility]

[Address]

We are submitting the Prequalification Bid for R&M of [Ash Handling Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that the sum of unutilised line of credit for fund based and non fund based limits & cash & bank balances including fixed deposits of our company, duly certified by the bankers as on not more than 30 days prior to the schedule date of bid opening, is not less than INR [XXXXXX] or in equivalent foreign currency.

The details are as under:

Sl. No.	Description	Amount in Indian Rupees or equivalent in foreign currency* as on a date not earlier than 30 days prior to the date of bid opening
1	Sanctioned Line of credit	
2	Unutilized Line of credit for fund based and non-fund based limits	
4	Cash and bank balances including fixed deposits	
4	We are enclosing Certificate from the Bankers in respect of unutilized Line of credit & bank balances as on(date)	*Yes/*No

Date:

Place:

(Signature).....

(Full Name).....

(Designation).....

(Company seal).....

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Request for Qualification For R&M of Ash Handling Plant of Unit No. <i>[..]</i> Capacity <i>[..]</i> of <i>[Name of the Power Plant]</i>	<i>[LOGO OF UTILITY]</i>
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Note: In case certificates from more than one bank are submitted, the certified unutilized limit shall be of the same date from all such banks.

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**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF CONTRACTOR
FOR
RENOVATION & MODERNISATION
OF
BALANCE OF PLANT (BOP)**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

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List of Formats & Data Sheets

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1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2
3.0	Format for Letter of Consent to be furnished by the Consortium Partners.	Annexure-3
4.0	Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1	Data Sheet-1
5.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.2.	Data Sheet-2
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8.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.3 (a) & 2.1.3 (b) on its own & Holding Company meet the financial QR	Data Sheet-5
9.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.3 (c) of RFQ document	Data Sheet-6

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1 INVITATION FOR QUALIFICATION

1.1 Introduction

[Give brief introduction about the name, location and details of the Power Plant of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of XXX MW Unit no.-XX ---- of the Power Plant]

1.2 INVITATION

[Name of The Utility], hereinafter referred to as "Employer / Owner / Purchaser", is undertaking Renovation & Modernization project of Unit No.[XXX] of the [XXX] Power Plant. Under this project, [Name of The Utility] invites sealed Pre-Qualification Tender from experienced and interested Indian bidders for the Renovation & Modernization Work of [Balance of Plant] package of Unit No.[XXX] of the [XXX] Power Plant on Domestic Competitive Bidding (DCB).

Interested bidders may collect the RFQ documents in person from [Name and Contact Details of Designated Official.....]. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....] to [.....]. Alternatively, the RFQ document can be downloaded from [Name of the Utility] website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to [Name and Contact Details of Designated Official.....] by [Date and Time].

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly and replacement/refurbishment of specified existing equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing & forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, carrying out of all associated civil works including supply of cement, steel etc., testing & commissioning and successful completion of trial operation & performance guarantee tests for [Balance of Plant] package of Unit no. [XXX] of [XXX] Power Plant comprising [.....] systems.

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]
(b)	Publication date of	:	[-----]

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--	-------------------

	RFQ		
(c)	Last date for issue of RFQ document	:	[-----]
(d)	Last Date & Time of Receipt of Pre-Qualification Bids and Date & Time of Opening of Prequalification Bids	:	[-----]
(e)	Date for identification of Qualified Bidders and Issuance of RFP	:	[-----]

If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of the Utility] is carrying out this Pre-Qualification Process to identify qualified bidders for the issuance of RFP Documents for the Tender of Renovation & Modernization work of [Balance of Plant] package of Unit no. [XXX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process.

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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in tendering process for the subject Renovation & Modernization work for [Balance of Plant] package, the bidder must meet the Technical Qualification Requirement specified at clause 2.1.1 and Financial Qualification Requirement specified at clause 2.1.3. As per the stipulation in Clause 2.1.1, the Bidder/Consortium Leader/Consortium Member(s)/Sub-Contractor(s), as the case may be, must meet the Qualification Requirements for BoP systems stipulated at Clause 2.1.2. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no. 2.1.4.

2.1.1 Technical Qualification Requirement for Bidder

The Bidder must meet Qualification Requirement stipulated at (a) or (b) or (c) below:

- (a) The bidder should have executed contract(s) on Engineering, Procurement and Construction (EPC) basis for at least one number of coal based / lignite based / gas based combined cycle power plant of installed capacity not less than 100 MW which has been commissioned during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above and has been in satisfactory operation for a period of not less than one year as on the original scheduled date of submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above. The scope of work of such Contract(s) must have included Engineering, Supply, installation (with all associated Mechanical, Electrical, Civil & Structural Works), testing and commissioning of Main power plant equipment (Boiler–Turbine-generator or Gas Turbine - HRSG - STG) with all associated integral auxiliaries.

In addition, the Bidder should meet the Qualification Requirement stipulated at clause 2.1.2 for the four BoP systems listed therein. If the Bidder does not meet the Qualification Requirement for some or all systems listed at Clause 2.1.2, he can employ Sub-Contractor(s) who meet Qualification Requirement stipulated for such system.

or

- (b) The bidder should have executed contract(s) on Engineering, Procurement and Construction (EPC) basis for Balance of Plant of at least one number of coal based / lignite based / gas based combined cycle power plant of installed capacity not less than 100 MW which has been commissioned during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above and has been in satisfactory operation for a period of not less than one year as on the original scheduled date of submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above. The scope of work of such Contract(s) must have included Engineering, Supply, installation (with all associated Mechanical, Electrical, Civil &

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Structural Works), testing and commissioning of at least the following four systems with all associated integral auxiliaries:

1. Cooling Tower
2. CW Pumps for Condenser Cooling
3. Water Pre-treatment Plant and/or Liquid Effluent Treatment Plant
4. Demineralization (DM) Plant

In addition, the Bidder should meet the Qualification Requirement stipulated at clause 2.1.2 for the four BoP systems listed therein. If the Bidder does not meet the Qualification Requirement for some or all systems listed at Clause 2.1.2, he can employ Sub-Contractor(s) who meet Qualification Requirement stipulated for such system (s).

or

- (c) The bidder can be a Consortium of firms who collectively meet the Qualification Requirement specified at Clause 2.1.2 for the four systems listed therein. The Consortium members shall designate one member as the Leader of the Consortium with whom the Contract will be entered into in case the Consortium emerges as the successful bidder. The maximum number of Consortium members shall be limited to four. Each of the Consortium Member, including Consortium Leader, must meet Qualification Requirement for at least one of the four stipulated systems. In such a case, each of the listed systems will be executed by the Consortium Partner who meets the Qualification Requirement stipulated for that system.

2.1.2 Technical Qualification Requirement for BoP Systems

2.1.2.1 Qualification Requirement for Cooling Tower

The bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above, should have designed, constructed and commissioned at least one (1) number of [Natural Draft/Induced Draft Cooling tower] with [splash type / film type fill], of capacity not less than {Insert the design Capacity of Existing Cooling Tower in m³/h} which is in successful operation for at least one (1) year as on the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above.

2.1.2.2 Qualification Requirement for CW Pumps for Condenser Cooling

The Bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above, should have designed, manufactured, supplied, erected/ supervised erection, and commissioned/ supervised commissioning of at least one (1) nos. of vertical wet pit pumps for condenser cooling water application/ comparable duty, of capacity not less than {Insert the design Capacity of Existing CW pump in m³/h}, having specific speed in the range of [4000–7000 (US units)] which are in successful operation for at least one (1) year as on the scheduled

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date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above.

2.1.2.3 Qualification Requirement for Water Pre-treatment Plant and/or Liquid Effluent Treatment Plant

The Bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above, should have designed, supplied, erected and commissioned at least one (1) numbers of water/waste water treatment plants, each with a total capacity of {Insert the design Capacity of Existing stream in m³/h} (minimum), comprising of clarifiers/tube settlers/ thickeners or a combination thereof. The plants should be in successful operation for at least One (1) years as on the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above.

2.1.2.4 Qualification Requirement for Demineralization (DM) Plant

The Bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above, should have designed, supplied, erected and commissioned at least one (1) number of ion exchange based demineralising plant, consisting of at least two (2) streams of minimum {Insert the design Capacity of Existing stream in m³/h} capacity, capable of producing outlet water quality of silica and conductivity not more than 0.02 ppm as SiO₂ and 0.2 micro mho/cm respectively, which are in successful operation for at least one (1) year as on the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above.

2.1.3 Financial Qualification Requirement

- (a) The average annual turnover of the Bidder or Consortium Leader, as the case may be, should be at least [Indian Rupees] millions or equivalent foreign currency as per audited annual accounts during the preceding three consecutive years – [FY], FY [.....] and FY [.....]. For the purpose of conversion of foreign currency to Indian Rupees, the TT Buying rate of State Bank of India as on 30 days prior to the date of submission of Bid will be considered. Other income will not be considered for arriving at the annual turnover.
- (b) The Net Worth of the Bidder or Consortium Leader, as the case may be, as on the last date of preceding Financial Year shall be positive.
- (c) The sum of bank balances (including fixed deposits) and available unutilized credit line of the bidder or Consortium Leader, as the case may be, (including non fund based credit lines) should not be less than [INR.....] as on not more than 30 days prior to the scheduled last date of submission of Pre-qualification Bid
- (d) In case the Bidder/Consortium Leader does not satisfy the Financial Criteria stipulated in the above clauses (a) and (b) on its own and the Holding Company having controlling interest in the Bidder / Consortium Leader, as the case may be, meets the stipulated turn-over requirements

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at Clause (a), then Financial Criteria stipulated in the above clauses (a) and (b) will be deemed to have been met, provided that the Net worth of such Holding Company as on the last day of the preceding financial year is at least equal to or more than [...]. In such a case, the Bidder / Consortium Leader has to submit a Letter of Undertaking from the Holding Company pledging unconditional and irrevocable financial support to the bidder for execution of the Contract.

To establish the financial capacity for performance of the contractual obligations, the Bidder shall furnish documentary proof of their audited annual turnover and net worth for the last three (3) financial years [FY], [FY] & [FY].

2.1.4 Other Criteria

- (a) Any firm who is or was involved as a Consultant in the preparation for this R&M Project for activities such as Feasibility Study or RLA/CA Study or Energy Audit or preparation of DPR/Tender Document or any other preparatory activity or any firm who is or was involved as a consultant for implementation of this R&M project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of this R&M project cannot participate as a bidder for this R&M Tender.
- (b) Any Bidder who is legally barred from the procurement process of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as a bidder for this R&M Tender.
- (c) Any firm or its associate company or parent company cannot participate as Bidder or Consortium Member in more than one Bid under this tender.

2.2 Qualification Documents

2.2.1 Documents to be submitted (Pre-qualification)

Bidders are required to furnish following documents for pre-qualification in [five (5)] copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates clearly indicating date of completion from the facility owner in respect of such completed contract(s).
- (iii) Name of any proposed Consortium member (s) along with letter of consent of consortium member.
- (iv) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity to the satisfaction of Employer. Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (v) Contracts in hand / pending jobs and their status along with value.
- (vi) Major pending legal cases.

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3 INSTRUCTION TO APPLICANTS

- 3.1. Only bidders pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the R&M work of [Balance of Plant] package and will be eligible to submit Bid Proposal for R&M work. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, project execution capability and financial resources to discharge the scope of service.
- 3.2. [Name of Utility] is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Bidder or Consortium leader or Consortium partner is found to be factually incorrect or manipulated, the Bidder or Consortium leader or Consortium partner as the case may be, will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the Bidder shall be on the basis of single bidder responsibility. The contract will be entered into only with the successful Bidder / Consortium leader. Thus the bidder / Consortium leader shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder / Consortium leader and Consortium partner shall not Sub-contract the entire scope of work, back to back or otherwise, for the performance of this contract.
- 3.5. The bidder meeting the Qualifying Requirement as a Consortium should enclose the Letter of Consent (as per the prescribed format) from the consortium Partner (s) along with the Pre-Qualification Bid signed by the Consortium Partners indicating the scope of work. However, in the event, the bidder is found pre-qualified and issued RFP document, while submitting the techno-commercial Bid Proposal for R&M work, the bidder (consortium leader) shall furnish a Consortium Agreement with the other Consortium member. No new consortium partner, (other than those qualified at Pre-qualification stage) will be permitted at the time of submitting the Techno commercial Bid. The Consortium Agreement must include but not limited to (1) Scope of Service of each Consortium Member, (2) Authorization in favour of Consortium Leader to Bid and act on behalf of the Consortium Members during tendering and execution stage, (3) Joint and several liability of all consortium members for the entire scope of service, (4) Undertaking that any dispute among Consortium Members will not relieve any Member from its obligations towards the Owner under this Contract, (5) Undertaking by each member for providing expertise, man power and other technical support for successful completion of the respective Scope of Service and (6) Undertaking that each Member

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will provide Additional Contract Performance Security in addition to the Contract Performance Security to be furnished by Consortium Leader.

- 3.6. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus ninety (90) days grace period.
- If the bidder is a Consortium of firms, in addition to the Contract Performance Guarantee (CPG) of 10% furnished by the Consortium Leader, each other consortium member will furnish Additional Contract Performance Guarantee equal to 1% of the Contract Price.
- 3.7. The Bidder shall provide satisfactory evidence that he and / or, where applicable, the consortium leader and consortium partners have adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid have an adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfilment of the qualifying requirements as specified are liable for rejection without assigning any reason.
- 3.8. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to confirm the bidder's / Consortium leader's & Consortium Partners' claim on experience and to assess the Bidder's / Consortium leader's & Consortium Partners' capability and capacity to perform the contract, should the circumstances warrant such an assessment in the overall interest of the project.
- 3.9. [Name of Utility] reserves the right to reject any or all Pre-Qualification Bids or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no bidder / intending bidder shall have any claim arising out of such action.
- 3.10. Participation Fee for an amount of [INR.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXXX]' is to be submitted along with the Pre-Qualification Bid. Pre-Qualification Bid received without the Participation Fee will be rejected. Participation Fee is non-refundable.
- 3.11. Language of Bid
- The Bid submitted by the Bidder and all correspondences and documents relating to the Bid exchanged by the bidder and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the

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bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.

3.12. Signature on Pre-Qualification Bid

The Pre-Qualification Bid must contain the name and place of business of the Bidder and each page of the Pre-Qualification Bid must be signed and sealed by the authorized person(s) of the Bidder / Consortium leader with his usual signature. The name of all persons signing should be typed or printed below the signature.

Satisfactory evidences of authority of the person signing on behalf of the bidder / Consortium leader shall be furnished with the Bid.

The Bidder / Consortium leader's name stated on the Pre-Qualification Bid shall be the exact legal name of the firm.

3.13. Method of Submission of Pre-Qualification Bid

The Pre-Qualification Bid shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of The Pre-Qualification Bid.

The outside of the covers should indicate clearly the name of the Bidder / Consortium leader and his address. In addition, the envelope or container should indicate the "Tender No. and Name of the work for which the Pre-Qualification Bid is submitted ". Pre-Qualification Bid with no indication given on the outside of the envelope that it is a Pre-Qualification Bid which therefore gets opened before the due date shall be liable to be disqualified. All the pages of the Pre-Qualification Bid shall be serially numbered.

The Pre-Qualification Bid, complete in all respects, must be submitted to the official and address mentioned below.

'[XXXXXX]

'[XXXXXX] '[XXXXXX]

Submission of Pre-Qualification Bid through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post either way.

Pre-Qualification Bids must reach the above office on or before '[XXXXXX] Hours (IST) on '[XXXXXX]. Any Pre-Qualification Bid received after the expiry of the time specified is liable for rejection.

3.14. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXXX] on Date and at Time indicated in row (d) in section 1.4 above.

The Pre-Qualification Bids shall be opened in the presence of such Bidders who may be present. The bidders are at liberty to be present or authorise their

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representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least *[15 (Fifteen) days]* before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. *[Name of Utility]* will issue interpretations and clarifications as it may deem fit.

3.15. Application Data Sheets and Forms

The Pre-Qualification Bid is to be submitted as per the Format at Annexure-1. The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Bid. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

List of Formats & Data Sheets

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2
3.0	Format for Letter of Consent to be furnished by the Consortium Partners.	Annexure-3
4.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1.	Data Sheet-1
5.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.2.	Data Sheet-2
6.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.3 (a)	Data Sheet-3
7.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.3 (b)	Datasheet-4
8.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause	Data Sheet-5

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List of Formats & Data Sheets

S.No	Description	Format/ Data Sheet No.
	2.1.3 (a) & 2.1.3 (b) on its own & Holding Company meet the financial QR	
9.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.3 (c) of RFQ document	Data Sheet-6

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Annexure-1

Format for Pre-Qualification Bid

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Renovation & Modernization of [.....] Package for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX].

To,

[Designated Officer XXXXX]

[Address XXXXX]

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified bidders for Renovation & Modernization of [Balance of Plant] Package for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Bidder/Leader of Consortium with name & designation of person authorized to submit the pre-qualification bid:

Name of Bidder/ Leader of Consortium: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1 of RFQ document *on our own / *in association with our Consortium Partner(s) [XXXXXX].

**We on our own meet the Qualification Requirement at Clause 2.1.2.1 of RFQ / *We in association with our Consortium Partner(s) (.....) meet the Qualification Requirement at Clause 2.1.2.1 of RFQ / *We will employ Sub-Contractor who will meet Qualification Requirement at 2.1.2.1.*

**We on our own meet the Qualification Requirement at Clause 2.1.2.2 of RFQ / *We in association with our Consortium Partner(s) (.....) meet the Qualification Requirement at Clause 2.1.2.2 of RFQ / *We will employ Sub-Contractor who will meet Qualification Requirement at 2.1.2.2.*

**We on our own meet the Qualification Requirement at Clause 2.1.2.3 of RFQ / *We in association with our Consortium Partner(s) (.....) meet the Qualification Requirement at Clause 2.1.2.3 of RFQ / *We will employ Sub-Contractor who will meet Qualification Requirement at 2.1.2.3.*

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**We on our own meet the Qualification Requirement at Clause 2.1.2.4 of RFQ / *We in association with our Consortium Partner(s) (.....) meet the Qualification Requirement at Clause 2.1.2.4 of RFQ / *We will employ Sub-Contractor who will meet Qualification Requirement at 2.1.2.4.*

**We on our own meet the Qualification Requirement at Clause 2.1.3 of RFQ / *We on the strength of our Holding Company (.....) meet the Qualification Requirement at Clause 2.1.3 of RFQ.*

(The bidder is required to give a detailed description indicating the specific part of the qualification requirement, which is met by the Bidder/ Consortium Member(s) meet which part of Qualification Requirement and which part of the Qualification Requirement will be met by Sub-Contractor(s). Bidder is also required to the relationship between the Bidder & others on whose strength Qualification Requirement is met.)

4.0 We confirm that neither we nor any of our Consortium Members/our associates/ affiliates are liable for exclusion from participation in tendering process under 'other criteria' stipulated under clause no.2.1.4 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

- (i) Covering Letter
- (ii) Power of Attorney in favor of persons signing on behalf of Bidder, Consortium members, and Holding Company, as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1
- (iv) Data Sheet regarding Technical Qualification Requirement at clause 2.1.2
- (v) Data Sheet regarding turnover requirement at RFQ clause no. 2.1.3 (a)
- (vi) Data Sheet regarding net worth requirement at RFQ at clause 2.1.3 (b)
- (vii) Data Sheet regarding bank balances & available unutilized credit line.
- (viii) Letter of Undertaking pledging unconditional & irrevocable financial support to the bidder for execution of the contract. (In case of financial QR is met on the strength of Holding Company).
- (ix) Letter of Consent of Consortium Partner in case of Consortium

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:-

- (i) List of order executed
- (ii) Copies of order
- (iii) Past performance certificate.

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- (iv) Contracts in hands/pending jobs along with value
- (v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.
- (vi) Copies of last 3 year audited financial statement.
- (vii) List of major litigations/disputes.
- (viii) Any other document.

7.0 We hereby attach participation fee of *[/INR-----/]* in the form of demand draft in favor of *'[XXXXXX]* payable at *'[XXXXXX]*.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to our best of the knowledge & belief.

Dated this *'[XXXXXX]* day of *'[XXXXXX] 20XX*

Yours Faithfully,

Signature *'[XXXXXX]*

Full Name *'[XXXXXX]*

Designation *'[XXXXXX]*

Company Seal *'[XXXXXX]*

Business Address: *'[XXXXXX]*

Country & province of Incorporation *'[XXXXXX]*

Contact details *'[XXXXXX]*

1. *Strike off whichever is not applicable

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Annexure-2

Format for Letter of Undertaking by Holding Company pledging unconditional
& irrevocable support to the Bidder for the execution of R&M work.

Ref.: [XXXXX]

Date : [XXXXX]

To,

/Designated Official of Utility XXXXX/
/Name & Address XXXXX/

Dear Sir/ Madam,

We, M/s..... declare that we are the holding company of
M/s..... (Name of the Bidder/Consortium Leader) and have
controlling interest therein.

M/s.....(Name of the Bidder/Consortium Leader) have sought financial
strength and support from us for meeting the stipulated Financial Qualifying
Requirement as per Clause 2.1.3 (a) & (b) of RFQ document.

We hereby undertake that we hereby pledge our unconditional & irrevocable
financial support for the execution of the said package to
M/s..... (Name of the Bidder//Consortium Leader), for
the execution of the Contract, in case they are awarded the Contract for the
said package at the end of the bidding process. We further agree that this
undertaking shall be without prejudice to the various liabilities that
M/s..... (Name of Bidder) would be required to
undertake in terms of the Contract including the Performance Security as well
as other obligations of the Bidder/Contractor.

This undertaking is irrevocable and unconditional, and shall remain in force till
the successful execution and performance of the entire contract and/or till it is
discharged by Employer.

Yours faithfully,
(Signature of Authorized
Signatory) on behalf of the
Holding Company)

Date: Name & Designation.....
Place:

Name of the Holding Company.....
Seal of the Holding Company.....

1. *Strike off whichever is not applicable

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Annexure-3

Letter Of Consent To Be Furnished By The Consortium Partners

We hereby declare that the undersigned firm (Name and Complete address of the Consortium Partner) hereby agrees to associate with (Name and Complete address of the Consortium Leader) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Consortium Partner) of '[XXXXXX]' Package for the Unit no. '[XXXXXX]' of. '[XXXXXX]' plant in the state of '[XXXXXX]' for '[XXXXXX]', India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of. '[XXXXXX]', fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Employer's Project site.

On award of LOA, we the Consortium Partner agrees to furnish on demand back up bank guarantee for 5 % of Contract Price for our Scope of Work.

1. Witness

For Consortium Partner

Signature: (Signature of the Authorized Signatory)
 Name Name
 Designation: Designation:
 Office Address Seal of the Company

2. Witness

For Bidder (Consortium Leader)

Signature: (Signature of the Authorized Signatory)
 Name Name
 Designation: Designation:
 Office Address Seal of the Company

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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1 :

To,
 Bidder/Consortium
 Partner/JV Partner's Name
 and Address:-
 [Designated Official]
 [Name of Utility]
 [Address]

We are submitting the Prequalification Bid for R&M of [Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

**We have executed contract(s) on Engineering, Procurement and Construction (EPC) basis for at least one number of coal based / lignite based / gas based combined cycle power plant of installed capacity not less than 100 MW which has been commissioned during the last 10 years preceding the original scheduled date for submission of Pre-Qualification Bids and has been in satisfactory operation for a period of not less than one year as on the original scheduled date of Pre-Qualification Bid opening. The scope of work of such Contract(s) included Engineering, Supply, installation (with all associated Mechanical, Electrical, Civil & Structural Works), testing and commissioning of Main power plant equipment (Boiler–Turbine-generator or Gas Turbine - HRSG - STG) with all associated integral auxiliaries. The details of the same are given below. We meet Qualification Requirement stipulated at Clause 2.1.1 (a). / *We have executed contract(s) on Engineering, Procurement and Construction (EPC) basis for Balance of Plant of at least one number of coal based / lignite based / gas based combined cycle power plant of installed capacity not less than 100 MW which has been commissioned during the last 10 years preceding the original scheduled date for submission of Pre-Qualification Bids and has been in satisfactory operation for a period of not less than one year as on the original scheduled date of Pre-Qualification Bid opening. The scope of work of such Contract(s) included Engineering, Supply, installation (with all associated Mechanical, Electrical, Civil & Structural Works), testing and commissioning of at least the following four systems with all associated integral auxiliaries:*

1. Cooling Tower
2. CW Pumps for Condenser Cooling
3. Water Pre-treatment Plant and/or Liquid Effluent Treatment Plant
4. Demineralization (DM) Plant

The details of the same are given below. We meet Qualification Requirement stipulated at Clause 2.1.1 (b).

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Type of Power Plant (Coal Fired / Lignite Fired/ Combined Cycle)			
5.	Contact No. & Date			
6.	Plant Capacity in MW			
7.	Starting Date of the Project			
8.	Schedule Date of Completion			
9.	Actual Date of Completion			
10.	Date of Commencement of Successful Operation			
11.	Scope of Work executed for the aforesaid Contract set includes the following:			
	(i) Engineering	Yes*/No*	Yes*/No*	Yes*/No*
	(ii) Procurement	Yes*/No*	Yes*/No*	Yes*/No*
	(iii) Construction	Yes*/No*	Yes*/No*	Yes*/No*
	(iv) Commissioning and Testing	Yes*/No*	Yes*/No*	Yes*/No*
	(v) Project Management	Yes*/No*	Yes*/No*	Yes*/No*
12.	Detail scope of Work			
13.	Certificate(s) from the Client is/are enclosed along with the bid at Annexure.....to this Attachment			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.

2. *Strike off whichever is not applicable

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Data Sheet -2

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.2 :

Bidder/Consortium
Partner/JV Partner's Name
and Address:-

To,
[Designated Official]
[Name of Utility]
[Address]

*We are (Name of Bidder/Consortium Partner) submitting the Prequalification Bid for R&M of [Balance of Plant] Package for Unit No. [...] of [...] Plant of [...]. / *We are associated with (Name of Consortium Leader) as Consortium Partner for R&M of Balance of Plant Package for Unit [...] of [...] Plant of [...]

We meet the Qualification Requirements at Clauses *2.1.2.1, *2.1.2.2, *2.1.2.3 and *2.1.2.4 The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
	- Email ID			
	- Web site address			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Capacity in MW of Unit			
5.	Starting date of Project			
6.	Scheduled date of completion			
7.	Actual date of completion			
8.	Date of commencement of successful Operation			
9.	Type of Power Plant (Coal Fired / Lignite Fired/ Combined Cycle)			
14.	Detail scope of Work			
15.	Certificate(s) from the Client is/are enclosed along with the			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	bid at Annexure.....to this Attachment			
12.	Scope of Work executed for the aforesaid Balance of Plant Package includes the following:			
	(vi) Designed	Yes*/No*	Yes*/No*	Yes*/No*
	(vii)Engineered	Yes*/No*	Yes*/No*	Yes*/No*
	(viii) Manufactured	Yes*/No*	Yes*/No*	Yes*/No*
	(ix) *Erected / *Supervised Erection	Yes*/No*	Yes*/No*	Yes*/No*
	(x) *Commissioned / *Supervised Commissioning	Yes*/No*	Yes*/No*	Yes*/No*
13.	Details of Balance of Plant			
13.1	Raw Water System			Yes*/No*
	i Number of Intake pumps			
	ii Type of Pump			
	iii Rated Flow			
	iv Rated Speed			
	v Total Developed Head			
	vi Range of operation			
	vii Maximum efficiency of the pump at design point			
	viii Intake well diameter			
	ix Intake well finished bed level			
	x Pump house inside clear plan dimension			
13.2	Water Pre-Treatment Plant			
	Aerator			
	i No. of Aerator			
	ii Type of Aerator			
	iii Design Flow			
	iv % of Sludge			
	Stilling Chamber			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	i Number			
	ii Capacity (Retention Time)			
	Flash Mixer			
	i Number			
	ii Type			
	iii Agitator Type			
	iv Agitator Number			
	v Capacity of each Agitator (Retention Time)			
	Flocculator			
	i Type			
	ii Material of Construction			
	iii Rated net output capacity			
	iv Retention time (minimum)			
13.3	CW System			
	i Number of CW pumps			
	ii Type of Pump			
	iii Rated Flow			
	iv Rated Speed			
	v Total Developed Head			
	vi Range of operation			
	vii Maximum efficiency of the pump at design point			
	viii Intake well diameter			
	ix Intake well finished bed level			
	x Pump house inside clear plan dimension			
	xi Size of CW Pipe in mm			
	xii Wall thickness of CW pipe in mm			
13.4	Cooling Tower			

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	i Type of Cooling Tower			
	ii Rated water flow per tower			
	iii Design wet bulb temperature			
	iv Approach			
	v Cooling range at rated flow			
	vi Design ambient relative humidity (average)			
	vii Evaporation loss (maximum)			
	viii Drift loss (maximum)			
	ix Draft loss			
13.5	DM Plant			
	i No. of DM Streams			
	ii No. of working streams			
	iii No. of standby streams			
	iv Water source			
	v Net permeate water output			
	vi Period between successive regenerations			
	vii Pressure Vessels Type			
	viii Number of Pressure Vessels (For Each type i.e. Strongly acidic cation exchanger (SAC), Weak Acid Cation exchanger (WAC), Strongly basic anion exchanger (SBA), Weak Base Anion exchanger (WBA), Mixed bed exchanger (MB)			
	ix Net outflow/unit	SAC, WAC - [...] SBA, WBA - [...] MB - [...]	SAC, WAC - [...] SBA, WBA - [...] MB - [...]	SAC, WAC - [...] SBA, WBA - [...] MB - [...]
	x Design surface flow rate	SAC, WAC - [...]	SAC, WAC - [...]	SAC, WAC - [...]

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[LOGO OF UTILITY]

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
		[...] SBA, WBA - [...] MB - [...]	[...] SBA, WBA - [...] MB - [...]	[...] SBA, WBA - [...] MB - [...]
	i Duty classification			

Date :

(Signature.)

Place :

(Printed Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.
2. *Strike off whichever is not applicable
3. Separate Data Sheet to be furnished for Bidder/Consortium Member (s)

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Data Sheet-3

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.3 (a):

Bidder/Consortium
Partner's Name
and Address

To,

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

In line with RFQ Document clause 2.1.3(a)), we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date:

(Signature).....

Place:

(Full Name).....

(Designation).....

(Company seal).....

1. *Strike off whichever is not applicable.

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Request for Qualification for the Selection of Contractor for R&M of Balance of Plant of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[LOGO OF UTILITY]

Data Sheet-4

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.3 (b):

Bidder/Consortium
Partner's Name
and Address:-

To,

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date:
Place:

(Signature).....
(Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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Data Sheet-5

Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.3 (a) & 2.1.3 (b) on its own & Holding Company meet the financial QR:

Bidder/Consortium
Leader's Name
and Address:-

To,

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

Since we do not meet Financial QR on own, we give the following details of Holding:-

Name and Address of the Holding Company:

Turnover and Network details of Holding Company follows:

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years as on date of Bid Opening.			
5	Net worth of Holding Company on last day of preceding financial year			
6	We have enclosed Balance Sheets and Profit & Loss Account of Holding Company duly certified by Chartered Accountant	*Yes/ *No		
7	We are enclosing a Letter of Undertaking from the Holding	*Yes/ *No		

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[LOGO OF UTILITY]

	Company, pledging unconditional and irrevocable financial support for execution of the contract by the bidder in case of award is enclosed	
--	--	--

Date:

(Signature).....

Place:

(Full Name).....

(Designation).....

(Company seal).....

1. *Strike off whichever is not applicable

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Data Sheet -6

Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.3 (c) of RFQ document:

Bidder/Consortium
Partner's Name
and Address

To,
[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that the sum of unutilised line of credit for fund based and non fund based limits & cash & bank balances including fixed deposits of our company, duly certified by the bankers as on not more than 30 days prior to the schedule date of bid opening, is not less than INR [XXXXXX] or in equivalent foreign currency.

The details are as under:

Sl. No.	Description	Amount in Indian Rupees or equivalent in foreign currency* as on a date not earlier than 30 days prior to the date of bid opening
1	Sanctioned Line of credit	
2	Unutilized Line of credit for fund based and non-fund based limits	
4	Cash and bank balances including fixed deposits	
4	We are enclosing Certificate from the Bankers in respect of unutilized Line of credit & bank balances as on .....(date)	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

Note: In case certificates from more than one bank are submitted, the certified unutilized limit shall be of the same date from all such banks.

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**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF CONTRACTOR
FOR
RENOVATION & MODERNISATION
OF
ELECTRICAL BALANCE OF PLANT (eBOP)**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

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4.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-2
5.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-3
6.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meets the financial QR	Data Sheet-4
7.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-5

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1 INVITATION FOR QUALIFICATION

1.1 Introduction

[Give brief introduction about the name, location and details of the Power Plant of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of XXX MW Unit no.-XX ---- of the Power Plant]

1.2 INVITATION

[Name of The Utility], hereinafter referred to as "Employer / Owner / Purchaser", is undertaking Renovation & Modernization project of Unit No.[XXX] of the [XXX] Power Plant. Under this project, *[Name of The Utility]* invites sealed Pre-Qualification Tender from experienced and interested bidders for the Renovation & Modernization Work of *[Electrical Balance of Plant]* package of Unit No.[XXX] of the [XXX] Power Plant on International Competitive Bidding (ICB).

Interested bidders may collect the RFQ documents in person from *[Name and Contact Details of Designated Official.....]*. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....]to [.....]. Alternatively, the RFQ document can be downloaded from *[Name of the Utility]* website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to *[Name and Contact Details of Designated Official.....]* by *[Date and Time]*.

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly and replacement/refurbishment of specified existing equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing & forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, carrying out of all associated civil works including supply of cement, steel etc., testing & commissioning and successful completion of trial operation & performance guarantee tests for *[Electrical Balance of Plant]* package of Unit no. [XXX] of [XXX] Power Plant.

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]
(b)	Publication date of RFQ	:	[-----]

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(c)	Last date for issue of RFQ document	:	[-----]
(d)	Last Date & Time of Receipt of Pre-Qualification Bids and Date & Time of Opening of Prequalification Bids	:	[-----]
(e)	Date for identification of Qualified Bidders and Issuance of RFP	:	[-----]

If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of The Utility] is carrying out this Pre-Qualification Process to identify qualified bidders for the issuance of RFP Documents for the Tender of Renovation & Modernization work of [Electrical Balance of Plant] package of Unit no. [XXX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process.

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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in tendering process for the subject Renovation & Modernization work for [Electrical Balance of Plant] package, the bidder must meet the Technical Qualification Requirement specified at clause 2.1.1 and Financial Qualification Requirement specified at clause 2.1.2. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no. 2.1.3.

2.1.1 Technical Qualification Requirement

[The Bidder, during the last 10 years preceding the scheduled date for submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above, should have designed, engineered, supplied, erected, tested and commissioned at least two E-BOP (Electrical Balance of Plant) packages of Thermal Power Plants of unit size 200 MW or above comprising Air Insulated Switchyard, Switchyard Automation System and Power Transformers which should have completed satisfactory operation for a period of not less than two (2) years as on the date of opening of Pre-Qualification Bid. Bidders should have experience of manufacturing, supply, erection, testing, commissioning of Power Transformers for Thermal Power Plants of unit size 200 MW or above which are in successful operation for the last minimum two years. In case, the bidder is not a manufacturer of 400/220 kV Air Insulated Switchyard and Switchyard Automation System, the bidder can source these equipments from the original Equipment Manufacturers who have supplied such equipments to Thermal Power Plants of unit size 200 MW or above which are in successful operation for the last minimum one year as on the original scheduled date of submission of Pre-Qualification Bids indicated in row (d) in section 1.4 above. However, the Bidder shall be fully responsible for the successful performance of all such bought out equipments as per the requirements of the contract.]

2.1.2 Financial Qualification Requirement

- (a) The average annual turnover of the Bidder should be at least [Indian Rupees] millions or equivalent foreign currency as per audited annual accounts during the preceding three consecutive years – [FY, FY [.....] and FY [.....]]. For the purpose of conversion of foreign currency to Indian Rupees, the TT Buying rate of State Bank of India as on 30 days prior to the date of submission of Bid will be considered. Other income will not be considered for arriving at the annual turnover.
- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year shall be positive.
- (c) The sum of bank balances (including fixed deposits) and available unutilized credit line of the bidder (including non fund based credit lines) should not be less than [INR.....] as on not more than 30 days prior to the scheduled last date of submission of Pre-qualification Bid

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- (d) In case the Bidder does not satisfy the Financial Criteria stipulated in the above clauses (a) and (b) on its own and the Holding Company having controlling interest in the Bidder meets the stipulated turn-over requirements at Clause (a), then Financial Criteria stipulated in the above clauses (a) and (b) will be deemed to have been met, provided that the Net worth of such Holding Company as on the last day of the preceding financial year is at least equal to or more than [.....]. In such a case, the Bidder has to submit a Letter of Undertaking from the Holding Company pledging unconditional and irrevocable financial support to the bidder for execution of the Contract.

To establish the financial capacity for performance of the contractual obligations, the Bidder shall furnish documentary proof of their audited annual turnover and net worth for the last three (3) financial years [FY] , [FY] & [FY].

2.1.3 Other Criteria

- (a) Any firm who is or was involved as a Consultant in the preparation for this R&M Project for activities such as Feasibility Study or RLA/CA Study or Energy Audit or preparation of DPR/Tender Document or any other preparatory activity or any firm who is or was involved as a consultant for implementation of this R&M project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of this R&M project cannot participate as a bidder for this R&M Tender.
- (b) Any bidder who is legally barred from the procurement process of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as a bidder for this R&M Tender.
- (c) Any firm cannot participate as Bidder in more than one Bid under this tender.

2.2 Qualification Documents

2.2.1 Documents to be submitted (Pre-qualification)

Bidders are required to furnish following documents for pre-qualification in [five (5)] copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates clearly indicating date of completion from the facility owner in respect of such completed contract(s).
- (iii) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity to the satisfaction of Employer. Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (iv) Contracts in hand / pending jobs and their status along with value.
- (v) Major pending legal cases.

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3 INSTRUCTION TO APPLICANTS

- 3.1. Only bidders pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the R&M work of [Electrical Balance of Plant] package and will be eligible to submit Bid Proposal for R&M work. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, project execution capability and financial resources to discharge the scope of service
- 3.2. [Name of Utility] is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Bidder is found to be factually incorrect or manipulated, the Bidder as the case may be, will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the Bidder shall be on the basis of single bidder responsibility. The contract will be entered into only with the successful Bidder. Thus the bidder shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder shall not Sub-contract the entire scope of work, back to back or otherwise, for the performance of this contract.
- 3.5. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus three (3) months grace period.
- The Bidder shall provide satisfactory evidence that he has adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid have an adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfilment of the qualifying requirements as specified are liable for rejection without assigning any reason.

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- 3.6. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to confirm the bidder's claim on experience and to assess the Bidder's capability and capacity to perform the contract, should the circumstances warrant such an assessment in the overall interest of the project.
- 3.7. [Name of Utility] reserves the right to reject any or all Pre-Qualification Bids or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no bidder / intending bidder shall have any claim arising out of such action.
- 3.8. Participation Fee for an amount of [INR.....] or [USD.....] or [Euro.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXXX]' is to be submitted along with the Pre-Qualification Bid. Pre-Qualification Bid received without the Participation Fee will be rejected. Participation Fee is non-refundable.
- 3.9. Language of Bid
The Bid submitted by the Bidder and all correspondences and documents relating to the Bid exchanged by the bidder and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.
- 3.10. Signature on Pre-Qualification Bid

The Pre-Qualification Bid must contain the name and place of business of the Bidder and each page of the EOI must be signed and sealed by the authorized person(s) of the Bidder with his usual signature. The name of all persons signing should be typed or printed below the signature.
Satisfactory evidences of authority of the person signing on behalf of the bidder shall be furnished with the Bid.
The Bidder name stated on the Pre-Qualification Bid shall be the exact legal name of the firm.
- 3.11. Method of Submission of Pre-Qualification Bid

The Pre-Qualification Bid shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of the Pre-Qualification Bid.
The outside of the covers should indicate clearly the name of the Bidder and his address. In addition, the envelope or container should indicate the "Tender No. and Name of the work for which the Pre-Qualification Bid is submitted ". Pre-Qualification Bid with no indication given on the outside of the envelope that it is a Pre-Qualification Bid which therefore gets opened before the due date shall be liable to be disqualified. All the pages of the Pre-Qualification Bid shall be serially numbered.

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The Pre-Qualification Bid, complete in all respects, must be submitted to the official and address mentioned below.

'[XXXXXX]
'[XXXXXX] '[XXXXXX]

Submission of Pre-Qualification Bid through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post either way.

Pre-Qualification Bids must reach the above office on or before '[XXXXXX] Hours (IST) on '[XXXXXX]. Any Pre-Qualification Bid received after the expiry of the time specified is liable for rejection.

3.12. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXXX] on *Date* and at *Time* indicated in row (d) in section 1.4 above.

The Pre-Qualification Bids shall be opened in the presence of such bidders who may be present. The bidders are at liberty to be present or authorise their representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Accredited Agents / representatives of foreign bidders in India are also permitted to submit the Pre-Qualification Bids on behalf of the foreign bidders with due Authorisation Letter.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least [15 (Fifteen) days] before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. [Name of Utility] will issue interpretations and clarifications as it may deem fit.

3.13. Application Data Sheets and Forms

The Pre-Qualification Bid is to be submitted as per the Format at Annexure-1. The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Bid. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Bid	Annexure-1
2.0	Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the bidder for the execution of R&M work.	Annexure-2

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S.No	Description	Format/ Data Sheet No.
3.0	Sample format for Data sheet regarding Technical Qualification Requirement at Clause No. 2.1.1.	Data Sheet-1
4.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-2
5.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Datasheet-3
6.0	Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meets the financial QR	Data Sheet-4
7.0	Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document	Data Sheet-5

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Annexure-1
Format for Pre-Qualification Bid

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Renovation & Modernization of [.....] Package for Unit No. [XXXXXX] of [XXXXXX] power plant of [XXXXXX].

To,

[Designated Officer XXXXX]

[Address XXXXX]

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified bidders for Renovation & Modernization of [Electrical Balance of Plant] Package for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Bidder with name & designation of person authorized to submit the pre-qualification bid:

Name of Bidder: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1 & 2.1.2 of RFQ document.

4.0 We confirm that neither we nor any of our associates/ affiliates are liable for exclusion from participation in tendering process under 'other criteria' stipulated under clause no.2.1.3 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

- (i) Covering Letter
- (ii) Power of Attorney in favor of persons signing on behalf of Bidder and Holding Company, as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1
- (iv) Data Sheet regarding turnover requirement at RFQ clause no. 2.1.2 (a)
- (v) Data Sheet regarding net worth requirement at RFQ at clause 2.1.2 (b)

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Request for Qualification For R&M of Electrical Balance of Plant of Unit No.[...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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- (vi) Data Sheet regarding bank balances & available unutilized credit line.
- (vii) Letter of Undertaking pledging unconditional & irrevocable financial support to the bidder for execution of the contract. (In case of financial QR is met on the strength of Holding Company).

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:

- (i) List of order executed
- (ii) Copies of order
- (iii) Past performance certificate.
- (iv) Contracts in hands/pending jobs along with value
- (v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.
- (vi) Copies of last 3 years audited financial statement.
- (vii) List of major litigations/disputes.
- (viii) Any other document.

7.0 We hereby attach participation fee of [INR-----] in the form of demand draft in favor of '[XXXXXX]' payable at '[XXXXXX]'.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to the best of our knowledge & belief.

Dated this '[XXXXXX]' day of '[XXXXXX] 20XX'

Yours Faithfully,

Signature '[XXXXXX]'

Full Name '[XXXXXX]'

Designation '[XXXXXX]'

Company Seal '[XXXXXX]'

Business Address: '[XXXXXX]'

Country & province of Incorporation '[XXXXXX]'

Contact details '[XXXXXX]'

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Request for Qualification For R&M of Electrical Balance of Plant of Unit No.[...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-2

Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the Bidder for the execution of R&M work.

Ref.: [XXXXX]

Date : [XXXXX]

To,
 /Designated Official of Utility XXXXX/
 /Name & Address XXXXX/

Dear Sir/ Madam,

We, M/s..... declare that we are the holding company of M/s..... (Name of the Bidder) and have controlling interest therein.

M/s.....(Name of the Bidder) have sought financial strength and support from us for meeting the stipulated Financial Qualifying Requirement as per Clause 2.1.2 (a) & (b) of RFQ document for the package..... (Name of the package) for Unit No. [XXXXX] of [XXXXX] power plant of [XXXXX] under RFQ no..... dated

We hereby undertake that we hereby pledge our unconditional & irrevocable financial support for the execution of the said package to M/s..... (Name of the Bidder), for the execution of the Contract, in case they are awarded the Contract for the said package at the end of the bidding process. We further agree that this undertaking shall be without prejudice to the various liabilities that M/s..... (Name of Bidder) would be required to undertake in terms of the Contract including the Performance Security as well as other obligations of the Bidder/Contractor.

This undertaking is irrevocable and unconditional, and shall remain in force till the successful execution and performance of the entire contract and/or till it is discharged by Employer.

Yours faithfully,
 (Signature of Authorized Signatory) on behalf of the Holding Company)

Date: Name & Designation.....
 Place:

Name of the Holding Company.....
 Seal of the Holding Company.....

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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1:

To,

Bidders's

Name

and Address:-

[Name of Utility]

[Address]

We are submitting the Prequalification Bid for R&M of [Electrical Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

[We have designed, engineered, supplied, erected, tested and commissioned at least two E-BOP (Electrical Balance of Plant) packages of Thermal Power Plants of unit size 200 MW or above comprising 400/220 kV Air Insulated Switchyard, Switchyard Automation System and Power Transformers, which have completed satisfactory operation for a period of not less than two (2) years as on the date of opening of Pre-Qualification Bid. We have experience of manufacturing, supply, erection, testing, commissioning of Power Transformers for Thermal Power Plants of unit size 200 MW or above which are in successful operation for at least two years.] The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Contact No. & Date			
5.	Starting Date of the Project			
6.	Schedule Date of Completion			
7.	Actual Date of Completion			
8.	Date of Commencement of Successful Operation			
9.	Scope of Work executed for the aforesaid Electrical Balance of Plant.			
10.	Details of the Plant/Systems executed			

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	- Details of 400/220 kV Air Insulated Switchyard executed			
	- Model			
	- Make			
	- Reference Standard			
	- Voltage			
	- Switchyard Automation System			
	- Make			
	- Model			
	- Communication Protocols Supported			
	- Protocol for Time Synchronization			
	- Power Transformer			
	- Application			
	- Name of the manufacturer			
	- Rating (MVA) with cooling arrangement			
	- Rated no load voltage HV winding LV winding			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.

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Data Sheet-2

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a):

To,

Bidder's Name [Designated Official]
and Address [Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Electrical Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

In line with RFQ Document clause 2.1.2(a) , we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable.

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Data Sheet-3

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b):

To,

Bidder's Name [Designated Official]
[Name of Utility]
and Address:- [Address]

We are submitting the Prequalification Bid for R&M of [Electrical Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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Data Sheet-4

Sample Format for Data Sheet regarding Turnover & Net Worth requirement when Bidder does not meet RFQ clause 2.1.2 (a) & 2.1.2 (b) on its own & Holding Company meets the financial QR:

To,

Bidder, Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Prequalification Bid for R&M of [Electrical Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

Since we do not meet Financial QR on own, we give the following details of Holding Company:-

Name and Address of the Holding Company:

Turnover of the Holding Company with following details:

Sl. No.	Financial Year	Amt. of Bidders Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of bid opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years as on date of Bid Opening.			
5	Net worth of Holding Company on last day of preceding financial year			
6	We have enclosed Balance Sheets and Profit & Loss Account of Holding duly certified by Chartered	*Yes/*No		

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	Accountant	
7	We are enclosing a Letter of Undertaking from the Holding Company, pledging unconditional and irrevocable financial support for execution of the contract by the bidder in case of award is enclosed	*Yes/ *No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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Data Sheet -5

Sample Format for Data Sheet regarding utilized credit line & Bank balances as per requirement at clause 2.1.2 (c) of RFQ document:

To,

Bidder's Name [Designated Official]
[Name of Utility]
and Address [Address]

We are submitting the Prequalification Bid for R&M of [Electrical Balance of Plant] Package for Unit No. [...] of [...] Plant of [...].

We hereby confirm that the sum of unutilised line of credit for fund based and non fund based limits & cash & bank balances including fixed deposits of our company, duly certified by the bankers as on not more than 30 days prior to the schedule date of bid opening, is not less than INR [XXXXXX] or in equivalent foreign currency. The details are as under:

Sl. No.	Description	Amount in Indian Rupees or equivalent in foreign currency* as on a date not earlier than 30 days prior to the date of bid opening
1	Sanctioned Line of credit	
2	Unutilized Line of credit for fund based and non-fund based limits	
4	Cash and bank balances including fixed deposits	
4	We are enclosing Certificate from the Bankers in respect of unutilized Line of credit & bank balances as on(date)	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

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Note: In case certificates from more than one bank are submitted, the certified unutilized limit shall be of the same date from all such banks.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF CONSULTANT
FOR
RENOVATION & MODERNISATION**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

Request for Qualification for Selection of Consultant for Renovation & Modernization of Unit No.[...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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List of Formats & Data Sheets

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1 INVITATION FOR QUALIFICATION

1.1 Introduction

{Give brief introduction about the name, location and details of the Power Plant for which the utility proposes to appoint a consultant for advising about the Renovation & Modernization and Life extension (R & M and LE) work for any of the identified units.}

1.2 Invitation

[Name of The Utility], hereinafter referred to as "Employer", plans to undertake Renovation & Modernization of Unit No.[XX] of the [XXX] [Coal / Lignite] based Power Plant and desires to appoint a Renovation & Modernization Consultant (R&M Consultant) for a) Carrying out investigation studies such as Hot and Cold Walk down Studies, Residual Life Assessment / Condition Assessment (RLA/CA) Studies and Energy Audit (EA) Studies, b) Preparing Feasibility Report and Detailed Project Report, c) Providing assistance in obtaining Regulatory approval, d) Preparing Tender Documents and d) Providing support in Tendering and Bid evaluation process to appoint R&M Contractor(s). Towards this end, [Name of The Utility] invites sealed Pre-Qualification Tenders from experienced and interested Consultancy Firms for providing Consultancy Services for Renovation & Modernization of Unit No.[XX] of the [XXX] Thermal Power Plant. Consultancy Firms both from India and abroad are eligible to participate in the Pre-Qualification Process and subsequent Request for Proposal process, if found eligible during Pre-Qualification process.

Interested Consultancy Firms may collect the RFQ documents in person from [Name and Contact Details of Designated Official]. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....] to [.....]. Alternatively, the RFQ documents can be downloaded from [Name of the Utility] website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to [Name and Contact Details of Designated Official] by [Date and Time].

1.3 Brief Scope of Work

The Scope of work of the R&M Consultant shall be divided in two Phases. First Phase shall cover scope up to obtaining regulatory approval for R&M works and Second Phase shall cover preparation of tender documents and bid evaluation for the selection of R&M Contractor(s) as described below.

Phase-I

- i) Review and Analysis of Operational Data and Trip Reports provided by Employer.

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- ii) Hot Walk Down Survey
- iii) Cold Walk Down Survey
- iv) Review of previous RLA/CA and EA Studies, if any.
- v) Conducting Residual Life Assessment (RLA) / Condition Assessment (CA) of the Equipments / Systems of complete Power Plant
- vi) Conducting Energy Audit and Performance Testing of major Equipments/ Systems of the Power Plant
- vii) Working out of various R& M Options for improving the Performance Parameters and extending the life of the Unit.
- viii) Finalizing the most cost effective option for R&M and LE of the unit.
- ix) Preparation of Feasibility Report (FR).
- x) Preparation of Detailed Project Report (DPR).
- xi) Providing Assistance to the Employer in obtaining necessary approvals from statutory / regulatory authorities.

Phase-II

- i) Basic Design & Engineering and Preparation of Tender Documents.
- ii) Support for bid evaluation for the selection of R&M Contractor(s), up to the placement of Letter of Award.

Note: Phase-II shall commence only after obtaining necessary approvals from statutory / regulatory authorities and after obtaining the Notice to Proceed from the "Employer".

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]
(b)	Publication date of RFQ	:	[-----]
(c)	Last date for issue of RFQ document	:	[-----]
(d)	Last Date & Time of Receipt of Pre-Qualification Applications	:	[-----]
(e)	Date for	:	[-----]

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	identification of Qualified Consultancy Firms Issuance of RFP		
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If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of the Utility] is carrying out this Pre-Qualification Process to identify qualified Consultancy Firms for the issuance of RFP Documents for selection of R&M Consultant for the Renovation & Modernization of Unit no. [XX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified Consultancy Firms having requisite technical expertise, relevant experience supported by adequate number of competent manpower and having adequate financial resources to fulfill their obligations.

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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in the RFP process for selection of the R&M Consultant for Renovation & Modernization of Unit no [...] of [...] thermal power plant, the Applicant must meet the two Technical Qualification Requirements specified at clause 2.1.1 and 2.1.2 below. If an Applicant meets only one of the two Technical Qualification Requirements (either Technical Qualification Requirement-1 at 2.1.1 or Technical Qualification Requirement -2 at clause 2.1.2) and does not meet the other, it can associate with another engineering consultancy firm that meets the other Technical Qualification Requirement. The Applicant can also be a Consortium of 2 (two) engineering consultancy firms who collectively meet the two Technical Qualification Requirements specified at clause 2.1.1 and 2.1.2 below.

In addition to meeting Technical Qualification Requirement, the Applicant must meet Financial Qualification Requirement at Clause 2.1.3 below. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no. 2.1.4.

2.1.1 Technical Qualification Requirement-1

The Applicant should be an engineering consultancy firm that has successfully completed at least 2 (two) number of technical consultancy assignments including DPR, Specifications, Bid Evaluation and Review of Vendor Drawings for coal/lignite fired thermal power plants of capacity 200 MW or more as on the date of submission of Pre-Qualification Application.

2.1.2 Technical Qualification Requirement-2

The Applicant during the last [10] years, must have successfully completed at least (1) one technical consultancy assignment for Renovation and Modernization of coal/lignite fired thermal power plant of 100 MW capacity or above comprising, a) Carrying out of investigation studies such as Hot and Cold Walk down Studies, Residual Life Assessment / Condition Assessment (RLA/CA) Studies and Energy Audit (EA) Studies, b) Preparation of the Feasibility Report and the Detailed Project Report, c) Preparation of the Tender Documents and d) Preparation of Tendering Documents and Bid evaluation to appoint R&M Contractor(s), as on the date of submission of Pre-Qualification Application.

Consultancy organizations which do not possess the requisite qualification of carrying out of investigation studies mentioned at a) above, may associate with such organizations which meet the required qualification, in the form of a joint venture or a sub-consultancy agreement.

2.1.3 Financial Qualification Requirement

- (a) The average annual turnover of the Applicant should be at least [Indian Rupees] millions or equivalent foreign currency as per audited

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annual accounts during the preceding three consecutive years – [FY], FY [.....] and FY [.....]. For the purpose of conversion of foreign currency to Indian Rupees, the TT Buying rate of State Bank of India as on 30 days prior to the date of submission of Bid will be considered. Other income will not be considered for arriving at the annual turnover.

(b) The Net Worth of the Bidder as on the last date of preceding Financial Year shall be positive.

2.1.4 Other Criteria

- (a) Any entity that is legally barred from participation in Consultancy assignments of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as an applicant or associate or consortium member for this R&M Consultancy Tender.
- (b) Any firm or its associate company cannot participate as Applicant or Associate or Consortium Member for more than one RFQ application under this R&M Consultancy Tender.

2.2 Qualification Documents

2.2.1 Documents to be submitted (Pre-qualification)

Applicants/Consortium Leaders are required to furnish following documents for pre-qualification in [five (5)] copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them, their Consortium Partners / Associates along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates from the previous employers in respect of such completed consultancy assignment(s) clearly indicating scope of and date of completion for each assignment.
- (iii) Names of proposed Associates or Consortium member if any, along with Letters of Consent from each Associate / Consortium Partner.
- (iv) Particulars of Key Personnel that must include inter alia their names, details regarding qualification, areas of expertise, professional experience and names of relevant projects.
- (v) Documents of company profile incorporating details of technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity for the satisfaction of Employer.
- (vi) Firm's audited accounts for last three (3) years along with a copy of latest income tax return filed.
- (vii) Consultancy Assignments in hand / pending jobs and their status along with value.
- (viii) Pending legal cases, if any.

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3 INSTRUCTION TO APPLICANTS

- 3.1. Only Applicants found pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the subject R&M Consultancy work and will be eligible to submit Bid Proposal for R&M work. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, competence of key personnel, project execution capability and financial resources to discharge the scope of service.
- 3.2. [Name of Utility] is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Applicant or Associate or Consortium leader or Consortium partner is found to be factually incorrect or manipulated, the Applicant or Associate or Consortium leader or Consortium partner as the case may be, will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the R&M Consultant shall be on the basis of single bidder responsibility. The Consultancy Contract will be entered into only with the successful Bidder (Sole Bidder or Principal Consultant or Consortium leader as the case may be). Thus the Bidder / Principal Consultant/ Consortium leader shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder, Bidder's Associate, Consortium leader and Consortium partner shall not subcontract the entire scope of work, back to back or otherwise, for the performance of the subject Consultancy Contract.
- 3.5. The Applicant, meeting the Qualifying Requirement on the strength of Associate (s), should enclose the Letter (s) of Association (as per the prescribed format) from the Associate (s) signed by the Associate (s) indicating the scope of work along with the Pre-Qualification Application. For each such Associate, while submitting the techno-commercial Bid Proposal for R&M Consultancy work, the Associate and Bidder (Principal Consultant) shall furnish a joint undertaking towards joint and several liability to the employer for the successful performance of Associate's Scope of Work. The undertaking shall be furnished as per the format to be specified in the RFP document.
- 3.6. The bidder meeting the Qualifying Requirement as a Consortium should enclose the Letter of Association (as per the prescribed format) from the consortium Partner along with the Pre-Qualification Application signed by the Consortium Partners indicating the scope of work. However, in the event, the

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bidder is found pre-qualified and is issued RFP document, while submitting the techno-commercial Bid Proposal for R&M Consultancy work, the bidder (consortium leader) shall furnish a Consortium Agreement with the other Consortium member. No new consortium partner, (other than those qualified at Pre-qualification stage) will be permitted at the time of submitting the Techno commercial Proposal. Further, while submitting the techno-commercial Bid Proposal for R&M work, the Consortium leader and Consortium members will furnish a joint undertaking towards diligent performance of their respective scope of work and towards joint and several liability to the employer for the successful performance of the Consultancy Contract. The undertaking shall be furnished as per the format to be specified in the RFP document.

- 3.7. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Employer within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to five percent (5%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the scheduled date of completion of R&M Consultant's work plus three (3) months grace period.

If the bidder is a Consortium of Consultancy firms, in addition to the Contract Performance Guarantee (CPG) of 5% furnished by the Consortium Leader, the other consortium members shall furnish Additional Contract Performance Guarantee equal to 2% of Contract Price.

If the Bidder meets Qualification Requirement on the strength of Associate (s), in addition to the Contract Performance Guarantee (CPG) of 5% furnished by the Bidder (Principal Consultant), each Associate shall furnish Additional Contract Performance Guarantee equal to 2% of Contract Price.

- 3.8. The Applicant/Consortium Leader shall provide satisfactory evidence that the applicant and / or, where applicable, the Associate (s)/ consortium partners have adequate capability and capacity to deliver the consultancy services properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the expertise, the number of experts and other supporting consultants, to meet the requirements appropriate to the works covered in his bid. Pre-Qualification Application submitted without the proper documentary evidence to substantiate fulfilment of the qualifying requirements as specified are liable for rejection without assigning any reason.

- 3.9. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to verify the Applicant's / Consortium leader's, Associate's and Consortium Partners' claim on experience and to assess the Applicant's / Consortium leader's, Associate's and Consortium Partners' capability and capacity to execute the

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subject R&M Consultancy contract, should the circumstances warrant such an assessment in the overall interest of the R&M project.

3.10. [Name of Utility] reserves the right to reject any or all Pre-Qualification Applications or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no Applicant / intending Applicant shall have any claim arising out of such action.

3.11. Participation Fee for an amount of [INR.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXX]' is to be submitted along with the Pre-Qualification Application. Pre-Qualification Application received without the Participation Fee will be rejected. Participation Fee is non-refundable.

3.12. Language of Bid
The Pre-Qualification Application submitted by the Applicant and all correspondences and documents relating to the Application exchanged by the Applicant and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.

3.13. Signature on Pre-Qualification Bid

The Pre-Qualification Application must contain the name and place of business of the Applicant and each page of the Application must be signed and sealed by the authorized person(s) of the Applicant / Consortium leader with his usual signature. The name of all persons signing should be typed or printed below the signature.

Satisfactory evidences of authority of the person signing on behalf of the Applicant / Consortium leader shall be furnished with the Application.

The Applicant / Consortium leader's name stated on the Pre-Qualification Application shall be the exact legal name of the firm.

3.14. Method of Submission of Pre-Qualification Bid

The Pre-Qualification Application shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of The Pre-Qualification Application.

The outside of the covers should indicate clearly the name of the Applicant / Consortium leader and his address. In addition, the envelope or container should indicate the "Tender No. and Name of the work for which the Pre-Qualification Application is submitted ". Pre-Qualification Application with no indication given on the outside of the envelope that it is a Pre-Qualification Application which therefore gets opened before the due date shall be liable to

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Request for Qualification for Selection of Consultant for Renovation & Modernization of Unit No.[...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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be disqualified. All the pages of the Pre-Qualification Application shall be serially numbered.

The Pre-Qualification Application, complete in all respects, must be submitted to the official and address mentioned below or may be sent by Courier or Registered Post the address mentioned below.

'[XXXXXX]

'[XXXXXX]'[XXXXXX]

Submission of Pre-Qualification Application through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post or courier either way.

Pre-Qualification Applications must reach the above office on or before '[XXXXXX] Hours (IST) on '[XXXXXX]. Any Pre-Qualification Application received after the expiry of the time specified is liable for rejection.

3.15. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXX] on '[Date XXXXX] at '[Time XXXXX] Hours (IST).

The Pre-Qualification Bids shall be opened in the presence of such bidders who may be present. The bidders are at liberty to be present or authorise their representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Accredited Agents / representatives of foreign bidders in India are also permitted to submit the Pre-Qualification Bids on behalf of the foreign bidders with due Authorisation Letter.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least [15 (Fifteen) days] before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. [Name of Utility] will issue interpretations and clarifications as it may deem fit.

3.16. Application Data Sheets and Forms

The Pre-Qualification Application is to be submitted as per the Format at Annexure-1.

The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Application. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

List of Formats & Data Sheets		
S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Application	Annexure-1

Document Number	Rev No.	Description	Page No.	Date of Issue
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2.0	Letter Of Consent To Be Furnished By The Associate	Annexure-2
3.0	Letter Of Consent To Be Furnished By The Consortium Partners	Annexure-3
4.0	Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1	Data Sheet-1
5.0	Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.2	Data Sheet-2
6.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.3 (a)	Data Sheet-3
7.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.3 (b)	Data Sheet-4

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LII-GETS12021-G-00100-012	01	Model RFQ for R&M Consultant	[10]	25.09.2014

Request for Qualification for R&M Consultancy Services for Unit No. [..] Capacity [..] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-1

Format for Pre-Qualification Application

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Renovation & Modernization Consultancy Services for [.....]

Package for Unit No. [XXXXXX] of [XXXXXX] thermal power plant.

[Designated Officer XXXXX]

[Address XXXXX]

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified Consultants for Renovation & Modernization Consultancy work for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Applicant/Leader of Consortium with name & designation of person authorized to submit the pre-qualification Application:

Name of Applicant/ Leader of Consortium: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1, 2.1.2 & 2.1.3 of RFQ document *on our own/ in association with our Associate (s) [XXXXXX] / in association with our Consortium Partner(s) [XXXXXX]. (Applicant to strike off whichever is not applicable).*

(The Applicant is required to give a detailed description indicating the specific part of the qualification requirement which is met by the Applicant/Associate(s)/ Consortium Member(s). Applicant is also required to give detailed description of the relationship between the Applicant & others on whose strength Qualification Requirement is stated to have met.)

4.0 We confirm that neither we nor any of our Associate (s) / our Consortium Members are liable for exclusion from participation in Pre-Qualification process under 'other criteria' stipulated under clause no.2.1.4 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

(i) Covering Letter

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Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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- (ii) Power of Attorney in favor of persons signing on behalf of Applicant, Associate (s) and Consortium member (s) as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1.
- (iv) Data Sheet regarding Technical Qualification Requirement at clause 2.1.2.
- (v) Data Sheet regarding turnover requirement at RFQ clause no. 2.1.3 (a)
- (vi) Data Sheet regarding net worth requirement at RFQ at clause 2.1.3 (b)
- (vii) Letter of Association of Consortium Partner(s) in case of Consortium
- (viii) Letter of Association of Associate(s) if applicable

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:-

- (i) List of orders executed
- (ii) Copies of orders
- (iii) Past performance certificate.
- (iv) Contracts in hands/pending jobs along with value
- (v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.
- (vi) Copies of last 3 years' audited financial statement.
- (vii) List of pending litigations/disputes.
- (viii) Any other document.

7.0 We hereby attach participation fee of [INR-----] in the form of demand draft No.....dated..... in favor of '[XXXXXX]' payable at '[XXXXXX]'.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to our best of the knowledge & belief.

Dated this '[XXXXXX]' day of '[XXXXXX] 20XX

Yours Faithfully,

Signature '[XXXXXX]

Full Name '[XXXXXX]

Designation '[XXXXXX]

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Company Seal '[XXXXXX]

Business Address: '[XXXXXX]

Country & province of Incorporation '[XXXXXX]

Contact details '[XXXXXX]

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Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-2

Letter Of Association To Be Furnished By The Associate

[Name and Complete Address of Applicant] is submitting the Prequalification Application for R&M Consultancy work for Unit No. [...] of [...] Plant of [...].

We hereby declare that the undersigned firm [Name and Complete address of the Associate] hereby agrees to associate with [Name and Complete address of the applicant] for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Associate) for R&M Consultancy services for the Unit no. '[XXXXXX]' of '[XXXXXX]' plant in the state of '[XXXXXX]', India. We also hereby undertake to ensure the diligent and timely completion of Consultancy Work covered in our scope of work adhering to high professional standard and also to depute our technical experts from time to time to the place of work / Employer's Project site as per requirement.

On award of LOA, we, the Associate, agrees to furnish on demand additional performance Security bank guarantee for 2 % of Contract Price.

1. Witness

For Associate

Signature:	(Signature of the Authorized Signatory)
Name	Name
Designation:	Designation:
Office Address	Seal of the Company

2. Witness

For Applicant

Signature:	(Signature of the Authorized Signatory)
Name	Name
Designation:	Designation:
Office Address	Seal of the Company

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-012	01	Model RFQ for R&M Consultant	[14]	25.09.2014

Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Annexure-3

Letter Of Association To Be Furnished By The Consortium Partners

We hereby declare that the undersigned firm (Name and Complete address of the Consortium Partner) hereby agrees to associate with (Name and Complete address of the Applicant/Consortium Leader) as Consortium Partner to form Consortium to Bid for R&M Consultancy Work under Tender No. [...] and for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Consortium Partner) of R&M Consultancy work for the Unit no. '[XXXXXX]' of '[XXXXXX]' Thermal Power Plant in the state of '[XXXXXX]' for '[XXXXXX]', India. We also hereby undertake to ensure the diligent and timely completion of Consultancy Work covered in our scope of work adhering to high professional standard and also to depute our technical experts from time to time to the place of work / Employer's Project site as per requirement.

On award of LOA, we the Consortium Partner agrees to furnish on demand back up bank guarantee for 2 % of Contract Price.

1. Witness

For Consortium Partner

Signature: (Signature of the Authorized Signatory)
Name Name
Designation: Designation:
Office Address Seal of the Company

2. Witness

For Applicant

Signature: (Signature of the Authorized Signatory)
Name Name
Designation: Designation:
Office Address Seal of the Company

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-012	01	Model RFQ for R&M Consultant	[15]	25.09.2014

Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1:

To,

Applicant/Consortium
Partner/Associate's Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

*We are submitting the Pre-Qualification Application for R&M Consultancy work for Unit No. [...] of [...] Plant of [...]. / *We are associated with (Name of Applicant) as Associate for R&M Consultancy work for Unit No. [...] of [...] Plant of [...]. / * We are associated with (Name of Consortium Leader) as Consortium Partner for R&M Consultancy work for Unit No. [...] of [...] Plant of [...].

We meet the Qualification Requirement stipulated at Clause No. 2.1.1 of RFQ document. The details of relevant experience are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Contact No. & Date			
5.	Starting Date of the Technical Consultancy Work			
6.	Schedule Date of Completion of the Technical Consultancy Work			
7.	Actual Date of Completion of the Technical Consultancy Work			
8.	Whether the Plant is coal/Lignite fired thermal power	Yes*/No*	Yes*/No*	Yes*/No*

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Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	station			
9.	Scope of Work executed for the aforesaid Technical Consultancy Work			
10.	Original order value of the contract aforesaid Technical Consultancy Work			
11.	Completed order value of the contract aforesaid Technical Consultancy Work			
12.	Certificate(s) from the Client is/are enclosed along with the Application at Annexure.....to this Data Sheet			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.

1. *Strike off whichever is not applicable

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Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
---	-------------------

Data Sheet-2

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.2:

To,

Applicant/Consortium
Partner/Associate's Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

*We are submitting the Pre-Qualification Application for R&M Consultancy work for Unit No. [...] of [...] Plant of [...]. / *We are associated with (Name of Applicant) as Associate for R&M Consultancy work for Unit No. [...] of [...] Plant of [...]. / * We are associated with (Name of Consortium Leader) as Consortium Partner for R&M Consultancy work for Unit No. [...] of [...] Plant of [...].

We meet the Qualification Requirement stipulated at Clause No. 2.1.1 of RFQ document. The details of relevant experience are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Contact No. & Date			
5.	Starting Date of the Consultancy Assignment			
6.	Schedule Date of Completion of the Consultancy Assignment			
7.	Actual Date of Completion of the Consultancy Assignment			
8.	Whether the Plant is coal/Lignite fired thermal power station	Yes*/No*	Yes*/No*	Yes*/No*
9.	Scope of Work executed for the			

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-012	01	Model RFQ for R&M Consultant	[18]	25.09.2014

Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	aforesaid the Consultancy Assignment.			
10.	Original order value of the contract aforesaid Technical Consultancy Work			
11.	Completed order value of the contract aforesaid Technical Consultancy Work			
12.	Certificate(s) from the Client is/are enclosed along with the Application at Annexure.....to this Data Sheet			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.
2. *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-012	01	Model RFQ for R&M Consultant	[19]	25.09.2014

Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-3

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.3 (a):

To,

Applicant's Name
and Address

[Name of Utility]
[Address]

*We are submitting the Pre-Qualification Application for R&M Consultancy work for Unit No. [...] of [...] Plant of [...] under Tender No. [...].

In line with RFQ Document clause 2.1.3(a) , we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Applicants Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of Pre-Qualification Application opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date:

(Signature).....

Place:

(Full Name).....

(Designation).....

(Company seal).....

1. *Strike off whichever is not applicable.

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Request for Qualification for R&M Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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Data Sheet-4

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.3 (b):

Applicant's Name
and Address

To,

[Designated Official]
[Name of Utility]
[Address]

*We are submitting the Pre-Qualification Application for R&M Consultancy work for Unit No. [...] of [...] Plant of [...] under Tender No. [...].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date:

(Signature).....

Place:

(Full Name).....

(Designation).....

(Company seal).....

- *Strike off whichever is not applicable

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00100-012	01	Model RFQ for R&M Consultant	[21]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL REQUEST FOR QUALIFICATION
FOR
SELECTION OF
IMPLEMENTATION SUPPORT CONSULTANT
FOR
RENOVATION & MODERNIZATION**

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

Request for Qualification for Selection of Implementation Support Consultant for Renovation & Modernization of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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List of Formats & Data Sheets

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1.0	Format for Pre-qualification Application	Annexure-1
2.0	Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1	Data Sheet-1
3.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-2
4.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Data Sheet-3

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Request for Qualification for Selection of Implementation Support Consultant for Renovation & Modernization of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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1 INVITATION FOR QUALIFICATION

1.1 Introduction

{Give brief introduction about the name, location and details of the Power Plant for which the utility is proposing to appoint an Implementation Support Consultant for R & M works.}

1.2 INVITATION

[Name of The Utility], hereinafter referred to as “Employer”, is planning to undertake Renovation & Modernization of Unit No.[XX] of the [XXX] Power Plant and desires to appoint a Implementation Support Consultant (IS Consultant). Towards this end, [Name of the Utility] invites sealed Pre-Qualification Tenders from experienced and interested Consultancy Firms for Implementation Support Consultancy Services for Renovation & Modernization of Unit No. [XX] of the [XXX] Power Plant. Consultancy Firms from both India and abroad are eligible to participate in the Pre-Qualification Process and subsequent Request for Proposal process if found eligible during pre-Qualification process.

Interested Consultancy Firms may collect the RFQ documents in person from [Name and Contact Details of Designated Official.....]. The RFQ documents can be collected between [---] hrs to [---] hrs on all working days from [.....] to [.....]. Alternatively, the RFQ document can be downloaded from [Name of the Utility] website [.....].

The Pre-Qualification Tender in the form and manner specified in the RFQ document along with necessary attachments and stipulated participation fee should be submitted to [Name and Contact Details of Designated Official.....] by [Date and Time].

1.3 Brief Scope of Work

Scope of work of the Implementation Support Consultant shall include:-

- To provide support to [Name of the Utility] during detailed engineering, supply, implementation and commissioning of R&M works.
- To review the detailed engineering drawings/design calculations, schedule planned for execution and commissioning of all the works in line with the broad parameters of accepted design.
- Preparation of work schedules and monitoring the progress of R&M works through close involvement with the Contractors and other agencies on behalf of Employer.
- Assistance to Employer in decisions making and in taking timely actions to ensure schedule adherence during the tenure of R&M project.

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LII-GETS12021-G-00100-013	01	Model RFQ for Implementation Support Consultant	[1]	25.09 2014

Request for Qualification for Selection of Implementation Support Consultant for Renovation & Modernization of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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- To flag critical problems as and when arises during the tenure of R&M project to Employer and suggest suitable remedial measures to control the situation.
- To provide assistance to the Employer in addressing any techno commercial / contractual and regulatory issues as and when these may arise during the course of the R&M project.

The detailed Scope of Work will be indicated in the Request for Proposal (RFP) that will be issued to pre-qualified applicants.

1.4 RFQ Details

(a)	Participation Fee	:	INR [---]/ USD [---]/ EUR [---]
(b)	Publication date of RFQ	:	[-----]
(c)	Last date for issue of RFQ document	:	[-----]
(d)	Last Date & Time of Receipt of Pre-Qualification Applications	:	[-----]
(e)	Date for identification of Qualified Consultancy Firms for Issuance of RFP	:	[-----]

If any of the date happens to be a public holiday, the deadline will be the next working day.

1.5 Objective of Request for Qualification

[Name of the Utility] is carrying out this Pre-Qualification Process to identify qualified Consultancy Firms for the issuance of RFP Documents for selection of Implementation Support Consultant for Renovation & Modernization of Unit no. [XX] of [XXX] Power Plant. The objective of the pre-qualification is to allow only the capable and qualified Consultancy Firms having requisite technical expertise, relevant experience, associated with adequate number of competent personnel and financial resources to participate in the selection process.

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LII-GETS12021-G-00100-013	01	Model RFQ for Implementation Support Consultant	[2]	25.09 2014

Request for Qualification for Selection of Implementation Support Consultant for Renovation & Modernization of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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2 QUALIFICATION REQUIREMENT

2.1 Qualification Requirement

To be pre-qualified for participation in the RFP process for selection of the Implementation Support Consultant for Renovation & Modernization of Unit no [...] of [...] power plant, the Applicant must meet the Qualification Requirements specified at clause 2.1.1 and 2.1.2. Further, the eligibility of the Bidders to participate in the Tendering process is subject to other criteria specified at clause no. 2.1.3.

2.1.1 Technical Qualification Requirement

The Applicant should be an engineering consultancy firm that must have successfully completed during the last [10] years at least 2 (two) number of engineering consultancy assignments pertaining to coal/lignite fired thermal power plants of unit size 200 MW or above as on the date of Pre-Qualification Bid opening. The Consultancy assignments may be for either green field power projects or Renovation & Modernization Power Project. The scope of work for each of the two reference consultancy assignments must have included the following:

1. Review & Approval of Vendor Drawings & Documents
2. Field Services (Assistance in Construction Supervision, Start up, Commissioning and Testing)

2.1.2 Financial Qualification Requirement

- (a) The average annual turnover of the Applicant should be at least [Indian Rupees] millions or equivalent foreign currency as per audited annual accounts during the preceding three consecutive years – [FY], FY [...] and FY [...]. For the purpose of conversion of foreign currency to Indian Rupees, the TT Buying rate of State Bank of India as on 30 days prior to the date of submission of Bid will be considered. Other income will not be considered for arriving at the annual turnover.
- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year shall be positive.

2.1.3 Other Criteria

- (a) Any Applicant who is legally barred from participation in Consultancy assignments of [name of Utility] on the grounds of previous violations of rules/regulations on fraud and corruption or any other reason cannot participate as an applicant for this Implementation Support Consultancy Tender.
- (b) Any firm or its associate company cannot participate as Applicant in more than one Bid under this Implementation Support Consultancy Tender.

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LII-GETS12021-G-00100-013	01	Model RFQ for Implementation Support Consultant	[3]	25.09 2014

Request for Qualification for Selection of Implementation Support Consultant for Renovation & Modernization of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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2.2 Qualification Documents

2.2.1. Documents to be submitted (Pre-qualification)

Bidders are required to furnish following documents for pre-qualification in *[five (5)]* copies and an application with requisite participation fee along with their Pre-Qualification Bid.

- (i) List of orders executed by them along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates clearly indicating date of completion from the employer in respect of such completed consultancy assignment(s).
- (iii) Particular of Key Personnel that must include inter alia name, details regarding qualification, area of expertise, professional experience and name of relevant projects.
- (iv) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity to the satisfaction of Employer.
- (v) Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (vi) Consultancy Assignments in hand / pending jobs and their status along with value.
- (vii) Major pending legal cases.

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LII-GETS12021-G-00100-013	01	Model RFQ for Implementation Support Consultant	[4]	25.09 2014

Request for Qualification for Selection of Implementation Support Consultant for Renovation & Modernization of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[LOGO OF UTILITY]
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3 INSTRUCTION TO APPLICANTS

- 3.1. Only Applicants pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the subject Implementation Support Consultancy Services Contract and will be eligible to submit Bid Proposal. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, competence of key personnel, project execution capability and financial resources to discharge the scope of service.
- 3.2. [Name of Utility] is committed to have most ethical business dealing with the Vendors, Bidders and Contractors of goods and services and deal with them in a transparent manner with Equity and Fairness. In case, certificate(s)/document(s) submitted by the Applicant is found to be factually incorrect or manipulated, the Applicant will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders.
- 3.3. The Scope of work of the Implementation Support Consultant shall be on the basis of single bidder responsibility. The Consultancy Contract will be entered into only with the successful Bidder. Thus, the Bidder shall be solely responsible and liable for all the technical, management and all other services required for completing the entire scope of work.
- 3.4. The Bidder shall not Sub-contract the entire scope of work, back to back or otherwise, for the performance of the subject Consultancy Contract.
- 3.5. As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Guarantee (CPG) in the Format to be specified in RFP document, in favour of the Employer within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to five percent (5%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in the documents and specifications. The CPG shall be valid till the scheduled date of completion of Implementation Support Consultant's work plus three (3) months grace period.
- 3.6. The Applicant shall provide satisfactory evidence that he has adequate capability and capacity to perform the consultancy work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the expertise and number of experts and other support staff, to meet the requirements appropriate to the works covered in his bid. Pre-Qualification Application submitted without the proper documentary evidence to substantiate fulfilment of the qualifying requirements as specified are liable for rejection without assigning any reason.

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- 3.7. Notwithstanding anything stated above, [Name of Utility] reserves the right to verify independently all statements / information submitted to confirm the Applicant's claim on experience and to assess the Applicant's capability and capacity to perform the subject Implementation Support Consultancy contract, should the circumstances warrant such an assessment in the overall interest of the R&M project.
- 3.8. [Name of Utility] reserves the right to reject any or all Pre-Qualification Applications or cancel / withdraw the Request for Qualification without assigning any reason whatsoever and in such case no Applicant / intending Applicant shall have any claim arising out of such action.
- 3.9. Participation Fee for an amount of [INR.....] or [USD.....] or [Euro.....] in the form of Demand Draft drawn in favour of '[Name of Utility]', payable at '[XXXXXX]' is to be submitted along with the Pre-Qualification Application. Pre-Qualification Application received without the Participation Fee will be rejected. Participation Fee is non-refundable.
- 3.10. Language of Bid
The Pre-Qualification Application submitted by the Applicant and all correspondences and documents relating to the Application exchanged by the Applicant and [Name of Utility] shall be written in English language. Any printed literature / material furnished by the bidder in any other language shall be accompanied by an authentic English translation of all the pertinent points. For purpose of interpretation of the bid, the English translation shall govern.
- 3.11. Signature on Pre-Qualification Bid

The Pre-Qualification Application must contain the name and place of business of the Applicant and each page of the Application must be signed and sealed by the authorized person(s) of the Applicant with his usual signature. The name of all persons signing should be typed or printed below the signature.
Satisfactory evidences of authority of the person signing on behalf of the Applicant shall be furnished with the Application.
The Applicant name stated on the Pre-Qualification Application shall be the exact legal name of the firm.
- 3.12. Method of Submission of Pre-Qualification Bid

The Pre-Qualification Application shall be submitted in one (1) original and five (5) identical copies indicating clearly as 'original' and 'copy' along with a soft copy in PDF format. The cover shall be pasted properly before applying the official seal. Failure to do so would result in rejection of The Pre-Qualification Application.
The outside of the covers should indicate clearly the name of the Applicant and his address. In addition, the envelope or container should indicate the

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"Tender No. and Name of the work for which the Pre-Qualification Application is submitted ". Pre-Qualification Application with no indication given on the outside of the envelope that it is a Pre-Qualification Application which therefore gets opened before the due date shall be liable to be disqualified. All the pages of the Pre-Qualification Application shall be serially numbered. The Pre-Qualification Application, complete in all respects, must be submitted to the official and address mentioned below or may be sent by Courier or Registered Post to the address mentioned below.

'[XXXXXX]
'[XXXXXX] '[XXXXXX]

Submission of Pre-Qualification Application through Fax, Telex, E-Mail will not be accepted.

[Name of Utility], takes no responsibility for delay, loss or non-receipt of documents or any letter sent by post or courier either way.

Pre-Qualification Applications must reach the above office on or before '[XXXXXX] Hours (IST) on '[XXXXXX]. Any Pre-Qualification Application received after the expiry of the time specified is liable for rejection.

3.13. Opening of Pre-Qualification Bid

The Pre-Qualification Bids received from the bidders as above will be opened at '[Place XXXXXX] on '[Date XXXXXX] at '[Time XXXXXX] Hours (IST).

The Pre-Qualification Bids shall be opened in the presence of such bidders who may be present. The bidders are at liberty to be present or authorise their representatives (not more than two per Bidder) to be present at the time of opening of Pre-Qualification Bids.

Accredited Agents / representatives of foreign bidders in India are also permitted to submit the Pre-Qualification Bids on behalf of the foreign bidders with due Authorisation Letter.

Clarification request regarding the content of RFQ Document and RFQ process, if any, should reach at least [15 (Fifteen) days] before the date stipulated for opening of Pre-Qualification Bid. Requests for clarification received after this will not be entertained. [Name of Utility] will issue interpretations and clarifications as it may deem fit.

3.14. Application Data Sheets and Forms

The Pre-Qualification Application is to be submitted as per the Format at Annexure-1.

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The following sample formats are to be used for the various attachments to be submitted with the Pre-Qualification Application. Wherever no sample format has been specified, Bidder is required to use any appropriate format as per prevalent practice in conformity with the requirement stipulated in RFQ document.

List of Formats & Data Sheets

S.No	Description	Format/ Data Sheet No.
1.0	Format for Pre-qualification Application	Annexure-1
2.0	Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1	Data Sheet-1
3.0	Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a)	Data Sheet-2
4.0	Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b)	Data Sheet-3

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Annexure-1

Format for Pre-Qualification Application

Date: - [XXXXXX]

RFQ No. [XXXXXX]

Name of Package: Implementation Support Consultancy Services for Renovation & Modernization of Unit No. [XXXXXX] of [XXXXXX] Thermal power plant.

To,

[Designated Officer XXXXX]

[Address XXXXX]

Dear Sir /Madam

1.0 Having examined the RFQ Document No. [XXXXXX], we the undersigned intend to participate in the pre-qualification process for selection of qualified Consultants for Implementation Support Consultancy services for unit [XXXXXX] of [XXXXXX] power plant of [XXXXXX]. Towards this end we submit the following details & documents for prequalification.

2.0 Name of the Applicant with name & designation of person authorized to submit the pre-qualification Application:

Name of Applicant: [.....]

Name & Designation of Authorized Person: [.....]

3.0 We meet the Qualification Requirement stipulated at clause no.2.1.1, 2.1.2 & 2.1.3 of RFQ document.

4.0 We confirm that neither we nor any of our Associate (s)/Affiliate (s) are liable for exclusion from participation in Pre-Qualification process under 'other criteria' stipulated under clause no.2.1.4 of RFQ document.

5.0 We are enclosing the following attachments as integral part of our Pre-Qualification Bid

- (i) Covering Letter
- (ii) Power of Attorney in favor of persons signing on behalf of Applicant, Associate (s) and Consortium member (s) as applicable.
- (iii) Data Sheet regarding Technical Qualification Requirement at clause 2.1.1
- (iv) Data Sheet regarding turnover requirement at RFQ clause no. 2.1.2 (a)

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(v) Data Sheet regarding net worth requirement at RFQ at clause 2.1.2 (b)

6.0 We are submitting the following supporting documents to demonstrate our qualifications & capability to execute the subject R&M work:-

(i) List of order executed

(ii) Copies of order

(iii) Past performance certificate.

(iv) Contracts in hands/pending jobs along with value

(v) Documents regarding company profile, technical manpower, financial strength, resources, construction equipment.

(vi) Copies of last 3 year audited financial statement.

(vii) List of pending litigations/disputes.

(viii) Any other document.

7.0 We hereby attach participation fee of [INR-----] in the form of demand draft in favor of '[XXXXXX]' payable at '[XXXXXX]'.

8.0 We certify that all the information and documents furnished with this Pre-Qualification Bid are true and genuine to our best of the knowledge & belief.

Dated this '[XXXXXX]' day of '[XXXXXX]' 20XX

Yours Faithfully,

Signature '[XXXXXX]'

Full Name '[XXXXXX]'

Designation '[XXXXXX]'

Company Seal '[XXXXXX]'

Business Address: '[XXXXXX]'

Country & province of Incorporation '[XXXXXX]'

Contact details '[XXXXXX]'

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Data Sheet-1

Sample format for Data Sheet regarding Technical Qualification Requirement at Clause No. 2.1.1:

To,

Applicant's Name
and Address:-

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Pre-Qualification Application for Implementation Support Consultancy Services Contract for R&M of Unit No. [...] of [...] Plant of [...].

We are an engineering consultancy firm and we have successfully completed at least 2 (two) number of engineering consultancy assignments pertaining to coal/lignite fire thermal power plants of unit size 200 MW or above during the last 5 (five) years. As per stipulated requirement at Clause No. 2.1.1 of RFQ document, the scope of work for each of the three reference consultancy assignments included the following:

1. Review & Approval of Vendor Drawings & Documents
2. Field Services (Assistance in Construction Supervision, Start up, Commissioning and Testing)

The details of the same are given below:

Sl.	Description	Installation No.1	Installation No.2	Installation No.3
1.	Name of the Thermal Power Station and its Location			
2.	Client Name and its Address, Fax and Tel. Nos.			
3.	Name and Designation of the responsible person in Client's organization.			
4.	Contact No. & Date			
5.	Starting Date of the Consultancy Assignment			
6.	Schedule Date of Completion of the Consultancy Assignment			
7.	Actual Date of Completion of the Consultancy Assignment			
8.	Whether the Plant is	Yes*/No*	Yes*/No*	Yes*/No*

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Sl.	Description	Installation No.1	Installation No.2	Installation No.3
	coal/Lignite fired thermal power station			
9.	The Consultancy Assignment was for a Green Field Power Project	Yes*/No*	Yes*/No*	Yes*/No*
10.	The Consultancy Assignment was for R&M of a Power Project	Yes*/No*	Yes*/No*	Yes*/No*
11.	The Scope of Work for the aforesaid Consultancy Assignment included:			
	(a) Review & Approval of Vendor Drawings & Documents	Yes*/No*	Yes*/No*	Yes*/No*
	(b) Field Services (Assistance in Construction Supervision, Start up, Commissioning and Testing)	Yes*/No*	Yes*/No*	Yes*/No*
12.	Scope of Work executed for the aforesaid Consultancy Assignment			
13.	Original order value of the contract aforesaid Consultancy Assignment			
14.	Completed order value of the contract aforesaid Consultancy Assignment			
15.	Certificate(s) from the Client is/are enclosed along with the Application at Annexure.....to this Data Sheet			

Date :

(Signature.)

Place :

(Full Name)

(Designation)

(Company Seal)

1. If required, continuation sheets may be used.

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1. *Strike off whichever is not applicable

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Data Sheet-3

Sample Format for Data Sheet regarding Turnover requirement stipulated at RFQ clause 2.1.2 (a):

To,

Applicant's Name
and Address

[Name of Utility]
[Address]

We are submitting the Pre-Qualification Application for Implementation Support Consultancy Services Contract for R&M of Unit No. [.....] of [.....] Plant of [.....].

In line with RFQ Document clause 2.1.2(a) , we confirm that our average annual turnover during the preceding three financial years as on date of bid opening is not less than [XXXXXX] or in equivalent foreign currency. In support of above, we are enclosing Balance Sheets and Profit & Loss Account duly certified by a Chartered Accountant.

Sl. No.	Financial Year	Amt. of Applicants Currency	Amt. in Rs.	Exchange rate as on 30 days prior to the schedule date of Pre-Qualification Application opening
1	[XXXXXX]			
2	[XXXXXX]			
3	[XXXXXX]			
4	Average Annual Turnover for the preceding three (3) Financial Years.			
5	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant			*Yes/*No

Date:

(Signature).....

Place:

(Full Name).....

(Designation).....

(Company seal).....

1. *Strike off whichever is not applicable.

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Data Sheet-4

Sample Format for Data Sheet regarding Net worth requirement specified at RFQ clause 2.1.2 (b):

To,

Applicant's Name
and Address
:-

[Designated Official]
[Name of Utility]
[Address]

We are submitting the Pre-Qualification Application for Implementation Support Consultancy Services Contract for R&M of Unit No. [.....] of [.....] Plant of [.....].

We hereby confirm that net worth of our company as on the last day of the preceding financial year is positive.

The Details are as under:

Sl. No.	Description	As on last day of the preceding financial year
1	Net worth on last date of preceding financial year.	-----
3	We have enclosed Balance Sheets and Profit & Loss Account duly certified by Chartered Accountant	*Yes/*No

Date: (Signature).....
Place: (Full Name).....
(Designation).....
(Company seal).....

1. *Strike off whichever is not applicable

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONSULTANT**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

**Tender Document for Selection of R&M Consultant for Unit No. [..]
Capacity [..] of [Name of the Power Plant]**

[Logo of Utility]

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Section	Description
Section-I	Commercial
Section-II	Terms of Reference

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONSULTANT

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

SECTION-I

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1.0 INVITATION FOR BID

Tender No : [-----]

1.1 Introduction

{Give brief introduction about the name, ownership, business & Power Projects of the utility inviting bid proposal for R & M Consultancy work}

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer”, is planning to undertake Renovation & Modernization of Unit No.[XX] of the [XXX] Thermal Power Plant and desires to appoint a Renovation & Modernization Consultant (R&M Consultant) to carry out preparatory work for Renovation & Modernization such as Residual Life Assessment (RLA) Study, Energy Audit (EA), Preparation of Feasibility Report (FR) and Detailed Project Report (DPR), providing assistance in obtaining Statutory & Regulatory approvals. [Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, invites sealed Bid Proposals in English language from Prequalified Applicants for the Renovation & Modernization Consultancy Services for Unit No.[XX] of [XXX] Power Plant as per scope of work Section-II.

1.3 Brief Scope of Work

The Scope of work of the R&M Consultant shall be divided in two Phases. First Phase shall cover scope up to obtaining regulatory approval for R&M works and Second Phase shall cover preparation of tender documents and bid evaluation for the selection of R&M Contractor(s) as described below.

Phase-I

- i) Review and Analysis of Operational Data and Trip Reports provided by Employer.
- ii) Hot Walk Down Survey
- iii) Cold Walk Down Survey
- iv) Review of previous RLA/CA and EA Studies, if any.
- v) Conducting Residual Life Assessment (RLA) / Condition Assessment (CA) of the Equipments / Systems of complete Power Plant
- vi) Conducting Energy Audit and Performance Testing of major Equipments/ Systems of the Power Plant
- vii) Working out of various R& M Options for improving the Performance Parameters and extending the life of the Unit.

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- viii) Finalizing the most cost effective option for R&M and LE of the unit.
- ix) Preparation of Feasibility Report (FR).
- x) Preparation of Detailed Project Report (DPR).
- xi) Providing Assistance to the Employer in obtaining necessary approvals from statutory / regulatory authorities.

Phase-II

- i) Basic Design & Engineering and Preparation of Tender Documents.
- ii) Support for bid evaluation for the selection of R&M Contractor(s), up to the placement of Letter of Award.

Note: Phase-II shall commence only after obtaining necessary approvals from statutory / regulatory authorities and after obtaining the Notice to Proceed from the "Employer".

The detailed scope of work is given in Terms of Reference Section-II.

1.4 Tender Details

(a)	Cost of Tender Documents	:	INR [---]
(b)	Bid Guarantee Amount	:	INR [-----]
(c)	Date of issuance of Tender Document	:	[-----]
(d)	Date & Time of pre-Bid Conference	:	[-----]
(e)	Last Date & Time of Receipt of Bid (Both Part I & Part II)	:	[-----]
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of Consultancy Services shall be as per SCC.

1.6 Bid Submission

- (a) The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.

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- (b) The Bid proposals are to be submitted in two parts in separate sealed covers as follows:

Part I : Bid Guarantee and Technical & Commercial Proposal without prices

Part II : Price Schedule.

- (c) All other terms and conditions along with the Terms of Reference, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- (d) Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:

*[Designation, Address and Contact details.....
.....]*

- (e) Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- (f) The Bid Prices must be quoted in Indian Rupees. All payments for the entire scope will be made in Indian Rupees.
- (g) Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- (h) The Tender Documents are meant for the exclusive purpose of bidding against the subject Consultancy Services tender and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Employer, intends to carry out the Renovation & Modernization of [Unit no.-XX ----- of the XXXX Power Plant]. [Name of The Utility] desires to appoint a Renovation & Modernization Consultant (R&M Consultant) to carry out preparatory work for Renovation & Modernization.

Under the subject Tender, [name of the Utility] invites bid for Renovation & Modernization Consultancy Services to be carried out as per the accompanying Terms of Reference. The Bidder shall submit the offer for complete scope of work indicated in the Terms of Reference.

2.2 Address and Contact Details of Employer

[Designation, Address and Contact details

-----]

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Employer will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.5 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.6 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents.

2.7 Time Schedule

The completion Time Schedule for Completion of R&M Consultancy Services shall be as given in the SCC.

2.8 Tender Documents

The scope of contract, terms of reference, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following Sections:

Section – I	:	Commercial Conditions
Section – I, Chapter-1	:	Invitation for Bid
Section – I, Chapter-2	:	Instructions To Bidders

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Section – I, Chapter-3	:	General Project Information
Section – I, Chapter-4	:	General Condition of Contract (GCC)
Section – I, Chapter-5	:	Special Condition of Contract (SCC)
Section – I, Chapter-6	:	Forms & Schedules
Section – II	:	Terms of Reference

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Employer.

Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Employer in writing by post or by e-mail followed by postal confirmation at the Owner's address indicated in ITB. The Employer will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than fifteen (15) days prior to the deadline for submission of bids prescribed by the Employer. Employer's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Employer will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operation and does not in any way adversely impact the interest of the Employer. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Owner may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the Tender Documents.

The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.9 Preparation of Bids

2.9.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is

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accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.9.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

The bidders are required to submit, the bids for the R&M Consultancy Services in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Methodology & Work Plan for discharging the consultancy services as per Terms of Reference, Details of Key Personnel along with their Curriculum Vitae, Deviations to Terms of Reference, Deviation to commercial Conditions, Overall Completion Time Period & Network Schedule, Resource Deployment Schedule, Detail of Sub-Consultants, Details of the present commitments & details of contracts in hand etc. Part-II Bid will comprise Quoted Price and Quoted Performance Guarantee Parameters. Initially, only the Part-I Bid will be opened and Part-II Bid will be kept in safe custody.

The Part-I Bid will be checked for responsiveness to techno-commercial conditions and a detailed Technical Evaluation will be carried out to assign a Technical Score to each Bid. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions and Technical Score is above a specified level.

2.9.3 Bid Submission

- (1). Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2). All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered.
- (3). *[One original and 3 (three) identical]* copies of the original with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., "Original", "Copy No. 1", "Copy No. 2" and "Copy No. 3").
- (4). In the event of discrepancy between "Original" and any copy of the bids, the hard copy of Original shall prevail.
- (5). All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (6). The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (7). The Bidder's Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (8). The Bid shall be submitted to [-----]. Bid submitted to any other office of Owner is liable for rejection. Bids submitted by Telefax or e-mail will be rejected

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- (9). Owner will receive Bids in respect of entire scope of work as set forth in the accompanying Terms of Reference. All bids shall be prepared and submitted in accordance with the Tender Documents.
- (10). Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Terms of Reference in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11). A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Owner's rights or the successful Bidder's obligations under the contract.
- (12). Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13). Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Consultant under the Contract.

2.9.4 Bid Guarantee

- (1). The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of "[-----]" payable at "[-----]".
- (2). The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank. Foreign Bidders may submit the Bank Guarantee from any bank in India as above or from any foreign bank which is in the approved list of RBI.
- (3). Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Owner at ([-----]). In the event of any deviation in this regard, the decision of Owner as to whether the same could be accepted or not, will be final and binding on the Bidder.
 - d) In case of foreign Bidder, the Bid Guarantee amount shall be in US Dollar / Euro/ Indian Rupee.

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- (4). The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Owner.
- (5). No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified herein above or from banks not specified hereinabove will be liable for rejection.
- (6). Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7). The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Owner or fails to submit Contract Performance Security (Bank Guarantee).
- (8). The Bid Guarantee of all unsuccessful Bidders shall be returned after selection of the successful Bidder. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Owner and acceptance thereof.

2.9.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part- I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part-I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Owner, at its discretion, may consider appropriate, shall be read out.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.
3. Owner takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

2.10 Composition of Techno Commercial Bid (Part-I Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 3 (three) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B of this Section).
- (ii). Bid Guarantee- as per Annexure A.
- (iii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iv). Letter of Undertaking as per Annexure-D to be furnished by the Bidder and Associate (s) regarding joint and several liability for Associate's scope of work if the Bidder has met Qualification Requirement with the help of Associate (s)
- (v). Consortium Agreement if the Bidder is a Consortium of Consultancy Firms. The Consortium Agreement must include but not limited to (1) Scope of Service of each Consortium Member, (2) Authorization in favour

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of Consortium Leader to Bid and act on behalf of the Consortium Members during tendering and execution stage, (3) Joint and several liability of all consortium members for the entire scope of service, (4) Undertaking that any dispute among Consortium Members will not relieve any Member from its obligations towards the Owner under this Contract, (5) Undertaking by each member for providing expertise, man power and other technical support for successful completion of the respective Scope of Service and (6) Undertaking that each other Consortium Member will provide Additional Contract Performance Bank Guarantee equivalent to 2% of Contract Price in addition to the Contract Performance Bank Guarantee equal to 5% of Total Contract Price to be furnished by Consortium Leader.

- (vi). Signed copy of all the corrigendum's/amendments/clarifications, if any issued for the tender
- (vii). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (viii). Deviations to the Commercial Conditions, if any, as per Schedule – F3.
- (ix). Deviations to Terms of Reference, if any, as per Schedule – F4.
- (x). Methodology and Work Plan for completing different tasks under the Consultancy Assignment. Bidder to indicate the scope of work to be covered with sufficient details regarding the tasks and subtasks to be covered.
- (xi). Details of Equipment and Instruments to be deployed for RLA Study/Condition Assessment and Energy Audit
- (xii). Details of Key Personnel as per Schedule – F5. Bidder to indicate the minimum number of hours each identified key person will spend on the Consultancy Assignment
- (xiii). Curriculum Vitae of each key person as per Schedule-F6
- (xiv). Organization Structure and Team Composition (Both Professional Staff and Support Staff)
- (xv). Staffing Schedule describing month-wise deployment of personnel
- (xvi). Details of the present commitments of the Bidder, details of contracts in hand
- (xvii). Details of Sub-Consultants, if any

The Part-I Bid shall not contain any Price data.

In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy the Bid in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation.

2.11 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices with break up as per Schedule-F1. Price given in Part-II Bid should cover the entire scope of work as given in Part-I of the offer. *[One original and 3 (three) identical]* copies shall be submitted.

1. The Price Bid shall contain the following :

- (i). Duly filled in Form of bid as per Annexure-C

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- (ii). Completely filled in Schedule of Prices Schedule – F1
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed format (Price Schedule). The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Owner shall be final. All entries shall be in English language only.
4. The Price shall be quoted in Indian Rupees only.

2.12 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the obligations of the Consultant mentioned in Tender Documents/Terms of Reference or to be reasonably inferred from the Tender Documents/Terms of Reference.

Bidders are required to quote the price for the entire commercial, contractual and technical obligations outlined in the tender documents.

Prices quoted by the Bidder shall remain firm for the term of the contract .

2.13 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if any shall be signed by the person signing the Bid. Printed literature, it enclosed need not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.14 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Owner may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Documents including the Terms of Reference by amendment.
2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Documents. Amendments will be hosted in Owner's website. Bidders are requested to visit Owner's website and note amendments, if any, before submission of bid. Owner shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.15 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

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2.16 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other interested parties are advised to refrain from contacting by any means, the Owner and/or his employees/ representatives on matters related to the Bids under consideration. The Owner, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

2.17 Validity of Bid

1. The Bid shall be kept valid for acceptance for *[120 days]* from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Owner from participating in any of the Owner's tenders.

2.18 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully informs himself as to all the conditions and matters which may in any way affect the 'Renovation and Modernization Consultancy Services to be rendered or the cost thereof. Bidders are free to visit the plant. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Owner.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Owner at least *[7 (seven) days]* before the date stipulated for pre-bid meeting. The Owner then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till *[14 days]* prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Owner. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.
3. Pre-Bid Conference will be organized and outcome of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Owner to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.

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5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

2.19 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Owner not later than [-----] Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

2.20 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Owner for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Owner, even though the Owner may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

2.21 Evaluation of Bid

The selection of the successful Bidder for award of the R&M Consultancy Services Contract will be based on both Quality of the Technical Proposal and Price quoted by the Bidder for the entire scope of work. The selection process will comprise the following steps:

1. First, Techno-Commercial offer will be assessed for completeness and responsiveness to commercial/contractual conditions. Only the Bids that are determined to be complete in all respects and responsive to commercial/contractual conditions will be taken up for further evaluation on the basis of Quality and Price.
2. Technical Proposal of Bidders, whose Bid is determined to be complete and responsive to commercial/contractual conditions, will be evaluated on the basis of Bidder's proposed methodology and Work Plan for discharging the Consultancy Assignment, experience of the Bidder and the experience & expertise of Key Personnel and will be assigned a Technical Score S_t . Only those Bidders whose Technical Proposals get a Technical Score of 70 marks or more out of 100 shall qualify for further consideration. All the Bidders with Technical Score of 70 or more will be considered for next stage of evaluation. It is not intended to short list a pre-determined number of Bidders on the basis of evaluation of Technical Proposal.
3. The Price Proposal of each Bidder with Technical Score of 70 or more will be assigned a Financial Score (S_f) on the basis of its cost competitiveness.
4. Each bidder will be assigned a Composite Score (S_c) equal to the weighted sum of Technical Score and Financial Score. Finally, the bidder with the highest Composite Score will be selected as R&M Consultant for the subject R&M Consultancy Services Contract.

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2.21.1 Evaluation of Technical Proposal

The evaluation of Technical Proposal will have three elements as depicted in Table below:

SI No	Parameter	Weightage	Basis of Evaluation
1	Methodology and Work Plan (S _{t-1})	20%	Bidder's understanding of Terms of Reference and clarity, completeness and soundness of methodology and work plan to achieve successful completion of the objectives of the R&M Consultancy work. The Bidder with the best submission will be assigned a score of 100 (S _{t-1} = 100). Other Bidders will be assigned scores below 100 considering the relative quality of the submission with respect to the best submission.
2	Bidder's Experience (S _{t-2})	40%	Each Bidder has to list up to 5 technical consultancy projects, pertaining to thermal power plants of unit size 200 MW or above, successfully executed by it during the last 10 years. Bidder has to furnish detailed scope of work executed by it for each listed consultancy project. Each such Project will be assigned a score out of 20 on the basis of size, nature & complexity of scope and similarity with the subject R&M Consultancy Service. If any Bidder lists less than 5 projects, a score of zero will be assigned for the shortfall number of project(s). For each Bidder, the sum of scores for the five projects will be the score (S _{t-2}) out of 100.
3	Experience and Expertise of Key Personnel (S _{t-3})	40%	The Bidder has to list name and other details of 10 key personnel of specified area of expertise in Schedule-F5 who are likely to be substantially associated with this R&M Consultancy assignment if the Bidder emerges as successful Bidder for award of the R&M Consultancy Services Contract. The Bidder is required to submit detailed Curriculum Vitae of these key personnel as per the format at Schedule-F6. Each identified Key Person will be assigned a score out of 10 based on their qualification and nature & quantum of experience in the specified area of expertise. For each Bidder, the sum of scores of these 10 key personnel will be the score (S _{t-3}) out of 100.

The Technical score of each Bidder will be equal to the weighted sum scores on three elements with indicated weights.

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$$S_t = 0.2 \times S_{t-1} + 0.4 \times S_{t-2} + 0.4 \times S_{t-3}$$

2.21.2 Evaluation of Price Bid

The Price Bid should be complete, unconditional and unqualified. For financial evaluation, the total Price indicated in the Price Schedule excluding Service Tax and associated surcharge & cess will be considered. The price indicated in the Price Bid shall be deemed as final and reflecting the total Price of the entire scope of services as per Terms of Reference. Failure by Bidder to include the price of any item shall not entitle the firm to be compensated and the Consultant shall be liable to fulfill its obligations as per the TOR. The Bidder with lowest quoted total price will be assigned a Financial Score (S_f) of 100. The financial score of other Bidders will be computed as follows:

$$S_f = 100 \times (\text{Lowest Quoted Total Price} / \text{Total Price quoted by the Bidder})$$

2.21.3 Composite Score

For selection of successful Bidder, the Technical Score will be a weight of 70% and Financial Score will be given a weight of 30%. For each Bidder, the Composite Score S_c will be computed as follows:

$$S_c = 0.7 \times S_t + 0.3 \times S_f$$

The Bidder who is determined to secure the highest Composite Score will be selected for award of the R&M Consultancy Contract.

2.21.4 Other Evaluation Conditions

(1) Arithmetical errors will be rectified on the following basis:

- If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.
- If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
- If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.

(2). Comparison of Bids will be between main Bids only. Alternative Bids will not be accepted and evaluated.

(3). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder shall not charge any amount separately for that item from the Owner. If the terms, such as 'not applicable' "-----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.22 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and Terms of Reference. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with "Original" of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily

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rejected and ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.

2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Owner at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Owner towards Owner's cost, loss and damage to Owner.

2.23 Blacklisting/Debarring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Owner.

2.24 Award of Contract

1. Award Criteria

The R&M Consultancy Service Contract will be awarded to the Bidder with the highest Composite Score as described in clause 2.21.

2. Owner's Right to Accept Any Bid and to Reject Any or All Bids

The Owner reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Owner's action.

3. Notification of Award

Prior to the expiration of the period of bid validity, the Owner will notify the successful Bidder in writing by registered letter or by email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Owner will promptly notify each unsuccessful Bidder and will discharge its bid security.

4. Signing the Contract Agreement

At the same time as the Owner notifies the successful Bidder that its bid has been accepted, the Owner will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

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Within *[twenty-eight (28)]* days of receipt of the Contract Agreement, the successful Bidder shall sign and date the Contract Agreement and return it to the Owner.

Cost of preparing Contract Agreement shall be borne by the bidder.

5. Performance Security

Within *[thirty (30) days]* after receipt of the Notification of Award, the successful Bidder shall furnish Contract Performance securities as per clause no 2.25. These Bank Guarantees shall be furnished in the form provided in the section "Forms and Procedures" of the bidding documents and shall be initially valid upto *[ninety (90)]* days after the scheduled date of completion of R&M Consultancy Service.

Failure of the successful Bidder to submit Contract Performance Security within stipulated time shall constitute sufficient grounds for the annulment of the award and forfeiture of his bid security, in which event the Owner may make the award to the next lowest evaluated Bidder or call for new bids.

6. Corrupt or Fraudulent Practices

The Owner requires that Bidders, Contractors and Consultants to observe the highest standard of ethics during the Pre-Qualification, Tendering (Request for Proposal) process and during the execution of the contracts. The Employer may reject a Bid Proposal of a successful Bidder if it emerges that the Bidder recommended for award has engaged in Corrupt or Fraudulent practices in competing for the subject contract. The Employer may declare a Bidding firm ineligible for participation in future tenders of the Employer, either indefinitely or for a stated period of time, if it at any time it emerges that the firm has engaged in Corrupt or Fraudulent practices in competing for or in executing a contract of the Owner. Corrupt Practice means the offering, giving, receiving or soliciting of anything of value to influence the tendering process or contract execution. Fraudulent practice means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Employer and includes collusive practice among Bidders designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition.

2.25 Contract Performance Bank Guarantee (CPBG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to five percent (5%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPG shall be valid till the Schedule Completion Time Period for Consultancy Services plus ninety (90) days grace period.

If the bidder is a Consortium Consultancy firms, in addition to the Contract Performance Guarantee (CPG) of 5% furnished by the Consortium Leader, each of the other consortium member shall furnish Additional Contract Performance Guarantee equal to 2% of Contract Price.

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If the Bidder meets Qualification Requirement on the strength of Associate (s), in addition to the Contract Performance Guarantee (CPG) of 5% furnished by the Bidder (Principal Consultant), each Associate shall furnish Additional Contract Performance Guarantee equal to 2% of Contract Price.

2.26 Vital Clauses

The following clauses in the Tender Specification & Form of Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Owner / Purchaser : [.....]
- Consultant : [.....]
- Project Title : [.....]
- Location : [.....]
- Latitude : [.....]
- Longitude : [.....]
- Elevation above MSL : [.....]
- Nearest Railway Station : [.....]
- Nearest Sea Port : [.....]
- Nearest Airport : [.....]
- Road Access/Approach to Site : [.....]

For Project & Site related detailed information, refer Terms of Reference Section-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Services, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract.
- iv. **"Contract"** means the Agreement entered into between Owner and Consultant as per the 'Contract Agreement' signed by the parties, including contract documents, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Consultant's Equipment"** means all equipment, machinery, tools, apparatus, appliances or things of every kind required in or for discharging the R&M Consultancy Services to be brought to the site by the Consultant.
- vii. **"Consultant"** means the person(s), Firm or a Company or Consortium of Firms whose bid to perform the R&M Consultancy Services Contract has been accepted by the Owner and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Consultant.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Owner for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.

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- ix. **"Consultant's Representative"** means any person nominated by the Consultant & approved by the Owner hereof to perform the duties delegated by the Consultant.
- x. **"Completion"** means the completion of R&M Consultancy Services by the Consultant (R&M Consultant) covering the entire Scope of Work as per the Terms of Reference and submission of all the reports and other deliverables incorporating Owner's observation on the draft reports to the satisfaction of the owner .
- xi. **"Consultancy Services" or "R&M Consultancy Service" or "Renovation & Modernization Consultancy Services"** means the entire services ancillary to the completion of entire scope of work as per the Terms of Reference.
- xii. **"Day"** means calendar day of the Gregorian calendar.
- xiii. **"Effective Date"** means the date from which the Time for Completion of R&M Consultancy Services and other milestones for execution of the Renovation & Modernization Consultancy Services as per the scope of work under this tender by the Consultant shall be determined.
- xiv. **"GCC"** means the General Conditions of Contract hereof.
- xv. **"Good Industry Practice"** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Consultant applying the standards generally adopted by global Engineering/Technical , except in so far as inconsistent with any applicable Indian law or directive.
- xvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Owner notifying the Consultant that its Bid Proposal has been accepted.
- xvii. **"Month"** means calendar month of the Gregorian calendar.
- xviii. **"Owner's Acceptance"** means the Owner has accepted that the Consultant (R&M Consultant) has successfully discharged the R&M Consultancy Services covering the entire scope of work as per the ToR adhering to industry standard and Good Industry Practice and all the reports & other deliverables submitted by the Consultant as part of the R&M Consultancy Services .
- xix. **"Owner" or "Purchaser" or "Employer"** shall means the [Name of the Utility], and includes its legal successors or permitted assignees.
- xx. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
- xxi. **"Project"** means the Owner's [-----] in respect of which the Contract has been signed.
- xxii. **"Project Manager"** means the person appointed by the Owner thereof and named as such, to perform the duties delegated by the Owner.
- xxiii. **"R&M Consultant" or "Renovation & Modernization Consultant"** means the person(s), Firm or a Company or Consortium of Firms whose bid to

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- perform the R&M Consultancy Services Contract has been accepted by the Owner and is also named "Consultant" in the Contract Agreement.
- xxiv. **"R&M Project"** means the proposed R&M work for Unit [.....] of [.....] plant of Owner. The subject R&M Consultancy Services package is being tendered to appoint an R&M Consultant for carrying out preparatory work for the R&M Project.
- xxv. **"SCC"** means the Special Conditions of Contract.
- xxvi. **"Site"** means the [.....] plant of [.....].
- xxvii. **"Sub Consultant"** means any firm or person to whom execution of any part of the subject R&M Consultancy Services Contract is subcontracted directly or indirectly by the Consultant, and includes its legal successors or permitted assignees.
- xxviii. **"Tender Documents"** means the document, setting out a description and specification of the Consultancy services and statement of the technical and other standards to which the Services are to be performed including any modifications thereto made in accordance with the Conditions. This includes the commercial specifications, Terms of Reference and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xxix. **"Tenderer"/"Bidder"/"Applicant"** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Owner, for the Project.
- xxx. **"Time for Completion"** means the time within which completion of R&M Consultancy Services by the Consultant (R&M Consultant) covering the entire Scope of Work as per the Terms of Reference and submission of all the reports and other deliverables incorporating Owner's observation on the draft reports to the satisfaction of the owner is to be attained in accordance with the stipulations and provisions of the Contract.
- xxxi. **"Writing" or "Written"** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Owner. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.

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- b) The Contract will be signed in three originals and the Consultant shall be provided with one signed original and the rest will be retained by the Owner.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. The bid & schedules/ attachment submitted by the Consultant.
- vi. Terms of Reference

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Independent Consultant

The Consultant shall be an independent Consultant performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Consultant shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or SubConsultants engaged by the Consultant in connection with the performance of the Contract shall be under the complete control of the Consultant and shall not be deemed to be employees of the Owner, and nothing contained in the Contract or in any subcontract awarded by the Consultant shall be construed to create any contractual relationship between any such employees, representatives or SubConsultants and the Owner.

4.6 Joint Venture or Consortium

If the Bidder/Consultant is a joint venture or consortium of two or more firms, all such firms shall be jointly and severally bound to the Owner for the fulfillment of the provisions of the Contract and the Bidder shall submit a letter of consent to this effect (with Part-I Bid) signed by all joint venture partners / consortium members. The joint venture/consortium partners shall designate one of such firms to act as a leader with authority to bind the joint venture or consortium. The

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composition or the constitution of the joint venture or consortium shall not be altered without the prior consent of the Owner.

4.7 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.8 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.9 Origin

"Origin" means the place where the materials, equipments and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.10 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or Electronic Data Interchange (EDI) to the address of the relevant party indicated in the Contract. Either party may change its postal, telefax number, or EDI address or addressee for receipt of such notices by ten (10) days' notice to the other party in writing

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

4.11 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [.....] shall have exclusive jurisdiction in all matters arising under the Contract.

4.12 Settlement of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Owner and the Consultant in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Owner & Consultant shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

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Either Owner or the Consultant may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities

Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Owner and the Consultant shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within *[twenty eight (28)]* days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by President, Institution of Engineers as the Appointing Authority.

If one party fails to appoint its arbitrator within *[forty-two (42)]* days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996.

The Place for Arbitration shall be *[...]*, India.

The language of arbitration shall be English.

The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- the parties shall continue to perform their respective obligations under the Contract unless they otherwise agree
- The Owner shall pay the consideration Consultant due to the Consultant.

4.13 Scope of Services

The Scope of Services shall be as per the Terms of Reference Section-II.

4.14 Time for Commencement and Completion

- a) The Consultant shall commence work on the Scope of Services under this Tender from the date of Letter of Award. Consultant shall thereafter proceed with the Services in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- b) The Consultant shall attain Completion of the Consultancy Services (or of a part where a separate time for Completion of such part is specified in the

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Contract) within the time stated in the SCC subject to time extensions, the Consultant is entitled under the contract conditions or time extension expressly granted by the Owner.

4.15 Consultant's Responsibilities

- a) Before entering into this contract the Consultant is responsible to have examined the data relating to the plant and facilities provided by the Owner, and on the basis of information that the Consultant could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Plant & Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve Consultant of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.
- b) The Consultant shall acquire in its name all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Consultant's and SubConsultant's personnel and entry permits for all imported Consultant's Equipment.
- c) The Consultant shall perform the Services in accordance with the Applicable Laws and shall take all practicable steps to ensure that any Sub-Consultant, as well as the Personnel and agents of the Consultant and any Sub-Consultant, comply with the Applicable Laws. The Consultant shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Consultant. The Consultant shall indemnify and hold harmless the Owner from and against any and all liabilities, damages, claims, fines, penalties and expenses of whatever nature arising or resulting from the violation of such laws by the Consultant.
- d) The Consultant shall perform the Services and carry out its obligations under this Contract with all due diligence, efficiency and economy, in accordance with generally accepted professional techniques and practices, and shall observe sound management practices, and employ appropriate advanced technology and safe and effective equipment, machinery, materials and methods. The Consultant shall always act, in respect of any matter relating to this Owner or to the Services, as a faithful advisor to the Owner, and shall at all times support and safeguard the Owner's legitimate interests in any dealings with Sub-Consultants or Third Parties.

4.16 Owner's Responsibilities

- a) The Owner shall be responsible for access to the plant and the Site and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract.
- b) The Owner shall facilitate plant shut down and controlled operation of the plant reasonably required to enable the Consultant to carry out Residual Life Assessment/ Condition Assessment studies and Energy Audit
- c) The owner shall make available to the Consultant all the plant operation data, Manufacturer's Manual, O&M Manual and other Technical data/information to

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the extent available with the Owner and reasonably required by the Consultant for discharging Services as per the Terms of Reference

- d) The Owner shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Owner to obtain them in the Owner's name, are necessary for the execution of the Contract.
- e) If requested by the Consultant, the Owner shall use its best endeavours to assist the Consultant in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Consultant or SubConsultants or the personnel of the Consultant or SubConsultants, as the case may be, to obtain.

4.17 Taxes & Duties

- a) The Owner shall bear and promptly pay Service Tax along with applicable Surcharge and Cess thereon, in respect of direct transaction between the Owner and the Consultant payable in India as per Indian law. All other Taxes and Duties will be borne by the Consultant.
- b) If any tax exemptions, reductions, allowances or privileges may be available to the Consultant, the Owner shall use its best endeavours to enable the Consultant to benefit from any such tax savings to the maximum allowable extent.

4.18 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Owner by the Consultant herein shall remain vested in the Consultant or, if they are furnished to the Owner directly or through the Consultant by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Owner shall however be free to reproduce all drawings, documents and other material furnished to the Owner for the purpose of the contract.

4.19 Confidential Information

- a) The Owner and the Consultant shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Consultant may furnish to its SubConsultant(s) such documents, data and other information it receives from the Owner to the extent required for the SubConsultant(s) to perform its work under the Contract, in which event the Consultant shall obtain from such SubConsultant(s) an undertaking of confidentiality similar to that imposed on the Consultant.
- b) The obligation of a party, shall not apply to that information which
 - now or hereafter enters the public domain through no fault of that party

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- can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto
- Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

4.20 Conflict of Interest

- a) The Consultant shall not have a Conflict of Interest and any breach hereof shall constitute a breach of the Agreement.
- b) During the term of this Contract and after its termination, the Consultant or any Associate or Consortium Partner thereof and any entity affiliated with the Consultant, as well as any Sub-Consultant and any entity affiliated with such Sub-Consultant, shall be disqualified from providing goods, works, services, loans or equity for any project resulting from or closely related to the Services and any breach of this obligation shall amount to a Conflict of Interest; provided that the restriction herein shall not apply after a period of five years from the completion of this assignment or to consulting assignments granted by banks/ lenders at any time; provided further that this restriction shall not apply to consultancy/ advisory services provided to the Owner in continuation of this Consultancy or to any subsequent consultancy/ advisory services provided to the Owner. For the avoidance of doubt, an entity affiliated with the Consultant shall include a partner in the Consultant's firm or a person who holds more than 5% (five per cent) of the subscribed and paid up share capital of the Consultant, as the case may be, and any Associate thereof.
- c) The Contract Price provided under the provisions of this Contract shall constitute the R&M Consultant's sole remuneration in connection with this Contract or the Services and the Consultant shall not accept for its own benefit any trade commission, discount or similar payment in connection with activities pursuant to this Contract or to the Services or in the discharge of its obligations hereunder, and the Consultant shall use its best efforts to ensure that any Sub-Consultant, as well as the Personnel and agents of either of them, similarly shall not receive any such additional remuneration.

4.21 Representatives

d) Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Owner shall appoint and notify the Consultant in writing of the name of the Project Manager. The Owner may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Consultant without delay. The Owner shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Owner at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

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All notices, instructions, information and other communications given by the Consultant to the Owner under the Contract shall be given to the Project Manager, except as herein otherwise provided.

e) Consultant's Team Leader

- If the Consultant's Team Leader is not named in the Contract, then within *[fourteen (14) days]* of the Effective Date, the Consultant shall appoint the Consultant's Team Leader and shall request the Owner in writing to approve the person so appointed. If the Owner makes no objection to the appointment within *[fourteen (14)]* days, the Team Leader shall be deemed to have been approved. If the Owner objects to the appointment within *[fourteen (14)]* days giving the reason there for, then the Consultant shall appoint a replacement within *[fourteen (14) days]* of such objection.
- The Consultant's Representative shall represent and act for the Consultant at all times during the currency of the Contract and shall give to the Project Manager all the Consultant's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Owner or the Project Manager to the Consultant under the Contract shall be given to the Consultant's Team Leader or, in its absence, its deputy, except as herein otherwise provided. The Consultant shall not revoke the appointment of the Consultant's Representative without the Owner's prior written consent, which shall not be unreasonably withheld. If the Owner consents thereto, the Consultant shall appoint some other person as the Team Leader.
- The Consultant's Team Leader may, subject to the approval of the Owner (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Consultant's Team Leader, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Owner and the Project Manager.
- The Owner may by notice to the Consultant object to any representative or person employed by the Consultant in the execution of the Contract who, in the reasonable opinion of the Owner, may behave inappropriately, may be incompetent or negligent, or may commit a serious breach of the Site regulations. In such cases, the Consultant will arrange suitable replacement.

4.22 Work Program

a) Consultant's Organization

The Consultant's Organization chart and list of key personnel and Team Leader identified for the Project will be appended to the Contract Agreement. The Consultant shall ensure adequate and timely availability of these personnel to work on this Consultancy Services. Consultant will also ensure availability and

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services of any additional personnel required for the successful and timely completion of the Scope of Services as per the Terms of Reference.

b) Program of Performance

Within *[twenty-eight (28)]* days after the date of Notification of Award of Contract, the Consultant shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply, transport, assemble, install and precommissioning the Facilities, as well as the date by which the Consultant reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Consultant to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Consultant shall accord with the Time Schedule included in Appendix 4 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Consultant shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Consultant's actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Consultant shall, at the request of the Owner or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

e) Work Procedures

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Owner and the Consultant, the Consultant may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

4.23 Substitution of Key Personnel

The Owner expects that all the Key Personnel specified in the Bid Proposal shall be available during the execution of R&M Consultancy Services. The Owner will not consider any substitution of Key Personnel except under compelling circumstances beyond the control of the Consultant and the concerned Key Personnel. Such substitution may be permitted only in exceptional cases subject to equally or better qualified and experienced personnel being provided to the satisfaction of the Owner.

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4.24 Sub-Consultant

The R&M Consultant or Consortium Leader or Associate shall not subcontract its entire scope of work back-to-back or otherwise. In any case, appointment of any Sub-Consultant to discharge any part of the Scope of Service under this Contract is subject to Owner's prior written approval. Owner may accept or reject any Sub-Consultant at its discretion.

4.25 Completion Time

The Consultant guarantees that it shall attain Completion of the entire Scope of Service as per the Terms of Reference or part thereof within the Time for Completion specified in the SCC.

4.26 Patents Indemnity

The Consultant shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Owner may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Consultant or the use of the such Facilities.

4.27 Accuracy of Data and Document

The Consultant shall be responsible for accuracy of the data collected by it directly or procured from other entities, the designs, drawings, estimates and all other details prepared by it as part of these services. Subject to the GCC provisions regarding limitation of Consultant's liability, the Consultant shall indemnify the Owner against any inaccuracy in its work which might surface during implementation of the R&M Project, if such inaccuracy is the result of any negligence or inadequate due diligence on part of the Consultant or arises out of its failure to conform to good industry practice. The Consultant shall also be responsible for promptly correcting, at its own cost and risk, the drawings including any re-survey / investigations.

4.28 Liability of R&M Consultant

- a) The R&M Consultant's liability under this Agreement shall be determined by the Applicable Laws and the provisions hereunder.
- b) The Consultant shall, subject to the limitation specified hereunder, be liable to the Owner for any direct loss or damage accrued or likely to accrue due to deficiency in Services rendered by it.
- c) Except in cases of criminal negligence or wilful misconduct by the Consultant, the aggregate liability of the Consultant (R&M Consultant) to the Owner, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Consultant to indemnify the Owner with respect to patent infringement.

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- d) Except in cases of criminal negligence or wilful misconduct by the Consultant, the Consultant shall not be liable to the Owner, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs,.

4.29 Equipment and Material provided by the Owner

Equipment and materials made available to the R&M Consultant by the Owner shall be the property of the Owner and shall be marked accordingly. Upon termination or expiration of this Contract Agreement, the Consultant shall furnish forthwith to the Owner, an inventory of such equipment and materials and shall return to the owner or otherwise dispose of such equipment and materials in accordance with the instructions of the Owner. While in possession of such equipment and materials, the R&M Consultant shall, unless otherwise instructed by the Owner in writing, insure them in an amount equal to their full replacement value.

4.30 Loss of or Damage to Property; Accident or Injury; Indemnification

The Consultant shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with Consultancy Services and by reason of the negligence of the Consultant or its SubConsultants, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Owner, its Consultants, employees, officers or agents.

4.31 Insurance

- a) The Consultant shall, for the duration of this Contract, take and maintain, and shall cause any Sub-Consultant to take and maintain, at its (or the Sub-Consultant's, as the case may be) own cost, but on terms and conditions approved by the Owner, insurance against the risks, and for the coverage, as specified hereunder and in accordance with good industry practice.
- b) Within 15 (fifteen) days of receiving any insurance policy certificate in respect of insurances required to be obtained and maintained under this clause, the Consultant shall furnish to the Owner, copies of such policy certificates, copies of the insurance policies and evidence that the insurance premia have been paid in respect of such insurance. No insurance shall be cancelled, modified or allowed to expire or lapse during the currency of this Contract.
- c) If the Consultant fails to effect and keep in force the aforesaid insurances for which it is responsible pursuant hereto, the owner shall, apart from having other recourse available under this Contract, have the option, without prejudice to the obligations of the Consultant, to take out the aforesaid insurance, to keep in force any such insurances, and pay such premia and recover the costs thereof from the Consultant, and the Consultant shall be liable to pay such amounts on demand by the Owner.

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- d) Except in case of Third Party liabilities, the insurance policies so procured shall mention the Owner as the beneficiary of the Consultant and the Consultant shall procure an undertaking from the insurance company to this effect; provided that in the event the Consultant has a general insurance policy that covers the risks specified in this Agreement and the amount of insurance cover is equivalent to 3 (three) times the cover required hereunder, such insurance policy may not mention the Owner as the sole beneficiary of the Consultant or require an undertaking to that effect.
- e) The risks and coverages shall include but not be limited to the following:
 - i. Third Party liability insurance as required under Applicable Laws, with a minimum coverage of [.....].
 - ii. Employer's liability and workers' compensation insurance in respect of the Personnel of the Consultant and of any Sub-Consultant, in accordance with Applicable Laws.
 - iii. Professional liability insurance for an amount no less than the Agreement Value.
- f) In case of consortium, the policy should be in the name of Consortium Leader and not in the name of individual Members of the consortium.

4.32 Owner's Prior Approval

The Consultant shall obtain the Owner's written prior approval in writing before taking any of the following actions:

- a) Replacing any Key Personnel listed in the Contract Schedule
- b) Discontinuing participation of any Key Personnel in this R&M Consultancy Services during the currency of the Contract
- c) Any other action that is specified in the Tender Document or Contract Agreement.

4.33 Ownership of Documents Prepared by Consultant (R&M Consultant)

- a) All plans, drawings, specifications, designs, reports and other documents (collectively referred to as "Consultancy Documents") prepared by the R&M Consultant (or by the Sub-Consultants or any Third Party) in performing the Services shall become and remain the property of the Owner, and all intellectual property rights in such Consultancy Documents shall vest with the Owner. Any Consultancy Document, of which the ownership or the intellectual property rights do not vest with the Owner under law, shall automatically stand assigned to the Owner as and when such Consultancy Document is created and the Consultant agrees to execute all papers and to perform such other acts as the Authority may deem necessary to secure its rights herein assigned by the R&M Consultant.
- b) The R&M Consultant shall, not later than termination or expiration of this Contract, deliver all Consultancy Documents to the Owner, together with a detailed inventory thereof. The Consultant may retain a copy of such Consultancy Documents. The R&M Consultant, its Sub-Consultants or a Third Party shall not use these Consultancy Documents for purposes unrelated to this Contract without the prior written approval of the Owner.

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- c) The Consultant shall hold the Owner harmless and indemnified for any losses, claims, damages, expenses (including all legal expenses), awards, penalties or injuries (collectively referred to as 'claims') which may arise from or due to any unauthorised use of such Consultancy Documents, or due to any breach or failure on part of the Consultant or its Sub-Consultants or a Third Party to perform any of its duties or obligations in relation to securing the aforementioned rights of the Owner.

4.34 Change in Laws & Regulation

If, after the date *[seven (7)]* days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Consultant and/or the Time for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Consultant has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Owner and the Consultant.

4.35 Force majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Owner or of the Consultant, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within *[fourteen (14)]* days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfil its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
- constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby
- if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.
- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than *[sixty (60)]* days or an aggregate period of more than one hundred and *[twenty (120)]* days on account of one

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or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.

- (g) Force Majeure shall not apply to any obligation of the Owner to make payments to the Consultant herein.

4.36 Change in the Scope of Services

The Owner shall have the right to propose, and subsequently require, the Consultant during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Scope of Services, provided that such Change falls within the general scope of the Services and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the assignment and the technical feasibility. The parties will agree on the change in Contract Price due Change in Scope of Services on mutual consultation basis.

4.37 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Consultant is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:

- Any Change in the Facilities or
- any occurrence of Force Majeure or
- any suspension order given by the Owner or reduction in the rate of progress or
- any changes in laws and regulations or
- any default or breach of the Contract by the Owner, or any activity, act or omission of any other Consultants employed by the Owner or
- any other matter specifically mentioned in the Contract;

By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Consultant.

- (b) Except where otherwise specifically provided in the Contract, the Consultant shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Owner and the Consultant shall agree upon the period of such extension.
- (c) The Consultant shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.38 Termination

(a) Termination for Owner's Convenience

The Owner may at any time terminate the Contract for any reason by giving the Consultant a notice of termination. Upon receipt of the notice of

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termination, the Consultant shall either immediately or upon the date specified in the notice of termination

- (i) Cease all further work.
- (ii) terminate all subcontracts, except those to be assigned
- (iii) remove all Consultant's Equipments from the Site, repatriate the Consultant's and its SubConsultants' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Consultant, subject to the payment, shall
 - deliver to the Owner the data collected during the course of the consultancy services and study reports prepared up to the date of termination
 - Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Consultant or its SubConsultants as at the date of termination in connection with the Facilities.
 - In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Consultant the following amounts
 - the Contract Price, attributable to the parts of the Services executed by the Consultant as on the date of termination
 - the costs reasonably incurred by the Consultant in the removal of the Consultant's Equipment from the Site and in the repatriation of the Consultant's and its SubConsultants' personnel
 - any amounts to be paid by the Consultant to its SubConsultants in connection with the termination of any subcontracts, including any cancellation charges
 - the additional cost of satisfying other obligations, commitments and claims that the Consultant may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Consultant's Default

- (i) The Owner, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons thereof to the Consultant:

the Consultant becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Consultant is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Consultant takes or suffers any other analogous action in consequence of debt

If the Consultant assigns or transfers the Contract or any right or interest therein in violation of the provision.

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If the Consultant, in the judgement of the Owner has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

(ii) If the Consultant

- has abandoned or repudiated the Contract
- has without valid reason failed to commence the Consultancy Services promptly for more than *[twenty eight (28)]* days after receiving a written instruction from the Owner to proceed
- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient personnel and other resources to execute the Services in the manner specified in the program at rates of progress that give reasonable assurance to the Owner that the Consultant can attain Completion of the Services by the Time for Completion as extended
- then the Owner may, without prejudice to any other rights it may possess under the Contract, give a notice to the Consultant stating the nature of the default and requiring the Consultant to remedy the same. If the Consultant fails to remedy or to take steps to remedy the same within *[fourteen (14)]* days of its receipt of such notice, then the Owner may terminate the Contract forthwith by giving a notice of termination to the Consultant.

(iii) The Consultant shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work,
- terminate all subcontracts, except those to be assigned to the Owner
- deliver to the Owner the data collected during the course of the consultancy services and study reports prepared up to the date of termination
- Deliver to the Owner all drawings, specifications and other documents prepared by the Consultant or its SubConsultants as at the date of termination in connection with the Services.

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- remove all Consultant's Equipments from the Site, repatriate the Consultant's and its SubConsultants' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition

(c) Termination by Consultant

i. If

- the Owner has failed to pay the Consultant any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Consultant may give a notice to the Owner that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Owner to remedy the same, as the case may be. If the Owner fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within [fourteen (14) days] after receipt of the Consultant's notice, or

- the Consultant is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, ,
then the Consultant may give a notice to the Owner thereof, and if the Owner has failed to pay the outstanding sum, to approve the invoice or supporting documents, to give its reasons for withholding such approval, or to remedy the breach within [twenty eight (28) days] of such notice, or if the Consultant is still unable to carry out any of its obligations under the Contract for any reason attributable to the Owner within twenty eight (28) days of the said notice.

If the Owner becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Owner takes or suffers any other analogous action in consequence of debt.

ii. If the Contract is terminated, then the Consultant shall immediately

- cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d)(ii)
- remove all Consultant's Equipment from the Site and repatriate the Consultant's and its SubConsultant's personnel from the Site

(v) The Consultant, subject to the payment, shall

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- deliver to the Owner the data collected during the course of the consultancy services and study reports prepared up to the date of termination
- Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Consultant or its SubConsultants as at the date of termination in connection with the Facilities.

In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Consultant the following amounts

- the Contract Price, attributable to the parts of the Services executed by the Consultant as on the date of termination
- the costs reasonably incurred by the Consultant in the removal of the Consultant's Equipment from the Site and in the repatriation of the Consultant's and its SubConsultants' personnel
- any amounts to be paid by the Consultant to its SubConsultants in connection with the termination of any subcontracts, including any cancellation charges
- the additional cost of satisfying other obligations, commitments and claims that the Consultant may in good faith have undertaken with third parties in connection with the Contract.

4.39 Assignment

The Consultant shall not, without the express prior written consent of the Owner, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Consultant shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract.

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Renovation & Modernization Consultancy Services for [-----]
- **Bid Document No. :** [-----]
- **The Owner is:**
 - Name of Owner: [-----]
 - Address of Owner: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]
- **The Project Manager is:**
 - Name of Project Manager: [-----]
 - Address of Project Manager: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]

5.2 Effective Date

The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization Consultancy work as per the scope of work under this tender by the Consultant.

The following three activities will be completed within *[two (2)]* months from the date of Letter of Acceptance:

(a) The contract agreement will be executed by the Owner and the Consultant. (b) The Consultant will submit to the Owner the Contract Performance Security, any Additional Performance Security associate etc if applicable, and the Advance Payment Security.

(c) The Owner will pay the Consultant the Advance Payment as per the Terms of Payment.

(d) The Consultant will submit the Inception Report and incorporate any change suggested by Owner in the Inception Report

The Owner will make the advance payment promptly once Consultant has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the

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Consultant to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Consultant under this tender:

	Task/Milestone	Time for Completion
	Phase-I	
1.	[Completion of RLA Study]	[.....]from Effective Date
2.	[Completion of Energy audit]	[.....]
3.	[.....]	[.....]
4.	[Submission of Draft Feasibility Report.]	[.....]
5.	[Submission of Final Feasibility Report]	[.....]
	
	[Submission of Draft Feasibility Report.]	[.....]
	[Submission of Final Feasibility Report]	[.....]
	Phase-II	
1	[Submission of Draft Tender Document]	[.....] from Notice to Proceed for Phase-II activities
2	[Submission of Final Tender Document]	

	[Submission of Techno-Commercial Bid Evaluation Report]	[.....] from Techno-Commercial Bid Opening Date
	[Submission of Price Bid Evaluation Report]	[.....] from Price Bid Opening Date

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5.4 NOT USED

5.5 NOT USED

5.6 Contract Price

- a) The Contract Price shall be as (Contract Price and Terms of Payment) of the Form of Contract Agreement.
- b) The Consultant shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

5.7 Terms of Payment

- a) The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement.
- b) No payment made by the Owner herein shall be deemed to constitute acceptance by the Owner of the Services or any part(s) thereof.
- c) All the payments will be made in INR.

5.8 Contract Securities

- a) The Consultant shall provide the securities specified below in favour of the Owner at the times, and in the amount, manner and form specified below.
- b) Advance Payment Security
 - The Consultant shall, within *[thirty (30)]* days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to *[ninety (90)]* days beyond the schedule date of Completion of R&M Consultancy Services.
 - The security shall be in the form of an Unconditional Bank Guarantee. The Advance payment Security shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of Services received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Services received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of R&M Consultancy Services and Owner's Acceptance thereof. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Consultant's responsibility and liabilities under the Contract including in respect of the Services for which the reduction in the value of security is allowed.

c) Performance Security (Contract Performance Bank Guarantee)

The Consultant shall, within *[thirty (30)]* days of the notification of award, provide a security for the due performance of the Contract for five percent (5%) of the Contract Price with an initial validity upto *[ninety (90)]* days beyond the Scheduled Completion Date for R&M Consultancy Services.

If the bidder is a Consortium of Consultancy firms, in addition to the Contract Performance Bank Guarantee (CPBG) of 5% furnished by the Consortium Leader, each of the other consortium member shall furnish Additional Contract Performance Bank Guarantee equal to 2% of Contract Price.

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Capacity [..] of [Name of the Power Plant]**

[Logo of Utility]

If the Bidder meets Qualification Requirement on the strength of Associate (s), in addition to the Contract Performance Bank Guarantee (CPBG) of 5% furnished by the Bidder (Principal Consultant), each Associate shall furnish Additional Contract Performance Bank Guarantee equal to 2% of Contract Price.

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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	Sample Format for Letter of Consent to be furnished by the Bidder and Associate
Schedule F1	Price Schedule
Schedule F2	Overall Time Schedule
Schedule F3	Deviation Schedule to Tender Document Section-I Commercial
Schedule F4	Deviation Schedule to Terms of Reference
Schedule F5	Details of Key Personnel
Schedule F6	Format for Curriculum Vitae (CV) of Key Personnel
II	Forms and Contract Schedules to form part of Contract
Annexure-F	Form of Contract
Contract Schedule-1	Terms of Payment
Contract Schedule-2	NOT USED
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Sub-Consultants
Contract Schedule-5	List of Key Personnel
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Security

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ANNEXURES & SCHEDULES

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.: Bank Guarantee No:
Date :

To:
 [Details of Designated Official]
 [-Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [.....] dated [.....] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [.....] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [R&M Consultancy Services package for], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [.....] (in words and figures) valid for 300 days from [.....] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [.....] Bank at (local address) [.....] having our Head Office at [.....] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of

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[.....] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

This Guarantee shall be irrevocable and shall remain valid upto [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorised officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
Name :
Designation :
Staff Code No. :

Banker's Seal :
Date :

Witness:

- Signature :
Full name in block letters :
Designation :
Address :
- Signature :
Full name in block letters :
Designation :
Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[-Name of Utility] [.....]

Sub : ____ (Name of Package) [.....]

Tender No. [.....]

Having carefully examined the Tender Specifications issued to us for your Tender No. [.....] dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the 'works' in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR _____ (Indian Rupees [.....] only) in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of 240 (Two Hundred Forty) days from the date of opening of bids by Purchaser and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to [Name of Utility], assignees or authorized nominees such sums of

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money as are stipulated in conditions contained in Tender Specification and agree to furnish Bank Guarantee for Contract Performance as per the proforma prescribed by Purchaser and for the sum equal to 5% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Purchaser is not bound to accept the lowest or any Bids received and Purchaser has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Purchaser and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From: Dated:

[.....]

[.....]

[.....]

To :

[.....]

[.....]

[.....]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire scope of work as described in the Terms of Reference in conformity with the specifications and Terms of Reference, as per prices quoted by us in the Schedule of Prices *[Schedule]* enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Employer *[Name of Utility]* and for the sum equal to 5% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Employer is received and accepted by the Employer

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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ANNEXURE – D
(SAMPLE FORMAT)

LETTER OF CONSENT

TO BE FURNISHED BY THE BIDDER and ASSOCIATE/Consortium Member

We hereby declare that the undersigned firm [-----] (Name and Complete address of the Associate/Consortium Member hereby agrees to associate with [-----] (Name and Complete address of the Bidder) for the successful completion of part scope of service as enclosed in the attachment (authenticated by the Bidder and Associate/Consortium Member for [-----] Package for the [-----] Project at [-----] in the state of [-----], India. We also hereby undertake to ensure high professional standard and timely completion of our scope of services of [-----] package and also depute our technical experts from time to time as applicable to the place of work / Owner's Project site.

On award of LOA, we the Associate/Consortium Member agree to furnish an on demand additional bank guarantee for 2% of Contract Price.

1. Witness

For Associate/Consortium Member

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address

Seal of the Company

2. Witness

For Bidder

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address:

Seal of the Company:

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ATTACHMENT TO THE LETTER OF CONSENT
Scope of Work of the Associate/Consortium Member:

For Bidder

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

For Associate/Consortium Member

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

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SCHEDULE – F1

PRICE SCHEDULE

S.No.	Description	INR
1	Price for RLA Study, Condition Assessment Study and LE Study (On Lump Sum Fixed Price Basis)	
2	Price of Energy Audit (On Lump Sum Fixed Price Basis)	
3	Price of studies for identification of R&M Option and preparation of Cost Estimate for R&M options (On Lump Sum Fixed Price Basis)	
4	Preparation of Feasibility Report (On Lump Sum Fixed Price Basis)	
5	Preparation of Detailed Project Report (On Lump Sum Fixed Price Basis)	
6	Price for providing support for obtaining regulatory approval (On Lump Sum Fixed Price Basis)	
7	Price for Basic Design & Engineering, Preparation of Tender Documents and Support for Vendor Selection (On Lump Sum Fixed Price Basis)	
8	Price of any additional Work/Service that the Bidder feels required for completing its scopes as per ToR and is not included at sl no. 1 to 6 above. (On Lump Sum Fixed Price Basis) Bidder to give sufficient detail for such work/service and detailed break up quoted price.	
9	Total Price excluding Service Tax on Direct Transaction between the Owner & Consultant (Sum of 1 to 8)	
10	Service Tax on Direct Transaction between the Owner & Consultant	
11	Total Price including Service Tax on Direct Transaction between the Owner & Consultant	

	Signature	:	
	Name	:	
	Designation	:	
	Company	:	
Company Seal			
	Date	:	

* * * * *

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SCHEDULE – F2

OVER ALL TIME SCHEDULE

(Bidder to fill-in and submit with its Bid)

S.No	Work Description	Days from Effective Date	
		Start	Finish

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I) . The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I) , then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F4

DEVIATION SCHEDULE TO TERMS OF REFERENCE

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Purchaser's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Purchaser's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F5
DETAILS OF KEY PERSONNEL

Sl No	Designation	Name	Educational Qualification	Professional Experience (years)	Present Employer	Employed with present Employer Since	Minimum No of Hours to be Deployed for this Consultancy Assignment
1	Team Leader						
2	Boiler Expert						
3	Turbine Expert						
4	Mechanical BoP Expert						
5	Electrical Expert						
6	C&I Expert						
7	Civil Expert						

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F6

Format for Curriculum Vitae (CV) of Key Personnel

1. Proposed Designation (As per Schedule-F5) :
2. Name of Key Person:
3. Date of Birth:
4. Nationality:
5. Educational Qualifications:
6. Employment Record:
(Starting with present position, list in reverse order every employment held.)
7. List of projects on which the Personnel has worked

SI No	Name of Project	Description of Responsibilities	Start Date and End Date of Association

8. Other present work commitment
9. Details of the role in the subject R&M Consultancy Services assignment and the time duration for which services are required for this assignment.

Certification:

- 1 I am willing to work on the R&M Consultancy Services assignment for [.....] project of [.....] and I will be available for entire duration of the Project assignment as required.
- 2 I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications and my experience.

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Place.....(Signature and name of the Key Personnel)

(Signature and name of the authorized signatory of the Bidder)

Notes:

Use separate form for each Key Personnel

* * * * *

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Form of Contract Agreement

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Form of Contract Agreement

THIS CONTRACT AGREEMENT is made the _____day of _____, 20_____.
BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of [country of Employer] and having its principal place of business at [address of Employer] (hereinafter called "the Employer"), and (2) [name of Contractor], a corporation incorporated under the laws of [country of Contractor] and having its principal place of business at [address of Contractor] (hereinafter called "the Contractor")

WHEREAS the Employer desires to engage the Contractor to provide R&M Consultancy Services comprising .
[.....]
[.....]
[.....]

("the R&M Consultancy Services") and the Contractor have agreed to such engagement upon and subject to the terms and conditions hereinafter appearing.
NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

- a) Contract Documents means this signed Contract agreement and its annexure/Contract Schedules, and the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. The following will constitute the Contract Documents:
 - i. The signed Contract Agreement & the annexure/ Contract Schedule thereto (highest precedence)
 - ii. Letter of award.
 - iii. Special Condition of Contract
 - iv. General Condition of Contract
 - v. Terms of Reference.
 - vi. The bid & its schedules/ attachment submitted by the contractor.
- b) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- c) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract

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- v. Terms of Reference.
- vi. The bid & schedules/ attachment submitted by the contractor.

1.3 Definitions

The Definitions of terms and expressions shall be as per General Conditions of Contract (GCC).

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder: [amount in local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this shall be as follows:

Task/Milestone	Time for Completion
For Phase-I	
[.....]	By [.....] months from Effective Date
[.....]	[.....]
[.....]	By [.....] months from Effective Date
[.....]	[.....]
[.....]	
For Phase-II	
[.....]	By [.....]weeks from Phase-II Notice to Proceed
[.....]	[.....]
[.....]	[.....]
[.....]	[.....]

The detailed Time Schedule shall be as per Contract Schedule 2.

Contract Schedules

The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

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IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]
----- [Title]

In the presence of -----

Signed by for and on behalf of the Contractor

-----[Signature]
----- [Title]

In the presence of -----

CONTRACT AGREEMENT

dated the -----day of-----, 20_ _

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

Contract Schedule 1 : Terms of Payment
Contract Schedule 2 : NOT USED
Contract Schedule 3 : Time Schedule
Contract Schedule 4 : List of Sub-Consultants
Contract Schedule 5 : List of Key Personnel

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Contract Schedule-1

Terms of Payment

The Employer shall pay the Contractor in the following manner and at the following times, on the basis of the Price Break down given in the Section on Price Schedules. Payments will be made in Indian Rupees. Application for payment in respect of part deliveries may be made by the Contractor as work proceeds.

I. Terms of Payment for Price for RLA Study, Condition Assessment Study and LE Study:

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
2	20% of the Lump Sum Price	Completion of all tests for Residual Life Assessment and Condition Assessment
3	30% of the Lump Sum Price	Submission of Draft RLA Study Report
4	30% of the Lump Sum Price	Submission of Final RLA Report and Owner's acceptance thereof
5	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

II. Terms of Payment for Price for Energy Audit:

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
2	20% of the Lump Sum Price	Completion of all tests and

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		measurement for Energy Audit
3	30% of the Lump Sum Price	Submission of Draft Energy Audit Report
4	30% of the Lump Sum Price	Submission of Final Energy Audit Report and Owner's acceptance thereof
5	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

III. Terms of Payment for Price of studies for identification of R&M Option and preparation of Cost Estimate for R&M options

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
2	20% of the Lump Sum Price	Submission of details regarding identified R&M options and their scope of work to the Owner
3	20% of the Lump Sum Price	Acceptance of R&M options and their scope of work by Owner
4	20% of the Lump Sum Price	Submission of details Cost Estimate for R&M options to the Owner
5	20% of the Lump Sum Price	Acceptance of Cost Estimate for R&M options by the Owner
6	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

IV. Terms of Payment for Price of Preparation of Feasibility Report

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract
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		Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
2	40% of the Lump Sum Price	Submission of Draft Feasibility Report to the Owner
3	40% of the Lump Sum Price	Submission of Final Feasibility Report and Owner's acceptance thereof
4	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

V. Terms of Payment for Price of Preparation of Detailed Project Report

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
2	40% of the Lump Sum Price	Submission of Draft Detailed Project Report to the Owner
3	40% of the Lump Sum Price	Submission of Final Detailed Project Report and Owner's acceptance thereof
4	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

VI. Terms of Payment for Price for providing support for obtaining regulatory approval

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract
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		Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
2	40% of the Lump Sum Price	Preparation of application and other inputs for submission to Regulator/Statutory Authority
3	40% of the Lump Sum Price	Preparation of replies to all queries raised by the Regulator and attending all the required meeting/hearings with Regulator/Statutory Authority
4	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

VII. Terms of Payment for Basic Design & Engineering, Preparation of Tender Documents and Assistance for Vendor Selection

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
	[%] of the Lump Sum Price	[Submission of Draft Tender Documents for RM Package-1]
	[%] of the Lump Sum Price	[Issue of RFP for R&M Package-1]
	[%] of the Lump Sum Price	[Completion of Techno-Commercial Bid Evaluation for R&M Package-1]
	[%] of the Lump Sum Price	[Formation of Contract for R&M Package-1]
	[%] of the Lump Sum Price	[Submission of Draft Tender Documents for RM Package-2]
	[%] of the Lump Sum Price	[Issue of RFP for R&M Package-2]
	[%] of the Lump Sum Price	[Completion of Techno-Commercial Bid Evaluation for R&M Package-2]

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	[%] of the Lump Sum Price	[Formation of Contract for R&M Package-2]

	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

VIII. Terms of Payment for Price of any additional Work/Service

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract Agreement, (3) Submission of Contract Performance Security, Additional Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
2	90% of the Lump Sum Price	Owner's Acceptance that the Contractor (R&M Consultant) has successfully and completely discharged the R&M Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

IX. NOT USED

X. Terms of Payment for Taxes & Duties

Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other Tax or Duty payable by Employer to the Contractor as per the Terms & Conditions of Contract shall be reimbursed on production of evidence of payment by Contractor.

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XI. Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor upon submission of evidence by the Contractor to the Employer as to the Contractor having paid such variation.

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Contract Schedule-2

NOT USED

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Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

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Contract Schedule-4

LIST OF SUB-CONSULTANTS

[List of approved subcontractors shall be placed]

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Contract Schedule-5
LIST OF KEY PERSONNEL

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Consultant]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:

Bank Guarantee No:

Date:

To:

[Name & Address of Owner (Utility)]

.....]

Dear Sirs,

1 In consideration of the [...] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Consultant's Name] having its registered office at.....hereinafter referred to as the 'CONSULTANT', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount in words], [amount in figures] and the same having been unequivocally accepted by the CONSULTANT and the CONSULTANT having agreed to provide a **Contract Performance Guarantee** for the faithful performance of the entire CONTRACT under the CONTRACT equivalent to 5% (five percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONSULTANT by reason of any breach of the said CONSULTANT of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to

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Rs.....(Rupees.....only). Any such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONSULTANT or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONSULTANT. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 4 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONSULTANT and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONSULTANT or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 5 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONSULTANT to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 6 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Consultant or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 7 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONSULTANT's liabilities.
- 8 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONSULTANT(S).
- 9 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended

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from time to time for such period as may be desired by [Name of Consultant.....] on whose behalf this guarantee has been given.

10 Signed at.....this.....day of.....20.....

Signature :

Name :

Designation :

Staff Code No :

Bank Seal

Date :

Witness:

1. Signature
Full name in block letters :
Occupation :
Address :
2. Signature :
Full name in block letters :
Occupation :
Address :

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONSULTANT**

SECTION-II – TERMS OF REFERENCE

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONSULTANT

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

SECTION-II – TERMS OF REFERENCE

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1 GENERAL

{Briefly explain the need and objective of R&M, give reference of the studies carried out to assess the health of the unit and the progress made till date for the implementation of R&M}

1.1 Project Background

{Give brief description of the unit and the latest performance parameters in terms of Average Load during the year, PLF, Availability Auxiliary Power Consumption, Heat Rate and the average Calorific Value of Coal being presently used in the Boiler.}

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2 ROLE OF R&M CONSULTANT

Role of R&M Consultant shall be as follows:-

- a. To assess the health condition of major systems; equipments and their components.
- b. To assess the causes of deterioration in performance and efficiency of the equipments/systems.
- c. To provide solutions for removing the deficiencies in performance and efficiency along with cost impact.
- d. To work out R&M options for improving the performance, output rating, extending the life of the plant and reducing the levels of emission from the unit.
- e. To carry out cost benefit analysis of various options and recommend the most attractive option for deciding the scope of work for R&M.
- f. To obtain necessary approvals from the concerned Regulatory Commission.
- g. Basic Design & Engineering and Preparation of Tender Documents.
- h. Support for Vendor Selection (up to placement of Letter of Award).

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3 SCOPE OF SERVICES

The detailed scope of services shall be as described below:

3.1 Data Collection

To collect the following data/information from the Employer:

- i) Operation data for the current year and the previous years.
- ii) Details of forced outages during the current and the previous years.
- iii) Information about the replacements / refurbishments done during the previous years.
- iv) Earlier reports of RLC/CA studies and Energy Audit Studies carried out, if any.
- v) Coal quality (along with its analysis) to be considered for redesign.
- vi) Any other information needed by R&M Consultant like original design specifications and drawings.

3.2 Studies to be carried out:

The R&M Consultant shall carry out the following studies through his team of experts:-

- i) Cold walk down survey of the plant covering all major systems/equipments.
- ii) Hot walk down survey of plant covering all major systems/equipments.
- iii) Residual Life Assessment / Condition Assessment of all applicable systems/equipments, including but not limited to the carrying out of following tests/studies:
 - a) Visual examinations
 - b) Fiberscopic /Boroscopic Inspections
 - c) Dye Penetration Tests
 - d) Magnetic Particle Inspection
 - e) Ultrasonic scanning
 - f) Ultrasonic thickness testing
 - g) Oxide Scale Thickness Measurements
 - h) In-situ Microstructure Replica Analysis
 - i) Hardness Measurement
 - j) Dimensional Measurement
 - k) Steam Path Audit
 - l) ELCID Test
 - m) Recurrent Surge Oscillograph (RSO) Test
 - n) Tan Delta Test
 - o) Destructive Tests to check the mechanical properties like tensile strength, yield strength, elongation etc.
- iv) Energy Audit:

R&M Consultant shall carry out the Energy Audit / Performance Tests of all major equipments/systems, including but not limited to the following:

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- b) Performance Test and Energy Audit of Air Pre-heaters.
- c) Performance Test and Energy Audit of Mills.
- d) Performance Test and Energy Audit of ID Fans, FD Fans and PA Fans.
- e) Performance Test of ESP.
- f) Performance Test for determining the Heat Rate of Turbine Generator.
- g) Performance Test of Condensers.
- h) Performance Test of LP/HP Feed Water Heaters.
- i) Performance Test and Energy Audit of CEPs/BFPs
- j) Performance Testing and Energy Audit of Water Intake Pumps, CW Pumps, RW Supply Pumps, Clarified Water Supply Pumps, DM Water Supply Pumps and Ash slurry Pumps.
- k) Cooling Tower Performance Test.
- l) Performance Test and Energy Audit of Compressed Air System.
- m) Performance Test and Energy Audit of Air Conditioning System.
- n) Energy Audit of Thermal Insulation.
- o) Energy Audit of Illumination System.
- p) Any other system considered important by the Utility.

3.3 Working out of R&M Options:

Working out of R&M options for the unit considering the following:

- i) Improving the Performance Parameters.
- ii) Increasing the Efficiency of equipments/systems.
- iii) Reducing the level of emissions so as to comply with the statutory norms.
- iv) Increasing the output from the unit.
- v) Extending the life of the unit by 20/25 years.

3.4 Cost Benefit Analysis:

Carrying out the cost benefit analysis of various options and arriving at the most attractive solution for the R&M of the unit.

3.5 Obtaining necessary approval:

The Consultant shall assist the Employer in obtaining necessary approval of the concerned Regulatory Commission.

3.6 Selection of R&M Contractor:

The Consultant will prepare RFQ & RFP for the selection of R&M Contractor. After the receipt of the Bids, the Consultant will prepare the Bid Evaluation Report.

3.7 Schedule For Completion Of Task:

The Contract will be implemented in accordance with the services indicated. The Consultant shall prepare and submit well in advance the complete schedule of completion of work and the schedule of manpower to be deployed.

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3.8 Final outputs required of the Consultant:

The following outputs are required from the Consultant:

1. Inception report within 30 days of date of effectiveness.
2. Residual Life Assessment / Condition Assessment Report.
3. Energy Audit Report.
4. Feasibility Report indicating various R&M options and their cost impact as well as selection of R&M option to be implemented.
5. Detailed Project Report.
6. RFQ & RFP for the R&M Contractor.
7. Technical Bid Evaluation Report for the selection of R&M Contractor.
8. Monthly Progress Reports.

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4 FACILITIES TO BE PROVIDED BY THE CLIENT:

Facilities which will be provided to the Consultant by the Client will include the following: -

A. Facility for the visiting Consultant:

- Lodging in Business Class Hotel or equivalent accommodation.
- Local conveyance.

B. Facility for the manpower posted at site:

- The accommodation will be provided either in the plant colony or in the guest house.
- The available Canteen / Mess facility.
- Temporary office space with intercom phone connected to PBX. (Outside / International calls on chargeable basis.)

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5 KEY PROFESSIONAL POSITIONS WHOSE CV WOULD BE EVALUATED:

S. No.	Key Position	Area of Specific Expertise desired	Minimum Qualification and Professional Experience Desired
1	Team Leader	Overall Management Team of R&M Consultant	Graduate Engineer with minimum 15 years relevant experience of Boiler / Turbine design/erection/commissioning preferably of 200 MW or above capacity. Good knowledge of project & safety aspects. The proposed individual should also have direct experience of handling an EPC Project of coal fired thermal power plant of 200 MW or above capacity.
2	Boiler Expert	Design- Engineering / Production, Project planning Erection and Commissioning	Graduate Mechanical Engineer with at least 5-10 years experience in the relevant fields, including direct experience of Boiler design/ erection /commissioning preferably of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.
3	Turbine Expert	Design- Engineering / Production, Project planning Erection and Commissioning	Graduate Mechanical Engineer with at least 5- 10 years experience in the relevant fields, including direct experience of Turbine design/ erection/ commissioning preferably of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.
4.	Mechanical BoP Expert	Design- Engineering / Production, Project planning Erection and Commissioning.	Graduate Mechanical Engineer with at least 5- 10 years experience in the relevant fields, including direct experience of Mechanical BoP of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.
5	Electrical Expert	Design- Engineering / Production, Project planning Erection and Commissioning	Graduate Electrical Engineer in Electrical Systems with at least 5-10 years experience in the relevant fields, including direct experience of design /erection/commissioning of Electrical Equipment /systems preferably of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.
6	Control and Instrumentation Expert	DCS Installation and Commissioning	Graduate Instrumentation Engineer with at least 5-10 years experience in the relevant fields. Including direct experience of design/ erection/ commissioning of electrical systems preferably of 200 MW or above capacity.

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S. No.	Key Position	Area of Specific Expertise desired	Minimum Qualification and Professional Experience Desired
7	Civil Expert	Design- Engineering/ Construction of Civil and Structural works.	Graduate Civil Engineer with at least 5-10 years experience in the relevant fields, including direct experience of Construction of Civil and Structural works of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.

Note:

After award of the contract the client expects all the proposed key personnel to be available during implementation of the contract as per the agreed staffing schedule at the time of negotiation. The Utility expects that Consultant will keep experts same throughout the contract period. If any replacement is required, the Consultant should ensure that there is a reasonable overlap between the staff to be replaced, wherever feasible/possible.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
IMPLEMENTATION SUPPORT CONSULTANT FOR
RENOVATION & MODERNIZATION**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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IMPLEMENTATION SUPPORT CONSULTANT FOR
RENOVATION & MODERNIZATION**

**RENOVATION & MODERNISATION
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1.0 INVITATION FOR BID

Tender No : [-----]

1.1 Introduction

{Give brief introduction about the name, ownership, business & Power Projects of the utility inviting bid proposal for Implementation Support Consultancy Service}

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, is planning to undertake Renovation & Modernization of Unit No.[XX] of the [XXX] Power Plant and desires to appoint a Implementation Support Consultant for the same. *[Name of The Utility]*, invites sealed Bid Proposals in English language from Prequalified Applicants for the Implementation Support Consultancy Services for Renovation & Modernization of Unit No.[XX] of the [XXX] Power Plant as per scope of work given in Section-II Terms of Reference.

1.3 Brief Scope of Work

Scope of work of the Implementation Support Consultant will include:-

- To provide support to *[Name of the Utility]* during detailed engineering, supply, implementation and commissioning of R&M works.
- To review the detailed engineering drawings/design calculations, schedule planned for execution and commissioning of all the works in line with the broad parameters of accepted design.
- Preparation of work schedules and monitoring the progress of R&M works through close involvement with the Contractors and other agencies on behalf of Employer.
- Assistance to Employer in decisions making and in taking timely actions to ensure schedule adherence during the tenure of R&M project.
- To flag critical problems as and when arises during the tenure of R&M project to Employer and suggest suitable remedial measures to control the situation.

To provide assistance to the Employer in addressing any techno commercial / contractual and regulatory issues as and when these may arise during the course of the R&M project.The detailed scope of work is given in Terms of Reference Section-II.

1.4 Tender Details

(a)	Cost of Tender Documents	:	INR [---]
(b)	Bid Guarantee Amount	:	INR [---]
(c)	Date of issuance of Tender Document	:	[-----]

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Tender Document for Selection of Implementation Support Consultant for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
--	-------------------

(d)	Date & Time of pre-Bid Conference	:	[-----]
(e)	Last Date & Time of Receipt of Bid (Both Part I & Part II)	:	[-----]
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of Consultancy Services shall be as per SCC.

1.6 Bid Submission

- (a) The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.
- (b) The Bid proposals are to be submitted in two parts in separate sealed covers as follows:
 - Part I** : Bid Guarantee and Technical & Commercial Proposal without prices
 - Part II** : Price Schedule.
- (c) All other terms and conditions along with the Terms of Reference, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- (d) Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:

[Designation, Address and Contact details.....]

..... /
- (e) Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- (f) The Bid Prices must be quoted in Indian Rupees. All payments for the entire scope will be made in Indian Rupees.
- (g) Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- (h) The Tender Documents are meant for the exclusive purpose of bidding against the subject Consultancy Services tender and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Employer, intends to carry out the Renovation & Modernization of [Unit no.-XX ----- of the XXXX Power Plant]. [Name of The Utility] desires to appoint a Implementation Support Consultant.

Under the subject Tender, [Utility] invites bid for Implementation Support Consultancy Services to be carried out as per the accompanying Terms of Reference. The Bidder shall submit the offer for complete scope of work indicated in the Terms of Reference.

2.2 Address and Contact Details of Employer

[Designation, Address and Contact details

-----/

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Employer will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.5 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.6 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents.

2.7 Time Schedule

The completion Time Schedule for Completion of Implementation Support Consultancy Services shall be as given in the SCC.

2.8 Tender Documents

The scope of contract, terms of reference, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following Sections:

Section – I	:	Commercial Conditions
Section– I, Chapter-1	:	Invitation for Bid
Section – I, Chapter-2	:	Instructions To Bidders
Section – I, Chapter-3	:	General Project Information

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Section – I, Chapter-4	:	General Condition of Contract (GCC)
Section – I, Chapter-5	:	Special Condition of Contract (SCC)
Section – I, Chapter-6	:	Forms & Schedules
Section – II	:	Terms of Reference

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Employer.

Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Employer in writing by post or by e-mail followed by postal confirmation at the Employer's address indicated in ITB. The Employer will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than fifteen (15) days prior to the deadline for submission of bids prescribed by the Employer. Employer's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Employer will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operation and does not in any way adversely impact the interest of the Employer. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Employer may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the Tender Documents.

The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.9 Preparation of Bids

2.9.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is

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accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.9.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

The bidders are required to submit, the bids for the Implementation Support Consultancy Services in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Methodology & Work Plan for discharging the consultancy services as per Terms of Reference, Details of Key Personnel along with their Curriculum Vitae, Deviations to Terms of Reference, Deviation to commercial Conditions, Overall Completion Time Period & Network Schedule, Resource Deployment Schedule, Detail of Sub-Consultants, Details of the present commitments & details of contracts in hand etc. Part-II Bid will comprise Quoted Price. Initially, only the Part-I Bid will be opened and Part-II Bid will be kept in safe custody.

The Part-I Bid will be checked for responsiveness to techno-commercial conditions and a detailed Technical Evaluation will be carried out to assign a Technical Score to each Bid. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions and Technical Score is above a specified level.

2.9.3 Bid Submission

- (1). Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2). All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered.
- (3). *[One original and 3 (three) identical]* copies of the original with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., "Original", "Copy No. 1", "Copy No. 2" and "Copy No. 3").
- (4). In the event of discrepancy between "Original" and any copy of the bids, the hard copy of Original shall prevail.
- (5). All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (6). The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (7). The Bidder's Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (8). The Bid shall be submitted to [-----]. Bid submitted to any other office of Employer is liable for rejection. Bids submitted by Telefax or e-mail will be rejected

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- (9). Employer will receive Bids in respect of entire scope of work as set forth in the accompanying Terms of Reference. All bids shall be prepared and submitted in accordance with the Tender Documents.
- (10). Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Terms of Reference in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11). A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Employer's rights or the successful Bidder's obligations under the contract.
- (12). Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13). Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Contractor under the Contract.

2.9.4 Bid Guarantee

- (1). The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of "[-----]" payable at "[-----]".
- (2). The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank. Foreign Bidders may submit the Bank Guarantee from any bank in India as above or from any foreign bank which is in the approved list of RBI.
- (3). Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Employer at ([-----]). In the event of any deviation in this regard, the decision of Employer as to whether the same could be accepted or not, will be final and binding on the Bidder.
- (4). The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Employer.

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- (5). No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified herein above or from banks not specified hereinabove will be liable for rejection.
- (6). Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7). The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Employer or fails to submit Contract Performance Security (Bank Guarantee).
- (8). The Bid Guarantee of all unsuccessful Bidders shall be returned after selection of the successful Bidder. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Employer and acceptance thereof.

2.9.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part– I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part–I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Employer, at its discretion, may consider appropriate, shall be read out.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.
3. Employer takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

2.10 Composition of Techno Commercial Bid (Part-I Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 3 (three) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B of this Section).
- (ii). Bid Guarantee- as per Annexure A.
- (iii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iv). Signed copy of all the corrigendum's/amendments/clarifications, if any issued for the tender
- (v). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (vi). Deviations to the Commercial Conditions, if any, as per Schedule – F3.
- (vii). Deviations to Terms of Reference, if any, as per Schedule – F4.
- (viii). Methodology and Work Plan for completing different tasks under the Consultancy Assignment. Bidder to indicate the scope of work to be

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covered with sufficient details regarding the tasks and subtasks to be covered.

- (ix). Details of Key Personnel as per Schedule – F5. Bidder to indicate the minimum number of hours each identified key person will spend on the Consultancy Assignment
- (x). Curriculum Vitae of each key person as per Schedule-F6
- (xi). Organization Structure and Team Composition (Both Professional Staff and Support Staff)
- (xii). Staffing Schedule describing month-wise deployment of personnel
- (xiii). Details of the present commitments of the Bidder, details of contracts in hand
- (xiv). Details of Sub-Consultants, if any

The Part-I Bid shall not contain any Price data.

In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy the Bid in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation.

2.11 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices with break up as per Schedule-F1. Price given in Part-II Bid should cover the entire scope of work as given in Part-I of the offer. *[One original and 3 (three) identical]* copies shall be submitted.

1. The Price Bid shall contain the following :

- (i). Duly filled in Form of bid as per Annexure-C
 - (ii). Completely filled in Schedule of Prices Schedule – F1
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed format (Price Schedule). The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
 3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Employer shall be final. All entries shall be in English language only.
 4. The Price shall be quoted in Indian Rupees only.

2.12 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the obligations of the Consultant mentioned in Tender Documents/Terms of Reference or to be reasonably inferred from the Tender Documents/Terms of Reference.

Bidders are required to quote the price for the entire commercial, contractual and technical obligations outlined in the tender documents.

Prices quoted by the Bidder shall remain firm for the term of the contract.

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2.13 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if any shall be signed by the person signing the Bid. Printed literature, it enclosed need not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.14 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Employer may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Documents including the Terms of Reference by amendment.
2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Documents. Amendments will be hosted in Employer's website. Bidders are requested to visit Employer's website and note amendments, if any, before submission of bid. Employer shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.15 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

2.16 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other interested parties are advised to refrain from contacting by any means, the Employer and/or his employees/ representatives on matters related to the Bids under consideration. The Employer, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

2.17 Validity of Bid

1. The Bid shall be kept valid for acceptance for *[120 days]* from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Employer from participating in any of the Employer's tenders.

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2.18 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully informs himself as to all the conditions and matters which may in any way affect the 'Implementation Support Consultancy Services to be rendered or the cost thereof. Bidders are free to visit the plant. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Employer.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Employer at least *[7 (seven) days]* before the date stipulated for pre-bid meeting. The Employer then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till *[14 days]* prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Employer. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.
3. Pre-Bid Conference will be organized and outcome of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Employer to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.
5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

2.19 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Employer not later than *[-----]* Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

2.20 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Employer for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Employer, even though the Employer may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

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2.21 Evaluation of Bid

The selection of the successful Bidder for award of the Implementation Support Consultancy Services Contract will be based on both Quality of the Technical Proposal and Price quoted by the Bidder for the entire scope of work. The selection process will comprise the following steps:

1. First, Techno-Commercial offer will be assessed for completeness and responsiveness to commercial/contractual conditions. Only the Bids that are determined to be complete in all respects and responsive to commercial/contractual conditions will be taken up for further evaluation on the basis of Quality and Price.
2. Technical Proposal of Bidders, whose Bid is determined to be complete and responsive to commercial/contractual conditions, will be evaluated on the basis of Bidder's proposed methodology and Work Plan for discharging the Consultancy Assignment, experience of the Bidder and the experience & expertise of Key Personnel and will be assigned a Technical Score S_t . Only those Bidders whose Technical Proposals get a Technical Score of 70 marks or more out of 100 shall qualify for further consideration. All the Bidders with Technical Score of 70 or more will be considered for next stage of evaluation. It is not intended to short list a pre-determined number of Bidders on the basis of evaluation of Technical Proposal.
3. The Price Proposal of each Bidder with Technical Score of 70 or more will be assigned a Financial Score (S_f) on the basis of its cost competitiveness.
4. Each bidder will be assigned a Composite Score (S_c) equal to the weighted sum of Technical Score and Financial Score. Finally, the bidder with the highest Composite Score will be selected as Implementation Support Consultant for the subject Implementation Support Consultancy Services Contract.

2.21.1 Evaluation of Technical Proposal

The evaluation of Technical Proposal will have three elements as depicted in Table below:

Sl No	Parameter	Weightage	Basis of Evaluation
1	Methodology and Work Plan (S_{t-1})	20%	Bidder's understanding of Terms of Reference and clarity, completeness and soundness of methodology and work plan to achieve successful completion of the objectives of the Implementation Support Consultancy work. The Bidder with the best submission will be assigned a score of 100 ($S_{t-1} = 100$). Other Bidders will be assigned scores below 100 considering the relative quality of the submission with respect to the best submission.
2	Bidder's Experience (S_{t-2})	40%	Each Bidder has to list up to 5 technical consultancy projects, pertaining to thermal power plants of unit size 200 MW or above,

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			successfully executed by it during the last 10 years. Bidder has to furnish detailed scope of work executed by it for each listed consultancy project. Each such Project will be assigned a score out of 20 on the basis of size, nature & complexity of scope and similarity with the subject R&M Consultancy Service. If any Bidder lists less than 5 projects, a score of zero will be assigned for the shortfall number of project(s). For each Bidder, the sum of scores for the five projects will be the score (St-2) out of 100.
3	Experience and Expertise Key Personnel (St-3)	40%	The Bidder has to list name and other details of 10 key personnel of specified area of expertise in Schedule-F5 who are likely to be substantially associated with this Implementation Support Consultancy assignment if the Bidder emerges as successful Bidder for award of the Implementation Support Consultancy Services Contract. The Bidder is required to submit detailed Curriculum Vitae of these key personnel as per the format at Schedule-..... Each identified Key Person will be assigned a score out of 10 based on their qualification and nature & quantum of experience in the specified area of expertise. For each Bidder, the sum of scores of these 10 key personnel will be the score (St-3) out of 100.

The Technical score of each Bidder will be equal to the weighted sum scores on three elements with indicated weights.

$$S_t = 0.2 \times S_{t-1} + 0.4 \times S_{t-2} + 0.4 \times S_{t-3}$$

2.21.2 Evaluation of Price Bid

The Price Bid should be complete, unconditional and unqualified. For financial evaluation, the total Price indicated in the Price Schedule F1 excluding Service Tax and associated surcharge & cess will be considered. The price indicated in the Price Bid shall be deemed as final and reflecting the total Price of the entire scope of services as per Terms of Reference. Failure by Bidder to include the price of any item shall not entitle the firm to be compensated and the Consultant shall be liable to fulfill its obligations as per the TOR. The Bidder with lowest quoted total price will be assigned a Financial Score (S_f) of 100. The financial score of other Bidders will be computed as follows:

$$S_f = 100 \times (\text{Lowest Quoted Total Price} / \text{Total Price quoted by the Bidder})$$

2.21.3 Composite Score

For selection of successful Bidder, the Technical Score will be a weight of 70% and Financial Score will be given a weight of 30%. For each Bidder, the Composite Score S_c will be computed as follows:

$$S_c = 0.7 \times S_t + 0.3 \times S_f$$

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The Bidder who is determined to secure the highest Composite Score will be selected for award of the Implementation Support Consultancy Contract.

2.21.4 Other Evaluation Conditions

(1) Arithmetical errors will be rectified on the following basis:

- If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.
- If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
- If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.

(2). Comparison of Bids will be between main Bids only. Alternative Bids will not be accepted and evaluated.

(3). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder shall not charge any amount separately for that item from the Employer. If the terms, such as 'not applicable' "-----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.22 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and Terms of Reference. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with "Original" of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily rejected and ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.
2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Employer at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Employer towards Employer's cost, loss and damage to Employer.

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2.23 Blacklisting/Debarring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Employer.

2.24 Award of Contract

1. Award Criteria

The Implementation Support Consultancy Service Contract will be awarded to the Bidder with the highest Composite Score as described in clause 2.21.

2. Employer's Right to Accept Any Bid and to Reject Any or All Bids

The Employer reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Employer's action.

3. Notification of Award

Prior to the expiration of the period of bid validity, the Employer will notify the successful Bidder in writing by registered letter or by email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Employer will promptly notify each unsuccessful Bidder and will discharge its bid security.

4. Signing the Contract Agreement

At the same time as the Employer notifies the successful Bidder that its bid has been accepted, the Employer will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

Within *[twenty-eight (28)]* days of receipt of the Contract Agreement, the successful Bidder shall sign and date the Contract Agreement and return it to the Employer.

Cost of preparing Contract Agreement shall be borne by the bidder.

5. Performance Security

Within *[thirty (30) days]* after receipt of the Notification of Award, the successful Bidder shall furnish Contract Performance securities as per clause no 2.25. These Bank Guarantees shall be furnished in the form provided in the section "Forms and Procedures" of the bidding documents and shall be initially valid upto *[ninety (90)]* days after the scheduled date of completion of Implementation Support Consultancy Service.

Failure of the successful Bidder to submit Contract Performance Security within stipulated time shall constitute sufficient grounds for the annulment of the award and forfeiture of his bid security, in which event the Employer may make the award to the next lowest evaluated Bidder or call for new bids.

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6. Corrupt or Fraudulent Practices

The Employer requires that Bidders, Contractors and Consultants to observe the highest standard of ethics during the Pre-Qualification, Tendering (Request for Proposal) process and during the execution of the contracts. The Employer may reject a Bid Proposal of a successful Bidder if it emerges that the Bidder recommended for award has engaged in Corrupt or Fraudulent practices in competing for the subject contract. The Employer may declare a Bidding firm ineligible for participation in future tenders of the Employer, either indefinitely or for a stated period of time, if it at any time it emerges that the firm has engaged in Corrupt or Fraudulent practices in competing for or in executing a contract of the Employer. Corrupt Practice means the offering, giving, receiving or soliciting of anything of value to influence the tendering process or contract execution. Fraudulent practice means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Employer and includes collusive practice among Bidders designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition.

2.25 Contract Performance Bank Guarantee (CPG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Employer within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to five percent (5%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPG shall be valid till the Schedule Completion Time Period for Consultancy Services plus ninety (90) days grace period.

2.26 Vital Clauses

The following clauses in the Tender Specification & Draft Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Employer / Purchaser : [-----]
- Consultant : [-----]
- Project Title : [-----]
- Location : [-----]
- Latitude : [-----]
- Longitude : [-----]
- Elevation above MSL : [-----]
- Nearest Railway Station : [-----]
- Nearest Sea Port : [-----]
- Nearest Airport : [-----]
- Road Access/Approach to Site : [-----]

For Project & Site related detailed information, refer Terms of Reference Section-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Services, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract.
- iv. **"Contract"** means the Agreement entered into between Employer and Consultant as per the 'Contract Agreement' signed by the parties, including contract documents, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Consultant's Equipment"** means all equipment, machinery, tools, apparatus, appliances or things of every kind required in or for discharging the Implementation Support Consultancy Services to be brought to the site by the Consultant.
- vii. **"Consultant"** means the person(s), Firm or a Company whose bid to perform the Implementation Support Consultancy Services Contract has been accepted by the Employer and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Consultant.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Employer for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.

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- ix. **"Consultant's Representative"** means any person nominated by the Consultant & approved by the Employer hereof to perform the duties delegated by the Consultant.
- x. **"Completion"** means the completion of Implementation Support Consultancy Services by the Consultant (Implementation Support Consultant) covering the entire Scope of Work as per the Terms of Reference and submission of all the reports and other deliverables incorporating Employer's observation on the draft reports to the satisfaction of the Employer .
- xi. **"Consultancy Services" or "Implementation Support Consultancy Services"** means the entire services ancillary to the completion of entire scope of work as per the Terms of Reference.
- xii. **"Day"** means calendar day of the Gregorian calendar.
- xiii. **"Effective Date"** means the date from which the Time for Completion of Implementation Support Consultancy Services and other milestones for execution of the Implementation Support Consultancy Services as per the scope of work under this tender by the Consultant shall be determined.
- xiv. **"GCC"** means the General Conditions of Contract hereof.
- xv. **"Good Industry Practice"** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Consultant applying the standards generally adopted by global Engineering/Technical , except in so far as inconsistent with any applicable Indian law or directive.
- xvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Employer notifying the Consultant that its Bid Proposal has been accepted.
- xvii. **"Month"** means calendar month of the Gregorian calendar.
- xviii. **"Employer's Acceptance"** means the Employer has accepted that the Consultant (Implementation Support Consultant) has successfully discharged the Implementation Support Consultancy Services covering the entire scope of work as per the ToR adhering to industry standard and Good Industry Practice and all the reports & other deliverables submitted by the Consultant as part of the Implementation Support Consultancy Services .
- xix. **"Employer" or "Purchaser" or "Employer"** shall means the [Name of the Utility], and includes its legal successors or permitted assignees.
- xx. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
- xxi. **"Project"** means the Employer's [-----] in respect of which the Contract has been signed.
- xxii. **"Project Manager"** means the person appointed by the Employer thereof and named as such, to perform the duties delegated by the Employer.

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- xxiii. **"Implementation Support Consultant" or "Consultant"** means the person(s), Firm or a Company or Consortium of Firms whose bid to perform the Implementation Support Consultancy Services Contract has been accepted by the Employer and is also named "Consultant" in the Contract Agreement.
- xxiv. **"R&M Project"** means the proposed R&M work for Unit [.....] of [.....] plant of Employer. The subject Implementation Support Consultancy Services package is being tendered to appoint an Implementation Support Consultant who will assist the Employer in implementation of the R&M Project.
- xxv. **"SCC"** means the Special Conditions of Contract.
- xxvi. **"Site"** means the [.....] plant of [.....].
- xxvii. **"Sub Consultant"** means any firm or person to whom execution of any part of the subject Implementation Support Consultancy Services Contract is subcontracted directly or indirectly by the Consultant, and includes its legal successors or permitted assignees.
- xxviii. **"Tender Documents"** means the document, setting out a description and specification of the Consultancy services and statement of the technical and other standards to which the Services are to be performed including any modifications thereto made in accordance with the Conditions. This includes the commercial specifications, Terms of Reference and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xxix. **"Tenderer"/"Bidder"/"Applicant"** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Employer, for the Project.
- xxx. **"Time for Completion"** means the time within which completion of Implementation Support Consultancy Services by the Consultant (Implementation Support Consultant) covering the entire Scope of Work as per the Terms of Reference and submission of all the reports and other deliverables incorporating Employer's observation on the draft reports to the satisfaction of the Employer is to be attained in accordance with the stipulations and provisions of the Contract.
- xxxi. **"Writing" or "Written"** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Employer. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

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4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Consultant shall be provided with one signed original and the rest will be retained by the Employer.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. The bid & schedules/ attachment submitted by the Consultant.
- vi. Terms of Reference

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Independent Consultant

The Consultant shall be an independent Consultant performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Consultant shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or SubConsultants engaged by the Consultant in connection with the performance of the Contract shall be under the complete control of the Consultant and shall not be deemed to be employees of the Employer, and nothing contained in the Contract or in any subcontract awarded by the Consultant shall be construed to create any contractual relationship between any such employees, representatives or SubConsultants and the Employer.

4.6 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to

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the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.7 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.8 Origin

"Origin" means the place where the materials, equipments and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.9 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or Electronic Data Interchange (EDI) to the address of the relevant party indicated in the Contract. Either party may change its postal, telefax number, or EDI address or addressee for receipt of such notices by ten (10) days' notice to the other party in writing

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

4.10 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [...] shall have exclusive jurisdiction in all matters arising under the Contract.

4.11 Settlement of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Employer and the Consultant in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Employer & Consultant shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

Either Employer or the Consultant may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities

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Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Employer and the Consultant shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within *[twenty eight (28)]* days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by President, Institution of Engineers as the Appointing Authority.

If one party fails to appoint its arbitrator within *[forty-two (42)]* days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996.

The Place for Arbitration shall be *[...]*, India.

The language of arbitration shall be English.

The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- the parties shall continue to perform their respective obligations under the Contract unless they otherwise agree
- The Employer shall pay the consideration Consultant due to the Consultant.

4.12 Scope of Services

The Scope of Services shall be as per the Terms of Reference Section-II.

4.13 Time for Commencement and Completion

- a) The Consultant shall commence work on the Scope of Services under this Tender from the date of Letter of Award. Consultant shall thereafter proceed with the Services in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- b) The Consultant shall attain Completion of the Consultancy Services (or of a part where a separate time for Completion of such part is specified in the Contract) within the time stated in the SCC subject to time extensions, the Consultant is entitled under the contract conditions or time extension expressly granted by the Employer.

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4.14 Consultant's Responsibilities

- a) Before entering into this contract the Consultant is responsible to have examined the data relating to the plant and facilities provided by the Employer, and on the basis of information that the Consultant could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Plant & Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve Consultant of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.
- b) The Consultant shall acquire in its name all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Consultant's and SubConsultant's personnel and entry permits for all imported Consultant's Equipment.
- c) The Consultant shall perform the Services in accordance with the Applicable Laws and shall take all practicable steps to ensure that any Sub-Consultant, as well as the Personnel and agents of the Consultant and any Sub-Consultant, comply with the Applicable Laws. The Consultant shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Consultant. The Consultant shall indemnify and hold harmless the Employer from and against any and all liabilities, damages, claims, fines, penalties and expenses of whatever nature arising or resulting from the violation of such laws by the Consultant.
- d) The Consultant shall perform the Services and carry out its obligations under this Contract with all due diligence, efficiency and economy, in accordance with generally accepted professional techniques and practices, and shall observe sound management practices, and employ appropriate advanced technology and safe and effective equipment, machinery, materials and methods. The Consultant shall always act, in respect of any matter relating to this Employer or to the Services, as a faithful advisor to the Employer, and shall at all times support and safeguard the Employer's legitimate interests in any dealings with Sub-Consultants or Third Parties.

4.15 Employer's Responsibilities

- a) The Employer shall be responsible for access to the plant and the Site and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract.
- b) The Employer shall make available to the Consultant all the plant operation data, Manufacturer's Manual, O&M Manual and other Technical data/information to the extent available with the Employer and reasonably required by the Consultant for discharging Services as per the Terms of Reference
- c) The Employer shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Employer to

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obtain them in the Employer's name, are necessary for the execution of the Contract.

- d) If requested by the Consultant, the Employer shall use its best endeavours to assist the Consultant in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Consultant or SubConsultants or the personnel of the Consultant or SubConsultants, as the case may be, to obtain.

4.16 Taxes & Duties

- a) The Employer shall bear and promptly pay Service Tax along with applicable Surcharge and Cess thereon, in respect of direct transaction between the Employer and the Consultant payable in India as per Indian law. All other Taxes and Duties will be borne by the Consultant.
- b) If any tax exemptions, reductions, allowances or privileges may be available to the Consultant, the Employer shall use its best endeavours to enable the Consultant to benefit from any such tax savings to the maximum allowable extent.

4.17 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Employer by the Consultant herein shall remain vested in the Consultant or, if they are furnished to the Employer directly or through the Consultant by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Employer shall however be free to reproduce all drawings, documents and other material furnished to the Employer for the purpose of the contract.

4.18 Confidential Information

- a) The Employer and the Consultant shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Consultant may furnish to its SubConsultant(s) such documents, data and other information it receives from the Employer to the extent required for the SubConsultant(s) to perform its work under the Contract, in which event the Consultant shall obtain from such SubConsultant(s) an undertaking of confidentiality similar to that imposed on the Consultant.
- b) The obligation of a party, shall not apply to that information which
- now or hereafter enters the public domain through no fault of that party
 - can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto
 - Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

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4.19 Conflict of Interest

- a) The Consultant shall not have a Conflict of Interest and any breach hereof shall constitute a breach of the Agreement.
- b) During the term of this Contract and after its termination, the Consultant or any Associate or Consortium Partner thereof and any entity affiliated with the Consultant, as well as any Sub-Consultant and any entity affiliated with such Sub-Consultant, shall be disqualified from providing goods, works, services, loans or equity for any project resulting from or closely related to the Services and any breach of this obligation shall amount to a Conflict of Interest; provided that the restriction herein shall not apply after a period of five years from the completion of this assignment or to consulting assignments granted by banks/ lenders at any time; provided further that this restriction shall not apply to consultancy/ advisory services provided to the Employer in continuation of this Consultancy or to any subsequent consultancy/ advisory services provided to the Employer. For the avoidance of doubt, an entity affiliated with the Consultant shall include a partner in the Consultant's firm or a person who holds more than 5% (five per cent) of the subscribed and paid up share capital of the Consultant, as the case may be, and any Associate thereof.
- c) The Contract Price provided under the provisions of this Contract shall constitute the Implementation Support Consultant's sole remuneration in connection with this Contract or the Services and the Consultant shall not accept for its own benefit any trade commission, discount or similar payment in connection with activities pursuant to this Contract or to the Services or in the discharge of its obligations hereunder, and the Consultant shall use its best efforts to ensure that any Sub-Consultant, as well as the Personnel and agents of either of them, similarly shall not receive any such additional remuneration.

4.20 Representatives

d) Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Employer shall appoint and notify the Consultant in writing of the name of the Project Manager. The Employer may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Consultant without delay. The Employer shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Employer at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

All notices, instructions, information and other communications given by the Consultant to the Employer under the Contract shall be given to the Project Manager, except as herein otherwise provided.

e) Consultant's Team Leader

- If the Consultant's Team Leader is not named in the Contract, then within *[fourteen (14) days]* of the Effective Date, the Consultant shall appoint

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the Consultant's Team Leader and shall request the Employer in writing to approve the person so appointed. If the Employer makes no objection to the appointment within [fourteen (14)] days, the Team Leader shall be deemed to have been approved. If the Employer objects to the appointment within [fourteen (14)] days giving the reason there for, then the Consultant shall appoint a replacement within [fourteen (14) days] of such objection.

- The Consultant's Representative shall represent and act for the Consultant at all times during the currency of the Contract and shall give to the Project Manager all the Consultant's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Employer or the Project Manager to the Consultant under the Contract shall be given to the Consultant's Team Leader or, in its absence, its deputy, except as herein otherwise provided. The Consultant shall not revoke the appointment of the Consultant's Representative without the Employer's prior written consent, which shall not be unreasonably withheld. If the Employer consents thereto, the Consultant shall appoint some other person as the Team Leader.
- The Consultant's Team Leader may, subject to the approval of the Employer (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Consultant's Team Leader, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Employer and the Project Manager.
- The Employer may by notice to the Consultant object to any representative or person employed by the Consultant in the execution of the Contract who, in the reasonable opinion of the Employer, may behave inappropriately, may be incompetent or negligent, or may commit a serious breach of the Site regulations. In such cases, the Consultant will arrange suitable replacement.

4.21 Work Program

a) Consultant's Organization

The Consultant's Organization chart and list of key personnel and Team Leader identified for the Project will be appended to the Contract Agreement. The Consultant shall ensure adequate and timely availability of these personnel to work on this Consultancy Services. Consultant will also ensure availability and services of any additional personnel required for the successful and timely completion of the Scope of Services as per the Terms of Reference.

b) Program of Performance

Within [twenty-eight (28)] days after the date of Notification of Award of Contract, the Consultant shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply,

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transport, assemble, install and precommissioning the Facilities, as well as the date by which the Consultant reasonably requires that the Employer shall have fulfilled its obligations under the Contract so as to enable the Consultant to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Consultant shall accord with the Time Schedule included in Appendix 4 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Consultant shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Consultant's actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Consultant shall, at the request of the Employer or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

e) Work Procedures

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Employer and the Consultant, the Consultant may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

4.22 Substitution of Key Personnel

The Employer expects that all the Key Personnel specified in the Bid Proposal shall be available during the execution of Implementation Support Consultancy Services. The Employer will not consider any substitution of Key Personnel except under compelling circumstances beyond the control of the Consultant and the concerned Key Personnel. Such substitution may be permitted only in exceptional cases subject to equally or better qualified and experienced personnel being provided to the satisfaction of the Employer.

4.23 Sub-Consultant

The R&M Consultant or Consortium Leader or Associate shall not subcontract its entire scope of work back-to-back or otherwise. In any case, appointment of any Sub-Consultant to discharge any part of the Scope of Service under this

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Contract is subject to Employer's prior written approval. Employer may accept or reject any Sub-Consultant at its discretion.

4.24 Completion Time

The Consultant guarantees that it shall attain Completion of the entire Scope of Service as per the Terms of Reference or part thereof within the Time for Completion specified in the SCC.

4.25 Patents Indemnity

The Consultant shall indemnify and hold harmless the Employer and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Employer may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Consultant or the use of the such Facilities.

4.26 Accuracy of Data and Document

The Consultant shall be responsible for accuracy of the data collected by it directly or procured from other entities, the designs, drawings, estimates and all other details prepared by it as part of these services. Subject to the GCC provisions regarding limitation of Consultant's liability, the Consultant shall indemnify the Employer against any inaccuracy in its work which might surface during implementation of the R&M Project, if such inaccuracy is the result of any negligence or inadequate due diligence on part of the Consultant or arises out of its failure to conform to good industry practice. The Consultant shall also be responsible for promptly correcting, at its own cost and risk, the drawings including any re-survey / investigations.

4.27 Liability of Implementation Support Consultant

- a) The R&M Consultant's liability under this Agreement shall be determined by the Applicable Laws and the provisions hereunder.
- b) The Consultant shall, subject to the limitation specified hereunder, be liable to the Employer for any direct loss or damage accrued or likely to accrue due to deficiency in Services rendered by it.
- c) Except in cases of criminal negligence or wilful misconduct by the Consultant, the aggregate liability of the Consultant (Implementation Support Consultant) to the Employer, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Consultant to indemnify the Employer with respect to patent infringement.
- d) Except in cases of criminal negligence or wilful misconduct by the Consultant, the Consultant shall not be liable to the Employer, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs.

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4.28 Equipment and Material provided by the Employer

Equipment and materials made available to the Implementation Support Consultant by the Employer shall be the property of the Authority and shall be marked accordingly. Upon termination or expiration of this Contract Agreement, the Consultant shall furnish forthwith to the Employer, an inventory of such equipment and materials and shall return to the Employer or otherwise dispose of such equipment and materials in accordance with the instructions of the Employer. While in possession of such equipment and materials, the R&M Consultant shall, unless otherwise instructed by the Employer in writing, insure them in an amount equal to their full replacement value.

4.29 Loss of or Damage to Property; Accident or Injury; Indemnification

The Consultant shall indemnify and hold harmless the Employer and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with Consultancy Services and by reason of the negligence of the Consultant or its SubConsultants, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Employer, its Consultants, employees, officers or agents.

4.30 Insurance

- a) The Consultant shall, for the duration of this Contract, take and maintain, and shall cause any Sub-Consultant to take and maintain, at its (or the Sub-Consultant's, as the case may be) own cost, but on terms and conditions approved by the Employer, insurance against the risks, and for the coverage, as specified hereunder and in accordance with good industry practice.
- b) Within 15 (fifteen) days of receiving any insurance policy certificate in respect of insurances required to be obtained and maintained under this clause, the Consultant shall furnish to the Employer, copies of such policy certificates, copies of the insurance policies and evidence that the insurance premia have been paid in respect of such insurance. No insurance shall be cancelled, modified or allowed to expire or lapse during the currency of this Contract.
- c) If the Consultant fails to effect and keep in force the aforesaid insurances for which it is responsible pursuant hereto, the Employer shall, apart from having other recourse available under this Contract, have the option, without prejudice to the obligations of the Consultant, to take out the aforesaid insurance, to keep in force any such insurances, and pay such premia and recover the costs thereof from the Consultant, and the Consultant shall be liable to pay such amounts on demand by the Employer.
- d) Except in case of Third Party liabilities, the insurance policies so procured shall mention the Employer as the beneficiary of the Consultant and the Consultant shall procure an undertaking from the insurance company to this effect; provided that in the event the Consultant has a general insurance policy that covers the risks specified in this Agreement and the amount of insurance cover is equivalent to 3 (three) times the cover required hereunder, such insurance

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policy may not mention the Employer as the sole beneficiary of the Consultant or require an undertaking to that effect.

- e) The risks and coverages shall include but not be limited to the following:
 - i. Third Party liability insurance as required under Applicable Laws, with a minimum coverage of [...].
 - ii. Employer's liability and workers' compensation insurance in respect of the Personnel of the Consultant and of any Sub-Consultant, in accordance with Applicable Laws.
 - iii. Professional liability insurance for an amount no less than the Agreement Value.
- f) In case of consortium, the policy should be in the name of Consortium Leader and not in the name of individual Members of the consortium.

4.31 Employer's Prior Approval

The Consultant shall obtain the Employer's written prior approval in writing before taking any of the following actions:

- a) Replacing any Key Personnel listed in the Contract Schedule
- b) Discontinuing participation of any Key Personnel in this R&M Consultancy Services during the currency of the Contract
- c) Any other action that is specified in the Tender Document or Contract Agreement.

4.32 Employership of Documents Prepared by Consultant

- a) All plans, drawings, specifications, designs, reports and other documents (collectively referred to as "Consultancy Documents") prepared by the Implementation Support Consultant (or by the Sub-Consultants or any Third Party) in performing the Services shall become and remain the property of the Employer, and all intellectual property rights in such Consultancy Documents shall vest with the Employer. Any Consultancy Document, of which the Employership or the intellectual property rights do not vest with the Employer under law, shall automatically stand assigned to the Employer as and when such Consultancy Document is created and the Consultant agrees to execute all papers and to perform such other acts as the Authority may deem necessary to secure its rights herein assigned by the Implementation Support Consultant.
- b) The Implementation Support Consultant shall, not later than termination or expiration of this Contract, deliver all Consultancy Documents to the Employer, together with a detailed inventory thereof. The Consultant may retain a copy of such Consultancy Documents. The Implementation Support Consultant, its Sub-Consultants or a Third Party shall not use these Consultancy Documents for purposes unrelated to this Contract without the prior written approval of the Employer.
- c) The Consultant shall hold the Employer harmless and indemnified for any losses, claims, damages, expenses (including all legal expenses), awards, penalties or injuries (collectively referred to as 'claims') which may arise from or due to any unauthorised use of such Consultancy Documents, or due to any breach or failure on part of the Consultant or its Sub-Consultants or a

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Third Party to perform any of its duties or obligations in relation to securing the aforementioned rights of the Employer.

4.33 Change in Laws & Regulation

If, after the date *[seven (7)]* days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Consultant and/or the Time for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Consultant has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Employer and the Consultant.

4.34 Force majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Employer or of the Consultant, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within *[fourteen (14)]* days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfil its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
 - constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby

if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.

- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than *[sixty (60)]* days or an aggregate period of more than one hundred and *[twenty (120)]* days on account of one or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.
- (g) Force Majeure shall not apply to any obligation of the Employer to make payments to the Consultant herein.

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4.35 Change in the Scope of Services

The Employer shall have the right to propose, and subsequently require, the Consultant during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Scope of Services, provided that such Change falls within the general scope of the Services and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the assignment and the technical feasibility. The parties will agree on the change in Contract Price due Change in Scope of Services on mutual consultation basis.

4.36 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Consultant is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:

- Any Change in the Facilities or
- any occurrence of Force Majeure or
- any suspension order given by the Employer or reduction in the rate of progress or
- any changes in laws and regulations or
- any default or breach of the Contract by the Employer, or any activity, act or omission of any other Consultants employed by the Employer or
- any other matter specifically mentioned in the Contract;

By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Consultant.

- (b) Except where otherwise specifically provided in the Contract, the Consultant shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Employer and the Consultant shall agree upon the period of such extension.
- (c) The Consultant shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.37 Termination

(a) Termination for Employer's Convenience

The Employer may at any time terminate the Contract for any reason by giving the Consultant a notice of termination. Upon receipt of the notice of termination, the Consultant shall either immediately or upon the date specified in the notice of termination

- (i) Cease all further work.
- (ii) terminate all subcontracts, except those to be assigned

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- (iii) remove all Consultant's Equipments from the Site, repatriate the Consultant's and its SubConsultants' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Consultant, subject to the payment, shall
 - ✓ deliver to the Employer the data collected during the course of the consultancy services and study reports prepared up to the date of termination
 - ✓ Deliver to the Employer all non-proprietary drawings, specifications and other documents prepared by the Consultant or its SubConsultants as at the date of termination in connection with the Consultancy services.

In the event of termination of the Contract for Employer's convenience, the Employer shall pay to the Consultant the following amounts

- ✓ the Contract Price, attributable to the parts of the Services executed by the Consultant as on the date of termination
- ✓ the costs reasonably incurred by the Consultant in the removal of the Consultant's Equipment from the Site and in the repatriation of the Consultant's and its SubConsultants' personnel
- ✓ any amounts to be paid by the Consultant to its SubConsultants in connection with the termination of any subcontracts, including any cancellation charges
- ✓ the additional cost of satisfying other obligations, commitments and claims that the Consultant may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Consultant's Default

- (i) The Employer, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons thereof to the Consultant:

the Consultant becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Consultant is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Consultant takes or suffers any other analogous action in consequence of debt

If the Consultant assigns or transfers the Contract or any right or interest therein in violation of the provision.

If the Consultant, in the judgement of the Employer has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

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"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Employer and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition.

(ii) If the Consultant

- has abandoned or repudiated the Contract
- has without valid reason failed to commence the Consultancy Services promptly for more than *[twenty eight (28)]* days after receiving a written instruction from the Employer to proceed
- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient personnel and other resources to execute the Services in the manner specified in the program at rates of progress that give reasonable assurance to the Employer that the Consultant can attain Completion of the Services by the Time for Completion as extended
- then the Employer may, without prejudice to any other rights it may possess under the Contract, give a notice to the Consultant stating the nature of the default and requiring the Consultant to remedy the same. If the Consultant fails to remedy or to take steps to remedy the same within *[fourteen (14)]* days of its receipt of such notice, then the Employer may terminate the Contract forthwith by giving a notice of termination to the Consultant.

(iii) The Consultant shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work,
- terminate all subcontracts, except those to be assigned to the Employer
- deliver to the Employer the data collected during the course of the consultancy services and study reports prepared up to the date of termination
- Deliver to the Employer all drawings, specifications and other documents prepared by the Consultant or its SubConsultants as at the date of termination in connection with the Services.
- remove all Consultant's Equipments from the Site, repatriate the Consultant's and its SubConsultants' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition

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(c) Termination by Consultant

i. If

- the Employer has failed to pay the Consultant any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Consultant may give a notice to the Employer that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Employer to remedy the same, as the case may be. If the Employer fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within *[fourteen (14) days]* after receipt of the Consultant's notice, or
- the Consultant is unable to carry out any of its obligations under the Contract for any reason attributable to the Employer, ,
then the Consultant may give a notice to the Employer thereof, and if the Employer has failed to pay the outstanding sum, to approve the invoice or supporting documents, to give its reasons for withholding such approval, or to remedy the breach within *[twenty eight (28) days]* of such notice, or if the Consultant is still unable to carry out any of its obligations under the Contract for any reason attributable to the Employer within twenty eight (28) days of the said notice.

If the Employer becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Employer takes or suffers any other analogous action in consequence of debt.

ii. If the Contract is terminated, then the Consultant shall immediately

- cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Employer pursuant to paragraph (d)(ii)
- remove all Consultant's Equipment from the Site and repatriate the Consultant's and its SubConsultant's personnel from the Site

(v) The Consultant, subject to the payment, shall

- o deliver to the Employer the data collected during the course of the consultancy services and study reports prepared up to the date of termination

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- Deliver to the Employer all non-proprietary drawings, specifications and other documents prepared by the Consultant or its SubConsultants as at the date of termination in connection with the Facilities.

In the event of termination of the Contract for Employer's convenience, the Employer shall pay to the Consultant the following amounts

- the Contract Price, attributable to the parts of the Services executed by the Consultant as on the date of termination
- the costs reasonably incurred by the Consultant in the removal of the Consultant's Equipment from the Site and in the repatriation of the Consultant's and its SubConsultants' personnel
- any amounts to be paid by the Consultant to its SubConsultants in connection with the termination of any subcontracts, including any cancellation charges
- the additional cost of satisfying other obligations, commitments and claims that the Consultant may in good faith have undertaken with third parties in connection with the Contract.

4.38 Assignment

The Consultant shall not, without the express prior written consent of the Employer, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Consultant shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract.

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Implementation Support Consultancy Services for [-----]
- **Bid Document No. :** [-----]
- **The Employer is:**
 - Name of Employer: [-----]
 - Address of Employer: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]
- **The Project Manager is:**
 - Name of Project Manager: [-----]
 - Address of Project Manager: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]

5.2 Effective Date

The Employer shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Implementation Support Consultancy work as per the scope of work under this tender by the Consultant.

The following three activities will be completed within *[two (2)]* months from the date of Letter of Acceptance:

- (a) The contract agreement will be executed by the Employer and the Consultant.
- (b) The Consultant will submit to the Employer the Contract Performance Security, any Additional Performance Security associate etc if applicable, and the Advance Payment Security.
- (c) The Employer will pay the Consultant the Advance Payment as per the Terms of Payment.
- (d) The Consultant will submit the Inception Report and incorporate any change suggested by Employer in the Inception Report

The Employer will make the advance payment promptly once Consultant has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Employer, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However,

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failure of the Consultant to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Consultant under this tender shall be as follows:

	Task/Milestone	Time for Completion
1.	[.....]	[.....]
2.	[Finalization of Work Plan.....]	[.....]from Effective Date
3.	[Submission of Monthly Progress Report]	[First week of next month]
4.	[.....]	[.....]
5.	[Comment/Approval of each engineering drawing]	[10 days from the date of submission]
..	[.....]	[.....]
	[Approval of Quality Plans]	[.....]
	[.....]	[.....]

5.4 NOT USED

5.5 NOT USED

5.6 NOT USED

5.7 Contract Price

- The Contract Price shall be as indicated in the Contract Agreement based on the Total Price quoted by the Bidder in the Price Schedule F1. The Price quoted by Bidder in the Price Schedule F1 will be deemed to include compensation for all expenses/costs incurred by the Bidder incidental to rendering all the Services and discharging all other obligations under this Contract and remuneration for rendering all the services as per the Terms of Reference.
- The Consultant shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

5.8 Terms of Payment

- The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement.
- No payment made by the Employer herein shall be deemed to constitute acceptance by the Employer of the Services or any part(s) thereof.
- All the payments will be made in INR.

5.9 Contract Securities

- The Consultant shall provide the securities specified below in favour of the Employer at the times, and in the amount, manner and form specified below.
- Advance Payment Security

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- The Consultant shall, within *[thirty (30)]* days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to *[ninety (90)]* days beyond the schedule date of Completion of R&M Consultancy Services.
- The security shall be in the form of an Unconditional Bank Guarantee. The Advance payment Security shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of Services received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Services received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of R&M Consultancy Services and Employer's Acceptance thereof. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Consultant's responsibility and liabilities under the Contract including in respect of the Services for which the reduction in the value of security is allowed.

c) Performance Security

The Consultant shall, within *[thirty (30)]* days of the notification of award, provide a security for the due performance of the Contract for five percent (5%) of the Contract Price with an initial validity upto *[ninety (90)]* days beyond the Scheduled Completion Date for R&M Consultancy Services.

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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	Not Used
Schedule F1	Price Schedule
Schedule F2	Overall Time Schedule
Schedule F3	Deviation Schedule to Tender Document Section-I Commercial
Schedule F4	Deviation Schedule to Terms of Reference
Schedule F5	Details of Key Personnel
Schedule F6	Format for Curriculum Vitae (CV) of Key Personnel
II	Forms and Contract Schedules to form part of Contract
Annexure-F	Form of Contract
Contract Schedule-1	Terms of Payment
Contract Schedule-2	NOT USED
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Sub-Consultants
Contract Schedule-5	List of Key Personnel
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Security

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No. [...] Capacity [...] of [Name of the Power Plant]**

[Logo of Utility]

ANNEXURES & SCHEDULES

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.:

Bank Guarantee No:

Date

:

To:

[Details of Designated Official]

[Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [.....] dated [.....] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [.....] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [Implementation Support Consultancy Services package for R&M of], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [.....] (in words and figures) valid for 300 days from [.....] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [.....] Bank at (local address) [.....] having our Head Office at [.....] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of

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[.....] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

This Guarantee shall be irrevocable and shall remain valid upto [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorised officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
Name :
Designation :
Staff Code No. :

Banker's Seal :
Date :

Witness:

1. Signature :
Full name in block letters :
Designation :
Address :
2. Signature :
Full name in block letters :
Designation :
Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[-Name of Utility] [.....]

Sub : ____ (Name of Package) *[.....]*

Tender No. *[.....]* _____

Having carefully examined the Tender Specifications issued to us for your Tender No. *[.....]* dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the entire scope of work as per Terms of Reference in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR _____ (Indian Rupees *[.....]* only) in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of 240 (Two Hundred Forty) days from the date of opening of bids by Purchaser and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to *[Name of Utility]*, assignees or authorized nominees such sums of money as are stipulated in conditions contained in Tender Specification and agree to

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furnish Bank Guarantee for Contract Performance as per the proforma prescribed by Purchaser and for the sum equal to 5% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Purchaser is not bound to accept the lowest or any Bids received and Purchaser has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Purchaser and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From:

Dated:

[.....]

[.....]

[.....]

To :

[.....]

[.....]

[.....]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire scope of work as described in the Terms of Reference in conformity with the specifications and Terms of Reference, as per prices quoted by us in the Schedule of Prices [Schedule] enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Employer [Name of Utility] and for the sum equal to 5% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Employer is received and accepted by the Employer

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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Witness:

1. Signature
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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SCHEDULE – F1

PRICE SCHEDULE

S.No.	Description	INR
1	Price for the entire scope of work on Lump Sum Fixed Price Basis	
9	Service Tax on Direct Transaction between the Owner & Consultant	
10	Total Price including Service Tax on Direct Transaction between the Owner & Consultant	

Signature :

Name :

Designation :

Company :

Company Seal

Date :

* * * * *

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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I) . The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I) , then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F4

DEVIATION SCHEDULE TO TERMS OF REFERENCE

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Purchaser's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Purchaser's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F5
DETAILS OF KEY PERSONNEL

Sl No	Designation	Name	Educational Qualification	Professional Experience (years)	Present Employer	Employed with present Employer Since	Minimum No of Hours to be Deployed for this Consultancy Assignment
1	Team Leader						
2	Boiler Expert						
3	Turbine Expert						
4	Mechanical BoP Expert						
5	Electrical Expert						
6	C&I Expert						
7	Civil Expert						

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F6

Format for Curriculum Vitae (CV) of Key Personnel

1. Proposed Designation (As per Schedule-F5) :
2. Name of Key Person:
3. Date of Birth:
4. Nationality:
5. Educational Qualifications:
6. Employment Record:
(Starting with present position, list in reverse order every employment held.)

7. List of projects on which the Personnel has worked

Sl No	Name of Project	Description of Responsibilities	Start Date and End Date of Association

8. Other present work commitment
9. Details of the role in the subject Implementation Support Consultancy Services assignment and the time duration for which services are required for this assignment.

Certification:

- 1 I am willing to work on the Implementation Support Consultancy Services assignment for [...] project of [...] and I will be available for entire duration of the Project assignment as required.
- 2 I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications and my experience.

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[Logo of Utility]

Place.....(Signature and name of the Key Personnel)

(Signature and name of the authorized signatory of the Bidder)

Notes:

Use separate form for each Key Personnel

* * * * *

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No. [...] Capacity [...] of [Name of the Power Plant]**

[Logo of Utility]

Form of Contract Agreement

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Form of Contract Agreement

THIS CONTRACT AGREEMENT is made the _____day of _____, 20_____.
BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of
[country of Employer] and having its principal place of business at [address of
Employer] (hereinafter called "the Employer"), and (2) [name of Contractor], a
corporation incorporated under the laws of [country of Contractor] and having its
principal place of business at [address of Contractor] (hereinafter called "the
Contractor")

WHEREAS the Employer desires to engage the Contractor to provide
Implementation Support Consultancy Services comprising .
[.....]
[.....]
[.....]

("the Implementation Support Consultancy Services") and the Contractor have
agreed to such engagement upon and subject to the terms and conditions
hereinafter appearing.

NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

- a) Contract Documents means this signed Contract agreement and its
annexure/Contract Schedules, and the complete documents, which are the
basis of finalization of the contract, including correspondence exchanged from
issue of tender till date of signing the contract. The following will constitute
the Contract Documents:
 - i. The signed Contract Agreement & the annexure/ Contract Schedule
thereto (highest precedence)
 - ii. Letter of award.
 - iii. Special Condition of Contract
 - iv. General Condition of Contract
 - v. Terms of Reference.
 - vi. The bid & its schedules/ attachment submitted by the contractor.
- b) All documents forming part of the Contract (and all parts thereof) are intended
to be correlative, complementary and mutually explanatory. The Contract
shall be read as a whole.
- c) The Contract will be signed in three originals and the Contractor shall be
provided with one signed original and the rest will be retained by the
Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents,
the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest
precedence)
- ii. Letter of award.
- iii. Special Condition of Contract

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- iv. General Condition of Contract
- v. Terms of Reference.
- vi. The bid & schedules/ attachment submitted by the contractor.

1.3 Definitions

The Definitions of terms and expressions shall be as per General Conditions of Contract (GCC).

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder: The Contract Price shall be:[amount of local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this shall be as follows:

	Task	Time for Completion
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]

The detailed Time Schedule shall be as per Contract Schedule 2.

Contract Schedules

The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]

----- [Title]

In the presence of -----

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Signed by for and on behalf of the Contractor

----- [Signature]

----- [Title]

In the presence of -----

CONTRACT AGREEMENT

dated the -----day of-----, 20-----

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

- Contract Schedule 1 : Terms of Payment
- Contract Schedule 2 : Price Adjustment
- Contract Schedule 3 : Time Schedule
- Contract Schedule 4 : List of Sub-Consultants
- Contract Schedule 5 : List of Key Personnel

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Tender Document for Implementation Support Consultancy Services for Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
--	-------------------

Contract Schedule-1

Terms of Payment

The Employer shall pay the Contractor in the following manner and at the following times. Payments will be made in Indian Rupees.

I. Terms of Payment for Contract Price:

1	10% of the Lump Sum Price	Initial Advance on (1)Acceptance of Letter of Award by the Contractor, (2) Signing of Contract Agreement, (3) Submission of Contract Performance Security and Advance Payment Security by Contractor and (4) Submission of Inception Report by the Contractor and Acceptance of the same by Owner
	[.....]% of the Lump Sum Price	[Finalization of Work Plan.]
	[.....]% of the Lump Sum Price	[.....]
	[.....]% of the Lump Sum Price	[Finalization of all quality plans.....]
	[.....]% of the Lump Sum Price	[.....]
	[.....]% of the Lump Sum Price	[.....]
	[.....]
	[.....]

Last Payment	10% of the Lump Sum Price	Owner's Acceptance that the Contractor (Implementation Support Consultant) has successfully and completely discharged the Implementation Support Consultancy Services and has submitted all the test data, reports, recommendation etc. to the Owner

II. NOT USED

III. Terms of Payment for Taxes & Duties

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Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other Tax or Duty payable by Employer to the Contractor as per the Terms & Conditions of Contract shall be reimbursed on production of evidence of payment by Contractor.

IV. Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor upon submission of evidence by the Contractor to the Employer as to the Contractor having paid such variation.

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--	-------------------

Contract Schedule-2

NOT USED

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[Logo of Utility]

Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

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Contract Schedule-4

LIST OF SUB-CONSULTANTS

[List of approved subcontractors shall be placed]

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[Logo of Utility]

**Contract Schedule-5
LIST OF KEY PERSONNEL**

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Consultant]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:

Bank Guarantee No:

Date:

To:

[Name & Address of Owner (Utility)]

.....]

Dear Sirs,

1 In consideration of the [...] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Consultant's Name] having its registered office at.....hereinafter referred to as the 'CONSULTANT', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount in words], [amount in figures] and the same having been unequivocally accepted by the CONSULTANT and the CONSULTANT having agreed to provide a **Contract Performance Guarantee** for the faithful performance of the entire CONTRACT under the CONTRACT equivalent to 5% (five percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONSULTANT by reason of any breach of the said CONSULTANT of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to

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Rs.....(Rupees.....only). Any such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONSULTANT or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONSULTANT. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 4 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONSULTANT and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONSULTANT or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 5 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONSULTANT to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 6 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Consultant or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 7 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONSULTANT's liabilities.
- 8 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONSULTANT(S).
- 9 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended

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**Tender Document for Selection of Implementation Support Consultant for
Unit No. [...] Capacity [...] of [Name of the Power Plant]**

[Logo of Utility]

from time to time for such period as may be desired by [Name of
Consultant.....] on whose behalf this guarantee has been given.

10 Signed at.....this.....day of.....20.....

Signature :

Name :

Designation :

Staff Code No :

Bank Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :
2. Signature :
Full name in block letters :
Occupation :
Address :

Document Number	Rev No	Description	Page No.	Date of Issue
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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
IMPLEMENTATION SUPPORT CONSULTANT**

SECTION-II – TERMS OF REFERENCE

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MODEL TENDER DOCUMENT FOR SELECTION OF IMPLEMENTATION SUPPORT CONSULTANT

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

SECTION-II – TERMS OF REFERENCE

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Tender Document for Selection of ISC Consultant for Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

1 GENERAL

{Briefly explain the need and objective of R&M, give reference of the studies carried out to assess the health of the unit and the progress made till date for the implementation of R&M}

1.1 Project Background

{Give brief description of the unit and the latest performance parameters in terms of Average Load during the year, PLF, Availability Auxiliary Power Consumption, Heat Rate and the average Calorific Value of Coal being presently used in the boiler.}

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2 ROLE OF IMPLEMENTATION SUPPORT CONSULTANT

Role of the ISC shall as follows:-

- a. To provide assistance to the Utility during detailed engineering, supply, implementation and commissioning of works.
- b. To prepare the work schedule and monitor the progress of works through close involvement with the Contractors and other agencies on behalf of the Utility.
- c. To review the detailed engineering drawings/design calculations, schedule planned for execution and commissioning of all the works in line with the broad parameters of accepted design.
- d. To assist the Utility in taking various decisions in the course of implementation of project and in taking timely actions to ensure that the time schedule envisaged for the project is adhered to.
- e. To draw attention of the Utility in case of any problems and suggest suitable remedial measures to control the situation.
- f. To assist the Utility in addressing any technical / commercial / contractual / legal / regulatory issues arising during the course of the implementation of the project.

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3 SCOPE OF SERVICES

The detailed scope of services shall be as described below:

3.1 Data Collection

Reports of studies like RLA/CA Reports, Energy Audit Report, Feasibility Report and DPR will be made available to ISC by the Owner.

3.2 Detailed Engineering Phase:

During Detailed Engineering phase, ISC shall-

- i) Co-ordinate between Vendors and Owner.
- ii) Resolve problems arising during all phases.
- iii) Monitor the progress of the work as per approved schedule.
- iv) Approve master list of contractor's design drawings along with submission / schedule.
- v) Categorize drawings as 'for approval' and 'for information' only.
- vi) Review and approve contractor's drawings / data sheet to ensure conformity to the technical specification requirements.
- vii) Review design clarification.
- viii) Follow-up with the contractors for expeditious submission of drawings for approval.
- ix) Report any delay to the Owner along with remedial action.
- x) Finalize list of major equipments for which shop performance tests have to be carried out.
- xi) Finalize delivery schedules for major equipments and sequential supplies to ensure uninterrupted erection work.
- xii) Prepare overall initial project schedule - L1 network and review of L2 and L3 networks as submitted by the contractors.
- xiii) Approve PG test procedures.

3.3 Supply Phase:

During Supplies phase, ISC shall –

- i) Assist the Owner in dealing with statutory authorities such as Boiler Inspectorate Directorate, Pollution Control Board etc. (if required)
- ii) Follow-up with the contractors for expeditious supplies as per approved schedule.
- iii) Report any delay to the Owner along with remedial action.

3.4 R&M Implementation Phase:

During R&M Implementation phase, ISC shall –

- i) Review the implementation plan, the need of erection machinery, tools and tackles and availability of trained manpower with the vendor.
- ii) Take review of pre-commissioning documents including pre- commissioning check-list.
- iii) Take review of O&M manual and write-up instruction relating to initial operation of the Unit.

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- iv) Take review and approval of as-built drawings prepared by the contractors based on the marked-up drawings showing the modifications carried out by them during execution.
- v) Ensure overall coordination between various contractors in planning and fixing priority of construction and installation
- vi) Monitor the progress.
- vii) Witness the PG Test and evaluate PG Test Reports.

Note: ISC would not be a party for any technical / commercial / legal dispute arising between the Utility and the manufacturer / vendor / contractor.

3.5 Schedule of Completion of Task:

The Contract will be implemented in accordance with the services indicated. The ISC shall prepare and submit well in advance the complete schedule of completion of work and the schedule of manpower to be deployed.

3.6 Reports / output to be provided by ISC:

The following outputs are required from ISC. The ISC may note that the listed reports herein are minimum requirement only. The reports / reviews to be submitted and tasks to be fulfilled will be as per requirement of the work to complete the task successfully.

- i) Monthly progress reports.
- ii) Report pertaining to the initial Project Schedule L-1 network of each package and review/finalize L2 and L3 networks.
- iii) Approval of Master list of drawing/ Datasheet of all the Contractors of all procurement packages including submission schedule preferably.
- iv) Review Completion report and approval of contractor's drawings / data sheet to ensure conformity to the technical specification requirements
- v) Finalization of list of major equipments for which shop performance tests have to be carried out.
- vi) Finalization of delivery schedules for major equipments from manufacturing units.
- vii) Approval of PG test procedures.
- viii) Review and finalization of pre-commissioning documents including pre- commissioning check-list,
- ix) Review and finalization of O&M manuals and write-up instruction relating to other allied services for initial operation of the equipment and the plant prepared by the contractors.
- x) Review and approval of "as-built" drawings prepared by the contractors based on the marked-up drawings showing the modifications carried out by them during construction/erection.
- xi) Furnishing clarifications to specifications and drawings, arrangement for getting modified drawings, coordination between project site-office and owner's head-office as required during erection of equipment and construction of civil works.
- xii) Perusal and monitoring of quality plans and implementation schedules during phases of implementation.
- xiii) PG Test evaluation and acceptance.

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4 KEY PROFESSIONAL POSITIONS WHOSE CV WOULD BE EVALUATED:

S. No.	Key Position	Area of Specific Expertise desired	Minimum Qualification and Professional Experience Desired
1	Team Leader (Project Management) and Specialist (Boiler/Turbine)	Overall Management of Project Implementation Support team.	Graduate Engineer, with minimum 15 years relevant experience in Project Management. Good knowledge of project safety & legal aspect. The proposed individual should also have direct experience of handling an EPC Project of coal fired thermal power plant of 200 MW or above capacity.
2	Specialist (Boiler)	Design- Engineering / Production, Project planning Erection and Commissioning	Graduate Mechanical Engineer with at least 5-10 years experience in the relevant fields, including direct experience of Boiler design/ erection /commissioning preferably of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.
3	Specialist (Turbine)	Design- Engineering / Production, Project planning Erection and Commissioning	Graduate Mechanical Engineer with at least 5- 10 years experience in the relevant fields, including direct experience of Turbine design/ erection/ commissioning preferably of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.
4	Specialist/s (Electrical)	Design- Engineering / Production, Project planning Erection and Commissioning	Graduate Electrical Engineer in Electrical Systems with at least 5-10 years experience in the relevant fields, including direct experience of design /erection/commissioning of Electrical Equipment /systems preferably of 200 MW or above capacity. Should have knowledge of relevant International and National testing code.
5	Specialist/s (Control and Instrumentation)	DCS Installation and Commissioning	Graduate Instrumentation Engineer with at least 5-10 years experience in the relevant field including direct experience of design/ erection/ commissioning of electrical systems preferably of 200 MW or above capacity.
6	Specialists - Civil	Supervision of civil and structural work	Graduate Civil Engineer with at least 5-10 years experience in the relevant fields including direct experience of design/ erection/ commissioning of electrical systems preferably of 200 MW or above capacity.
7	Besides the above mentioned experts, Consultant should appoint sufficient nos. of commissioning engineers of relevant faculty at site during Commissioning and PG Test. The owner will provide support staff of relevant faculty who will associate with the Experts of Consultant during site supervision and field quality monitoring as well as during preparing required reports.		

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Note:

After award of the contract the client expects all the proposed key personnel to be available during implementation of the contract as per the agreed staffing schedule at the time of negotiation. The Utility expects that Consultant will keep experts same throughout the contract period. If any replacement is required, the Consultant should ensure that there is a reasonable overlap between the staff to be replaced, wherever feasible/possible.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-I
COMMERCIAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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2. Site & Project Specific Information
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4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
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(TO BE FILLED BY BIDDER)**

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List of Acronym

CIF	: Cost Insurance Freight
CPBG	: Contract Performance Bank Guarantee
CST	: Central Sales Tax
EDI	: Electronic Data Interchange
EUR	: Euro
FOB	: Free on Board
GCC	: General Conditions of Contract
GOI	: Government of India
GST	: Goods & Service tax
ICB	: International Competitive Bidding
INR	: Indian Rupees
I&C	: Instrumentation & Control
ITB	: Instruction to Bidder
JV	: Joint Venture
LOA	: Letter of Award
LOI	: Letter of Intent
MoEF	: Ministry of Environment and Forests
MSL	: Mean Sea Level
PERT	: Program evaluation and review technique
RBI	: Reserve Bank of India
R & M	: Renovation and Modernization
SCC	: Special Conditions of Contract
TMCR	: Turbine Maximum Continuous Rating
UNCITRAL	: United Nations Commission on International Trade Law
USD	: US Dollar
VAT	: Value added Tax

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1.0 INVITATION FOR BID

Tender No : [-----]

1.1 Introduction

[Give brief introduction about the name, ownership, business & Power Projects of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of XXX MW Unit no.-XX ----- of the Power Plant]

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, invites sealed Tenders in English language from Prequalified Bidders for the Renovation & Modernization of Boiler & Auxiliaries package of Unit No.[XXX] of the [XXX] Power Plant on International Competitive Bidding (ICB) basis as per the scope of work given Technical Specification Volume-II.

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly of existing equipment / systems, replacement of specified equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing and forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, all associated civil works including supply of cement, steel etc., testing & commissioning, successful completion of trial operation and guarantee tests for [XXX] package of Unit no. [XXX] of [XXX] Power Plant. The detailed scope of work is given in technical specification Vol. II.

The brief scope of work is given below: -

[-----]
[-----]
[-----]
]

For detailed Scope of Work & Services, refer Section-I of Volume-II of this Specification.

1.4 Tender Details

(a)	Cost of Tender Documents	:	INR [---]/ USD [---]/ EUR [---]
(b)	Bid Guarantee Amount	:	INR [-----]/ USD [-----]/ Euro [-----]
(c)	Date of issuance of Tender Document	:	[-----]
(d)	Date & Time of pre-Bid Conference	:	[-----]
(e)	Last Date & Time of	:	[-----]

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	Receipt of Bid (Both Part I & Part II)		
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of facilities and performance guarantee test shall be as per SCC.

1.6 Bid Submission

- The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.
- The Bid proposals are to be submitted in two parts in separate sealed covers as follows:
 - Part I** : Bid Guarantee and Technical & Commercial Proposal without prices
 - Part II** : Price Schedule and Schedule of Functional Guarantee parameters with values.
- All other terms and conditions along with the Technical Specifications, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:

[Designation, Address and Contact details

-----]
-----]

- Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the respective quoted Foreign Currencies.
- Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- The Tender Documents are meant for the exclusive purpose of bidding against the subject package and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Owner, intends to carry out the Renovation & Modernization of [Unit no.-XX ----- of the XXXX Power Plant].

Under the subject Tender, [Utility] invites bid for Renovation & Modernization of Boiler & Auxiliaries package of the said Renovation & Modernization work to be carried out as per the accompanying Technical Specifications. The Bidder shall submit the offer for complete scope of work indicated in the Technical Specification.

2.2 Address and Contact Details of Owner

[Designation, Address and Contact details

-----]
-----]

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Owner's Consultant

[-----], hereinafter referred to as "Consultant" is the Consulting Engineer for the project, appointed by the Owner, [-----], to provide project consultancy services.

2.5 Sources of Fund

[Utility] intends to finance the subject Package of the said renovation & modernization work, through Internal and other sources & External/ Domestic Commercial/ Borrowing from international development funding agencies. [Utility] has tied up the required fund for this package.

2.6 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Owner will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.7 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.8 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents. It shall include the following:

- Disassembly of existing equipment/ systems as required.
- Detailed design of the systems/equipment covering all Mechanical, Electrical, Control & Instrumentation, Civil and Structural works.
- Complete manufacture, including shop inspection and testing.
- Providing engineering drawings, data, operational & maintenance manuals, etc., for the Owner's review/ approval.

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- (e) Packing, forwarding and transportation including insurance from the manufacturer's works to plant site and transportation from storage yard to erection site.
- (f) Receipt, storage, preservation and conservation of system/equipment at site including construction of storage facility viz. covered, semi-covered, air-conditioned, open yard at the space allocated at site by Owner including storage-cum-erection and all other specified & statutorily required insurance.
- (g) Pre-assembly, if any, erection, testing, commissioning, completion of plant and equipment/ system, conducting trial operation, performance guarantee test and handing over of all the plant and equipment/ system covered under this specification.
- (h) Carry out all related civil and structural works at site including construction of foundations, buildings, structures etc. Including supply of cement and steel and all other required materials.
- (i) Supply of mandatory spares and tools & tackles.
- (j) Training of Owner's personnel.

Detailed scope is provided in Volume-II of the Technical Specifications.

Bids not covering the entire scope mentioned hereinabove may be treated as incomplete and hence are liable for rejection.

2.9 Time Schedule

The completion Time Schedule for Completion of R&M work and Performance Guarantee Tests shall be as given in the SCC.

2.10 Tender Documents

The scope of contract, technical specification, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following volumes:

Volume – I	:	Commercial
Volume – I Chapter-1	:	Invitation for Bid
Volume – I Chapter-2	:	Instructions To Bidders
Volume – I Chapter-3	:	General Project Information
Volume – I Chapter-4	:	General Condition of Contract (GCC)
Volume – I Chapter-5	:	Special Condition of Contract (SCC)
Volume – I Chapter-6	:	Forms & Schedules
Volume – II	:	Technical Specifications
Volume – II Section-I	:	Project Technical Specification
Volume – II	:	Detailed Technical Specification-Mechanical

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Section-II, Part-A		
Volume – II Section-II, Part-B	:	Detailed Technical Specification-Electrical
Volume – II Section-II, Part-C	:	Detailed Technical Specification-I&C
Volume – II Section-II, Part-D	:	Detailed Technical Specification-Civil
Volume – III	:	Technical Schedules
Volume – III, Part-A	:	Technical Schedule-Mechanical
Volume – III, Part-A	:	Technical Schedule-Electrical
Volume – III, Part-A	:	Technical Schedule-I&C

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Owner.

The Bidder is expected to examine all instructions, forms, terms, conditions, specifications and other information in the bidding documents. Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Owner in writing by post or by e-mail followed by postal confirmation at the Owner's address indicated in ITB. The Owner will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than twenty-one (21) days prior to the deadline for submission of bids prescribed by the Owner. Owner's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Owner will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operational and does not any way adversely impact the interest of the Owner. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Owner may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the bidding documents.

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The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.11 Preparation of Bids

2.11.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.11.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

The bidders are required to submit, the bids for the Renovation and Modernization work in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical Data Sheets, List of Tools & Tackles, Deviations to Technical and Commercial Specifications/Conditions, Overall Completion Time Period & L-1 Network Schedule, Resource Deployment Schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part-II Bid will comprise Quoted Price and Quoted Performance Guarantee Parameters. Initially, only the Part-I Bid will be opened and Part-II Bid is kept in safe custody.

After evaluation of the Techno-Commercial (Part-I) Bids, each Bidder who has submitted a broadly responsive Part-I Bid, will be invited for Techno-Commercial Discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a memorandum. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions. The date & time for opening of Price Bid will be intimated separately.

Techno-Commercial Bid should not contain any price data.

Price Bid should not contain any matter in respect of Technical and / or Commercial aspects other than the details specifically sought by the Owner.

2.11.3 Bid Submission

- (1). Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2). All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered. All bids shall be prepared in the English language only, by typing or printing.

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- (3). [One original and 9 (nine) identical] copies of the original with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., "Original", "Copy No. 1", "Copy No. 2" etc.).
- (4). All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (5). The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (6). The Bidder's Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (7). In the event of discrepancy between "Original" and any copy of the bids, the hard copy of Original shall prevail.
- (8). The Bid shall be submitted to [-----]. Bid submitted to any other office of Owner is liable for rejection. Bids submitted by Telefax or e-mail will be rejected
- (9). Owner will receive Bids in respect of all the equipment/systems and scope of work as set forth in the accompanying Technical Specifications. All bids shall be prepared and submitted in accordance with the Tender Documents.
- (10). Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Technical Specifications in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11). A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Owner's rights or the successful Bidder's obligations under the contract.
- (12). Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13). Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Contractor under the Contract.
- (14). Either the Indian agent or the foreign Principal directly could bid in a tender, but not both. The same applies to an Indian agent/dealer representing and Indian manufacturer. In case both submit the tenders, the tender of the manufacture will alone be considered.
- (15). An agent representing one manufacturer in a tender will not be allowed to quote on behalf of another manufacturer along with previous manufacturer in a subsequent / parallel tender for the same item.

2.11.4 Bid Guarantee

- (1). The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of "[-----]" payable at "[-----]".

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- (2). The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank. Foreign Bidders may submit the Bank Guarantee from any bank in India as above or from any foreign bank which is in the approved list of RBI.
- (3). Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Owner (at '[-----]'). In the event of any deviation in this regard, the decision of Owner as to whether the same could be accepted or not, is final and binding on the Bidder.
 - d) In case of foreign Bidder, the Bid Guarantee amount shall be in US Dollar / Euro/ Indian Rupee.
- (4). The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Owner.
- (5). No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified here in above or from banks not specified hereinabove will be liable for rejection.
- (6). Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7). The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Owner or fails to submit Contract Performance Guarantee
- (8). The Bid Guarantee of all unsuccessful Bidders shall be returned after price cover opening and price evaluation. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Owner and acceptance thereof.

2.11.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part– I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part–I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Owner, at its discretion, may consider appropriate, shall be read out. The Part – II (Price Bid) will be lodged and opening of the same will be intimated separately to those Bidders whose Part-I Bid willd be determined to be substantially responsive to Tender Conditions and Technical specifications in all respects.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.

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3. Owner takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

2.12 Composition of Techno Commercial Bid (Part-1 Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 9 (nine) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B of this Volume).
- (ii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iii). Letter of consent: To be furnished by the Bidder Consortium Partners/Individual Companies of the Group (as the case may be)- as per Annexure—D of this Volume
- (iv). Letter of Unequivocal Consent to be furnished by the Bidder and Assignee as per Annexure-E of this Volume
- (v). Bid Guarantee- as per Annexure A.
- (vi). Schedule of Prices as per Schedule – F1 (Table 1 to Table-7) with the word "Quoted" in lieu of Price data and all other details except price data.
- (vii). Mandatory spares as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (viii). Recommended spares (with the word "Quoted" in lieu of Price data)
- (ix). Tools & Tackles as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (x). Schedule of Performance Guarantees- as per Schedule – F1 (Table-8) with the word "Quoted" in lieu of Performance Guarantee parameters
- (xi). Signed copy of all the corrigendum's/amendments/clarifications, if any issued for the tender
- (xii). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (xiii). Deviations to the Commercial specification, if any, as per Schedule – F3.
- (xiv). Deviations to Technical Specifications, if any, as per Schedule – F4.
- (xv). Requirements of the Contractor at site, as per Schedule – F5.
- (xvi). Resource deployment schedule as per Schedule – F6
- (xvii). Details of the present commitments of the Bidder, details of contracts in hand
- (xviii). Details of Sub-Contractors/Sub-Suppliers/Sub-Vendors, if any
- (xix). Quality Assurance Programme
- (xx). Technical Details to be furnished with the Bid as called for in the Technical Specification Vol-II and Technical Bid Data Sheet Vol-III.
- (xxi). Schedule of weights and dimensions
- (xxii). Coefficients and indices for price variation formula

The Part-I Bid shall not contain any Price data.

2.13 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices and the Performance Guarantee parameters only in the specified format. Price given in Part-II should cover the entire

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scope of work as given in Part-I of the offer including list of mandatory spares and Tools & tackles with itemized price and should be as per Schedule of Price enclosed. **[One original and 9 (Nine) identical]** copies shall be submitted.

1. The Price Bid shall contain the following :

- (i). Duly filled in Form of bid as per Annexure-B & Annexure-C
 - (ii). Completely filled in Schedule of Prices Schedule – F1 (Table 1 to Table-7)
 - (iii). Completely filled in Schedule of Performance Guarantees Schedule – F1 (Table-8).
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed formats. The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
 3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Owner shall be final. All entries shall be in English language only.
 4. The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the quoted Foreign Currencies.
 5. Prices in Indian supply shall be quoted on Ex-works supply of plant & equipment basis including Packing & forwarding. Inland transportation, Insurance charges, etc. shall be indicated separately.
 6. Prices of imported supply of plant & equipment directly consigned to site shall be quoted on CIF Indian port of entry basis. The bidder shall also quote separately for FOB port of shipment price for ocean freight for Marine insurance, all port charges including customs clearance and inland transport charges from port of destination to Owner's site.
 7. Custom Duty, Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation.

2.14 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the Contractor's obligations mentioned in tender document specification or to be reasonably inferred from the tender documents/ specification in respect of the disassembly/ dismantling of existing equipment facility as specified, design, manufacture, including procurement and subcontracting (if any), delivery, construction, installation, commissioning, completion of the facilities and conductance of Performance Guarantee tests for the facilities including supply of mandatory spares, recommended spare & tools/ tackles (if any). This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the facilities, conducting Guarantee tests and, where so required by the tender documents, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the tender documents, all in accordance with the requirements of the Conditions of Contract and Technical Specifications.

Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the tender documents.

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Prices quoted by the Bidder shall be subject to adjustment during performance of the Contract to reflect changes in the cost of labour, material, etc. Bidder A bid submitted with a fixed price quotation will not be rejected, but the price adjustment will be treated as zero. The price adjustment provision will not be taken into consideration in bid evaluation.

2.15 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if any shall be signed by the person signing the Bid. Printed literature, it enclosed need not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.16 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Owner may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Specifications by amendment.
2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Specifications, which will be notified. Amendments will be hosted in Owner's website. Bidders are requested to visit Owner's website and note amendments, if any, before submission of bid. Owner shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.17 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

2.18 Information to be Furnished with the Bid

1. The Bid (Part-I) must clearly indicate the name of the manufacturer, the type or model of each principal item of equipment proposed to be supplied and erected. The Bid should also contain drawings and descriptive materials indicating general dimensions, material from which the parts are manufactured, principles of operation and the extent of pre-assembly involved, major erection equipment required to be deployed, method of erection and the proposed erection Organization structure.
2. The above information shall be provided by the Bidder in the form of separate sheets, drawings, catalogues, etc.
3. Any Bid not containing sufficient descriptive material to describe accurately the system / equipment proposed may be treated as incomplete and hence rejected. Such descriptive materials and drawings submitted by the Bidder will be retained by the Owner. Any major departure from these 'drawings and descriptive material submitted will not be permitted during the execution of the Contract' without specific written permission of the Owner.
4. Oral statements made by the Bidder at any time regarding quality, quantity or arrangement of the equipment or any other matter will not be considered.

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5. Standard catalogue pages and other documents of the Bidder may be used in the Bid to provide additional information and data as deemed necessary by the Bidder.
6. In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy of all data sheets, Schedule, List of Mandatory spares, tools & tackles and Bar Chart/PERT as well as deviation tables in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation. Bidder shall submit all the filled in datasheet also in soft copy. Bidder shall also furnish soft copies and hard copies of Data Sheet with filled in details wherever details are required to be indicated by the Bidder.

2.19 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other interested parties are advised to refrain from contacting by any means, the Owner and/or his employees/ representatives on matters related to the Bids under consideration. The Owner, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

2.20 Validity of Bid

1. The Bid shall be kept valid for acceptance for **[180 days]** from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Owner from participating in any of the Owner's tenders.

2.21 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully informs himself as to all the conditions and matters which may in any way affect the 'Renovation and Modernization work to be carried out or the cost thereof. Bidders are required to visit the plant to get familiarized with local conditions. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Owner.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Owner at least **[7 (seven) days]** before the date stipulated for pre-bid meeting. The Owner then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till **[21 days]** prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Owner. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.

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3. Pre-Bid Conference will be organized and outcome of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Owner to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.
5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

2.22 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Owner not later than [-----] Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

2.23 Single Bidder Responsibility

1. The scope of supply and services shall be under single Bidder responsibility.
2. The successful Bidder should not sub contract the entire work on back to back basis or otherwise.

2.24 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Owner for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Owner, even though the Owner may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

2.25 Deputation of Representatives for Discussion

After opening of the Bid, if the Owner desires to have techno-commercial discussion on the Bid, the Bidder shall be in a position to depute his competent representatives of various disciplines at short notice with full authority for finalising technical parameters as well as Commercial Terms and Conditions of the Tender.

2.26 Evaluation of Bid

1. For evaluation and comparison of price bid, the prices indicated at [-----] summary of Prices as per Schedule [-----] will be considered. The Bids received will be evaluated by the Owner to ascertain the lowest evaluated substantially responsive Bid vis-à-vis the Tender Specifications. The Bidder has to satisfy himself that full information is furnished as required in the specifications. Lack of particulars or incomplete information furnished will run the risk of rejection of the bid. The following major procedures would be followed for evaluation of bids.
2. All the Bidders would be brought on par with reference to Technical Specification, Commercial Condition, Instructions to Bidders and subsequent techno-commercial discussions/ clarifications.

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3. After the evaluation of Part-I bids (techno-commercial bids) and before opening of Part-II bids (Price Bids), in case the bidders are asked to make changes to their techno commercial offer that may have price implications, Owner may give the bidders opportunity to submit addendum to price bid covering the price implication only against such changes before the opening of Part-II bids (Price Bids). All the bidders will be notified, at least 15 days before the Price Bid opening date, about such changes against which they can submit addendum to Price Bid.
4. Commercial loading would be done for non-compliance of commercial terms and conditions of the Tender Specifications other than the vital clauses, as the case may be.
5. To facilitate evaluation and comparison, the Owner will convert all bid prices expressed in foreign currencies into Indian Rupee at State Bank of India Bills Selling exchange rates prevailing on the date of opening of the price bid.
6. The Bidder is eligible for a price variation as per Tender Condition. However Price variation shall not be considered for Bid evaluation.
7. Technical loading will be done for omission of price data in respect of equipment/facilities, spares, tools & tackles, etc. The highest quoted corresponding price will be loaded against such omission. If no quoted price is available, the loading will be done as per the corresponding price as estimated by the Owner.
8. The Bidder has to meet the minimum functional performance levels indicated in Volume-II Technical Specification for all categories of Guarantees. If one or more of Functional Performance Parameters offered by the Bidder is inferior to the minimum functional performance level (i.e. higher or lower than maximum or minimum value specified in Technical Specification), then such bid will be considered non-responsive and rejected.
9. The quoted values for Performance Guaranteed Parameters given in Table below would be evaluated using evaluation factors specified. The evaluation factors shall be applicable to the differential values calculated from among the Bidders of corresponding item with appropriate highest or lowest value (i.e., the best quoted value) as the base. The evaluation will be based on the guarantee parameters inclusive of all tolerance furnished at the Guaranteed Condition. Bidders to note that the values indicated in the Schedule of Performance Guarantees shall be inclusive of all tolerances including measurement uncertainty.

Table-Bid Evaluation Factors

Sl. No.	Functional Performance Parameter	Evaluation Factor Rate
1.	BOILER Efficiency at 100% TMCR (At rated steam parameters)	[-----] INR per 0.01% difference in efficiency
2.	Auxiliary Power	[-----]INR per kW

The evaluation factors rate shall be prorated for any fractions of the specified value.

- (1). Arithmetical errors will be rectified on the following basis:

- If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.

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- If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
 - If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.
- (2). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder shall not charge any amount separately for that item from the Owner. If the terms, such as 'not applicable' "-----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.27 Local Conditions

1. The Bidder shall inspect the site and shall satisfy himself of the site conditions and shall apprise himself of the procedure for engagement of agencies/labour and shall collect any other information, which may be required before submitting the Bid.
2. Wages not less than Minimum wages for Contract labour shall be paid as applicable in this region from time to time. Claims and objections due to ignorance of site conditions will not be considered after submission of Bid.
 - (i). The Bidder is required to carefully examine the Technical & General Specification, commercial Terms and Conditions, drawings and other details relating to work given in the Tender Specification and get fully acquainted as to all conditions and matters which may in any way affect the work or the cost thereof.
 - (ii). The Bidder shall be deemed to have exhaustively examined the Tender Specifications including the Form of Contract, to have obtained all information and clarifications on all matters whatsoever that might affect the carrying out of the work and to have satisfied himself as to the adequacy of his Bid. He is deemed to have known the scope, nature and magnitude of the work and the requirements of materials and labour involved etc. and as to all work he has to complete in accordance with the Contract for the adequacy of his Bid.
 - (iii). The Bidder shall be deemed to have visited and carefully examined the plant/ site and surroundings, to have satisfied himself about the nature and details of all existing structures, if any, and also as to the nature and conditions of the railways, roads, bridges and culverts, means of transport and communications, whether by land, water or air and as to possible interruptions thereto and the access to and from the site, to have made independent enquiries, examined and satisfied himself as to the sources for obtaining earth, gravel, sand, stones, bricks and all other construction materials, the site for disposal of surplus earth and debris, the available accommodation, underground existing services, sub-soil water conditions, storms, prevailing winds, climatic conditions and all other similar matters which may affect the work.
 - (iv). The Bidder shall be deemed to have acquainted himself with the Indian Income tax Act, 1961, Indian Companies Act, 1956, Indian Customs Act,

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1962, Indian Central Excise Act, Value Added Tax, Indian Sales Tax Act, Indian Electricity Act, Central Electricity Authority Regulations, Indian Boiler Regulations, Factories Act, Pollution Control Regulations and other related Acts & Laws prevalent in the State of [-----] and in India and as amended from time to time. The Owner shall not entertain any request for clarifications from the Bidders regarding such local conditions.

- (v). Any neglect or omission or failure on the part of the bidder in obtaining necessary and reliable information as stated above or on any other matter affecting the Bidder shall not relieve him from any risk or liabilities or the entire responsibility for completion of the work in accordance with the Tender Specifications.

2.28 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and technical specification. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with “Original” of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily rejected and ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.
2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Owner at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Owner towards Owner’s cost, loss and damage to Owner.

2.29 Blacklisting/Debaring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Owner.

2.30 Award of Contract

1. Award Criteria
 - The Owner will award the contract to the successful Bidder whose Techno-commercial bid has been determined to be substantially responsive and Price Bid to be the lowest evaluated bid, further provided that the Bidder is determined to be qualified to perform the contract satisfactorily.
 - The Owner reserves the right to vary the quantity of any of the Items / Spares and / or delete any Item / Spares altogether at the time of Award of Contract.
2. Owner's Right to Accept Any Bid and to Reject Any or All Bids

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The Owner reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Owner's action.

3. Notification of Award

Prior to the expiration of the period of bid validity, the Owner will notify the successful Bidder in writing by registered letter (Letter of Award or LOA) or by email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Owner will promptly notify each unsuccessful Bidder and will discharge its bid security.

4. Signing the Contract Agreement

At the same time as the Owner notifies the successful Bidder that its bid has been accepted, the Owner will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

Within *[twenty-eight (28)]* days of receipt of the Contract Agreement, the successful Bidder / assignee of foreign bidder (if applicable) shall sign and date the Contract Agreement and return it to the Owner.

5. Corrupt or Fraudulent Practices

The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, the Owner:

- The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, the Owner :
 - "corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution; and
 - "fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner, and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition;
- will reject a proposal for award if it determines that the Bidder recommended for award has engaged in corrupt or fraudulent practices in competing for the contract in question;
- Will declare a firm ineligible, either indefinitely or for a stated period of time, to be awarded a contract if it at any time determines that the firm has engaged in corrupt or fraudulent practices in competing for or in executing a contract of the Owner.

6. Fraud Prevention Policy

The Bidder along with its associate/collaborator/sub-contractors/sub-vendors/consultants/service providers shall strictly adhere to the Fraud Prevention Policy of Owner displayed on its tender website and shall immediately apprise the Owner about any fraud or suspected fraud as soon as it comes to their notice. A certificate to this effect shall be furnished by the bidder along with his bid.

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2.31 Agency Commission

No Agency commission shall be payable under the Contract.

2.32 Contract Performance Bank Guarantee (CPBG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period. If the contract price is in more than one currency, CPBG shall be 10% of respective currency.

If the bidder is a joint venture of two firms who collectively meet the Qualifying Requirement, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the bidder, each of the JV partner shall furnish Additional Contract Performance Guarantee equal to 1% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder and Additional Contract Performance Bank Guarantee furnished by the JV partners taken together shall be 12% of the Contract Price.

If the bidder is a Consortium of two firms, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the Consortium Leader, the other consortium member will furnish Additional Contract Performance Bank Guarantee equal to 2% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder (Consortium Leader) and Additional Contract Performance Bank Guarantee furnished by the other consortium member taken together shall be 12% of the Contract Price.

In case of a successful foreign bidder, if the Owner accepts to enter into the Second Contract and / or Third Contract with the assignee, then, within Thirty (30) days after receipt of Letter of Award, the assignee shall furnish an additional Contract Performance Bank Guarantee for five percent (5%) of the value of the Contract entered into with the assignee (i.e. for five percent of aggregate value of component Contract(s) entered into with the assignee).

2.33 Contract Quality Assurance

1. The Bidder shall include in his Bid a detailed Quality Assurance Programme containing the overall quality, management and procedures which he proposes to follow in the performance of the 'Works' during various phases.
2. After Letter of Award (LOA) the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall form a part of the 'Contract'.

2.34 Codes & Standards

Specifications give reference to Indian or internationally accepted Standards. However, equipment or materials meeting other recognized National or International Standards, which ensure an equal or superior quality than Standards specified, will also be accepted. For details of codes and standards refer Technical specification, Volume-II.

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2.35 Vital Clauses

The following clauses in the Tender Specification & Draft Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Warranty
- Liquidated Damages
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Owner / Purchaser : [-----]
- Consultant : [-----]
- Project Title : [-----]
- Location : [-----]
- Latitude : [-----]
- Longitude : [-----]
- Elevation above MSL : [-----]
- Nearest Railway Station : [-----]
- Nearest Sea Port : [-----]
- Nearest Airport : [-----]
- Road Access/Approach to Site : [-----]

For Project & Site related detailed information, refer Clause No. 2 of Section-I of Volume-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Works, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract Agreement.
- iv. **"Contract"** means the Agreement entered into between Owner and Contractor as per the 'Contract Agreement' signed by the parties, including contract documents, contract schedule, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Contractor's Equipment"** means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities.
- vii. **"Contractor"** means the person(s), Firm or a Company whose bid to perform the Contract has been accepted by the Owner and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Contractor.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Owner for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.
- ix. **"Contractor's Representative"** means any person nominated by the Contractor & approved by the Owner hereof to perform the duties delegated by the Contractor.
- x. **"Consulting Engineer"** means Owner's Engineer appointed by the Owner. Also refers to any other firm(s) or person(s) as may be appointed by the Owner from time to time.

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- xi. **“Commissioning”** means the construction of plant and equipment for operation of the Facility at rated capacity are complete and the plant and equipment achieves the designated full load/full capacity, at designated fuel/input.
- xii. **“Completion”** means that the Facilities (or a specific part thereof where specific parts are agreed) have been completed operationally and structurally and put in a tight and clean condition, and that all work in respect of pre-commissioning of the Facilities or such specific part thereof has been completed and commissioning has been attained as per Technical Specifications.
- xiii. **“Competent Authority”** means any agency, authority, department, inspectorate, ministry or statutory person (whether autonomous or not) of GOI, [Name of the State], Ministry of Environment and Forests (MoEF) any other State of the Republic of India or any local authority.
- xiv. **“Day”** means calendar day of the Gregorian calendar.
- xv. **“Defect Liability Period”** means the period of validity of the warranties given by the Contractor, commencing at completion of the Facilities or a part thereof, during which the Contractor is responsible for defects with respect to the Facilities.
- xvi. **“Effective Date”** means the date from which the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor shall be determined.
- xvii. **“Erection Services”** means those entire services ancillary to the supply of the plant and equipment for the Facilities, to be provided by the Contractor under the Contract. e.g. transportation and provision of marine or other similar insurance, inspection, expediting, site preparation works (including the provision and use of Contractor's Equipment and the supply of all construction materials required), installation, testing, Pre-commissioning, commissioning, operations, maintenance, the provision of operations and maintenance manuals, training of Owner's Personnel etc.
- xviii. **“Facilities”** means the plant and equipment to be supplied and installed, as well as all the Installation Services to be carried out by the Contractor under the Contract.
- xix. **“Force Majeure”** means mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- xx. **“GCC”** means the General Conditions of Contract hereof.
- xxi. **“Good Industry Practice”** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Contractor, equipment manufacturer or operator applying the standards generally adopted by global Contractors, global equipment manufacturers and operators in the construction or operation of power generation facilities or the manufacture of equipment therefore, except in so far as inconsistent with any applicable Indian law or directive.
- xxii. **“Guarantee Test(s)”** means the test(s) specified in the Technical Specifications to be carried out to ascertain whether the Facilities or a

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specified part thereof is able to attain the Functional/Performance Guarantees specified in the Technical Specification.

- xxiii. **"Incoterms"** means International rules for interpreting trade terms published by the International Chamber of Commerce (latest edition), Paris (France). Unless inconsistent with any provisions of the contract, the meaning of any trade term and the rights and obligations of the parties there under shall be as prescribed by Incoterms.
- xxiv. **"Inspector/Inspecting Engineer"** means the Owner or any person nominated by the Owner from time to time, to inspect the equipment of works under the contract and/or the duly authorized representative of the Owner.
- xxv. **"Latent Defect"** means the defects inherent in the material or arising out of design deficiency which does not manifest itself during the Warranty Period/Defect Liability Period, as described in this GCC.
- xxvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Owner notifying the Contractor that its Bid Proposal has been accepted.
- xxvii. **"Month"** means calendar month of the Gregorian calendar.
- xxviii. **"Manufacturer's Works" or "Contractor's Works"** means the place used by the Contractor, its manufacturer, supplier, collaborators or sub-contractors/vendors/sub-vendors for the performance of the works.
- xxix. **"Operational Acceptance"** means the acceptance by the Owner of the Facilities (or any part of the Facilities where the Contract provides for acceptance of the Facilities in parts), which certifies the Contractor's fulfillment of the Contract in respect of performance guarantees of the Facilities.
- xxx. **"Owner" or "Purchaser"** shall means the [Name of the Utility], , and includes its legal successors or permitted assignees.
- xxxi. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
- xxxii. **"Pre-commissioning"** means the testing, checking and other requirements specified in the Technical specifications that are to be carried out by the Contractor in preparation for commissioning.
- xxxiii. **"Project"** means the Owner's [-----] in respect of which the Contract has been signed.
- xxxiv. **"Project Consultant" or "Owner's Consultant"** means the engineering firm or person(s) appointed by the Owner to render engineering project consultancy services for the project.
- xxxv. **"Project Manager"** means the person appointed by the Owner thereof and named as such, to perform the duties delegated by the Owner.
- xxxvi. **"Plant and Equipment"** means permanent plant, equipment, systems, machinery, apparatus, articles and things of all kinds to be provided and incorporated in the Facilities by the Contractor under the Contract (including the spare parts to be supplied by the Contractor under the Contract Agreement), but does not include Contractor's Equipment.
- xxxvii. **"SCC"** means the Special Conditions of Contract hereof.

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- xxxviii. **"Site"** means the land and other places upon which the Facilities are to be installed, and such other lands or places as may be specified in the Contract as forming part of the Site.
- xxxix. **"Sub Contractor", including "Vendors/Sub-Vendors"**, means any firm or person to whom execution of any part of the Facilities, including preparation of any design or supply of any plant and equipment is subcontracted directly or indirectly by the Contractor, and includes its legal successors or permitted assignees.
- xl. **"Tender Documents"** means the document, setting out a description and specification of the Works and statement of the technical and other standards to which the Works are to be performed including any modifications thereto made in accordance with the Conditions. This includes the technical & commercial specifications and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xli. **"Tenderer"/"Bidder"** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Owner, for the Project.
- xl.ii. **"Time for Completion"** means the time within which completion of the Facilities as a whole (or of a part of the Facilities where a separate time for completion of such part has been specified) is to be attained in accordance with the stipulations and provisions of the Contract.
- xl.iii. **"Warranty Period" or "Defect Liability Period"** means the period during which the Contractor shall remain liable for repair or replacement of any defective part of the works performed under the contract, free of cost.
- xl. iv. **"Work(s)"** means and includes the tasks of furnishing of equipment, labour & services, transport, handling, unloading and storage at site, civil construction and complete erection, testing, commissioning putting into satisfactory operation and completion of successful performance tests, reliability tests and any other guaranteed parameters as defined in the Contract, replacement, modification, repair of defective parts or equipment during warranty period and rectification of latent defects during latent defect period.
- xl. v. **"Writing" or "Written"** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Owner. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

Terms and expressions not herein defined shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

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4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Owner.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing submitted by the contractor.
- vi. The bid & schedules/ attachment.

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Construction of the Contract

The Contracts to be entered between the Owner and the Contractor shall be as under:

- 'First Contract' for CIF Supply of all Offshore Plant and Equipments and Materials including Mandatory Spares to be supplied from abroad.
- 'Second Contract' for Ex-Works Supply of all Plant and Equipments and Materials including Mandatory Spares of Indian origin.

'Third Contract' for providing all services i.e. Port Handling, Port Clearance and Port Charges for the imported goods, further Loading and Inland Transportation for Delivery at Site, Unloading, Storage, Handling at Site, Installation, Insurance, Testing and Commissioning including carrying out Guarantee Tests for all the Equipments supplied under the First Contract and the Second Contract and all other services specified in the Tender Documents. All the above Contracts will contain a cross-fall breach clause specifying that breach of one Contract will constitute breach of the other Contracts which will confer a right on the Owner to terminate the other Contracts also at the risk and the cost of the Contractor.

The foreign bidder, however, has the option, to be exercised as a part of its bid proposal, to propose an Assignee in its bid to execute the Second Contract and/or the Third Contract. Such foreign bidder shall furnish a written unequivocal consent (with Part-I Bid) of the proposed Assignee to work as independent Contractor on the terms

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and conditions offered by the bidder For the scope of work envisaged by the foreign bidder, in its bid, to be executed by Assignee, the Assignee should have relevant/required capacity and experience of executing similar job. The bidder shall substantiate with relevant/required documents in the bid to establish capacity and experience of the Assignee.

If the foreign bidder has proposed an Assignee in its bid to execute the Second Contract and/or the Third Contract and has also furnished written unequivocal consent of the proposed Assignee to work as an independent Contractor on the terms and conditions offered by the bidder and if the Owner is satisfied with the capacity and experience of the Assignee proposed in the bid, the Owner will enter into the "Second Contract" and/or the "Third Contract" with the Assignee. However, if the Owner in its judgment does not find acceptable the Assignee proposed in the bid as its Contractor, then on the request of the Owner, the Bidder shall have option to propose an alternate Assignee on the same terms and conditions and cost as offered in its bid. In case the Assignee option is not exercised by the Bidder or if the Assignee fails to enter into Contract(s) with the Owner or if the Owner in its judgment does not find acceptance of the Assignee as its Contractor, then the foreign bidder shall be obliged to enter into and execute all the contracts envisaged to be entered upon this Tender with the Owner covering the entire scope of work envisaged in the Tender Documents on the same terms and conditions and cost as offered in its Bid.

If any foreign bidder has proposed an Assignee in his bid to execute the Second Contract and/or the Third Contract and has also furnished written unequivocal consent of the proposed Assignee to work as independent Contractor on the terms and conditions offered by the bidder and if the Owner is satisfied with capacity and experience of the Assignee, the Owner will enter into the 'Second Contract' and/or 'Third Contract' with the said Assignee. In case no Assignee has been proposed by the foreign bidder in his bid or if the Assignee fails to enter into the Second Contract and/or Third Contract with the Owner or if the Owner in its judgment does not find acceptance of the proposed Assignee as its Contractor, then the foreign bidder shall be obliged to enter into and execute all the three Contracts with the Owner.

If the Owner accepts to enter into Second Contract and/or Third Contract with the Assignee of foreign bidder, the said Assignee, in addition to the Contract Performance Securities to be provided by the foreign Contractor shall provide within [twenty eight (28)] days of Notification of Award, separate Contract Performance Bank Guarantee equivalent to ten percent (5%) of the value of the Contract(s) entered into with the Assignee for the due performance of the Contract, with an initial validity upto [ninety (90) days] beyond the scheduled Defects Liability Period.

The award of the separate Contracts shall not in any way dilute the responsibility of the Contractor for the successful completion of the Facilities as per Contract Documents and a breach in one Contract shall automatically be construed as a breach of the other Contract(s) which will confer a right on the Owner to terminate the other Contract(s) also at the risk and the cost of the Contractor.

4.6 Independent Contractor

The Contractor shall be an independent contractor performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Contractor shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or Subcontractors engaged by the Contractor in connection with the performance of the Contract shall be under the complete control of the Contractor and shall not be

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deemed to be employees of the Owner, and nothing contained in the Contract or in any subcontract awarded by the Contractor shall be construed to create any contractual relationship between any such employees, representatives or Subcontractors and the Owner.

4.7 Joint Venture or Consortium

If the Bidder/Contractor is a joint venture or consortium of two or more firms, all such firms shall be jointly and severally bound to the Owner for the fulfillment of the provisions of the Contract and the Bidder shall submit a letter of consent to this effect (with Part-I Bid) signed by all joint venture partners / consortium members. The joint venture/consortium partners shall designate one of such firms to act as a leader with authority to bind the joint venture or consortium. The composition or the constitution of the joint venture or consortium shall not be altered without the prior consent of the Owner.

4.8 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.9 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.10 Origin

"Origin" means the place where the materials, equipments and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.11 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or E-mail to the address of the relevant party indicated in the Contract.

Either party may change its postal address, telefax number, or E-mail address or addressee for receipt of such notices by ten (10) days' notice to the other party in writing

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

4.12 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [.....] shall have exclusive jurisdiction in all matters arising under the Contract.

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4.13 Settlement Of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Owner and the Contractor in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Owner & Contractor shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

Either Owner or the Contractor may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities

Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Owner and the Contractor shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within *[twenty eight (28)]* days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by the Appointing Authority for arbitrator is given below.

Appointing Authority for Arbitrator:

- President, Institution of Engineers in case of an Indian Contractor.
- President, International Chambers of Commerce, Paris in case of a Foreign Contractor.

If one party fails to appoint its arbitrator within *[forty-two (42)]* days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Arbitration proceedings as follows:-

- In case of a foreign contractor the arbitration proceeding shall be conducted in accordance with the United Nations Commission on International Trade Law (UNCITRAL) Arbitration Rules of 1976.
- In case of an Indian Contractor Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996
- In case of a foreign associate of the contractor, the arbitration proceedings shall be conducted in accordance with the United Nation Commission on International Trade Law (UNCITRAL) Arbitration Rules of 1976.

The Place for Arbitration shall be: *[New Delhi]*, India.

The language of arbitration shall be English.

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The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- the parties shall continue to perform their respective obligations under the Contract unless they otherwise agree
- The Owner shall pay the Contractor consideration due to the Contractor.

4.14 Scope of Facilities

- a) Unless otherwise expressly limited in the Technical Specifications, Facilities the Contractor's obligations cover the provision of all Plant and Equipments including spares and the performance of all Services required for design, manufacture (including procurement, quality assurance, construction, installation, associated civil works, Structural and others construction works, precommissioning and delivery) of the Plant and Equipment and the installation, commissioning, completion of facilities and performance testing of the Facilities in accordance with the plans, procedures, specifications, drawings, codes and any other documents as specified in the Technical Specifications. Such specifications include, but are not limited to, the provision of supervision and engineering services; the supply of labour, materials, equipment, spare parts and accessories; Contractor's Equipments; construction utilities and supplies; temporary materials, structures and facilities; transportation loading & unloading.
- b) The Contractor shall, unless specifically excluded in the Contract, perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for attaining Completion of the Facilities.

4.15 Time for Commencement and Completion

- a) The Contractor shall commence work on the scope of work under this Tender from the date of Letter of Award. Contractor shall thereafter proceed with the Facilities in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- b) The Contractor shall attain Completion of the Facilities (or of a part where a separate time for Completion of such part is specified in the Contract) within the time stated in the SCC subject to time extensions, the contractor is entitled under the contract conditions or time extension expressly grouted by the Owner.

4.16 Spare Parts

In addition to the supply of Mandatory Spare Parts included in the Contract, the Contractor agrees to supply other spare parts (recommended spares) required for the operation and maintenance of the Facilities for 3 years. However, the identity, specifications and quantities of such spare parts and the terms and conditions relating to the supply thereof are to be agreed between the Owner and the Contractor, and the price of such spare parts shall be that given in Price Schedule for recommended spares. The price of such spare parts shall include the purchase price therefor and other costs and expenses (including the Contractor's fees) relating to the supply of spare parts. The prices of recommended spares covered in price schedule shall be

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valid for a period of six months after the date of Notification of Award of Main Equipment and Mandatory Spares.

- The Contractor shall supply the recommended spares at the same terms and conditions as are otherwise applicable to this Contract.
- All the spares for the equipment under the Contract will strictly conform to the Specification and other relevant documents and will be identical to the corresponding main equipment/components supplied under the Contract and shall be fully interchangeable.
- All the Mandatory Spares covered under the Contract shall be manufactured along with the main equipments as a continuous operation and the delivery of the spares will be affected along with the main equipments in a phased manner and the delivery would be completed by the respective dates for the various categories of equipment as per the agreed schedule. If order for the Recommended Spares has been placed with the Contractor prior to commencement of manufacture of the main equipment this shall be applicable for manufacturer of recommended spares as well.
- The Contractor will provide the Owner with the manufacturing drawings, catalogues, assembly drawings and any other document required by the for the recommended spares. Such details will be furnished to the Owner as soon as they are prepared but in any case not later than six months prior to commencement of manufacture of the corresponding main equipment.
- In addition to the spares recommended by the Contractor, if the Owner further identifies certain particular items of spares, the Contractor will submit the prices and delivery quotation for such spares within [30] days of receipt of such request with a validity period of 6 months for consideration by the Owner and placement of order for additional spares, if the Owner so desires.
- The quality plan and the inspection requirement finalised for the main equipment will also be applicable to the corresponding spares.
- The Contractor will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/components/equipment covered under the Contract and will further ensure with his vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.
- The Contractor shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered under the Contract. The same provision will also be applicable to spares supplied by Sub-contractors.
- For the first 6 years from the schedule date of completion of facilities the prices will be derived from the corresponding Ex-Works Price at which the order for such spares have been placed by Owner as a part of Mandatory Spares or Recommended Spares, or from the rates of Mandatory Spares or Recommended Spares as quoted by/negotiated with the Contractor. Ex-Works order price of future spares shall be computed in accordance with the price adjustment provisions covered under the main Contract excepting that the base indices will be counted from the scheduled date of Commissioning of the last equipment under the main project. The Contractor will indicate in advance the delivery period of the items of spares, which the Owner may procure in accordance with this clause. In case of emergent requirements of

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spares, the Contractor would make every effort to expedite the manufacture and delivery of such spares on the basis of mutually agreed time schedule.

- In case the Contractor fails to supply the mandatory or recommended spares in the terms stipulated above, the Owner shall be entitled to purchase the same from the alternate sources at the risk and the cost of the Contractor and recover from the Contractor, the excess amount paid by the Owner over the rates worked on the above basis. In the event of such risk purchase by the Owner, the purchases will be as per the Works and Procurement Policy of the Owner prevalent at the time of such purchases and the Owner at his option may include a representative from the Contractor in finalising the purchases.
- It is expressly understood that the final settlement between the parties in terms of relevant clauses of the Contract Documents shall not relieve the Contractor of any of his obligations under the provision of long term availability of spares and such provisions shall continue to be enforced till the expiry of 6 years period reckoned from the scheduled date of Commissioning of the Plant and Equipment unless otherwise discharged expressly in writing by the Owner.
- The Contractor shall warrant that all spares supplied will be new and in accordance with the Contract Documents and will be free from defects in design, material and workmanship. The defects liability period for spares shall be 12 months from the date it is put to use. In case of failure of any spare part due to fault in design material or workmanship the same part will be replaced by the contractor without any extra cost of the Owner.

In case of any failure in the original component/equipments due to faulty designs, materials and workmanship, the corresponding spare parts, if any, supplied will be replaced without any extra cost to the Owner unless a joint examination and analysis by the Owner and the Contractor of such spare parts prove that the defect found in the original part that failed, can safely be assumed not to be present in spare parts. Any replaced spare parts will have the Defects Liability period of 12 months from the date it is put in use. The discarded spare parts will become the property of the Contractor as soon as they have been replaced by the Contractor. In any case the defect liability of spares will expire at the end of 48 months from the date of their receipt at site

The Defects Liability of spares that are not used within 18 months from the respective date of the delivery at Site will, be subject to condition that all such spares are stored in accordance with Contractor's standard recommended practice, if any, and the same has been furnished to the Owner.

4.17 Contractor's Responsibilities

- a) The Contractor shall design, manufacture (including associated purchases and/or subcontracting), disassemble/dismantle wherever required, install, commission and complete the Facilities and carryout the Guarantee tests with due care and diligence in accordance with the Contract.
- b) Before entering into this contract the Contractor is responsible to have examined the data relating to the Facilities provided by the Owner, and on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve contractor of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.

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- c) The Contractor shall acquire in its name all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Contractor's and Subcontractor's personnel and entry permits for all imported Contractor's Equipment.
- d) The Contractor shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any and all liabilities, damages, claims, fines, penalties and expenses of whatever nature arising or resulting from the violation of such laws by the Contractor.

4.18 Owner's Responsibilities

- a) The Owner shall be responsible for acquiring and providing legal and physical possession of the Site and access thereto, and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract, including all requisite rights of way.
- b) The Owner shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Owner to obtain them in the Owner's name, are necessary for the execution of the Contract.
- c) If requested by the Contractor, the Owner shall use its best endeavours to assist the Contractor in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Contractor or Subcontractors or the personnel of the Contractor or Subcontractors, as the case may be, to obtain.
- d) The Owner shall be responsible for the continued operation of the Facilities after Completion.

4.19 Taxes & Duties

- a) Custom Duty, Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation. The reimbursement of these taxes shall be on actual subject to the quoted value of these taxes as ceiling corresponding to the base price. Additional liability of taxes and duties arising out of price variation shall be reimbursed against documentary evidence over and above the ceiling (quoted value). Statutory variation in Indian taxes and duties will be dealt with as per the relevant stipulations of the specification. Except as otherwise specifically provided in the Contract, the Contractor shall bear and pay all Taxes, Duties, Levies and Charges including Entry Tax, Service Tax, if applicable in connection with the Facilities in India and outside India. All taxes, duties & levies on works contract, if any, shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- b) All taxes, duties and levies including entry tax/octroi (if any) in respect of all components, equipments and material to be dispatched directly from the sub-

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vendor's works to site shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.

- c) In case there is introduction of GST or any other tax in lieu of existing Excise Duty/Service Tax and VAT/ Sales Tax, the contract price will be adjusted for the impact of any differential tax liability subject to documentary evidence. This will be restricted to direct transaction between the owner and contractor, and bought out items directly dispatched from sub-vendor's works to project site.
- d) Further all taxes, duties and levies including sales tax on works contract, Entry Tax, if any, in respect of civil construction works, erection & commissioning if any and custom duty/sales tax as applicable on the materials used for such construction works shall be to the contractor's account and no separate claim in this regard will be entertained by the Owner. Incidence of Service Tax & cess on any component of the Bid Price shall be to the Contractor's account and bidders shall include Service Tax as applicable at the date seven (7) days prior to the date of bid submission in the bid price. The Contract Price will be adjusted for impact of any change in the rate of service tax or cess on service tax subsequent to this date for direct transactions between the Owner and the Contractor.
- e) If any tax exemptions, reductions, allowances or privileges may be available to the Contractor, the Owner shall use its best endeavours to enable the Contractor to benefit from any such tax savings to the maximum allowable extent.

4.20 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Owner by the Contractor herein shall remain vested in the Contractor or, if they are furnished to the Owner directly or through the Contractor by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Owner shall however be free to reproduce all drawings, documents and other material furnished to the Owner for the purpose of the contract including, if required, for operation and maintenance.

4.21 Confidential Information

- a) The Owner and the Contractor shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Contractor may furnish to its Subcontractor(s) such documents, data and other information it receives from the Owner to the extent required for the Subcontractor(s) to perform its work under the Contract, in which event the Contractor shall obtain from such Subcontractor(s) an undertaking of confidentiality similar to that imposed on the Contractor.
- b) The Owner shall not use such documents, data and other information received from the Contractor for any purpose other than the operation and maintenance of the Facilities. Similarly, the Contractor shall not use such documents, data and other information received from the Owner for any purpose other than the design, procurement of Plant and Equipments, construction or such other work and services as are required for the performance of the Contract.
- c) The obligation of a party, shall not apply to that information which
 - now or hereafter enters the public domain through no fault of that party

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- can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto
- Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

4.22 Representatives

a) Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Owner shall appoint and notify the Contractor in writing of the name of the Project Manager. The Owner may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Contractor without delay. The Owner shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Owner at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

All notices, instructions, information and other communications given by the Contractor to the Owner under the Contract shall be given to the Project Manager, except as herein otherwise provided.

b) Contractor's Representative & Construction Manager

- If the Contractor's Representative is not named in the Contract, then within *[fourteen (14) days]* of the Effective Date, the Contractor shall appoint the Contractor's Representative and shall request the Owner in writing to approve the person so appointed. If the Owner makes no objection to the appointment within *[fourteen (14)]* days, the Contractor's Representative shall be deemed to have been approved. If the Owner objects to the appointment within *[fourteen (14)]* days giving the reason there for, then the Contractor shall appoint a replacement within *[fourteen (14) days]* of such objection.
- The Contractor's Representative shall represent and act for the Contractor at all times during the currency of the Contract and shall give to the Project Manager all the Contractor's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Owner or the Project Manager to the Contractor under the Contract shall be given to the Contractor's Representative or, in its absence, its deputy, except as herein otherwise provided. The Contractor shall not revoke the appointment of the Contractor's Representative without the Owner's prior written consent, which shall not be unreasonably withheld. If the Owner consents thereto, the Contractor shall appoint some other person as the Contractor's Representative.
- The Contractor's Representative may, subject to the approval of the Owner (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Contractor's Representative, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take

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effect unless and until a copy thereof has been delivered to the Owner and the Project Manager.

- From the commencement of installation of the Facilities at the Site until Operational Acceptance, the Contractor's Representative shall appoint a suitable person as the construction manager (hereinafter referred to as "the Construction Manager"). The Construction Manager shall supervise all work done at the Site by the Contractor and shall be present at the Site throughout normal working hours except when on leave, sick or absent for reasons connected with the proper performance of the Contract. Whenever the Construction Manager is absent from the Site, a suitable person shall be appointed to act as his or her deputy.
- The Owner may by notice to the Contractor object to any representative or person employed by the Contractor in the execution of the Contract who, in the reasonable opinion of the Owner, may behave inappropriately, may be incompetent or negligent, or may commit a serious breach of the Site regulations.
- If any representative or person employed by the Contractor is removed.

4.23 Work Program

a) Contractor's Organization

The Contractor shall supply to the Owner and the Project Manager a chart showing the proposed organization to be established by the Contractor for carrying out work on the Facilities. The chart shall include the identities of the key personnel together with the curricula vitae of such key personnel to be employed within **[twenty one (21)]** days of the Effective Date. The Contractor shall promptly inform the Owner and the Project Manager in writing of any revision or alteration of such an organization chart.

b) Program of Performance

Within **[twenty-eight (28)]** days after the date of Notification of Award of Contract, the Contractor shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply, transport, assemble, install and precommissioning the Facilities, as well as the date by which the Contractor reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Contractor to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Contractor shall accord with the Time Schedule included in Appendix 4 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Contractor shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Contractor's actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Contractor shall, at the request of the Owner or

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the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

e) **Work Procedures**

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Owner and the Contractor, the Contractor may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

4.24 Subcontracting

- a) The Contract Agreement specifies major items of supply or services and a list of approved Subcontractors against each item, including vendors. Insofar as no Subcontractors are listed against any such item, the Contractor shall prepare a list of Subcontractors for such item for inclusion in such list. The Contractor may from time to time propose any addition to or deletion from any such list. The Contractor shall submit any such list or any modification thereto to the Owner for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Owner for any of the Subcontractors shall not relieve the Contractor from any of its obligations, duties or responsibilities under the Contract.
- b) The Contractor shall select and employ its Subcontractors/Subvendors for such major items from those listed.

4.25 Design and Engineering

a) **Specifications and Drawings**

The Contractor shall execute the basic and detailed design and the engineering work in compliance with the provisions of the Contract, or where not so specified, in accordance with good engineering practice. The Contractor shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents that it has prepared, whether such specifications, drawings and other documents have been approved by the Project Manager or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Contractor by or on behalf of the Owner.

b) **Codes and Standards**

Wherever references are made in the Contract to codes and standards in accordance with which the Contract shall be executed, the edition or the revised version of such codes and standards current at the date *[twenty eight (28)]* days prior to date of bid submission shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

c) **Approval/Review of Technical Documents by Project Manager**

The Contractor shall prepare (or cause its Subcontractors to prepare) and furnish to the Project Manager the documents for its approval Any part of the Facilities covered by or related to the documents to be approved by the Project Manager shall be executed only after the Project Manager's approval thereof.

Project Manager shall either return one copy thereof to the Contractor with its approval endorsed thereon or shall notify the Contractor in writing of its disapproval

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thereof and the reasons there for and the modifications that the Project Manager proposes. The Project Manager shall not disapprove any document, except on the grounds that the document does not comply with some specified provision of the Contract or that it is contrary to good engineering practice. The procedure for submission of the documents by the Contractor and their approval by the Project Manager shall be discussed and finalised with the Contractor.

If any dispute or difference occurs between the Owner and the Contractor in connection with or arising out of the disapproval by the Project Manager of any document and/or any modification(s) thereto that cannot be settled between the parties within a reasonable period, then such dispute or difference may be referred to an Adjudicator. If such dispute or difference is referred to an Adjudicator, the Project Manager shall give instructions as to whether and if so, how, performance of the Contract is to proceed. The Contractor shall proceed with the Contract in accordance with the Project Manager's instructions, provided that if the Adjudicator upholds the Contractor's view on the dispute, then the Contractor shall be reimbursed by the Owner for any additional costs incurred by reason of such instructions and shall be relieved of such responsibility or liability in connection with the dispute and the execution of the instructions as the Adjudicator shall decide, and the Time for Completion shall be extended accordingly.

The Project Manager's approval, with or without modification of the document furnished by the Contractor, shall not relieve the Contractor of any responsibility or liability imposed upon it by any provisions of the Contract except to the extent that any subsequent failure results from modifications required by the Project Manager.

4.26 Procurement

a) Plant and Equipment

The Contractor shall manufacture or procure and transport all the Plant and Equipments in an expeditious and orderly manner to the Site.

b) Transportation

The Contractor shall at its own risk and expense transport all the Plant and Equipments and the Contractor's Equipments to the Site by the mode of transport that the Contractor judges most suitable under all the circumstances. Unless otherwise provided in the Contract, the Contractor shall be entitled to select any safe mode of transport operated by any person to carry the Plant and Equipments and the Contractor's Equipment. Upon dispatch of each shipment of the Plant and Equipments and the Contractor's Equipments, the Contractor shall notify the Owner by telex, cable, telefax, facsimile or Electronic Data Interchange (EDI) of the description of the Plant and Equipments and of the Contractor's Equipments, the point and means of dispatch, and the estimated time and point of arrival in the country where the Site is located, if applicable, and at the Site. The Contractor shall furnish the Owner with relevant shipping documents to be agreed upon between the parties.

The Contractor shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Plant and Equipments and the Contractor's Equipments to the Site. The Owner shall use its best endeavours in a timely and expeditious manner to assist the Contractor in obtaining such approvals, if requested by the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any claim for damage to roads, bridges or any other traffic facilities that may be caused by the transport of the Plant and Equipments and the Contractor's Equipments to the Site.

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- c) The Contractor shall, at its own expense, handle all imported Plant and Equipments and spares and Contractor's Equipments at the point(s) of import and shall handle any formalities for customs clearance

4.27 Installation

a) Setting Out/Supervision/Labor

Bench Mark: The Contractor shall be responsible for the true and proper setting-out of the Facilities in relation to bench marks, reference marks and lines provided to it in writing by or on behalf of the Owner.

If, at any time during the progress of installation of the Facilities, any error shall appear in the position, level or alignment of the Facilities, the Contractor shall forthwith notify the Project Manager of such error and, at its own expense, immediately rectify such error to the reasonable satisfaction of the Project Manager. If such error is based on incorrect data provided in writing by or on behalf of the Owner, the expense of rectifying the same shall be borne by the Owner.

Contractor's Supervision: The Contractor shall give or provide all necessary superintendence during the installation of the Facilities, and the Construction Manager or its deputy shall be constantly on the Site to provide full time superintendence of the installation. The Contractor shall provide and employ only technical personnel who are skilled and experienced in their respective callings and supervisory staff who are competent to adequately supervise the work at hand.

The Contractor shall provide and employ on the Site in the installation of the Facilities such skilled, semi-skilled and unskilled labor as is necessary for the proper and timely execution of the Contract. The Contractor is encouraged to use local labour that has the necessary skills. Unless otherwise provided in the Contract, the Contractor shall be responsible for the recruitment, transportation, accommodation and catering of all labour, local or expatriate, required for the execution of the Contract and for all payments in connection therewith.

The Contractor shall at its own expense provide the means of repatriation to all of its and its Subcontractor's personnel employed on the Contract at the Site to their various home countries. It shall also provide suitable temporary maintenance of all such persons from the cessation of their employment on the Contract to the date programmed for their departure. In the event that the Contractor defaults in providing such means of transportation and temporary maintenance, the Owner may provide the same to such personnel and recover the cost of doing so from the Contractor.

The Contractor shall, in all dealings with its labour and the labor of its Subcontractors currently employed on or connected with the Contract, pay due regard to all recognized festivals, official holidays, religious or other customs and all local laws and regulations pertaining to the employment of labor.

b) Contractor's Equipments

All Contractors' Equipments brought by the Contractor onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Contractor shall not remove the same from the Site without the Project Manager's consent that such Contractor's Equipments are no longer required for the execution of the Contract. Unless otherwise specified in the Contract, upon completion of the Facilities, the Contractor shall remove from the Site all Equipments brought by the Contractor onto the Site and any surplus materials remaining thereon.

The Owner will, if requested, use its best endeavours to assist the Contractor in obtaining any local, state or national government permission required by the

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Contractor for the export of the Contractor's Equipments imported by the Contractor for use in the execution of the Contract that is no longer required for the execution of the Contract.

c) Site Regulations and Safety

The Owner and the Contractor shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. The Contractor shall prepare and submit to the Owner, with a copy to the Project Manager, proposed Site regulations for the Owner's approval, which approval shall not be unreasonably withheld.

Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Facilities, gate control, sanitation, medical care, and fire prevention.

d) Opportunities for Other Contractors

The Contractor shall, upon written request from the Owner or the Project Manager, give all reasonable opportunities for carrying out the work to any other contractors employed by the Owner on or near the Site. If the Contractor, upon written request from the Owner or the Project Manager, makes available to other contractors any roads or ways the maintenance for which the Contractor is responsible, permits the use by such other contractors of the Contractor's Equipments, or provides any other service of whatsoever nature for such other contractors, the Owner shall fully compensate the Contractor for any loss or damage caused or occasioned by such other contractors in respect of any such use or service, and shall pay to the Contractor reasonable remuneration for the use of such equipments or the provision of such services.

The Contractor shall also so arrange to perform its work as to minimize, to the extent possible, interference with the work of other contractors. The Project Manager shall determine the resolution of any difference or conflict that may arise between the Contractor and other contractors and the workers of the Owner in regard to their work.

The Contractor shall notify the Project Manager promptly of any defects in the other Contractors' work that come to its notice, and that could affect the Contractor's work. The Project Manager shall determine the corrective measures, if any, required to rectify the situation after inspection of the Facilities. Decisions made by the Project Manager shall be binding on the Contractor.

e) Emergency Work

If, by reason of an emergency arising in connection with and during the execution of the Contract, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Facilities, the Contractor shall immediately carry out such work.

If the Contractor is unable or unwilling to do such work immediately, the Owner may do or cause such work to be done as the Owner may determine is necessary in order to prevent damage to the Facilities. In such event the Owner shall, as soon as practicable after the occurrence of any such emergency, notify the Contractor in writing of such emergency, the work done and the reasons there for. If the work done or caused to be done by the Owner is work that the Contractor was liable to do at its own expense under the Contract, the reasonable costs incurred by the Owner in connection therewith shall be paid by the Contractor to the Owner. Otherwise, the cost of such remedial work shall be borne by the Owner.

f) Site Clearance

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Site Clearance in Course of Performance: In the course of carrying out the Contract, the Contractor shall keep the Site reasonably free from all unnecessary obstruction, store or remove any surplus materials, clear away any wreckage, rubbish or temporary works from the Site, and remove any Contractor's Equipments no longer required for execution of the Contract. **Clearance of Site after Completion:** After Completion of all parts of the Facilities, the Contractor shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site and Facilities clean and safe.

g) Watching and Lighting

The Contractor shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper execution and the protection of the Facilities, or for the safety of the owners and occupiers of adjacent property and for the safety of the public as per specification.

4.28 Testing & Inspections

- a) The Contractor shall at its own expense carry out at the place of manufacture and/or on the Site all such tests and/or inspections of the Plant and Equipments and any part of the Facilities as are specified in the Contract.
- b) The Owner and the Project Manager or their designated representatives shall be entitled to attend the aforesaid test and/ or inspection, provided that the Owner shall bear all costs and expenses incurred in connection with such attendance including, but not limited to, all travelling and board and lodging expenses.
- c) Whenever the Contractor is ready to carry out any such test and/or inspection, the Contractor shall give a reasonable advance notice of such test and/or inspection and of the place and time thereof to the Project Manager. The Contractor shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Owner and the Project Manager (or their designated representatives) to attend the test and/or inspection.
- d) The Contractor shall provide the Project Manager with a certified report of the results of any such test and/or inspection. If the Owner or Project Manager (or their designated representatives) fails to attend the test and/or inspection, or if it is agreed between the parties that such persons shall not do so, then the Contractor may proceed with the test and/or inspection in the absence of such persons, and may provide the Project Manager with a certified report of the results thereof.
- e) The Project Manager may require the Contractor to carry out any test and/or inspection not required by the Contract, provided that the Contractor's reasonable costs and expenses incurred in the carrying out of such test and/or inspection shall be added to the Contract Price. Further, if such test and/or inspection impede the progress of work on the Facilities and/or the Contractor's performance of its other obligations under the Contract, due allowance will be made in respect of the Time for Completion and the other obligations so affected.
- f) If any Plant and Equipment or any part of the Facilities fails to pass any test and/or inspection, the Contractor shall either rectify or replace such Plant and Equipment or part of the Facilities and shall repeat the test and/or inspection upon giving a notice.
- g) If any dispute or difference of opinion shall arise between the parties in connection with or arising out of the test and/or inspection of the Plant and Equipments or part of the Facilities that cannot be settled between the parties within a reasonable period of time, it may be referred to the Adjudicator.
- h) The Contractor shall afford the Owner and the Project Manager, at the Owner's expense, access at any reasonable time to any place where the Plant and

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Equipments are being manufactured or the Facilities are being installed, in order to inspect the progress and the manner of manufacture or installation, provided that the Project Manager shall give the Contractor a reasonable prior notice.

- i) The Contractor agrees that neither the execution of a test and/ or inspection of Plant and Equipments or any part of the Facilities, nor the witnessing of any test by the Owner, nor the issuance of any test certificate shall relieve the Contractor of any obligation under this Contract.
- j) No part of the Facilities or foundations shall be covered up on the Site without the Contractor carrying out any test and/or inspection required under the Contract. The Contractor shall give a reasonable notice to the Project Manager whenever any such part of the Facilities or foundations is ready or about to be ready for test and/or inspection; such test and/or inspection and notice thereof shall be subject to the requirements of the Contract.
- k) The Contractor shall uncover any part of the Facilities or foundations, or shall make openings in or through the same as the Project Manager may from time to time require at the Site, and shall reinstate and make good such part or parts.

4.29 Completion of the Facilities

- a) As soon as the Facilities or any part thereof has, in the opinion of the Contractor, been completed operationally and structurally and put in a tight and clean condition as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Contractor shall so notify the Owner in writing.
- b) The Owner shall supply the operating and maintenance personnel as specified in the Contract for Precomissioning of the Facilities or any part thereof.
- c) As soon as all works in respect of Precomissioning are completed and, in the opinion of the Contractor, the Facilities or any part thereof is ready for Commissioning, the Contractor shall commence Commissioning as per procedures stipulated in Technical Specifications, and as soon as Commissioning is satisfactorily completed, the Contractor shall so notify the Project Manager in writing.
- d) If the Project Manager notifies the Contractor of any defects and/ or deficiencies, the Contractor shall then correct such defects and/or deficiencies.

If the Project Manager is satisfied that the Facilities or that part thereof have reached Completion, the Project Manager shall, within **[seven (7)]** days after receipt of the Contractor's notice, issue a Completion Certificate stating that the Facilities or that part thereof have reached Completion as at the date of the Contractor's notice.

If the Project Manager is not so satisfied, then it shall notify the Contractor in writing of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's notice, and the above procedure shall be repeated.

- e) If the Project Manager fails to issue the Completion Certificate and fails to inform the Contractor of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's notice, or if the Owner makes use of the Facilities or part thereof, then the Facilities or that part thereof shall be deemed to have reached Completion as of the date of the Contractor's notice, or as of the Owner's use of the Facilities, as the case may be.
- f) As soon as possible after Completion, the Contractor shall complete all outstanding minor items so that the Facilities are fully in accordance with the requirements of the Contract, failing which the Owner will undertake such completion and deduct the costs thereof from any monies owing to the Contractor.

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- g) Upon Completion, the Owner shall be responsible for the care and custody of the Facilities or the relevant part thereof, together with the risk of loss or damage thereto, and shall thereafter take over the Facilities or the relevant part thereof.

4.30 Commissioning & Operation Acceptance

a) Commissioning

Commissioning of the Facilities or any part thereof Acceptance shall be completed by the Contractor as per procedures detailed in the Technical Specifications. The Contractor shall, unless otherwise specified in Contract/ Tender Specifications, supply the utilities, lubricants, chemicals, catalysts, facilities, services and other matters required for Commissioning.

b) Guarantee Test

The Guarantee Tests (and repeats thereof) shall be conducted by the Contractor after Commissioning of the Facilities or the relevant part thereof to ascertain whether the Facilities or the relevant part can attain the Functional Guarantees specified in the Contract Documents. The Contractor's and Project Manager's advisory personnel shall attend the Guarantee Test. The Owner shall promptly provide the Contractor with such information as the Contractor may reasonably require in relation to the conduct and results of the Guarantee Tests (and any repeats thereof). If for reasons not attributable to the Contractor, the Guarantee Tests of the Facilities or the relevant part thereof cannot be successfully completed within the period from the date of Completion, specified in the SCC or any other period agreed upon by the Owner and the Contractor, the Contractor shall be deemed to have fulfilled its obligations with respect to the Functional Guarantees.

c) Operational Acceptance

Operational Acceptance shall occur in respect of the Facilities or any part thereof when

- the Guarantee Tests have been successfully completed and the Functional Guarantees are met; or
- The Guarantee Tests have not been successfully completed or has not been carried out for reasons not attributable to the Contractor within the period from the date of Completion specified in the SCC or any other agreed upon period as specified in GCC.
- The Contractor may give a notice to the Project Manager requesting the issue of an Operational Acceptance Certificate in respect of the Facilities or the part thereof specified in such notice as at the date of such notice.
- The Project Manager shall, after consultation with the Owner, and within forty five (45) days after receipt of the Contractor's notice, issue an Operational Acceptance Certificate. If within [forty five (45)] days after receipt of the Contractor's notice, the Project Manager fails to issue the Operational Acceptance Certificate or fails to inform the Contractor in writing of the justifiable reasons why the Project Manager has not issued the Operational Acceptance Certificate, the Facilities or the relevant part thereof shall be deemed to have been accepted as at the date of the Contractor's said notice.

d) Partial Acceptance

If the Contract specifies that Completion, Commissioning and Guarantee Tests shall be carried out in respect of parts of the Facilities, the provisions relating to

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Completion and Commissioning including the Guarantee Tests shall apply to each such part of the Facilities individually, and the Operational Acceptance Certificate shall be issued accordingly for each such part of the Facilities. If a part of the Facilities comprises facilities such as buildings, for which no Commissioning or Guarantee Tests are required, then the Project Manager shall issue the Operational Acceptance Certificate for such facility when it attains Completion, provided that the Contractor shall thereafter complete any outstanding minor items that are listed in the Operational Acceptance Certificate.

4.31 Completion Time and Liquidated Damage

a) **Completion Time Period**

The Contractor guarantees that it shall attain Completion of the Facilities (or a part for which a separate time for completion is specified in the SCC) within the Time for Completion specified in the SCC.

b) If the Contractor fails to attain Completion of the Facilities or any part thereof within the Time for Completion, the Contractor shall pay to the Owner liquidated damages in the amount computed at the rates specified in the SCC. The aggregate amount of such liquidated damages shall in no event exceed the amount specified as "Maximum" in the SCC.

However, the payment of liquidated damages shall not in any way relieve the Contractor from any of its obligations to complete the Facilities or from any other obligations and liabilities of the Contractor under the Contract.

c) No bonus will be given for earlier completion of the facilities or part thereof.

4.32 Defects Liability

a) The Contractor warrants that the Facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the Plant and Equipments supplied and of the work executed.

b) The Defects Liability Period shall be **[eighteen (18)]** months from the date of Completion of the Facilities (or any part thereof) or **[twelve (12)]** months from the date of Operational Acceptance of the Facilities (or any part thereof).

If during the Defects Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipments supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect. The Contractor shall not be responsible for the repair, replacement or making good of any defect or of any damage to the Facilities arising out of or resulting from any of the following causes:

- improper operation or maintenance of the Facilities by the Owner
- operation of the Facilities outside specifications provided in the Contract
- Normal wear and tear.

c) The Owner shall give the Contractor a notice stating the nature of any such defect together with all available evidence thereof, promptly following the discovery thereof. The Owner shall afford all reasonable opportunity for the Contractor to inspect any such defect.

d) The Owner shall afford the Contractor all necessary access to the Facilities and the Site to enable the Contractor to perform its obligations.

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- e) If the repair, replacement or making good is of such a character that it may affect the efficiency of the Facilities or any part thereof, the Owner may give to the Contractor a notice requiring that tests of the defective part of the Facilities shall be made by the Contractor immediately upon completion of such remedial work, whereupon the Contractor shall carry out such tests.
- f) If the Contractor fails to commence the work necessary to remedy such defect or any damage to the Facilities caused by such defect within a reasonable time (which shall in no event be considered to be less than fifteen (15) days), the Owner may, following notice to the Contractor, proceed to do such work, and the reasonable costs incurred by the Owner in connection therewith shall be paid to the Owner by the Contractor or may be deducted by the Owner from any monies due to the Contractor or claimed under the Performance Security.
If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defects Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the Defects Liability Period extended by a period of **[twelve (12) month]** from the time such replacement/repair of the Facilities or any part thereof.

4.33 Functional Guarantees

The Contractor guarantees that during the Guarantee Tests, the Facilities and all parts thereof shall attain the Functional Guarantees as per the Contract. If, for reasons attributable to the Contractor, Functional Guarantees are not met either in whole or in part, the Contractor shall, within a mutually agreed time, at its cost and expense make such changes, modifications and/or additions to the Plant or any part thereof as may be necessary to meet such Guarantees. The Contractor shall notify the Owner upon completion of the necessary changes, modifications and/or additions, and shall seek the Owner's consent to repeat the Guarantee Test. If the specified Functional Guarantees are not established even during the repeat of the Guarantee Tests, the Owner may at its option, either reject the plant and equipment and recover from the Contractor payments already made or Accept the equipment/system/plant after levying Liquidated Damages as specified.

4.34 Patents Indemnity

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Owner may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Contractor or the use of the such Facilities.

4.35 Limitation of liability

Except in cases of criminal negligence or wilful misconduct by the Contractor, the aggregate liability of the Contractor to the Owner, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Contractor to indemnify the Owner with respect to patent infringement.

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Except in cases of criminal negligence or wilful misconduct by the Contractor, the Contractor shall not be liable to the Owner, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs, provided that this exclusion shall not apply to any obligation of the Contractor to pay liquidated damages to the Owner.

4.36 Transfer of Ownership

Ownership of the Plant and Equipments (including spare parts) to be imported into India shall be transferred to the Owner upon loading on to the mode of transport to be used to convey the Plant and Equipments from the country of origin to that country.

Ownership of the Plant and Equipments (including spare parts) procured from within India shall be transferred to the Owner when the Plant and Equipments including spares are loaded on to the mode of transport to be used to convey the Plant and Equipments including spares from the works to the site and upon endorsement of the despatch documents in favour of the Owner. Ownership of the Contractor's Equipments used by the Contractor and its Subcontractors in connection with the Contract shall remain with the Contractor or its Subcontractors. Ownership of any Plant and Equipments in excess of the requirements for the Facilities shall revert to the Contractor upon Completion of the Facilities or at such earlier time when the Owner and the Contractor agree that the Plant and Equipments in question are no longer required for the Facilities, provided quantity of any Plant and Equipments specifically stipulated in the Contract shall be the property of the Owner whether or not incorporated in the Facilities. Notwithstanding the transfer of ownership of the Plant and Equipments, the responsibility for care and custody thereof together with the risk of loss or damage shall remain with the Contractor until Completion of the Facilities.

4.37 Care of Facilities

The Contractor shall be responsible for the care and custody of the Facilities or any part thereof until the date of Completion of the Facilities, where the Contract provides for Completion of the Facilities in parts, until the date of Completion of the relevant part, and shall make good at its own cost any loss or damage that may occur to the Facilities or the relevant part thereof from any cause whatsoever during such period. The Contractor shall also be responsible for any loss or damage to the Facilities caused by the Contractor or its Subcontractors in the course of any work carried out.

4.38 Loss of or Damage to Property; Accident or Injury; Indemnification

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with the supply and installation of the Facilities and by reason of the negligence of the Contractor or its Subcontractors, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Owner, its contractors, employees, officers or agents.

4.39 Insurance

- a) The Contractor shall at its expense take out and maintain in effect, or cause to be taken out and maintained in effect, during the performance of the Contract, the insurances set forth below in the sums and with the deductibles and other conditions as specified. The identity of the insurers and the form of the policies

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shall be subject to the approval of the Owner, who should not unreasonably withhold such approval.

- Cargo Insurance during Transport:-Covering loss or damage occurring while in transit from the Contractor's or Subcontractor's works or stores until arrival at the Site, to the Plant and Equipments (including spare parts therefor) and to the Contractor's Equipments.
 - Installation All Risks Insurance:-Covering physical loss or damage to the Facilities at the Site, occurring prior to Completion of the Facilities, with an extended maintenance coverage for the Contractor's liability in respect of any loss or damage occurring during the Defects Liability Period while the Contractor is on the Site for the purpose of performing its obligations during the Defects Liability Period.
 - Third Party Liability Insurance: - Covering bodily injury or death suffered by third parties (including the Owner's personnel) and loss of or damage to property occurring in connection with the supply and installation of the Facilities.
 - Automobile Liability Insurance:-Covering use of all vehicles used by the Contractor or its Subcontractors (whether or not owned by them) in connection with the execution of the Contract.
 - Workers' Compensation:-In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Owner's Liability: - In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Other Insurances Such other insurances as may be specifically agreed upon by the parties.
- b) The Owner shall be named as co-insured under all insurance policies taken out by the Contractor pursuant except for the Third Party Liability, Workers' Compensation and Owner's Liability Insurances, and the Contractor's Subcontractors shall be named as co-insured's under all insurance policies taken out by the Contractor except for the Cargo Insurance During Transport, Workers' Compensation and Owner's Liability Insurances. All insurers' rights of subrogation against such co-insured's for losses or claims arising out of the performance of the Contract shall be waived under such policies.
- c) The Form of Contract Agreement, deliver to the Owner certificates of insurance (or copies of the insurance policies) as evidence that the required policies are in full force and effect. The certificates shall provide that no less than twenty one (21) days' notice shall be given to the Owner by insurers prior to cancellation or material modification of a policy.
- d) The Contractor shall ensure that, where applicable, its Subcontractor(s) shall take out and maintain in effect adequate insurance policies for their personnel and vehicles and for work executed by them under the Contract, unless such Subcontractors are covered by the policies taken out by the Contractor.
- e) The Owner shall at its expense take out and maintain in effect during the performance of the Contract those insurances specified.
- f) the Owner may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Contractor under the Contract any premium that the Owner shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Contractor. If the Owner fails to take out and/or maintain in effect the insurances the Contractor may take out and maintain in effect any such insurances and may from time to time deduct from any amount

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due the Owner under the Contract any premium that the Contractor shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Owner. If the Contractor fails to or is unable to take out and maintain in effect any such insurances, the Contractor shall nevertheless have no liability or responsibility towards the Owner, and the Contractor shall have full recourse against the Owner for any and all liabilities of the Owner herein.

- g) The Owner shall give to the Contractor all such reasonable assistance as may be required by the Contractor. With respect to insurance claims in which the Owner's interest is involved, the Contractor shall not give any release or make any compromise with the insurer without the prior written consent of the Owner. With respect to insurance claims in which the Contractor's interest is involved, the Owner shall not give any release or make any compromise with the insurer without the prior written consent of the Contractor.
- h) Wherever total damages/loss of equipments/materials, would occur, the Contractor will be entitled to payment of all payments received from the underwriters except the following amounts:
 - The amount paid to the Contractor under the Contract in respect of equipments/materials damaged/lost (excluding the pro-rata initial advance) but including the entire amount of escalation, if any, already paid to the Contractor.
 - Custom Duties and taxes which have already been paid by the Owner.
 - In case of damage to any equipments/materials during any stage, the Contractor upon rectification of the damaged equipment to the satisfaction of the Owner shall be paid to the extent of full claims settled by the underwriters.
- i) All the Plants & Equipment being supplied by the Owner free of cost for installation of the equipment, cabling, earthing and lightning protection etc. by the Contractor, covered by this specification shall be kept insured by the Contractor against loss, damage, theft, pilferage, fire etc. from the point of unloading at Site upto the time of taking over by the Owner including handling, in plant transportation, storage, installation, testing and commissioning, etc. and the Contractor shall be fully responsible for making good of any loss or damage at his own cost within a reasonable time as mutually agreed upon by the Owner and the Contractor. Any loss/damage shall be brought to the Owner's notice immediately. The premium paid by the Contractor to the Insurance Company for such insurance shall be reimbursed by the Owner to the Contractor at actual against documentary proof to be furnished by the Contractor. The Contractor shall obtain competitive quotation for such insurance and shall take prior approval from the Owner before taking the insurance. The insurable value of the equipment being procured by the Owner will be intimated to the Contractor for the purpose of insurance.
 - It will be the responsibility of the Contractor to lodge, pursue and settle all claims with the Insurance Company in case of any damage, loss, theft, pilferage, fire, etc. and the Owner shall be kept informed about it. The losses, if any, will have to be borne by the Contractor, if the claims are not lodged and pursued properly or in the time or if the same are not settled by the Insurance Company.

4.40 Change in Laws & Regulation

- a) If, after the date **[seven (7)]** days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any

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change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Contractor and/or the Time for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Contractor has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Owner and the Contractor and not on procurement of raw materials, intermediary components etc. by the Contractor. Notwithstanding the foregoing, such additional or reduced costs shall not be separately paid or credited if the same has already been accounted for in the price adjustment provisions wherever applicable.

4.41 Force Majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected. Force Majeure events include Acts of God, Acts of Government, war, sabotage, riots, civil commotion, revolution, flood, earthquake, cyclone, fire, epidemic etc.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within **[fourteen (14)]** days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfill its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
 - constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby
 if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.
- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than **[sixty (60)]** days or an aggregate period of more than one hundred and **[twenty (120)]** days on account of one or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.
- (g) Force Majeure shall not apply to any obligation of the Owner to make payments to the Contractor herein.

4.42 Change in the Facilities

(a) Introducing a Change

- The Owner shall have the right to propose, and subsequently require, the Contractor during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Facilities (hereinafter called "Change"), provided that such Change falls within the general scope of the

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Facilities and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the Facilities and the technical compatibility of the Change envisaged with the nature of the Facilities as specified in the Contract.

- The Contractor may from time to time during its performance of the Contract propose to the Owner (with a copy to the Project Manager) any Change that the Contractor considers necessary or desirable to improve the quality, efficiency or safety of the Facilities. This includes any additional scope of work that the contractor thinks is essential for achieving the minimum performance level specified in the SCC or the Contract. The Owner may at its discretion approve or reject any Change proposed by the Contractor.
- No change made necessary because of any default of the Contractor in the performance of its obligations under the Contract shall be deemed to be a Change, and such change shall not result in any adjustment of the Contract Price or the Time for Completion.

(b) Changes Originating from Owner

- If the Owner proposes a Change, it shall send to the Contractor a "Request for Change Proposal," requiring the Contractor to prepare and furnish to the Project Manager as soon as reasonably practicable a "Change Proposal," which shall include the following:
 - ✓ brief description of the Change
 - ✓ effect on the Time for Completion
 - ✓ estimated Cost of the Change
 - ✓ effect on Functional Guarantees (if any)
 - ✓ effect on any other provisions of the Contract.
- The pricing of any Change shall, as far as practicable, be calculated in accordance with the rates and prices included in the Contract. If the rates and prices of any change are not available in the Contract, the parties thereto shall agree on specific rates for the valuation of the Change.
- If before or during the preparation of the Change Proposal it becomes apparent that the aggregate effect of compliance therewith and with all other Change Orders that have already become binding upon the Contractor to increase or decrease the Contract Price as originally set forth in the Contract Agreement by more than fifteen (15) percent, the Contractor may give a written notice of objection thereto prior to furnishing the Change Proposal as aforesaid. If the Owner accepts the Contractor's objection, the Owner and the Contractor shall agree on specific rates for valuation of the change.
- Upon receipt of the Change Proposal, the Owner and the Contractor shall mutually agree upon all matters therein contained including agreement on rates if such rates are not available in the Contract or if the limit of 15% set forth has been exceeded. Within **[fourteen (14)]** days after such agreement, the Owner shall, if it intends to proceed with the Change, issue the Contractor with a Change Order.
- If the Owner is unable to reach a decision within **[fourteen (14)]** days, it shall notify the Contractor with details of when the Contractor can expect a decision.

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- If the Owner decides not to proceed with the Change for whatever reason, it shall, within the said period of *[fourteen (14)]* days, notify the Contractor accordingly.
- If the Owner and the Contractor cannot reach agreement on the price for the Change, an equitable adjustment to the Time for Completion, or any other matters identified in the Change Proposal, the Owner may nevertheless instruct the Contractor to proceed with the Change by issue of a "Pending Agreement Change Order."

Upon receipt of a Pending Agreement Change Order, the Contractor shall immediately proceed with effecting the Changes covered by such Order. The parties shall thereafter attempt to reach agreement on the outstanding issues under the Change Proposal.

(c) Changes Originating from Contractor

- The Contractor shall submit to the Project Manager a written "Application for Change Proposal," giving reasons for the proposed Change and including the information. Upon receipt of the Application for Change Proposal, the parties shall follow the procedures indicated above for "Request for Change Proposal."

4.43 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Contractor is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:
- Any Change in the Facilities or
 - any occurrence of Force Majeure or
 - any suspension order given by the Owner or reduction in the rate of progress or
 - any changes in laws and regulations or
 - any default or breach of the Contract by the Owner, or any activity, act or omission of any other contractors employed by the Owner or
 - any other matter specifically mentioned in the Contract;
- By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Contractor.
- (b) Except where otherwise specifically provided in the Contract, the Contractor shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Owner and the Contractor shall agree upon the period of such extension.
- (c) The Contractor shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.44 Suspension

- (a) The Owner/ Project Manager may, by notice to the Contractor, order the Contractor to suspend performance of any or all of its obligations under the Contract. Such notice shall specify the obligation of which performance is to be suspended, the effective date of the suspension and the reasons therefor. The

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Contractor shall thereupon suspend performance of such obligation (except those obligations necessary for the care or preservation of the Facilities) until ordered in writing to resume such performance by the Project Manager/ Owner.

If, by virtue of a suspension order given by the Project Manager/ Owner, other than by reason of the Contractor's default or breach of the Contract, the Contractor's performance of any of its obligations is suspended for an aggregate period of more than *[ninety (90)]* days, then at any time thereafter and provided that at that time such performance is still suspended, the Contractor may give a notice to the Project Manager requiring that the Owner shall, within *[twenty eight (28)]* days of receipt of the notice, order the resumption of such performance or request and subsequently order a change, excluding the performance of the suspended obligations from the Contract.

- (b) If the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas;

Then the Contractor may by *[fourteen (14)]* days' notice to the Owner suspend performance of all or any of its obligations under the Contract, or reduce the rate of progress. If the Contractor's performance of its obligations is suspended or the rate of progress is reduced, then the Time for Completion shall be extended, and any and all additional costs or expenses incurred by the Contractor as a result of such suspension or reduction shall be paid by the Owner to the Contractor in addition to the Contract Price, except in the case of suspension order or reduction in the rate of progress by reason of the Contractor's default or breach of the Contract.

- (c) During the period of suspension, the Contractor shall not remove from the Site any Plant and Equipment, any part of the Facilities or any Contractor's Equipment, without the prior written consent of the Owner.

4.45 Termination

(a) Termination for Owner's Convenience

The Owner may at any time terminate the Contract for any reason by giving the Contractor a notice of termination. Upon receipt of the notice of termination, the Contractor shall either immediately or upon the date specified in the notice of termination

- (i) cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition.
- (ii) terminate all subcontracts, except those to be assigned
- (iii) remove all Contractor's Equipments from the Site, repatriate the Contractor's and its Subcontractors' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Contractor, subject to the payment, shall

- ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination

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- ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- ✓ Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Contractor the following amounts

- ✓ the Contract Price, attributable to the parts of the Facilities executed by the Contractor as on the date of termination
- ✓ the costs reasonably incurred by the Contractor in the removal of the Contractor's Equipment from the Site and in the repatriation of the Contractor's and its Subcontractors' personnel
- ✓ any amounts to be paid by the Contractor to its Subcontractors in connection with the termination of any subcontracts, including any cancellation charges
- ✓ costs incurred by the Contractor in protecting the Facilities and leaving the Site in a clean and safe condition
- ✓ the additional cost of satisfying other obligations, commitments and claims that the Contractor may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Contractor's Default

- (i) The Owner, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons therefor to the Contractor:

If the Contractor becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Contractor is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Contractor takes or suffers any other analogous action in consequence of debt

If the Contractor assigns or transfers the Contract or any right or interest therein in violation of the provision.

If the Contractor, in the judgement of the Owner has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders

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(prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

(ii) If the Contractor

- has abandoned or repudiated the Contract
- has without valid reason failed to commence work on the Facilities promptly the progress of Contract performance for more than **[twenty eight (28)]** days after receiving a written instruction from the Owner to proceed
- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient materials, services or labor to execute and complete the Facilities in the manner specified in the program at rates of progress that give reasonable assurance to the Owner that the Contractor can attain Completion of the Facilities by the Time for Completion as extended

then the Owner may, without prejudice to any other rights it may possess under the Contract, give a notice to the Contractor stating the nature of the default and requiring the Contractor to remedy the same. If the Contractor fails to remedy or to take steps to remedy the same within **[fourteen (14)]** days of its receipt of such notice, then the Owner may terminate the Contract forthwith by giving a notice of termination to the Contractor.

(iii) The Contractor shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d) below
- deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Works and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

(iv) The Owner may enter upon the Site, expel the Contractor, and complete the Facilities itself or by employing any third party. The Owner may, to the exclusion of any right of the Contractor over the same, take over and use with the payment of a fair rental rate to the Contractor, with all the maintenance costs to the account of the Owner and with an indemnification by the Owner for all liability including damage or injury to persons arising

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out of the Owner's use of such equipment, any Contractor's Equipments owned by the Contractor and on the Site in connection with the Facilities for such reasonable period as the Owner considers expedient for the supply and installation of the Facilities.

Upon completion of the Facilities or at such earlier date as the Owner thinks appropriate, the Owner shall give notice to the Contractor that such Contractor's Equipment will be returned to the Contractor at or near the Site and shall return such Contractor's Equipments to the Contractor in accordance with such notice. The Contractor shall thereafter without delay and at its cost remove or arrange removal of the same from the Site.

- (v) The Contractor shall be entitled to be paid the Contract Price attributable to the Facilities executed as at the date of termination, the value of any unused or partially used Plant and Equipments on the Site, and the costs, if any, incurred in protecting the Facilities and in leaving the Site in a clean and safe condition. Any sums due to the Owner from the Contractor accruing prior to the date of termination shall be deducted from the amount to be paid to the Contractor under this Contract.
- (vi) If the Owner completes the Facilities, the cost of completing the Facilities by the Owner shall be determined.

If the sum that the Contractor is entitled to be paid, plus the reasonable costs incurred by the Owner in completing the Facilities, exceeds the Contract Price, the Contractor shall be liable for such excess.

The Owner and the Contractor shall agree, in writing, on the computation described above and the manner in which any sums shall be paid.

(c) Termination by Contractor

- i. If
 - the Owner has failed to pay the Contractor any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Contractor may give a notice to the Owner that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Owner to remedy the same, as the case may be. If the Owner fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within **[fourteen (14) days]** after receipt of the Contractor's notice, or
 - the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas or failure to obtain any governmental permit necessary for the execution and/or completion of the Facilities which the Owner is required to obtain as per provision of the Contract or as per relevant applicable laws of the country,

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then the Contractor may give a notice to the Owner thereof, and if the Owner has failed to pay the outstanding sum, to approve the invoice or supporting documents, to give its reasons for withholding such approval, or to remedy the breach within *[twenty eight (28) days]* of such notice, or if the Contractor is still unable to carry out any of its obligations under the Contract for any reason attributable to the Owner within twenty eight (28) days of the said notice, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.

- ii. If the Owner becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Owner takes or suffers any other analogous action in consequence of debt, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.
- iii. If the Contract is terminated, then the Contractor shall immediately
 - cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
 - terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d)(ii)
 - remove all Contractor's Equipment from the Site and repatriate the Contractor's and its Subcontractor's personnel from the Site
 - In addition, the Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as of the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
 - ✓ Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as of the date of termination in connection with the Facilities.
- iv. If the Contract is terminated, the Owner shall pay to the Contractor all payments, and reasonable compensation for all loss or damage sustained by the Contractor arising out of, in connection with or in consequence of such termination.
- (d) The expression "Facilities executed" shall include all work executed, Erection Services provided, any all Plant and Equipments acquired (or subject to a legally binding obligation to purchase) by the Contractor and used or intended to be used for the purpose of the Facilities, up to and including the date of termination.
- (e) In calculating any payment due from the Owner to the Contractor, account shall be taken of any sum previously paid by the Owner to the Contractor under the Contract, including any advance payment paid.

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4.46 Assignment

The Contractor shall not, without the express prior written consent of the Owner, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Contractor shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Renovation & Modernization of Boiler & Auxiliaries Package for [-----]
- **Bid Document No. :** [-----]
- **The Owner is:**
 - Name of Owner: [-----]
 - Address of Owner: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]
- **The Project Manager is:**
 - Name of Project Manager: [-----]
 - Address of Project Manager: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]

5.2 Effective Date

The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor.

The following three activities will be completed within **[two (2)]** months from the date of Letter of Acceptance:

(a) The contract agreement will be executed by the Owner and the Contractor. (b) The Contractor will submit to the Owner the Contract Performance Bank Guarantee, any Additional Contract Performance Bank Guarantee by assignee, JV Partner, Consortium Member etc if applicable, and the Advance Payment Bank Guarantee.

(c) The Owner will pay the Contractor the Advance Payment as per the Terms of Payment.

The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Owner shall be as follows:

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1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Owner) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Owner may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

5.4 Liquidated Damage for Delay

5.5 Rate of Liquidated Damage for Delay

If the Contractor fails to successfully achieve completion of R&M activities and commissioning of the retrofitted facilities as per the scope of work within the time period specified in SCC, the Contractor shall pay to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

1.	Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	Liquidated Damage payable at the rate Rs.[.....] for each week of delay
2.	Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	Liquidated Damage payable at the rate Rs [.....] for each day of delay

The Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender are independent and shall be applied separately.

5.6 Liquidated Damage for Non-fulfilment of Functional Guarantees

If the Contractor fails to successfully achieve the Functional Guarantees during Performance Guarantee Test as per the Tender Specification, the Contractor shall pay

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to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

Sl. No.	Functional Guarantee Parameter	Rate of Liquidated Damage
1	Boiler Capacity in TPH at rated parameters at superheater outlet, the coal being fired from the range specified.	[.....] INR per Tonnes/Hr. shortfall
2	Boiler Efficiency at 100% TMCR	[.....] INR per 0.01% decrease
3	Auxiliary Power in kW	[.....] INR per kW increase

The reference condition for Performance Guarantee Parameters shall be as per Volume-II Technical Specification.

The Liquidated Damage for non-fulfillment of the different Functional Guarantee Parameters are independent of one another and shall be applied separately.

{Note: The rate of LD for any Functional Guarantee Parameter shall be at least 1.5 times the corresponding Bid Evaluation Factor}

5.7 Maximum Leviable Liquidated Damages

The amount of Liquidated Damage for delay shall be limited to a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd)contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares. This limit is applicable for the Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender taken together.

The aggregate amount of **Liquidated Damage for non-fulfillment of functional guarantee shall be limited to** a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd)contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The limit on maximum leviable Liquidated Damage for Delay and maximum leviable Liquidated Damage for non-fulfillment of functional guarantee are independent of each other and shall apply separately.

5.8 Payment of Liquidated Damages

Contractor shall pay to the owner any Liquidated Damages that are payable as per the provisions of the Contract within thirty (30) days of receipt of Owner's invoice setting forth amount of Liquidated Damages that are then due and payable. If Contractor delays payment of Liquidated Damages that are payable under the provisions of the Contract beyond thirty (30) days, Owner, at its discretion, shall be entitled to recover such amounts by either setting off the relevant unpaid amount against any payment(s) due to the Contractor or by making a demand under Contract Performance Bank Guarantee.

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5.9 Contract Price

- a) The Contract Price shall be as (Contract Price and Terms of Payment) of the Form of Contract Agreement.
- b) The Contractor shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

5.10 Terms of Payment

- a) The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement. The procedures to be followed in making application.
- b) No payment made by the Owner herein shall be deemed to constitute acceptance by the Owner of the Facilities or any part(s) thereof.
- c) The currency or currencies in which payments are made to the Contractor under this Contract to the Form of Contract Agreement, subject to the general principle that payments will be made in the currency or currencies in which the Contract Price has been stated in the Contractor's bid.

5.11 Contract Securities (Bank Guarantees)

- a) The Contractor shall provide the Bank Guarantees specified below in favour of the Owner at the times, and in the amount, manner and form specified below.
- b) Advance Payment Bank Guarantee
 - The Contractor shall, within **[thirty (30)]** days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to **[ninety (90)]** days beyond the date of Completion of Facilities.
 - The security shall be in the form of an Unconditional Bank Guarantee. The Advance payment Bank Guarantee shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of equipment/facilities received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Facilities supplied and received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of those Facilities. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Contractor's responsibility and liabilities under the Contract including in respect of the Facilities for which the reduction in the value of security is allowed.
- c) Performance Bank Guarantee
 - The Contractor shall, within **[thirty (30)]** days of the notification of award, provide a Bank Guarantee for the due performance of the Contract for ten percent (10%) of the Contract Price with an initial validity upto **[ninety (90)]** days beyond the Defects Liability Period. If the Owner enters into the Contract with the Assignee of a foreign Contractor, the said Assignee, in addition to the Contract Performance Bank Guarantee to be provided by the Contractor for ten percent (10%) of the value of all the Contracts shall provide within **[thirty (30)]** days of the Notification of Award, a separate Contract Performance Bank Guarantee equivalent to five percent (5%) of the value of Contract entered into with the assignee, (i.e. five percent of the aggregate value of the component Contracts entered to with the Assignee) for the due performance of Contract with an initial validity up to **[Ninety (90)]** days beyond the Defects Liability Period.

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- If the bidder is a joint venture of two firms who collectively meet the Qualifying Requirement, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the bidder, each of the JV partner shall furnish Additional Contract Performance Guarantee equal to 1% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder and Additional Contract Performance Bank Guarantee furnished by the JV partners taken together shall be 12% of the Contract Price.
- If the bidder is a Consortium of two firms, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the Consortium Leader, the other consortium member will furnish Additional Contract Performance Bank Guarantee equal to 2% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder (Consortium Leader) and Additional Contract Performance Bank Guarantee furnished by the other consortium member taken together shall be 12% of the Contract Price.

d) The performance Bank Guarantees shall be denominated in the currency or currencies of the Contract, or in a freely convertible currency acceptable to the Owner.

5.12 Sequential Supply

The Contractor is required to supply the material and equipment under the Contract in a sequential manner as per the requirement at site for erection. If Contractor supplies any material/equipment ahead of the requirement as per the agreed Detailed Time Schedule, the Owner, at its discretion, may withhold progressive payment for such material/equipment till the time it is due for supply as per the agreed Detailed Time Schedule.

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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	Sample Format for Letter of Consent to be furnished by The Bidder And / Consortium Partners / Individual Companies of the Group
Annexure-E	Sample Format Letter Of Unequivocal Consent To Be Furnished By The Bidder and The Assignee
Schedule F1 Table-1	Summary Of Price Schedule
Schedule F1 Table-2	Price Schedule For Supply Of Plant And Equipment Including Packing And Forwarding Charges
Schedule F1 Table-3A	Price Schedule For Mandatory Spares
Schedule F1 Table-3B	Price Schedule For Recommended Spares
Schedule F1 Table-4	Price Schedule For Tools & Tackles
Schedule F1 Table-5	Price Schedule For Unloading, Handling, Storage, Preservation At Site, Erection, Testing, Commissioning And Performance Guarantee Tests Of Plant And Equipment
Schedule F1 Table-6	Price Schedule For Civil works
Schedule F1 Table-7	Price Schedule For Training Charges
Schedule F1 Table-8	Schedule Of Performance Guarantee Parameters
Schedule F2	Over All Time Schedule
Schedule F3	Deviation Schedule To Tender Document Vol-I Commercial
Schedule F4	Deviation Schedule To Technical Specification

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Schedule F5	Requirements Of The Contractor At Site
Schedule F6	Contractor's Resource Deployment Schedule
Schedule F9	Coefficients And Indices for Price Variation Formula
II	Forms and Appendices to form part of Contract
Annexure-F	Form of Contract Agreement
Contract Schedule-1	Terms of Payment
Contract Schedule-2	Price Adjustment
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Approved Subcontractors
Contract Schedule-5	Scope of Works and Supply by the Owner
Contract Schedule-6	Functional Guarantees
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Bank Guarantees

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ANNEXURES & SCHEDULES

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.: Bank Guarantee No:
Date :

To:
 [Details of Designated Official]
 [-Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [.....] dated [.....] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [.....] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [Name of package and R&M project], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [.....] (in words and figures) valid for 300 days from [.....] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [.....] Bank at (local address) [.....] having our Head Office at [.....] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of [.....] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

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This Guarantee shall be irrevocable and shall remain valid upto [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorised officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
 Name :
 Designation :
 Staff Code No. :

Banker's Seal :
 Date :

Witness:

1. Signature :
 Full name in block letters :
 Designation :
 Address :

2. Signature :
 Full name in block letters :
 Designation :
 Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[Name of Utility] [.....]

Sub : ____ (Name of Package) [.....]

Tender

No.

[.....]

Having carefully examined the Tender Specifications issued to us for your Tender No. [.....] dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the 'works' in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification. The plant, equipment and systems offered are of the best and latest technology and of international standards.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR _____ (Indian Rupees [.....] only)/US\$ _____ (US Dollars [.....] only)/Euro _____ (Euro [.....] only) in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of 180 (One Hundred and Eighty) days from the date of opening of bids by Purchaser and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to [Name of Utility], assignees or authorized nominees such sums of money as are stipulated in conditions contained in Tender Specification and agree to furnish Bank

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Guarantee for Contract Performance as per the proforma prescribed by Purchaser and for the sum equal to 10% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Purchaser is not bound to accept the lowest or any Bids received and Purchaser has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Purchaser and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

Witness:

1. Signature :
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From:

Dated:

[.....]

[.....]

[.....]

To :

[.....]

[.....]

[.....]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire works as described in the specifications in conformity with the specifications and Tender Specifications, as per prices quoted by us in the Schedule of Prices and Schedule of Performance Guarantees *[Schedule]* enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Employer *[Name of Utility]* and for the sum equal to 10% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Employer is received and accepted by the Employer

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

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1. Signature
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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ANNEXURE – D
(SAMPLE FORMAT)

LETTER OF CONSENT

TO BE FURNISHED BY THE BIDDER and CONSORTIUM PARTNERS

We hereby declare that the undersigned firm [-----] (Name and Complete address of the Consortium Partners) hereby agrees to associate with [-----] (Name and Complete address of the Bidder) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Bidder and Consortium Partner [-----] Package for the [-----] Project at [-----] in the state of [-----], India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of [-----] package, fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Owner's Project site.

On award of LOA, we the Consortium Partner agree to furnish an on demand back up bank guarantee for 2 % of Contract Price.

1. Witness

For Consortium Partner

Signature:	(Signature of the Authorized Signatory)
Name:	Name:
Designation:	Designation:
Office Address	Seal of the Company

2. Witness

For Bidder

Signature:	(Signature of the Authorized Signatory)
Name:	Name:
Designation:	Designation:
Office Address:	Seal of the Company:

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ATTACHMENT TO THE LETTER OF CONSENT
Scope of Work of the Each Consortium Partner:

For Bidder

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

For Each Consortium Partner

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

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ANNEXURE – E

SAMPLE FORMAT

LETTER OF UNEQUIVOCAL CONSENT TO BE FURNISHED BY THE BIDDER AND THE ASSIGNEE

We hereby declare that the undersigned firm [-----] (Name and Complete address of the Assignee) hereby agree to act as a Assignee to the Firm [-----] (Name and Complete address of the Bidder) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Bidder and the Nominee) of [-----] Package for the [-----] Project at [-----] in the state of [-----], India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of [-----] package, fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Owner's Project site.

We, the Assignee, agree to work as an independent contractor, with respect to the 2nd/3rd Contract or both, on such additional terms and conditions, as may be agreed to, between the Owner and the Foreign Bidder.

On award of LOA, we the ASSIGNEE agree to furnish an additional Contract Performance Bank Guarantee for 5%, of the aggregate value of the component contracts entered in to with us.

1. **Witness**

For Assignee

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address

Seal of the Company

2. **Witness**

For Bidder

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address:

Seal of the Company:

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ATTACHMENT TO THE LETTER OF UNEQUIVOCAL CONSENT

1 Scope of Work of the Assignee:

For Bidder

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

For Assignee

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

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SCHEDULE – F1: TABLE - 1

SUMMARY OF PRICE SCHEDULE

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.1	Supply of imported Plant & equipment including technological and misc. structures with all accessories (FOB) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum and firm price basis.		
1.2	Ocean freight on lumpsum and firm price basis for 1.1 above.		
1.3	Marine insurance on lumpsum and firm price basis for 1.1 above.		
1.4	CIF Cost (1.1+1.2+1.3)		
2.	All port charges including port handling, port rent, and port clearance on lumpsum and firm price basis.		
3.	Supply of indigenous Plant & Equipment including Technological and misc. structures with all accessories (Ex-Works) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum price basis.		
4.	Sales Tax Payable on Indigenous equipment - on Ceiling basis. (a) VAT (b) Central Sales Tax (CST)		
5.	(a) Inland transport of imported plant & equipment on lumpsum and firm price basis.		
	(b) Inland transport of Indigenous plant & equipment on lumpsum and firm price basis		
6.	Lumpsum price for Civil Works including, supplies such as cement, reinforcement steel, all foundation bolts etc.at site cost, including Design & Engineering and Construction of entire Civil works.		
7.	Erection services including dismantling/disassembly. unloading, handling, storage and preservation at site, Erection, testing, commissioning and PG tests of plant & equipment on lumpsum price basis		
8.	Marine cum erection insurance on lumpsum and firm price basis (excluding marine insurance indicated in Sl. No. 1.3 above)		
9.	Foreign supervision charges in India during erection, commissioning & PG test on firm price basis with ceiling.		

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(In Figures and Words)

S.No.	Description	Foreign Currency	INR
10.	Training charges on firm price basis with ceiling.		
11.	VAT on Works Contract on ceiling basis		
12.	Service Tax including Education Cess on Ceiling basis		
13.	Others, if any (Please specify),		
14.	Total price of package (excluding mandatory spares and Tools & Tackles. (Total of SI.Nos.1.4 + 2 to 13).		
15.	Mandatory Spares on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-3)		
16.	Tools & Tackles on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-4)		
17.	Grand total price of package including Mandatory Spares and Tools & Tackles. (Total of SI Nos 14+15+16).		

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 2

**PRICE SCHEDULE FOR SUPPLY OF PLANT AND EQUIPMENT INCLUDING
PACKING AND FORWARDING CHARGES**

(In Figures and Words)

S.No.	Description	Foreign Supply	Indigenous Supply
		FOB Price in Foreign Currency	Supply price including packing and forwarding in INR
1	Mechanical Equipment		
1.1			
1.2			
...			
...			
...			
...			
...			
...			
...			
	Sub Total (1)		
2.	Electrical Equipment		
2.1			
2.2			
...			
...			
...			
	Sub Total (2)		
3	Control & Instrumentation Equipment		
3.1			
3.2			
...			

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(In Figures and Words)

S.No.	Description	Foreign Supply	Indigenous Supply
		FOB Price in Foreign Currency	Supply price including packing and forwarding in INR
...			

	Sub Total (3)		
4	Total (1 + 2 + 3)		

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3A
PRICE SCHEDULE FOR MANDATORY SPARES

(In Figures and Words)

S. No.	Description	Foreign Price In Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Mandatory Spares including Packing and Forwarding on lumpsum and firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	CIF Cost (1.1 +1.2+1.3)		
2	All port charges including port rent, port handling charges, port clearance on lumpsum and firm price		
3	Supply (Ex-works) of Mandatory Spares including Packing and Forwarding on lumpsum and Firm Price		
4.	a) Inland transport for Imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5	Insurance excluding 1.3 above (Lumpsum and firm price basis)		
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7	Total price of Mandatory Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3B
PRICE SCHEDULE FOR RECOMMENDED SPARES

(In Figures and Words)

S. No.	Description	Foreign Price In Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Recommended Spares including Packing and Forwarding on lumpsum and firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	CIF Cost (1.1 +1.2+1.3)		
2	All port charges including port rent, port handling charges, port clearance on lumpsum and firm price		
3	Supply (Ex-works) of Recommended Spares including Packing and Forwarding on lumpsum and Firm Price		
4.	a) Inland transport for Imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5	Insurance excluding 1.3 above (Lumpsum and firm price basis)		
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7	Total price of Recommended Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-4
PRICE SCHEDULE FOR TOOLS & TACKLES

(In Figures and Words)

S. No	Description	Foreign Price in Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Tools and Tackles including Packing and Forwarding on Lumpsum and Firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	C.I.F Cost (1.1 +1.2+1.3)		
2.	All port charges including port rent, port handling charges, port clearance on Lumpsum and firm price		
3.	Supply (Ex-works) of Tools and Tackles including Packing and Forwarding on Lumpsum and firm Price		
4.	a) Inland transport for imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5.	Insurance excluding 1.3 above (lumpsum and firm price basis)		
6.	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7.	Total price of Tools and Tackles (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-5

**PRICE SCHEDULE FOR ERECTION SERVICES INCLUDING
DISMANTLING/DIASSEMBLY, UNLOADING, HANDLING, STORAGE,
PRESERVATION AT SITE, ERECTION, TESTING, COMMISSIONING AND
PERFORMANCE GUARANTEE TESTS OF PLANT AND EQUIPMENT**

(In Figures and Words)

S.No.	Description	Total Price for complete work at Site in Indian Rupees
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		
	Sub Total (3)	
4	Total (1 + 2 + 3)	

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 6

PRICE SCHEDULE FOR CIVIL WORKS

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.			
2			
3			
4			
5			
.....			
.....			
	Total		

Signature :

Name :

Designation :

Company :

Company Seal

Date :

SCHEDULE – F1: TABLE - 7

PRICE SCHEDULE FOR TRAINING CHARGES

(In Figures and Words)

S.No.	Description	Man-Months	Foreign Currency	INR

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1.				
2				
3				
4				
5				
.....				
.....				
	Total			

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 8

SCHEDULE OF PERFORMANCE GUARANTEE PARAMETERS

The Bidder shall furnish performance guarantee of the Package in respect of all items listed below.

Category – I: Performance Guarantees under Liquidated Damages [L.D]

S. No	Particulars	Unit	Value inclusive of design, manufacture and all other Tolerances including measurement uncertainty
1			
2			
3			
.....			
.....			

Category – II: Mandatory Performance Guarantees

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			

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S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
3			
.....			
.....			

Category -III: Requirement under Demonstration Category

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			
3			
....			
.....			
.....			

Company Seal

Signature :
Name :
Designation :
Company :

Date :

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SCHEDULE – F2
OVER ALL TIME SCHEDULE
(Bidder to fill-in and submit with its Bid)

S.No	Work Description	Days from Effective Date	
		Start	Finish
1	Design & Engineering		
2	Manufacture of Plant/Equipment		
	(a)		
	(b)		
	(c)		
		
		
3	Delivery of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
4	Dismantling/Disassembly of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
5	Civil work at Site		
6	Erection of of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
7	Trial Operation & Provisional Take Over		
8	Performance Guarantee tests Completion and Final Take Over		

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I) . The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I) , then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F4

DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Purchaser's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Purchaser's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

Document Number	Rev No	Description	Page No.	Date of Issue
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SCHEDULE – F5

REQUIREMENTS OF THE CONTRACTOR AT SITE

(Bidder to fill-in and return with its Bid)

The Bidder shall state his requirements against each of the following including the basis of requirements:

A.	Requirements Description	Quantity

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE - F6
CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE

A) Construction Equipment

The Bidder shall indicate the schedule of construction equipment, proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
1									
2									
3									
...									
...									

B) Resource Deployment Schedule

The Bidder shall indicate the schedule of manpower resources proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
2.	Human Resources								
2.1	Engineering Category								
2.1.1	Project Engineers								
2.1.2	Mechanical Engineers								
2.1.3	Electrical Engineers								
2.1.4	Civil Engineers								
2.1.5	C&I Engineers								
2.1.6	Commissioning Engineers								
2.1.7	Structural Engineers								
2.1.8	Others (bidder shall indicate) as applicable for the work								
2.2	Supervisory Category								
2.2.1	Const. Manager								
2.2.2	Electrical Supervisors								
2.2.3	Mechanical Supervisors								
2.2.4	C&I Supervisors								
2.2.5	Civil Supervisors								
2.2.6	Purchase Officer (s)								
2.2.7	Finance/Site Office								
2.2.8	Inspection/Quality Control								
2.2.9	Others (Bidder shall indicate) as applicable for the work								

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S. No.	Type of Resource	Months						
2.3	Labour Category							
2.3.1	Welder							
2.3.2	Fitter							
2.3.3	Rigger							
2.3.4	Un-skilled labour							
2.3.5	Others (Bidder shall indicate) as applicable for the work							

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F9

COEFFICIENTS AND INDICES FOR PRICE VARIATION FORMULA

(Bidder to fill-in and return with its Bid)

Sl No	Component of Contract Price	Coefficients	Indices
1	Ex-Works/FOB price component of Plant and Equipment excluding mandatory spares	a= b= c L _b	A= B= C= L=
2	Erection Services Component		EF=
3	Civil Works Component	a= b= c= d= e=	MI= LI= FI= SI= CI=

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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Form of Contract Agreement

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Form of Contract Agreement

THIS CONTRACT AGREEMENT is made the _____ day of _____, 20_____.
 BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of [country of Employer] and having its principal place of business at [address of Employer] (hereinafter called “the Employer”), and (2) [name of Contractor], a corporation incorporated under the laws of [country of Contractor] and having its principal place of business at [address of Contractor] (hereinafter called “the Contractor”)

WHEREAS the Employer desires to engage the Contractor to dismantle/disassemble, design, manufacture, test, deliver, install, complete and commission certain Facilities, viz.

[.....]
 [.....]
 [.....]

(“the Facilities”) and the Contractor have agreed to such engagement upon and subject to the terms and conditions hereinafter appearing.

NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

a) Contract Documents means this signed Contract agreement and its annexure/appendices, and the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. The following will constitute the Contract Documents:

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing.
- vi. The bid & its schedules/ attachment submitted by the contractor.

a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.

b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing.
- vi. The bid & schedules/ attachment submitted by the contractor.

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1.3 Definitions

" The Definitions of terms and expressions shall be as per GCC clause 4.1. Terms and expressions not defined in GCC shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder: The Contract Price shall be the aggregate of: [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Employer shall be as follows:

1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Employer) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Employer may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

The detailed Time Schedule shall be as per Contract Schedule 2.

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Contract Schedules

The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]

-----[Title]

In the presence of -----

Signed by for and on behalf of the Contractor

-----[Signature]

-----[Title]

In the presence of -----

CONTRACT AGREEMENT

dated the_-----day of-----, 20_-----

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

- | | |
|-----------------------|---|
| Contract Schedule 1 : | Terms of Payment |
| Contract Schedule 2 : | Price Adjustment |
| Contract Schedule 3 : | Time Schedule |
| Contract Schedule 4 : | List of Approved Subcontractors |
| Contract Schedule 5 : | Scope of Works and Supply by the Employer |
| Contract Schedule 6 : | Functional Guarantees |

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Contract Schedule-1

Terms of Payment

The Owner shall pay the Contractor in the following manner and at the following times, on the basis of the Price Break down given in the Section on Price Schedules. Payments will be made in the currencies quoted by the Bidder unless otherwise agreed between the parties. Application for payment in respect of part deliveries may be made by the Contractor as work proceeds.

I. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares) supplied from Abroad:

1	10% of the total FOB price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	50% of FOB price for each identified equipment as progressive payment and 100% of Ocean Freight and Marine Insurance Charges pro-rata to the value of the equipment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of FOB price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer
4	20% of the total FOB price	On Completion of Facilities
5	5% of the total FOB price	Successful completion of Performance Guarantee Test

II. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares) supplied from within India:

1	10% of the total Ex-Works price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	50% of Ex-Works price for each identified equipment as progressive payment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of Ex-Works price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer

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4	20% of the total Ex-Works price	On Completion of Facilities
5	5% of the total Ex-Works price	Successful completion of Performance Guarantee Test

III. Terms of Payment for Supply of Mandatory Spares and Recommended Spares

1	70% of the CIF Price of each Spare from Abroad or 70% of the Ex-Works Price of each Spare from within India	Upon dispatch of the identified Spare after dispatch clearance by employer on raising of invoice by the Contractor and submission of evidence of shipment
2	30% of the CIF Price of each Spare from Abroad or 30% of the Ex-Works Price of each Spare from within India	On receipt of Spare at site and physical verification and certification by the Employer

IV. Terms of Payment for Local Transportation, Inland Transit Insurance and port clearance charges & port charges

For Plant & Equipment except Spares		
1	100% of Local Transportation, Inland Transit Insurance and Port Clearance & Port Charges pro-rata to value of the equipment	On receipt of Equipment at site and upon raising of Invoice by the Contractor
For Spares		
2	100% of Local Transportation, Inland Transit Insurance and Port Clearance & Port Charges pro-rata to value of Spare	On receipt of Spare at site and upon raising of Invoice by the Contractor

V. Terms of Payment for Erection of Plant & Equipment

1	10% of Total Price for Erection of Plant & Equipment	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Erection of Plant & Equipment as progressive payment pro-rata to value of plant & equipment erected	On certification by Employer of successful erection of plant & equipment and successfully passing of quality checks
3	10% of Total Price for Erection of Plant & Equipment	On Completion of Facilities
4	5% of Total Price for Erection of Plant & Equipment	Successful completion of Performance Guarantee Test

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VI. Terms of Payment for Civil Works

1	10% of Total Price for Civil Works	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Civil Works as progressive payment	On certification by Employer regarding value of work completed & successfully passing of quality checks
3	10% of Total Price for Civil Works	On Completion of Facilities
4	5% of Total Price for Civil Works	Successful completion of Performance Guarantee Test

VII. Terms of Payment for Price Adjustment Amount

Any increase in the Price of any component Contract shall be paid as per the Terms of Payment for base price. The initial 10% advance payment pertaining to increase in price shall be paid along with progressive payment of that equipment. Reduction to the Contract Price, if any, due to price adjustment provisions, shall be effected by recovering 100% of the reduction amount (including advance) from any of the Contractor's bills falling immediately due for payment.

VIII. Terms of Payment for Taxes & Duties

Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other Tax or Duty payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon receipt of corresponding Plant & Equipment or Spare at site and submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such Taxes & Duties.

IX. Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such variation.

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Contract Schedule-2

PRICE ADJUSTMENT

- (i) The Contract Price shall be subject to price adjustment during performance of the Contract to reflect changes in the cost of labour and material in accordance with the provisions described below.
- (ii) Only following components of the Contract Price will be subject to Price adjustment :
 - (a) Ex-Works (India) price of plant and equipment excluding Mandatory Spares manufactured within India and FOB price component for plant and equipment excluding Mandatory spares supplied from abroad. The price adjustment amounts towards these price components shall be without any ceiling.
 - (b) Erection Services component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
 - (c) Civil Works component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
- (iii) Price adjustment amounts towards aforesaid components of Contract Price shall be paid in the respective currencies of Contract.
- (iv) The indices for price adjustment shall necessarily be of the country of origin of goods/labour and shall be well established and nationally recognized in that country. Preferably Government indices shall be used.
- (v) The price adjustment formula for the components of the Contract Price above shall be as stipulated hereinafter.
- (vi) **Ex-Works/FOB price component of Plant and Equipment excluding mandatory spares**

The price component of the equipment for any shipment/ dispatch comprises of a fixed portion (designated as 'F' and the value of which is specified hereunder) and a variable portion linked with the indices for various materials and labour.

The amount of price adjustment towards variable portion payable/recoverable on each shipment/dispatch shall be computed as under:

$$ES = ES_1 - ES_0$$

ES₁ will be computed as follows:

$$ES_1 = ES_0 \left\{ F + a \times \frac{A_1}{A_0} \times f_1 + b \times \frac{B_1}{B_0} \times f_2 + c \times \frac{C_1}{C_0} \times f_3 + Lb \times \frac{L_1}{L_0} \times f_{lb} \right\}$$

Where

ES = Adjustment to Ex-Works/FOB price component expressed in the currency of the Contract payable to the contractor for each shipment/dispatch

ES₁ = Adjusted amount of Ex-works/FOB price component expressed in the

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currency of the Contract payable to the Contractor for each shipment/dispatch

ES_0 = Ex-works/FOB price for the plant and equipment in the currency of the Contract, shipment/dispatch wise.

- The fixed portion of the ex-works/FOB component of the Contract Price (F) shall be 0.15.
- a, b, c etc. shall be co-efficient of major materials/items involved in the ex-works/FOB component of the Contract Price. The sum of these co-efficient shall be between 0.50 to 0.60.
- A, B, C etc. shall be published price indices of corresponding major materials/items. Such indices shall necessarily be of the country of origin of goods.
- 'Lb' shall be co-efficient for labour component in the ex-works/ FOB component of the Contract Price which shall be between 0.25 to 0.35.
- 'L' shall be labour index.
- Sum of all the material co-efficient and the labour co-efficient shall be 0.85.

f_1, f_2, f_3, f_{lb} etc. are Exchange rate correction factors for the respective materials and f_{lb} is the exchange rate correction factor for labour with reference to the currency of the country of origin of index and the respective contract currency, such that

$$f = \frac{Z_0}{Z_1}$$

where Z is the no. of units of the currency of the country of the origin of index, which is equivalent to one unit of the respective contract currency. The exchange rates to be used for calculation of factor 'f' shall be as per State Bank of India Bills Selling Exchange Rates.

For the indices(A, B, C etc.), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid.. For ' Z_0 ', subscript 'o' refers to value as on the date of opening of Part-I Bid.

Subscript '1' refers to indices/exchange rates as of:

- (a) three months prior to the date of shipment/dispatch for labour, and
- (b) six months prior to the date of shipment/dispatch for material.

In case of shipments/dispatches which are delayed beyond the schedule date of shipment/dispatch for reasons attributable to the Contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of shipment/dispatch and the actual date of shipment/dispatch.

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The above formula for price adjustment will be applicable if the currency in which the contract price is expressed is different from the currency of the country of origin of labour and material indices. In other case, formula shall be applied without the exchange rate correction factor 'f'.

(vii) Erection Services Component

The price component for erection services comprises of a fixed portion and a variable portion linked with the index of labour.

The monthly price adjustment amount for the erection services component of the Contract Price will be computed separately for Indian currency and for foreign currency part, if any, related to expatriate supervision/labour as per the formula given below:

(a) Indian Rupee part of the Erection Services

$$ER = ER_1 - ER_0$$

ER₁ will be computed as follows:

$$ER_1 = ER_0 (0.15 + 0.85 \frac{FL_1}{FL_0})$$

Where:

ER	=	Adjustment to erection services component of contract price expressed in Indian Rupees payable to the contractor for each billing.
ER ₁	=	Adjusted amount of erection services component of Contract Price expressed in Indian Rupees payable to the Contractor.
ER ₀	=	Value of the Erection work done in the billing period (month)
FL	=	Indian field labour index namely, All India Consumer Price Index for Industrial Workers (All India Monthly Average) as published by Labour Bureau, Simla, Government of India.

(b) Foreign Currency portion of the Erection Services

$$EE = EE_1 - EE_0$$

EE₁ will be computed as follows:

$$EE_1 = EE_0 (0.15 + 0.85 \frac{EF_1}{EF_0} \times f)$$

Where:

EE	=	Adjustment to erection services component of Contract Price expressed in foreign currency payable to the contractor for each billing.
EE ₁	=	Adjusted amount of erection services component of Contract Price expressed in foreign currency payable to the contractor for each billing.
EE ₀	=	Value of foreign currency portion of Erection work done in the billing period (month)

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EF = Index for Expatriate field labour component of the Erection Price of Installation work. Such index shall necessarily be of the country of nationality of the labour.

f = Exchange rate correction factor for expatriate labour with reference to currency of country of origin of index for expatriate labour and the respective contract currency, such that

$$f = \frac{Z_0}{Z_1}$$

where Z is the no. of units of the currency of the country of origin of index, which is equivalent to one unit of the respective contract currency. The ex-change rates to be used for calculation of factor 'f' shall be as per State Bank of India Bills Selling Exchange.

For the indices, subscript 'o' refers to indices as on 30 days prior to date set for opening of bids. For 'Z₀', subscript 'o' refers to value as on the date of opening of Part-I Bid.

For the indices, subscript '1' refers to the indices as applicable for the month of execution of the erection work. For the exchange rates, subscript '1' refers to the exchange rates as applicable on the last day of the month of execution of the erection work.

In case of erection activities which are delayed beyond the schedule date for reasons attributable to the contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of completion and actual date of completion of the respective erection activity.

(viii) The following components of the contract price shall not be subject to price adjustment and shall remain firm during the execution of the contract :

- (1) Ocean Freight and Marine Insurance for Plant and Equipment, mandatory spares and recommended spares.
- (2) Ex-works/FOB price component for Mandatory spares & Recommended Spares.
- (3) Inland Transportation charges (including Inland Transit Insurance, port clearance, port handling & port charges) for plant & equipment and Spare Parts.

(ix) Civil Works Component

The Price of Civil Works for any month comprises a fixed part designated as 'F' and variable parts linked to indices for labour, steel, cement, other commodities and Fuel & Power. The monthly price adjustment amount for the civil works component of the Contract Price will be computed as per the formula given below:

$$EC = EC_1 - EC_0$$

EC₁ will be computed as follows:

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$$EC_1 = EC_0 \left\{ F + a \times \frac{MI_1}{MI_0} + b \times \frac{LI_1}{LI_0} + c \times \frac{FI_1}{FI_0} + d \times \frac{SI_1}{SI_0} + e \times \frac{CI_1}{CI_0} \right\}$$

Where

EC = Adjustment to Civil Works price component expressed in the currency of the Contract payable to the contractor for each month

EC₁ = Adjusted amount of Civil Works price component expressed in the currency of the Contract payable to the Contractor for each month

EC₀ = Value of Civil Works done expressed in the currency of the Contract for the billing period (month).

- The fixed portion (F) of the Civil Works component of the Contract Price shall be 0.15.
- 'a' is the coefficient for material cost other than cement and steel involved in the Civil Works component of the Contract Price and it shall be 0.15.
'b' is the coefficient for labour cost involved in the Civil Works component of the Contract Price and it shall be 0.3.
'c' is the coefficient for Fuel & Power cost involved in the Civil Works component of the Contract Price and it shall be 0.05.
'd' is the coefficient for steel cost involved in the Civil Works component of the Contract Price and it shall be 0.25.
'e' is the coefficient for cement cost involved in the Civil Works component of the Contract Price and it shall be 0.10.

- MI shall be All India Whole Sale Price Index for all commodities as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry.

LI shall be All India Consumer Price Index for industrial labour as published by Labour Bureau, Government of India

FI shall Index Number of Wholesale Price for group Fuel & Power as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

SI shall Index Number of Wholesale Price for Steel as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

CI shall Index Number of Wholesale Price for Cement as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

For the indices(MI, LI,FI, SI and CI), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid. Subscript '1' refers to indices as of one prior to the month for which Civil Works is being billed.

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Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

SI No.	Work Description	Start (Months from Effective Date)	Finish (Months from Effective Date)
1			
2			

Note: Detailed PERT network agreed between Owner and Contractor to be placed below above table.

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Contract Schedule-4
LIST OF SUB-CONTRACTORS

[List of approved subcontractors shall be placed]

SI No.	Equipment / Work Description	Approved Sub-Vendor / Sub-Contractor
1		1.
		2.
		3
		4
		5
2		1.
		2.
		3
		4
		5
3		1.
		2.
		3
		4
		5

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Contract Schedule-6
FUNCTIONAL GUARANTEES

[Functional Guarantees shall be placed]

SI No.	Functional Guarantee Parameter	Unit	Guaranteed Value
Category-I Performance Guarantee			
1			
2			
3			
4			
....			
Category-II Performance Guarantee			
1			
2			
3			
4			
....			
Category-III Performance Guarantee			
1			
2			
3			
4			
....			

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Contractor]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:	Bank Guarantee No:	Date:
--------	--------------------	-------

To:

[Name & Address of Owner (Utility)]

.....
.....]

Dear Sirs,

- 1 In consideration of the [...] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Contractor's Name] having its registered office at.....hereinafter referred to as the 'CONTRACTOR', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures] and the same having been unequivocally accepted by the CONTRACTOR and the CONTRACTOR having agreed to provide a **Contract Performance Bank Guarantee** for the faithful performance of the entire CONTRACT including the Warranty Obligations /Liabilities under the CONTRACT equivalent to 10% (ten percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

- 2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONTRACTOR by reason of any breach of the said CONTRACT of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to Rs.....(Rupees.....only). Any

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such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONTRACTOR or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The Bank further irrevocably guarantees and undertakes to pay any amount due and payable by the CONTRACTOR by reasons of non-fulfilment of any of the following obligations of the Contractor:
 - (a) Successful and satisfactory operation of the plant & equipment supplied and erected under the said Contract as per the Technical Specifications and other Tender/Contract documents.
 - (b) That the equipment installed under the said Contract shall be new and in accordance with Contract Documents and be free from all defects in design, engineering, material workmanship and performance for a period of 12 calendar months after final takeover of the equipment by the OWNER and that upon written notice from the OWNER, the CONTRACTOR shall remedy free of any expense to the OWNER, such defects as noticed and developed under the normal use of the said plant & equipment, within the said guarantee period.
- 4 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONTRACTOR. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 5 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONTRACTOR and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONTRACTOR or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 6 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONTRACTOR to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 7 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Contractor or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 8 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONTRACTOR's liabilities.

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- 9 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONTRACTOR(S).
- 10 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended from time to time for such period as may be desired by [Name of Contractor.....] on whose behalf this guarantee has been given.
- 11 Signed at.....this.....day of.....20.....

Signature :
 Name :
 Designation :
 Staff Code No :

Bank Seal

Date :

Witness:

1. Signature :
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

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2. Technical Schedules -Electrical
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ABBREVIATIONS

{The utilities are advised to use the following standard abbreviations while preparing Model Tender Document for their power plant.}

AAQ	Ambient Air Quality
AC	Alternating Current
ACB	Air Circuit Breaker
ACDB	AC Distribution Board
ACG	Automatic Control Gear
AHP	Ash Handling Plant
AHU	Air Handling Unit
ASME	American Society of Mechanical Engineers
ATRS	Automatic Turbine Run up System
ATT	Automatic Turbine Testing
AVR	Automatic Voltage Regulator
BHEL	Bharat Heavy Electricals Ltd.
BFP	Boiler Feed Water Pump
BMCR	Boiler Maximum Continuous Rating
BOD	Biochemical Oxygen Demand
BOP	Balance of Plant
BTD	Bearing Temperature Detector
CA	Condition Assessment
CAVT	Cold Air Velocity Air Flow Test
CBD	Continuous Blow Down

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CCTV	Closed Circuit Television
CEA	Central Electricity Authority
CEMS	Continuous Emission Monitoring System
CERC	Central Electricity Regulatory Commission
CFBC	Circulating Fluidized Bed Combustion
CHP	Coal Handling Plant
CRH	Cold Re-Heat
CRT	Cathode Ray Tube
CLCS	Closed Loop Control System
CMMS	Computerized Maintenance Management System
COC	Cycle of Concentration
COD	Chemical Oxygen Demand
CT	Cooling Tower, Current Transformer
CV	Control Valve
CW	Cooling Water
DB	Distribution Board
DC	Direct Current
DCDB	Direct Current Distribution Board
DCS	Distributed Control System
DDCMIS	Digital Distributed Control Monitoring Information System
DG	Diesel Generator
DGA	Dissolved Gas Analyser
DM	Demineralization

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DMCW	Demineralized Cooling Water
DP	Differential Pressure
E	Earthed
ECO	Economizer
EHC	Electro-Hydraulic Control
ELCID	Electromagnetic Core Imperfection Detection
EOT	Electrically Operated Travelling Crane
ESP	Electro Static Precipitator
ESV	Emergency Stop Valve
ETP	Effluent Treatment Plant
EWS	Engineer's Work Station
FD	Forced Draft
FO	Fuel Oil
FOPH	Fuel Oil Pump House
FSSS	Furnace Safeguard Supervisory System
GC	Gland Condenser
GCV	Gross Calorific Value
GA	General Arrangement
GT	Generator Transformer
HCA	Host Country Approval
HFO	Heavy Fuel Oil
HPS	Heavy Petroleum Stock
HPTB	High Pressure Turbine Bypass

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HMI	Human Machine Interface
HP	High Pressure
HRH	Hot Re-Heat
HT	High Tension
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
HVWS	High Velocity Water Spray System
IBD	Intermittent Blow Down
IBR	Indian Boiler Regulations
I&C	Instrumentation and Control
ICB	International Competitive Bidding
ID	Induced Draft
IGV	Inlet Guide Vane
I/O	Input / Output
IPT	Intermediate Pressure Turbine
IPR	Inter Posing Relay
ISA	Indian Standard Angle
ISMB	Indian Standard Medium Beam
ISMC	Indian Standard Medium Channel
IV	Interceptive Valve
LAN	Local Area Network
LDB	Lighting Distribution Board
LDO	Light Diesel Oil

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LE	Life Extension
LP	Low Pressure
LP	Lighting Panel
LPA	Loss Prevention Association of India
LPT	Low Pressure Turbine
LPTB	Low Pressure Turbine Bypass
LRSB	Long Retractable Soot Blower
LSHS	Low Sulfur High Stock
LT	Low Tension
LTSH	Low Temperature Super Heater
LVS	Large Video Screen
MCC	Motor Control Centre
MCCB	Module Case Circuit Breaker
MHVT	Multi High Velocity Thermocouple
MOCB	Minimum Oil Circuit Breaker
MoEF	Ministry of Environment & Forest
MS	Main Steam
MSSV	Main Stream Safety Valve
NDT	Non Destructive Test
NABL	National Accreditation Board for Testing and Calibration Laboratories
NSPBD	Non Segregated Phase Bus Duct
O&M	Operation and Maintenance

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OEM	Original Equipment Manufacturer
OPC	Object linked embedded Process Control
OWS	Operator Working Station
PA	Primary Air
PDB	Power Distribution Board
PLF	Plant Load Factor
PCC	Power Control Centre
PMCC	Power cum Motor Control Centre
PRDS	Pressure Reducing De-superheating Station
PLC	Programmable Logic Controller
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RH	Reheater
RLA	Residual Life Assessment
RO	Reverse Osmosis
RPM	Respirable Particulate Matter
rpm	Revolutions Per Minute
RMS/ rms	Root Mean Square Value
RSO	Recurrent Surge Oscillograph
RTD	Resistance Temperature Detector
SADC	Secondary Air Damper Control
SG	Steam Generator

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SH	Super Heater
SPM	Suspended Particulate Matter
STMS	Smart Transmitter Monitoring System
SWAS	Steam and Water Analysis System
TFT	Thin Film Transistor (Monitor)
TG	Turbo Generator
TMCR	Turbine Maximum Continuous Rating
TPS	Thermal Power Station
TR	Tons of Refrigeration
TC	Thermocouple
TSE	Turbine Stress Evaluator
TSI	Turbine Supervisory Instruments
TSS	Total Suspended Solids
UCR	Unit Control Room
UE	Unearthed
UPS	Uninterruptible Power Supply
VT	Voltage Transformer
VFD	Variable Frequency Drive
VVVF	Variable Voltage and Variable Frequency Drive

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1 INTENT OF SPECIFICATION

- 1.1 The intent of this Specification is to Renovate and Modernize various equipment & systems of Boiler and it's auxiliaries including but not limited to [Coal Mills, Coal Feeders, Primary Air fans, Forced Draft fans, Induced Draft fans, Electro Static Precipitator, Main steam piping, Cold reheat piping, Hot reheat piping, Upstream & downstream piping of HP & LP Turbine bypass valve, Auxiliary Steam System, Valves and all associated Electrical system, Control & Instrumentation systems and associated Civil & Structural work]. The renovated Boiler shall be capable of operating with the following parameters to feed the Turbo-Generator which is being renovated to give the output of [210/215/220/250] MW. Steam Parameters at the outlet of HP turbine and Feed Water parameters at the inlet of Economiser under the scope of Turbo Generator Package are also given below:

Table: 1.1

Description	Units	Design Parameters
Steam Flow at Final SH outlet	T / hr	[...]
Steam Pressure at ESV inlet	kg/cm2	[...]
Steam Temperature at ESV inlet	deg C	[...]
Re-heater Flow	T / hr	[...]
Steam Pressure at HPT outlet	kg/cm2	[...]
Steam Temperature at HPT outlet	deg C	[...]
Steam Pressure at IV inlet	kg/cm2	[...]
Steam Temperature at IV inlet	deg C	[...]
Feed Water Flow	T / hr	[...]
Feed Water Pressure at inlet of Economiser	kg/cm2	[...]
Feed Water Temperature at inlet of Economiser.	deg C	[...]

- 1.2 The Bidder shall carry out the required replacement / refurbishment / retrofitting of the Boiler & its Auxiliaries as per the requirements of his design so as to make the same capable of operating for an extended life of [20/25] years and producing the steam at the desired parameters mentioned in Table-1.1 in order to be compatible with the requirement of Turbo-Generator package. The scope

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of replacement / refurbishment / retrofitting shall include but shall not be limited to the scope of work mentioned at clause 4.6 which is based on the recommendation of RLA/CA and EA studies conducted during [...]. However, any other items/systems which have not been specifically mentioned but are considered necessary by the Bidder for giving the intended performance of Boiler & its Auxiliaries, shall also be included in the scope of Bidder and shall be separately highlighted by the Bidder in his proposal.

- 1.3 Bidders are required to quote the performance guarantee values for Boiler output, Boiler efficiency, ESP outlet emission and the Auxiliary power consumption in response to the minimum/maximum performance parameters specified in the Table 1.2 below.

Table: 1.2

S.No.	Parameter	Performance Guarantee Values
1	Boiler Output/Capacity in TPH at BMCR Condition (at rated parameters at superheater outlet, the coal being fired from the range specified)	[...]
2	Boiler Efficiency at 100% TMCR (%)	[...]
3	Maximum Auxiliary Power Consumption (kW)	[...]
4	ESP Outlet Dust Emission (mg/Nm ³)	[...]

Bidders to note that in case performance guarantee values quoted for Boiler output and ESP outlet emission are inferior to the minimum/maximum specified values, the bids will be considered as non responsive. In case of Boiler efficiency and Auxiliary power consumption, the best quoted value shall be considered as base parameter and other bids shall be cost loaded as per difference between base parameter and respective quoted guaranteed parameter multiplied by evaluation factors specified in the Commercial Volume (Volume-I).

- 1.4 The modified/replaced/retrofitted equipment will conform to the requirements of the Specification prescribed in Section-II of Volume-II. The relevant technical details like OEM's Specifications and Drawings for the existing equipment required to be modified / replaced / retrofitted have also been provided in Volume-II, Section-II for the reference of the Bidders.
- 1.5 Bidders are required to carry out necessary modifications / replacement in the existing mechanical / electrical equipment or systems including related civil/structural works as per Specification requirement and also based on their own assessment.

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- 1.6 The scope of work for R&M shall include designing / re-designing, basic and detailed engineering, re-engineering, refurbishing / retrofitting, supply, inspection and testing at supplier's works, packing, forwarding to site, forwarding from site to Bidder's facilities, unloading and storage at site, pre-assembly, machining if required, site fabrication, erection, replacing of various equipment and systems, application of thermal insulation, carrying out all pre-commissioning checks/ tests and any other work required to complete the system, commissioning and trial operation, performance tests of various equipment and systems covered under this Specification. Bidder's scope shall also include dismantling of the existing equipment/ facilities, including unloading & transportation to designated storage / disposal yard, wherever required as a result of augmentation of existing mechanical, electrical, I&C and civil/structural/ architectural works. The Bidder shall restore the equipment/ facilities, whenever applicable, after carrying out necessary renovations/modifications under the scope of R&M works.
- All the tools & tackles, labour and other facilities required for dismantling and restoration shall also be in the scope of the Bidder.
- Bidder shall also put back into service all the systems/equipment of the units after completion of R&M works, whether any modification is carried out on the same or not. All necessary tools, tackles, labour, instruments, spares, consumables etc. required for putting back into operation shall also be provided by the Bidder.
- 1.7 It is not the intent to specify completely herein all aspects of services and equipment to be provided by the Bidder who in any case shall be responsible for fulfillment of the intent of Specification. Irrespective of whether specifically mentioned or not, the services, equipment and systems to be provided in accordance with this Specification shall also form a part of the scope of work and shall conform in all respects to the highest standard of engineering, design, quality and workmanship so that after completion of R&M work by the Bidder, the plant shall be capable of performing completely in a safe, reliable and sustained manner as acceptable to the Owner.
- 1.8 Unless otherwise specifically clarified by the Owner, interpretation by the Owner in respect of scope of supplies & services and the meaning of the Specifications, drawings, requirements of operation, maintenance, redundancy etc., shall be final and binding on the Bidder. Owner shall have the right to reject or accept any work or material which in his assessment is not technically complete and proven to meet the requirements of this Specifications and/or applicable National and International Codes & Standards mentioned elsewhere in this Specification.
- 1.9 The requirements, conditions, appendices etc, given in various parts/ sections of technical Specifications shall form integral part of this Specification. Bidder is required to carefully examine and understand the Specifications and seek clarifications, if required, to ensure that he has understood the Specifications as intended by the Owner. In the absence of any specific clarifications made to the Owner during Bidding stage, the interpretation of Owner shall be final. The

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Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. All such points are required to be clarified & resolved during Bidding stage.

- 1.10 Any deviation or variation from the scope of supply and services or the intent of the Specification shall be clearly brought out under the schedule of Technical / Commercial deviations, irrespective of the fact that such deviation / variation may be standard practice or possible interpretation of the Specifications by the Bidder. In case, no clear and specific deviation is taken by the Bidder in the relevant schedule of Bid Proposal Sheet while making his Bid proposal, it will be construed that the Bidder shall comply with the stipulations of the Specification fully with regard to scope of services and supplies to be provided by him to achieve the objective of R&M. Further, unless otherwise specifically clarified by the Owner, the interpretation by the Owner in respect of scope of supplies and services to be performed by the Bidder shall be final and binding.

- 1.11 If the Bidder feels that, in his opinion certain features brought out in his offer are superior to what has been specified, these may be highlighted separately in the Bid. The Bidder at his own discretion may also make Alternate offers, which in his opinion are of superior technology, material etc. to the specified requirements leading to better performance like efficiency / output etc. of the units after renovation. In such case, the Bidder shall carry out a comprehensive study and clearly identify the scope of offer in his alternate proposal. The Bidder shall furnish that detailed study to Owner along with the Bid where the Bidder shall bring out in detail the scope of modifications required to be carried out by him in the various systems and equipment including but not limited to *[Boiler & auxiliaries, Coal Mills, Coal Feeders, Primary Air fans, Forced Draft fans, Induced Draft fans, Electro Static Precipitator, Main steam piping, Cold reheat piping, Hot reheat piping, Upstream & downstream piping of HP & LP Turbine bypass valve, Auxiliary Steam System, valves and all associated Electrical system, Control & Instrumentation systems and associated Civil & Structural work etc.]*.

Such Alternate proposals shall be supplemented with sufficient amount of information like specified design standards and performance requirements, Bidder's experience, operating feedback, provenness, etc. for justifying such proposals. Implications of such Alternate offers on the performance, output, efficiency, auxiliary power consumption, etc. shall be clearly brought out in the Bid to enable the Owner to determine the advantages, superiority and acceptability of the proposals.

However the Bidder's Base offer shall necessarily be in line with the Specification requirements. Under no circumstances the equipment and services as specified shall be brought out as an Alternate offer.

The Base offers will be evaluated as per procedure outlined in the Bid documents and the Alternate Offers of the lowest evaluated Bidder will only be considered for acceptance or otherwise. Owner may reject alternative proposals submitted by the Bidder at his sole discretion, without assigning any reason what so ever.

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- 1.12 In the event of conflict between requirements of any two clauses of the Specification documents or requirements of different Codes/ Standards specified, the more stringent requirement as per the interpretation of the Owner shall apply, unless confirmed otherwise by the Owner in writing.
- 1.13 The General technical conditions pursuant to the Contract, placed separately in this Specification, shall form an integral part of the Specification. These conditions shall supplement all the detailed technical Specification and requirement identified in this Specification.
- 1.14 Out of complete unit comprising of mechanical, electrical, C&I systems and equipment, some components/systems are envisaged to be replaced with new ones having better design features while some of the other components are to be refurbished / upgraded by the Bidder under present R&M Work. It shall be the responsibility of the Bidder to ensure that components/ equipment/ systems being supplied new OR components/ equipment/ systems being refurbished / upgraded by him are fully compatible and integrated with the existing equipment / systems so as to give safe, reliable and sustained operation of the complete unit. Modifications needed on the assembled equipment to ensure complete integration are to be brought out by the Bidder in the Bid and such modifications, if any, after Owner's approval shall be carried out by the Bidder to the satisfaction of the Owner.
- 1.15 The unit shall be designed to operate continuously in base load and cyclic load operation. The systems shall operate without any restriction over the entire range of operating conditions. The Bidder shall ensure that after R&M there are no restrictions/ alterations in modes of operations of this unit, as per the original/existing plant operation philosophy, including achieving base load, peak load and cyclic load operation.
- 1.16 As the various equipment/ systems/ components are to be fitted in the unit, Bidder is advised to visit the plant site to get fully conversant with the job, site conditions, and constraints, and collect all the information as required and as available before quoting against this Specification.
- 1.17 A brief extract of the existing unit, the original design details/ performance parameters along with plant details, operating history and known problem areas; wherever possible are brought out in the successive section of this Specification. Relevant plant layout drawings and certain key schematic drawings, as available, have also been provided in Annexure-I of this section of the specification for the purpose of familiarization & guidance only. The successful Bidder shall prepare and provide the additional drawings and documents describing the design and engineering details and the manuals for carrying out erection, commissioning and operation of the renovated unit.

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2 SITE & PROJECT SPECIFIC INFORMATION

2.1 Project Name

Project Title: [...]

Existing Capacity: [X xMW]

2.2 Project Location

The proposed project site is located at [...], in District [...] in the state of [...]. The location details of the project site are as indicated below:

Table: 2.1

Particulars	
Latitude	[.....'"] N
Longitude	[.....'"] E
Height above mean sea level	[...] m
Seismic Zone	Zone - [...]
Distance from [...] town	[...] km
Distance from national highway No. [...]	[...] km
Distance from state highway No. [...]	[...] km
Distance of nearest airport [...]	[...] km
Distance of nearest seaport [...]	[...] km

2.3 Climatological Data

Table: 2.2

Particulars	
Highest monthly mean of daily maximum temperature	[...] deg C
Lowest monthly mean of daily maximum temperature	[...] deg C
Highest monthly mean of daily minimum temperature	[...] deg C

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Particulars	
Lowest monthly mean of daily minimum temperature	[...] deg C
Annual mean of daily maximum temperature	[...] deg C
Annual mean of daily minimum temperature	[...] degC
Extreme highest temperature	[...] deg C
Extreme lowest temperature	[...] deg C
Design ambient temperature (unless specified otherwise)	{50} deg C
Relative Humidity: Maximum Minimum	[...] % [...]
Average annual rainfall	[...] cm
Heaviest rainfall in 24 hours so far	[...] cm
Number of rainy days in a year	[...]
Highest monthly mean of wind speed	[...] km/h
Lowest monthly mean of wind speed	[...] km/h
Maximum wind speed	[...] km/h

Table: 2.3

Season	Dry bulb temperature	Wet bulb temperature
Summer	[...] DegC	[...] deg C
Monsoon	[...] DegC	[...] degC
Winter	[...] DegC	[...] deg C

2.4

Fuel

At present the power station is sourcing coal from [...] coal mines. The coal is being transported to the project site by [Indian Railways/ MGR system/ cross country conveyor]. Proximity of Railway line to site from Railway Station is about

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[.....] km. The railway link shall also be used for transportation of heavy equipment to site during construction phase and to bring main and secondary fuel to the power plant during operation of plant.

2.4.1 Coal and Ash Analysis

- a. Proximate and ultimate analysis of coal (on as received basis)

Table: 2.4

Sl. No.	Particulars	Unit	Performance Coal	Worst Coal	Best Coal
(i)	Proximate Analysis				
1	Moisture	%	[....]	[....]	[....]
2	Ash	%	[....]	[....]	[....]
3	Volatile Matter	%	[....]	[....]	[....]
4	Fixed Carbon	%	[....]	[....]	[....]
	Total	%	100	100	100
(ii)	Gross calorific value	kCal/kg	[....]	[....]	[....]
(iii)	Grindability index	HGI	[....]	[....]	[....]
(iv)	Ultimate analysis				
1	Carbon	%	[....]	[....]	[....]
2	Hydrogen	%	[....]	[....]	[....]
3	Sulphur	%	[....]	[....]	[....]
4	Nitrogen	%	[....]	[....]	[....]
5	Oxygen (by difference)	%	[....]	[....]	[....]
6	Moisture	%	[....]	[....]	[....]
7	Ash	%	[....]	[....]	[....]
	Total	%	100	100	100

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b. Ash analysis

Table: 2.5

Characteristics	Unit	Range/ value
SiO ₂	%	[... / ...]
Al ₂ O ₃	%	[... / ...]
Fe ₂ O ₃	%	[... / ...]
TiO ₂	%	[... / ...]
CaO	%	[... / ...]
MgO	%	[... / ...]
Chloride as Cl	%	[... / ...]
Sulphate as SO ₄	%	[... / ...]
Alkalies as NaOH	mg/kg	[... / ...]
Chromium as Cr	mg/kg	[... / ...]
Mercury as Hg	mg/kg	[... / ...]
Lead as Pb	mg/kg	[... / ...]
Cadmium as Cd	mg/kg	[... / ...]
Nickel as Ni	mg/kg	[... / ...]
Zink as Zn	mg/kg	[... / ...]
Copper as Cu	mg/kg	[... / ...]

2.4.2

Secondary Liquid Fuels

[Analysis of Heavy Fuel Oil (HFO/HPS/LSHS as applicable) & Light Diesel Oil (LDO)]:

{Analysis of Heavy fuel oil (HFO/HPS/LSHS as applicable) and Light diesel oil (LDO) which is being used in the existing Boiler for start-up, coal flame stabilization and low load operation shall be specified in the table given below:}

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Table: 2.6

SL. No.	Particulars	Range/ value
(A)	Analysis of heavy furnace oil (HFO)	
i)	Specification	[Furnace oil conforming to IS:1593, heavy grade]
ii)	Average gross calorific value	[... / ...] kCa1/kg
iii)	Flash point	[... / ...] deg C
iv)	Pour point	[... / ...] deg C
v)	Kinematic viscosity at 50 °C	[... / ...] centistokes
vi)	Specific heat	[... / ...] kcal/kg/DegC
vii)	Ash	[... / ...] % by weight
viii)	Sediment	[... / ...] % by weight
ix)	Sulphur	[... / ...] % by weight
x)	Water content	[... / ...] % by volume
xi)	Acidity	[... / ...]
xii)	Specific gravity	[... / ...]
(B)	Analysis of heavy petroleum stock (HPS)	
i)	Calorific value	[... / ...] kCa1/kg
ii)	Acidity inorganic	[... / ...]
iii)	Flash point	[... / ...] deg C
iv)	Pour point	[... / ...] deg C
v)	Kinematic viscosity in cst at 50°C	[... / ...] cst

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SL. No.	Particulars	Range/ value
vi)	Kinematic viscosity in cst at 100 °C	[... / ...] cst
vii)	Sediment	[... / ...] % by weight
viii)	Ash	[... / ...] % by weight
ix)	Sulphur	[... / ...] % by weight
x)	water content	[... / ...] % by Volume
(C)	Analysis for low sulphur heavy stock (LSHS) fuel oil	
i)	Gross calorific value	[... / ...] kCal/kg
ii)	Flash point	[... / ...] deg C
iii)	Pour point	[... / ...] deg C
iv)	Ash content	[... / ...] % by weight
v)	Total sulphur	[... / ...] % by weight
vi)	Sediment	[... / ...] % by weight
vii)	Water content	[... / ...] % by Volume
viii)	Viscosity (maximum)	At 38 deg C - [... / ...] cst At 50 deg C - [... / ...] cst At 60 deg C - [... / ...] cst At 70 deg C - [... / ...] cst At 80 deg C - [... / ...] cst At 90 deg C - [... / ...] cst At 99 degC - [... / ...] cst At 100degC - [... / ...] cst At 110degC - [... / ...] cst
ix)	Specific gravity	[... / ...]

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SL. No.	Particulars	Range/ value
x)	Specific heat	[... / ...] kCal/kg/degC
(D)	Light Diesel Oil (LDO)	[As per IS:1460 (latest)]

2.5

Water Analysis

[Describe the source of consumptive and / or cooling water (name of river or sea or bore well) and the type of condenser cooling system being adopted for the unit.]

Chemical analysis of water which is used for this project is indicated as below:

Table: 2.7

Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
A	Raw Water Analysis		
1	Calcium	mg/l	[...]
2	Magnesium	mg/l	[...]
3	Sodium	mg/l	[...]
4	Potassium	mg/l	[...]
5	Total Cations	meq/l	[...]
6	Bicarbonates	mg/l	[...]
7	Carbonates	mg/l	[...]
8	Nitrate	mg/l	[...]
9	Chloride	mg/l	[...]
10	Sulphate	mg/l	[...]
11	Total Anions	meq/l	[...]
12	Silica	mg/l	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
13	Iron Fe	mg/l	[...]
14	pH value	.....	[...]
15	Turbidity	NTU	[...]
16	Total Dissolved Solids	mg/l	[...]
17	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[...]
18	BOD	mg/l	[...]
19	COD	mg/l	[...]
B	Clarified Water Analysis		
1	Calcium	mg/l	[...]
2	Magnesium	mg/l	[...]
3	Sodium	mg/l	[...]
4	Potassium	mg/l	[...]
5	Total Cations	meq/l	[...]
6	Bicarbonates	mg/l	[...]
7	Carbonates	mg/l	[...]
8	Nitrate	mg/l	[...]
9	Chloride	mg/l	[...]
10	Sulphate	mg/l	[...]
11	Total Anions	meq/l	[...]
12	Silica	mg/l	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
13	Iron Fe	mg/l	[....]
14	pH value	.....	[....]
15	Turbidity	NTU	[....]
16	Total Dissolved Solids	mg/l	[....]
17	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[....]
C	Demineralised Water for Power Cycle Make up		
The quality parameters of demineralised water is in use for make up to the condenser hotwell and make up to the closed cycle equipment cooling water (ECW) system is as below:			
1	pH	{6.8 – 7.2}
2	Silica, as SiO ₂	ppm	≤{0.01}
3	Conductivity	micro mho/cm	≤{0.1}

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3 EXISTING PLANT DETAILS

The Power Plant, is of the configuration of [...x...MW]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The boiler for the unit is of [PF/CFBC] design. The boiler is provided with [front & rear/ corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [... substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...&...] coal mines. The consumptive water for the power plant is being sourced from [...river /...sea].

3.1 Operational Background

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The deterioration experienced over the years in Plant's Average Performance Parameters is shown in Table 3.1.

{Furnish in the Table 3.1 below, the Average Values over the life (say 25 years)}

Table: 3.1
Unit's Average Performance Parameters over the Life

Years after Installation	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
5	[...]	[...]	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Table 3.2 indicated below, illustrates variations over the last five years in the performance parameters.

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{Furnish in the Table 3.2 below, the Average Values for the last five years. However, for the Parameters in respect of 'One Year back' and 'Current Year', furnish the Maximum, the Minimum and the Average Values.}

Table: 3.2
Unit's Performance Parameters during the Last Five Years

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
Four Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Three Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Two Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
One Year back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Current year	[...]	[...]	[...]	[...]	[...]	[...]	[...]

3.1.1

Auxiliary Power Consumption of Boiler & Auxiliaries

Table-3.3

Sl. No.	Equipment/System	Units	Power Consumption
1	Mills	kW	[...]
2	PA Fans	kW	[...]
3	FD Fans	kW	[...]
4	ID Fans	kW	[...]
5	Air Heaters	kW	[...]
6	Coal Feeders	kW	[...]
7	Boiler Start up drain Recirculation Pump (If applicable)	kW	[...]
8	Seal Air Fan	kW	[...]

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Sl. No.	Equipment/System	Units	Power Consumption
9	Lube Oil Pumps for Fans/Air Heaters/Mill System etc.	kW	[...]
10	Scanner Air Fans	kW	[...]
11	Electrostatic Precipitator	kW	[...]
12	Gas Recirculation Fan (If applicable)	kW	[...]
13	DM Cooling Water Pump for Boiler & Auxiliaries	kW	[...]
14	Auxiliary Cooling Water Pumps (If applicable within Boiler & Auxiliaries Package)	kW	[...]
15	Any other continuous running loads	kW	[...]
16	Total Auxiliary Power Consumption of Boiler and Auxiliaries	kW	[...]

3.1.2

Stack Emissions, Ambient Air Quality and Process Effluents

The Project has been regularly monitoring the environmental parameters such as stack monitoring, ambient air quality (AAQ), noise pollution and liquid waste pollution in accordance with applicable norms by employing [M/s....., which is an agency approved by State Pollution Control Board].

The existing environmental data and the limits specified for different pollutants, the locations of their measurements and the frequency of monitoring are given in the table below.

Table 3.3
Status of Stack Emissions, Ambient Air Quality and Process Effluents

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
Stack Emissions	SPM (mg/Nm ³)	Not to exceed [...]	[...]		[...]	[...]
Ambient Air Quality		On 24 Hrs Basis	On 24 Hrs Basis	On Annual Basis		
	SPM	[...]	[...]	[...]		

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)			Parameters Achieved		No. of locations for measurement	Frequency of Sampling.		
	(µg/m³)					[...]	[...]		
	RPM	[...]	[...]	[...]	[...]				
	(µg/m³)								
	SO ₂	[...]	[...]	[...]	[...]				
	(µg/m³)								
	NO _x	[...]	[...]	[...]	[...]	[...]	[...]		
	(µg/m³)								
	ETP Treated Water Quality							[...]	[...]
	pH	[...]		[...]					
	Colour	[...]		[...]					
Odour	[...]		[...]						
Temperature	[...]		[...]						
TSS (mg/l)	[...]		[...]						
Oil & grease (mg/l)	[...]		[...]						
COD (mg/l)	[...]		[...]						
(mg/l)									
BOD (mg/l)	[...]		[...]						
(mg/l)									
Chloride (mg/l)	[...]		[...]						
(mg/l)									
Sulphate (mg/l)	[...]		[...]						
(mg/l)									

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
	TDS (mg/l)		
	Zinc (mg/l)	...	...
	Fluoride (mg/l)	...	...
	Mercury (mg/l)	...	...

3.1.3

Feedback from the Plant Operators

Detailed discussions were held with the Plant operators who provided the feedback about the design and operation related problems of various systems. These are listed in the Table 3.4 below.

Table 3.4
Feedback from the Plant Operators

S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
1
2
3
4
5
6
7
8
9

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S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
...	[.....]	[.....]	[.....]

3.1.4 Tripping and Maintenance Record

{Indicate in the table below the tripping and maintenance record for the past three years.}

Table: 3.5

Year	Total Trippings	No. of Trippings due to Boiler Tube Leakages	Other Major Causes of Trippings	Maintenance carried out
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current Year	[.....]	[.....]	[.....]	[.....]

3.1.5 Maximum Achievable Load due to performance constraint

[Due to performance constraint of various equipment of Boiler & Auxiliaries including ESP, the maximum generation from the unit is restricted to [...] MW. The operational data at the above maximum load is indicated in the table below.]

Table: 3.6

Nature of constraint	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]

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3.1.6 Record of Reportable Accidents

[The record of reportable accidents for the past three years, is mentioned in the Table below]

Table: 3.7

Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current Year	[.....]	[.....]	[.....]	[.....]

3.1.7 Operation & Maintenance Difficulties due to Plant Limitations

[Difficulties are being experienced in day to day maintenance of the plant due to design deficiency, layout of the plant, obsolescence of equipment and non availability of spare parts etc. These are mentioned in the Table below]

Table: 3.8

S.No.	Nature of Difficulty	Specific Reason (Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

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3.2 Salient Technical Feature of Boiler & its Auxiliaries

{Describe in this sub-section, the Design Parameters and Salient Features of all the important Equipment and Systems of Pulverized Fuel (PF) Boiler & Auxiliaries or Circulating Fluidized Bed Combustion Boilers(CFBC), as applicable and as mentioned below.}

3.2.1 PF Boiler & Auxiliaries

a) PF Boiler

[The Boiler is of natural circulation, pulverized fuel fired, dry bottom, balanced draft using direct firing system. The design parameters of the Boiler are furnished below]

Table: 3.9

Description	Units	Design Parameters
Steam Flow at Final SH outlet	T / hr	[...]
Steam Pressure at SH outlet	kg/cm ²	[...]
Steam Temperature at SH outlet	deg C	[...]
Re-heater Flow	T / hr	[...]
Steam Pressure at RH outlet	kg/cm ²	[...]
Steam Temperature at RH outlet	deg C	[...]
Feed Water Flow	T / hr	[...]
Feed Water Pressure at inlet of Economiser	kg/cm ²	[...]
Feed Water Temperature at inlet of Economiser.	deg C	[...]

b) Furnace

[The boiler is equipped with a water cooled furnace of balanced draft and fusion welded membrane wall construction. It is equipped with.....numbers of coal burners and.....numbers of oil burners located at numbers of elevations. The design parameters of the Furnace are furnished below.]

Table: 3.10

Description	Units	Design Parameters
Type of Firing	[.....]

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Description	Units	Design Parameters
Combustion Chamber Volume	m ³	[.....]
Furnace Dimensions (Width x Depth x Height)	m	[.....]
Heating Surface Areas		[.....]
i) Water Walls	m ²	[.....]
ii) Superheaters	m ²	[.....]
iii) Reheaters	m ²	[.....]
iv) Economiser	m ²	[.....]
v) Air Heater	m ²	[.....]
vi) Steam Coil Air Heater	m ²	[.....]
vii) Temperature Measurement of Super-heater tubes, whether provided.	Yes / No	[.....]
viii) Temperature Measurement of Re-heater tubes, whether provided.	Yes / No	[.....]

c) **Super Heaters and Re-Heater**

[The super heaters are composed of four sections, a platen section, a pendant section, a rear low temperature section and a steam cooled wall & roof section. The Re-heater consists of two sections, the front pendant and the rear pendant sections. The details are given below:]

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Table: 3.11

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Low Temperature Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Platen Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Pendant Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Ceiling and Enclosure Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Front Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Rear Assembly	[.....]	[.....]	[.....]	[.....]	[.....]

d) **Economiser**

[The Economizer is of a single stage, continuous plane tube and horizontal, mixed flow type, located in the second pass of the boiler]

Table: 3.12

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Economiser	[.....]	[.....]	[.....]	[.....]	[.....]

e) **Steam Coil Air Pre-Heater**

[Steam Coil Air Pre-heater is being used during initial and low load operation.the details are given below]

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Table: 3.13

Description	Units	Design Parameters
Steam Coil Air Pre-Heater		
Type	.....	[.....]
No. per Boiler	.....	[.....]
Medium	.....	[.....]
Heating surface in	m ²	[.....]

f) **Air Pre-Heater**

The air pre-heater is of regenerative rotary type. Special sealing arrangements have been provided in the air pre-heater to prevent leakage between air and gas sides. Adjustable sector plates have also been provided to prevent the leakage during expansion. The heating surfaces of the air pre-heater have been provided with two types of cleaning systems, soot blowing and water washing system.]

Table: 3.14

Description	Units	Design Parameters
Re- Generative Air Pre-Heater		
Type	.....	[.....]
No. per Boiler	.....	[.....]
Medium	.....	<ul style="list-style-type: none"> • Primary Air • Secondary Air • Flue gas
Heating surface	m ²	[.....]
Heating Element Layer Depth		
Hot layer (Open hearth steel)	mm	[.....]
Intermediate Layer (open hearth steel)	mm	[.....]
Cold layer-corten –A steel	mm	[.....]
Rotor Drive		
Motor	HP	[.....]

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Description	Units	Design Parameters
Voltage	V	[.....]
Speed	rpm	[.....]
Cleaning Device		
Motor	HP	[.....]
Speed reducer	.....	[Reduction Ratio.....]
Auxiliary air motor		
Motor	HP	[.....]
Air Pressure	kg/cm ²	[.....]
Speed	rpm	[.....]
Guide bearing		
Type	....	[.....]
Oil Capacity	Liter	[.....]
Motor rating	HP	[.....]
Supporting bearing		
Type	....	[.....]
Lubrication	....	[.....]
Oil capacity	Liter	[.....]
Motor rating	HP	[.....]
Flue Gas Temperature at APH outlet (Corrected to 0% air leakage)	□C	[.....]

{In Case of vertical Tubular type following shall be provided}

Description	Units	Design Parameters
Number per Boiler	
Details of each Air heater		

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Description	Units	Design Parameters
Type	[.....]
No. of gas passes	[.....through the tubes]
No. of air passes	....	[.....across the tubes]
Flow	....	[Counter flow]
Number of bank in the main section	....	[.....]
Number of bank in the cold end section	....	[.....]
Details of Each Bank:		
Tube outside diameter	mm	[.....]
Tube thickness	mm	[.....]
Tube material		[.....]
Tube arrangement		[.....]
Tube length	m	[.....]
No. of tubes across air flow	....	[.....]
No. of tubes with air flow	....	[.....]
Tube pitch with air flow	mm	[.....]
No. of tubes	....	[.....]
Heating surface	m ²	[.....]
Total heating surface per Air heater	m ²	[.....]
Total Air-heater heating surface per boiler	m ²	[.....]

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a) Raw Coal Bunkers

[Each boiler is provided with [...] raw coal bunkers. The total capacity of the bunkers is to meet [...] hour's requirement at maximum mills capacity of the unit. The upper portion of the bunkers is of cylindrical shape made of carbon steel plate, while the conical portion is made of stainless steel plate. Each outlet of the bunker is provided with an isolation gate which is motor operated. In addition to the isolation gates, rod gates have been provided to control the flow of coal from the bunkers]

b) Raw Coal Feeders

[One gravimetric type of raw coal feeder has been provided for each coal mill. The coal feeders have been provided with micro-processor based controls with variable frequency drive. The feeders have been provided with dual independently measuring load cells. All parts of the feeders coming in contact with coal, except the belt, are made of stainless steel]

Table: 3.15

Description	Units	Design Parameters
Type	....	[.....]
Number	....	[.....]
Rated capacity each	tones/hr	[.....]
Required capacity	tones/hr	[.....]
Motor power required.	BHP	[.....]
Motor speed	rpm	[.....]
Speed Variation	....	[.....]
Width of feeder	mm	[.....]
Length between inlet and outlet connections (approx.)	mm	[.....]
Centre line distance between feeder inlet and mill inlet connections (approx.)	mm	[.....]
Depth of Coal bed	mm	[.....]

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c) **Fuel Firing System**

[The boiler is working on a direct firing system. The pulverized coal is being dried and transported to the coal burners by means of hot primary air being supplied by two primary air fans. The boiler is having [front and rear/corner/down shot] firing system. There are [...] pulverized coal burners and [...] oil burners. The burners are located at [...] floors.

d) **Coal Mills**

[The unit is provided with numbers of [BHEL] Make [XRP-783] bowl type mills, out of which mills are designed to work with designed coal andnumbers of mills are standby . The rated capacity of each mill isT/h.]

Table: 3.16

Description	Units	Design Parameters
Make and Model of Mills	.....	[....]
Capacity of Mills	T/hr	[....]
Size of raw coal (max.)	mm	[....]
Total Number of Mills per boiler	Nos.	[....]
Number of Mills to work per boiler with design coal quality	Nos.	[....]
Motor Rating	kW	[....]
Airflow per mill	T/h	[....]
Air temperature at Mill inlet	°C	[....]
Mill outlet temperature	°C	[....]
Fineness	%Thru' 200 Mesh	[....]
Motor		
Rating	kW	[....]
Voltage	kV	[....]
Frequency	Hz	[....]

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Description	Units	Design Parameters
Speed	rpm	[...]

e) **Primary Air Fans**

[Two Primary Air (PA) Fans have been provided for each boiler. Each PA Fan is designed to meet 60% MCR condition of the boiler. The PA Fans are Hot PA Fans. Details are given below:]

Table: 3.17

Description	Units	Design Parameters
Type		[...]
Make and Model of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Speed	rpm	[...]
Discharge Pressure	mmwc	[...]
Temperature of Hot Air	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]
Wk ² of runner & shaft	kg-m ²	
Bearings		[2 spherically seated, H.S. ring lubricated, with assisted lubrication water cooled. In board bearing on base plate, outboard bearing on pedestal.]

f) **Forced Draft Fans**

[Two Forced Draft (FD) Fans have been provided for each boiler. Each FD Fan is designed to meet 60% MCR condition of the boiler. The FD Fans supply combustion air to the boiler, mill air through PA Fans and tempering air to control the classifier temperature of the mills. Details are given below:]

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Table: 3.18

Description	Units	Design Parameters
Type	[...]
Make and Model of Fans	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Air	°C	[...]
Runner Diameter	mm	[...]
Wk ² of runner & shaft	kg-m ²	[...]
Speed	rpm	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]
Bearing		[Two spherically seated high speed pressure lubricated. The outboard bearing supported on pedestal, the inboard on base plate.]
Power Coupling	.....	[...]

g) **Induced Draft Fans**

[Two Induced Draft (ID) Fans have been provided for each boiler. Each ID Fan is designed to meet 60% MCR condition of the boiler. Each ID Fan evacuates flue gases through two parallel paths of ESP and discharge them into stack through separate ducting. Details are given below:]

Table: 3.19

Description	Units	Design Parameters
Type	[...]

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Description	Units	Design Parameters
Make and Model of Fans	[...]
Number of Fans per Boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Flue Gases	°C	[...]
Runner Diameter	mm	[...]
Wk ² of runner & shaft	kg m ²	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]
Bearing		[Two spherically seated high speed pressure lubricated. The outboard bearing supported on pedestal, the inboard on base plate]
Power coupling		

h) **Wall Blowers and Long Retractable Soot Blowers (LRSBs)**

[Adequate number of Wall Blowers and Long Retractable Soot Blowers (LRSBs) are being used for cleaning the soot deposited on the heating surfaces of the water walls and super heaters respectively. Manually operated soot blowing system has been provided. Details are given below:]

Table: 3.20

Description	Units	Design Parameters
Wall Blowers		
Make and Model of Wall Blowers	[...]
No. of Wall Blowers per boiler at water walls	Nos.	[...]

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Description	Units	Design Parameters
Medium of soot blowing at water walls	[...]
LRSBs		
Make and Model of LRSBs	.....	[...]
No. of LRSBs per boiler at pendant surfaces of pressure parts	Nos.	[...]
Medium of soot blowing at pendant surfaces of pressure parts	.....	[...]
No. of LRSBs per boiler at convection pass tube banks	Nos.	[...]
Medium of soot blowing at convection pass tube banks	.....	[...]

i) **ESP**

[An Electrostatic Precipitator (ESP) has been installed on the cold end side of the Air Pre-heater to remove the particulate matter from the flue gases. The ESP has been provided with Gas Distribution System, Collecting Electrodes, Discharge Electrodes, Transformer Rectifier Sets and [electrically/mechanically] operated rapping system. The hoppers of ESP have been provided with [capacitance] type level indicators and thermostatically controlled heating elements. Details are given below:]

Table: 3.21

Description	Units	Design Parameters
Make and Model of ESP	.....	[...]
Number of Passes per ESP	Nos.	[...]
Number of fields per pass	Nos.	[...]
Gas Flow	m ³ /sec	[...]
Inlet dust concentration	mg/Nm ³	[...]
Gas Temperature at ESP Inlet	deg C	[...]
Dust concentration at outlet	mg/Nm ³	[...]

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Description	Units	Design Parameters
Type of Electrodes	[...]
Spacing between the Collecting Plates	mm	[...]
Voltage Level	kV	[...]
Type of Control	.....	[...]
Gas Velocity in ESP	m/sec	[...]
Specific Collection Area	m ² /m ³ /sec	[...]
Aspect Ratio	.....	[...]
Particle Migration Velocity	cm/sec	[...]
Numbers of TR Sets	.....	[...]
Rating of TR Sets	.....	[...]
Plate Area/TR Set	m ² /TR Set	[...]
Storage Capacity of ESP Hoppers	hrs	[...]
Pressure Drop	mmwc	[...]
Dust Collection Efficiency with (N-1) fields in operation	%	[...]
Corona Power per unit of effective collection area	Watts/m ²	[...]

j) **Main steam piping, Cold reheat piping, Hot reheat piping & Auxiliary Steam Piping**

Table: 3.22

Description	Units	Design Parameters
Main Steam Line		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]

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Description	Units	Design Parameters
Size	mm	[...]
Material	[...]
Class	[...]
Upstream of HP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Downstream of HP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	[...]
Class	[...]
Cold Reheat Line		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]

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Description	Units	Design Parameters
Material	[...]
Class	[...]
Hot Reheat Line		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Upstream of LP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Downstream of LP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]

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Description	Units	Design Parameters
Class	[...]
Auxiliary Steam Piping		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Other LP Piping		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]

3.2.2 CFBC Boiler and Auxiliaries

a) CFBC Boiler

[The Boiler is of natural circulation, circulating fuel bed combustion, single drum, dry bottom, balanced draft using limestone /dolomite as absorbent The boiler is provided with water cooled/ steam cooled Cyclone Separator(s) to remove coarser entrained solid particles from the flue gases which are returned to the combustor bed via loop seal. An External Fluidized Bed Heat Exchanger (EFBHE) has also been provided to extract heat from a part of the solids before their return to the combustor bed. The design parameters of the Boiler are furnished below.]

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Table: 3.23

Description	Units	Design Parameters
Steam Flow at Final SH outlet	T / hr	[...]
Steam Pressure at SH outlet	kg/cm ²	[...]
Steam Temperature at SH outlet	deg C	[...]
Re-heater Flow	T / hr	[...]
Steam Pressure at RH outlet	kg/cm ²	[...]
Steam Temperature at RH outlet	deg C	[...]
Feed Water Flow	T / hr	[...]
Feed Water Pressure at inlet of Economiser	kg/cm ²	[...]
Feed Water Temperature at inlet of Economiser.	deg C	[...]

b) **Furnace**

[The furnace consists of membrane type water walls to provide most of evaporative boiler surface. The fuel for the boiler is (coal/lignite). The combustor bed material for the boiler is composed of (ash, sand and sorbent). Lower zone of the furnace is lined with refractory. Staged combustion is achieved by injecting the primary air under the bed and the secondary air above the refractory zone. The bottom of the furnace is provided with a fluidizing air distributor grid. Stainless steel air nozzles are mounted on the distributor grid to supply the primary air. Design Parameters of the furnace are furnished below.]

Table: 3.24

Description	Units	Design Parameters
Furnace Volume	m ³	[.....]
Dimensions of Furnace (Width x Depth x Height)	m	[.....]

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Description	Units	Design Parameters
Height of Refractory lined lower zone	m	[.....]
Elevation of Fuel Injection	m	[.....]
Elevation of Sorbent Injection	m	[.....]
Elevation of Secondary Air Injection	m	[.....]
Minimum fluidization velocity	m/s	[.....]
Superficial velocity	m/s	[.....]
Bed Temperature	deg C	[.....]
Coal / Lignite Feed Particle Size	[...] to [...]mm	[.....]
Type of Sorbent Used	....	[.....]
Sorbent Feed Particle Size	microns	[.....]
Calcium/Sulfur Ratio	....	[.....]
Sulfur Removal Efficiency	%	[.....]
Combustion Efficiency	%	[.....]
Heating Surface Areas		
i) Water Walls	m ²	[.....]
ii) Superheaters	m ²	[.....]
iii) Reheaters	m ²	[.....]

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Description	Units	Design Parameters
iv) Economiser	m ²	[.....]
v) Air Heater	m ²	[.....]
vi) Steam Coil Air Heater	m ²	[.....]
vii) Temperature Measurement of Super-heater tubes, whether provided.	Yes / No	[.....]
viii) Temperature Measurement of Re-heater tubes, whether provided.	Yes / No	[.....]

c) Cyclone(s)

Description	Units	Design Parameters
Number of Cyclones	....	[....]
Type of Cyclones	....	[....]
Method of Cooling(Water Cooled / Steam Cooled)	----	[....]
Inlet gas velocity	m/s	[....]
Concentration of solids at the inlet	kg/m ³	[....]
Particle Size Range	[...to ...] µm	[....]
Pressure drop	mmwc	[....]

d) Loop Seal

Description	Units	Design Parameters
Type of Loop Seal	[....]
Arrangement of fuel feeding	[....]

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Description	Units	Design Parameters
Arrangement of sorbent feeding	[...]
Number of Blowers	----	[...]
Capacity of Blowers	m ³ /s	[...]
Discharge Pressure of Blowers	mmwc	[...]

e) **External Fluidized Bed Heat Exchanger (If provided in the existing system)**

Description	Units	Design Parameters
Material of Heat Exchanger tubes	....	[...]
Surface Area of Heat Exchanger tubes	....	[...]
Arrangement of fuel feeding		
Arrangement of sorbent feeding		
Number of Blowers	----	[...]
Capacity of Blowers	m/s	[...]
Discharge Pressure of Blowers	mmwc	[...]

f) **Bottom Ash Removal System**

{Describe the type of bottom ash removal system provided to remove bed ash to maintain bed height, to remove oversize particles, to maintain bed pressure drop and to avoid accumulation & consequent de-fluidization}.

g) **Bottom Ash Cooling System**

{Describe the type of bottom ash cooling system provided, the medium of cooling the bottom ash and the design temperature of the cooled bottom ash}

h) **Super Heaters and Re-Heater**

[The super heaters are composed of four sections, a platen section, a pendant section, a rear low temperature section and a steam cooled wall & roof section. The Re-heater

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consists of two sections, the front pendant and the rear pendant sections. The details are given below:]

Table: 3.25

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Low Temperature Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Platen Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Pendant Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Ceiling and Enclosure Super Heater	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Front Assembly	[.....]	[.....]	[.....]	[.....]	[.....]
Reheater-Rear Assembly	[.....]	[.....]	[.....]	[.....]	[.....]

i) **Economiser**

[The Economizer is of a single stage, continuous plane tube and horizontal, mixed flow type, located in the second pass of the boiler]

Table: 3.26

Description	No. of coils / tubes	Pitch (mm)	Dia.x Thickness (mm)	Heating Surface (m ²)	Material
Economiser	[.....]	[.....]	[.....]	[.....]	[.....]

j) **Steam Coil Air Pre-Heater**

[Steam Coil Air Pre-heater is being used during initial and low load operation. The details are given below]

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Table: 3.27

Description	Units	Design Parameters
Steam Coil Air Pre-Heater		
Type	.....	[.....]
No. per Boiler	.....	[.....]
Medium	.....	[.....]
Heating surface in	m ²	[.....]

k) **Air Pre-Heater**

[The air pre-heater is of vertical Tubular type. The details are given below]

Table: 3.28

Description	Units	Design Parameters
Number per Boiler	....	[.....]
Details of each Air heater	....	[.....]
Type	....	[.....]
No. of gas passes	....	[.....through the tubes]
No. of air passes	....	[.....across the tubes]
Flow	....	[Counter flow]
Number of bank in the main section	....	[.....]
Number of bank in the cold end section	....	[.....]
Details of Each Bank:		
Tube outside diameter	mm	[.....]
Tube thickness	mm	[.....]
Tube material	[.....]

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Description	Units	Design Parameters
Tube arrangement	[.....]
Tube length	m	[.....]
No. of tubes across air flow	[.....]
No. of tubes with air flow	....	[.....]
Tube pitch with air flow	mm	[.....]
No. of tubes	....	[.....]
Heating surface	m ²	[.....]
Total heating surface per Air heater	m ²	[.....]
Total Air-heater heating surface per boiler	m ²	[.....]

l) Fuel Bunkers

[The boiler is provided with [...] bunkers of fuel (coal/lignite). The capacity of each bunker is to meet [...] hour's requirement of the boiler. The conical hopper portions of the bunker are lined with stainless steel.]

m) Fuel Feeding System

[From the bunkers, fuel flows down a vertical chute to individual extraction feeders placed under each conical hoppers, which are of drag chain type. These feeders are provided with variable frequency drives (VFDs) so that fuel feed rate can be controlled by varying the speed of the feeders. Fuel from these box feeders is again fed to common main drag chain feeders from where the fuel is conveyed to the combustor bed of the furnace.]

n) Sorbent Bunker

[The boiler is provided with [...] sorbent bunkers of Limestone/ dolomite. The capacity of each bunker is to meet [...] hour's requirement of the boiler. Flow of sorbent is controlled with gravimetric feeders]

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o) Start up Burners

[Start up burners using LDO have been provided to raise the temperature of the combustor bed to the auto ignition temperature of the fuel. For this purpose, [...] burners have been placed in the primary air duct leading to the combustor bed]

p) Primary Air Fans

[Two Primary Air (PA) Fans have been provided for each boiler. Each PA Fan is designed to meet 60% MCR condition of the boiler. The PA Fans are Hot PA Fans. Details are given below:]

Table: 3.29

Description	Units	Design Parameters
Type	.....	[...]
Make and Model of Fans	.....	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Speed	rpm	[...]
Discharge Pressure	mmwc	[...]
Temperature of Hot Air	°C	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]
W _k ² of runner & shaft	kg-m ²	
Bearings		[2 spherically seated, H.S. ring lubricated, with assisted lubrication water cooled. In board bearing on base plate, outboard bearing on pedestal.]

q) Secondary Air Fans

[Two Secondary Air (SA) Fans have been provided for each boiler. Each SA Fan is designed to meet 60% MCR condition of the boiler. The SA Fans supply secondary air to the combustor. Details are given below:]

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Table: 3.30

Description	Units	Design Parameters
Type	[...]
Make and Model of Fans	[...]
Number of fans per boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Air	°C	[...]
Runner Diameter	mm	[...]
Wk ² of runner & shaft	kg-m ²	[...]
Speed	rpm	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]
Bearing		[Two spherically seated high speed pressure lubricated. The outboard bearing supported on pedestal, the inboard on base plate.]
Power Coupling	.....	[...]

r) Induced Draft Fans

[Two Induced Draft (ID) Fans have been provided for each boiler. Each ID Fan is designed to meet 60% MCR condition of the boiler. Each ID Fan evacuates flue gases through two parallel paths of ESP and discharge them into stack through separate ducting. Details are given below:]

Table: 3.31

Description	Units	Design Parameters
Type	[...]

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Description	Units	Design Parameters
Make and Model of Fans	[...]
Number of Fans per Boiler	Nos.	[...]
Capacity	m ³ /sec	[...]
Discharge Pressure	mmwc	[...]
Temperature of Flue Gases	°C	[...]
Runner Diameter	mm	[...]
Wt ² of runner & shaft	kg m ²	[...]
Motor Rating	kW	[...]
Method of Regulation	....	[...]
Bearing		[Two spherically seated high speed pressure lubricated. The outboard bearing supported on pedestal, the inboard on base plate]
Power coupling	....	[...]

s)

Soot Blowers

{Please indicate in the table below, the type, the location and number of soot blowers provided in the existing CFBC Boiler.}

Table: 3.32

Description	Units	Design Parameters
Make and Model of Soot Blowers provided.	.....	[...]
No. of Soot Blowers per boiler.	Nos.	[...]
Location of Soot Blowers	[...]
Medium of soot blowing.	[...]

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t) ESP

[An Electrostatic Precipitator (ESP) has been installed on the cold end side of the Air Pre-heater to remove the particulate matter from the flue gases. The ESP has been provided with Gas Distribution System, Collecting Electrodes, Discharge Electrodes, Transformer Rectifier Sets and [electrically/mechanically] operated rapping system. The hoppers of ESP have been provided with [capacitance] type level indicators and thermostatically controlled heating elements. Details are given below:]

Table: 3.33

Description	Units	Design Parameters
Make and Model of ESP	.....	[....]
Number of Passes per ESP	Nos.	[....]
Number of fields per pass	Nos.	[....]
Dust concentration at outlet	mg/Nm ³	[....]
Type of Control	.....	[....]
Gas Velocity in ESP	m/sec	[....]
Specific Collection Area	m ² /m ³ /sec	[....]
Aspect Ratio	.....	[....]
Particle Migration Velocity	cm/sec	[....]
Numbers of TR Sets	.....	[....]
Rating of TR Sets	.....	[....]
Plate Area/TR Set	m ² /TR Set	[....]
Storage Capacity of ESP Hoppers	hrs	[....]
Pressure Drop	mmwc	[....]
Dust Collection Efficiency with (N-1) fields in operation	%	[....]

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u) Main steam piping, Cold reheat piping, Hot reheat piping & Auxiliary Steam Piping

Table: 3.34

Description	Units	Design Parameters
Main Steam Line		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Upstream of HP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Downstream of HP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]

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Description	Units	Design Parameters
Class	[...]
Cold Reheat Line		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Hot Reheat Line		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Upstream of LP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]
Class	[...]

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Description	Units	Design Parameters
Downstream of LP turbine bypass valve		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Auxiliary Steam Piping		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
Other LP Piping		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]
Class	[...]

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Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
--	-------------------

3.2.3 Electrical System

a) General Technical Parameters

[The Major design parameters of the electrical systems/Equipment are furnished below:]

Table: 3.35

Description	Units	Design Parameters
Make/Manufacturer		[....]
Model No		[If applicable]
Installation		[....]
Nominal voltage	kV	[....]
Highest System voltage	kV	[....]
Short circuit current	kA	[....]
Impulse withstand voltage	kV (Peak)	[....]
One minute power frequency withstand voltage	kV (rms)	[....]
Reference ambient temperature	°C	[....]
Rated Current	Amp	[....]

6.6/0.433 kV Transformer

[The 6.6 / 0.433 kV transformer is designed to cater 100% of Power plant auxiliary load of respective system like Boiler auxiliary, HVAC etc, with 2 x100% configuration is followed. For ESP system electrical scope of work shall start from 6.6 kV Unit switchgear outgoing and shall include HV cable termination, HV cable, LT transformer, NSPBD, LV switchgear and further distribution. The design parameters of the 6.6 / 0.433 kV transformer are furnished below:]

Table: 3.36

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type		[Oil/Dry.....]
Transformer application		[..Service]

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Description	Units	Design Parameters
Installation		[...Indoor/Outdoor.]
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap		[.....]
Rated frequency	Hz	[.....]
Winding connection and vector group		[.....]
System fault level	kA	[HV.....]; [LV.....]
Impulse withstand voltage / Power frequency withstand voltage of windings	kV	[.....]
System earthing (a) HV (b) LV		[.....] [.....]
Type of tap changer		[.....]
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at a) Full load b) 75% load	%	[.....]
No of Cooler Bank and Capacity (If applicable)	No & %	[.....]

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Description	Units	Design Parameters

b) LV Switchgear (PMCC/MCC)

[The LV Switchgear is provided with two incomers and bus coupler with outgoing feeders intend for specific Auxiliary services. All the MCC/PMCC to feed the boiler auxiliary like ESP PCC/PMCC/MCC, FOPH PCC/PMCC/MCC, Boiler MCC, Boiler Valve MCC, Soot Blower MCC, Bottom Ash Handling System MCC, Emergency MCCs, AC ventilation MCC, PDBs, ACDBs, etc. are the part of Boiler package. The design parameters of the LV Switchgear are furnished below:]

Table: 3.37

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Rated voltage, phases & frequency	V, Hz	[.....]
System neutral earthing		[.....]
Maximum system voltage	V	[.....]
One minute power frequency Voltage		[.....]
(a) Power circuits	V	[.....]
(b) Control Circuits	V	[.....]
Continuous current rating of bus bars		[.....]
Short Circuit rating of Bus bar with duration	kA & sec	[.....]
Bus bar Material	Al/Cu	[.....]
Type- Fully Draw out/Fixed		[.....]

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c) Non Segregated Phase Bus Duct (NSPBD)

[Diesel generating sets are installed for meeting the power requirements of essential auxiliaries (viz. jacking oil pumps, AC lube oil pump, hydrogen seal oil pump, float charger for DC battery, emergency lighting, scanner air fan and stator cooling water pump) during total failure of AC Power Supply in the power station. Diesel generating sets are located in the CD bay at the ground floor. The details are mentioned below]

[The NSPBD which connects 6.6 / 0.433 kV transformer to LV Switchgear required for boiler auxiliaries and associated equipment. The design parameters of the NSPBD are furnished below:

Table: 3.38

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type of bus duct		[.....]
Rated voltage and No. of phase	V	[.....]
Material of Bus bar and Enclosure		[.....]
Rated Current	A	[.....]
Designation (From and To)		[.....]
Type of cooling (NSPBD)		[.....]
Maximum temperature rise of conductor over 50°C ambient	°C	[.....]
Maximum temperature rise of enclosure over 50°C ambient	°C	[.....]
One minute power frequency voltage withstand	KV (RMS)	[.....]
Continuous current rating at 50°C design	A	[.....]

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Description	Units	Design Parameters
ambient air temperature		
One second short circuit withstand rating	KA (RMS)	[.....]
Momentary short circuit withstand current	KA (Peak)	[.....]

d) **HV Cables**

[The HV cables of 6.6kV UE Voltage grade is used for feeding 6.6kV motors as well as 6.6 / 0.433 kV transformers (under boiler package) from 6.6 kV Unit or station switchgear. HV cable termination at both the end shall be in boiler package. The design parameters of the HV Cables are furnished below:]

Table: 3.39

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]

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Description	Units	Design Parameters
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

e) **LV Cables**

[The LV cables of 1.1kV Voltage grade are used for feeding LV motors as well as for sub distribution system boards/MCC/PMCC/ACDB/DBs etc. The design parameters of the LV Cables are furnished below:

Table: 3.40

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]

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Description	Units	Design Parameters
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

f) Control (Core) Cables

[The Control cables of 1.1kV Voltage grade are used for Protection, CT, VT connection and feedback/interlock signals. The design parameters of the LV Cables are furnished below:

Table: 3.41

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]

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Description	Units	Design Parameters
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

g) 6.6 kV Motor

[All the 6.6kV motor in boiler packages shall be directly fed from the 6.6kV Unit/station switchgear. 6.6kV Unit and station switchgear shall be part of TG package. The provision of Nos of outgoing feeder shall be kept in 6.6kV switchgear in co-ordination with the boiler package Bidder. The design parameters of 6.6 kV motors used in Boiler package are furnished below]:

Table: 3.42

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Application		[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Frame Size		[.....]
Type of Cooling		[.....]
Installation		[.....]
Duty Type		[.....]
Load Factor		[.....]
Full load current		[.....]

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Description	Units	Design Parameters
Starting current & Starting PF	Times Normal current	[.....]
Winding connection	Star/Delta	[.....]
Full load speed		[.....]
Power factor and Efficiency		[.....]
Class of insulation		[.....]
Method of starting :		[.....]
Main terminal box details		[.....]
Space Heater Details		[.....]
CT details if provided with differential protection		[.....]
RTD/BTD Details		[.....]

h) LV Motor

[All the LV motor in boiler package shall be feeded from the MCC/PMCC of this package. The design parameters of LV motors used for Boiler package are furnished below]:

Table: 3.43

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Application		[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]

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Description	Units	Design Parameters
Frame Size		[.....]
Type of Cooling		[.....]
Installation		[.....]
Duty Type		[.....]
Load Factor		[.....]
Full load current		[.....]
Starting current & Starting PF	Times Normal current	[.....]
Winding connection	Star/Delta	[.....]
Full load speed		[.....]
Power factor and Efficiency		[.....]
Class of insulation		[.....]
Method of starting :		[.....]
Main terminal box details		[.....]
Space Heater Details		[.....]
RTD/BTD Details		[.....]

i) **Electrical Actuators**

[The design parameters of Electrical Actuators used for Boiler package are furnished below]:

Table: 3.44

Description	Units	Design Parameters
Make/Manufacturer		[.....]

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Description	Units	Design Parameters
Application		[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Installation		[.....]
Duty Type		[.....]
Load Factor		[.....]
Type		[... Integral/Non Integral.....]
Class of Insulation		[.....]

j) **Illumination System**

[The illumination system of Unit No. [...] of [Name of the Power Plant] is categorized mainly as Normal, Emergency and DC lighting. The illumination system of indoor area/Building (under the scope of Boiler package), Outdoor area are covered in this Boiler Package. Lighting system for other area are covered respective packages. Lighting Distribution Board (LDB) is normally getting supply from 415V PMCC. Each LDB is provided with lighting transformer for isolation of lighting circuit from power circuit and also for limiting short time current rating. Outgoing circuits of LDB will feed Lighting panels which is placed local to fixtures. It is envisaged that separate LDB for indoor as well as for outdoor area. Emergency Lighting system is same as normal system however it will get supply from Emergency 41V PMCC backed up with DG set. The Design parameters of Illumination System and its major components comprising of LDB with transformer, Lighting Panel, Lighting Fixtures, Lighting wires and Lighting Poles are furnished below]:

Table: 3.45

Description	Units	Design Parameters
Lighting System:		
Voltage		
a)AC system		
Rated Voltage	V	[.....]

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Description	Units	Design Parameters
Maximum Voltage	V	[.....]
b)DC system		
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
One Minute Withstand Voltage	V	[.....]
System Short-Circuit Level		
a) 415V AC	kA(rms)	[.....]
b) 220V DC	kA(DC)	[.....]
LDB/LP:		
Manufacturer Name		[.....]
Mounting		
a)LDB		[...Floor.....]
b) LP		[...Wall.....]
Installation		[.....](For each application i.e. for Indoor/Outdoor and area)
Type, No of Circuits/Feeder rating		[.....]
Lighting Transformer:		
Make of Transformer		[.....]
Type of Transformer		[...Dry.....]
Rating	kVA	[.....]
Voltage Ratio		[.....]

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Description	Units	Design Parameters
Impedance	%	[.....]
Lighting Wires:		
Make		[.....]
Voltage Grade	V	[.....]
Conductor Material	Cu/Al	[.....]
Size	Sq.mm	[.....]
Lighting Fixtures:		
Make		[.....]
Type of Luminaries		[.....]
Ballast Type		[.....]
Lighting Poles:		
Make		
Type of Poles		

k) Cable Carrier System

[The Cable Carrier system of Unit No. [...] of [Name of the Power Plant] is described as below: Indoor Buildings are provided with Cable cellar/Trench and outdoor areas are provided with Pipe cum cable rack/Duct bank/Trench. Separate Tray is envisaged for HV cables. LV cables, Control cables and Instrumentation cables in the order that HV cables Tray at the top followed by LV, Control and Instrumentation Tray. Ladder type tray is used for HV, LV and Control cables, however Perforated Tray to be used for Instrumentation cables. The Cable carrier system of indoor area/Building (under the Boiler package), Outdoor area are covered in this Boiler Package. Cable carrier system for other area are covered in respective packages. However if any cable of other package comes under the boiler area, Boiler package Bidder has to provide sufficient space in their cable carrier system to accommodate other package cables. Similarly if Boiler package cable run though any other package area, they will keep the provision of sufficient space in their cable carrier system to accommodate the boiler package cables. The Design parameters of Cable Carrier System are furnished below]:

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Table: 3.46

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Size of Tray	mm	[.....]
Material		[.....]
Application		[.....] (I.e. HV/LV/Control/Inst.)
Type of Tray		[.....] (i.e.Ladder/Perforated)
Thickness of Tray	mm	[.....]
Thickness of Galvanization	mm	[.....]
Tray Cover Size	mm	[.....]
Cable Tray Accessories		
Tee	mm	[.....] {List out all size}
Cross	mm	[.....]{List out all size}
Bends	Deg	[.....]{List out all size}
Reducer	mm	[.....] to [.....]{List out all size}
Steel Supports		
a) ISMC	mm	[.....]{List out all size}
b) ISA		[.....]{List out all size}

I) Earthing and Lightning System

[The Earthing & Lightning System of Unit No. ...] of [Name of the Power Plant] is described as below:

All above ground earthing of boiler auxiliaries / structure /equipments / skids / pipes /column etc are under the boiler package. Earth point/earth pad of the each equipment shall be connected to the main earth grid via risers. Provision of Sufficient nos. of riser shall be kept in the BOP package. Sizes of the earth flat/bar/wire shall be depending

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upon the rating of equipment and earth fault current is to be carried during fault condition. The Design parameters of Earthing and Lightning System are furnished below]:

Table: 3.47

Description	Units	Design Parameters
Earthing System:		
Make/Manufacturer		[.....]
Main Earthing Conductor		
a) Material		[.....]
b) Dia		[.....]
Treated Earth Pit/Earth Rod(Dia and Length)	mm & m	[.....]
Size of Earth Conductor		[.....]{List out size of Flat Earth conductor used for different equipments of Power plant and no of points }
a) 6.6kV Switchgear		
b) LV Switchgear		
c) 6.6kV Motors		
d) LV Motors {List out KW rating wise}		
e) Control panel, LPBS etc.	mm x mm	
f) Transformer Body		
g) Transformer Neutral {List out Transformer wise}		
h) Any other panel/Equipments		

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Description	Units	Design Parameters
Lightning System:		
Air Termination Rod		[.....]
a) Dia & Length		[.....]
b) Material		
Down comer		[.....]
a) Material		[.....]
b) Size		
Lightning Electrode with test link		[.....]
a) Material		[.....]
b) Dimension(Length and Dia)		

3.2.4 Control & Instrumentation

[The existing control and instrumentation system generally is an old analogue based system and requires large scale replacement owing to obsolescence of the existing equipment. Furnace Supervisory Safeguard System (FSSS) is of obsolete design for which, no spares are available. Soot blowers are of manual type. No online Boiler Tube Leakage detection system has been provided. HP- LP bypass system is in the form of standalone control panel. Integrated microprocessor based closed loop control, open loop control, sequential control and bulk data acquisition system for Boiler & auxiliaries, TG & auxiliaries, station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level are therefore to be envisaged for the plant.]

3.2.5 Civil Works

Bidder shall go through the details of the existing Buildings / Structures / Foundations / Facilities mentioned hereunder (but not limited to) for the thorough understanding of conditions of the same. In order to assess the quantum of Civil / Structural / Architectural R&M work within the package, Bidder shall also carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions at site and identification of modification requirements in any other structure or foundation not included here. Conditional details of important buildings / structures / foundations / facilities which require major modifications have been described below:

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{Details of the existing foundations in the boiler area, with its auxiliaries like PA fan, FD fan, ID fan as well as Electrostatic Precipitator shall be indicated in this section. Also the available GA/Construction Drawing including Load Data shall also be provided.}

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4 SCOPE OF SUPPLY & SERVICES

4.1 The scope of supply and services

The scope of supply and services to be provided by the Bidder shall include all such activities as required to meet the target and intent of this Specification. The scope for each unit shall generally cover, but will not be limited to the following:

- (i) Replacement of some of the existing components with new components of improved and better design.
- (ii) Incorporation of new systems / components wherever required in line with the Specification.
- (iii) Refurbishing / Retrofitting of some of the components in the existing equipment/system.
- (iv) All types of civil/structural works like modification and strengthening of foundation of existing and upgraded equipment, making new structures or foundations (if applicable), dismantling, restoration, supply and erection of any temporary supports or any other construction work required for implementation of renovation work.

All structural modifications/strengthening of existing structure of building, Boiler, Fans, ESP etc. including supply, fabrication and erection of any new structure and provision of any additional platform if required for access to new equipment or existing equipment as specified.

Supply of all materials, equipments, machinery and manpower required for civil/structural R&M works.

Site enabling works as per the requirements to support civil/structural R&M works.

- (v) Design, engineering, submission of design calculations for review and approval, manufacturing, inspection and testing at suppliers' works, packing, forwarding to site, unloading, erection, supervision, pre-commissioning, testing and commissioning and performance testing of the equipment / systems and works indicated in clause No. 4.5 of this technical Specification.
- (vi) Mandatory spares, start-up and commissioning spares. The general requirements in respect of various types of spares are given in Clause 9 of this section of Technical Specification.
- (vii) Packing, transportation and transit insurance of all materials required for renovation / replacement work as per this Specification from the supplier's/sub supplier's works to [Name of the Plant], unloading, preservation and storage at site. Packing, transportation, transit insurance, clearance from all concerned agencies etc. of all components/materials required to be forwarded from [Name of the Plant] to Bidder's facilities and back to [Name of the Plant].
- (viii) Dismantling of the systems, handling and storage of dismantled equipment, reassembly and re-erection / reinstallation along with associated inspection, testing,

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commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.

- (ix) Materials which are removed from the existing machines but are not re-used during the re-assembly of the machines as well as those components which are found to be beyond refurbishment shall be the property of Owner and shall be deposited at Owner's designated stores. Bidder shall prepare a record of all such dismantled material and hand it over to the Owner.
- (x) Loading, transportation, unloading and disposal of scrap to the designated storage/disposal yard.
- (xi) It shall be responsibility of the Bidder to obtain on behalf of the Owner the necessary approvals of Inspection Authority / Chief Inspector of Boilers as may be required for design and design calculations, manufacturing, erection procedure renovation as called for under the IBR. Bidder shall also be responsible for obtaining approval from the other statutory authorities in India, as may be required, for other plants and systems supplied by him. All such documentation submitted to statutory authorities shall also be submitted to the Owner for his review.

Handling of materials at site including handling / transportation as required to take equipment components to the workshop for carrying out the modification work and to bring it back for installation. All arrangement for such activities is to be done by the Bidder.

- (xii) Erection of all material supplied new for renovation (including erection of components, replacing old components). Re-erection of any component / equipment removed for modification so as to make complete unit consisting of Boiler and related auxiliaries including electrical & control and instrumentation equipment /system ready for commissioning.
- (xiii) All gas cutting / dismantling, edge preparation, welding, bolting etc. and conductance of all NDTs like radiography, ultrasonic testing, MPI, die penetration testing etc. Any new matching pieces, piping, hangers & supports etc. required for assembly of equipment/ systems, as per system requirements shall also be included in the scope of the Bidder.
- (xiv) All Pre-commissioning activities as may be required such as hydraulic testing, air & gas tightness test, steam blowing, floating of safety valves, oil flushing etc. including erection and dismantling of all temporary systems like piping / tanks etc. and Conductance of all demonstration tests including performance test.
- (xv) Assisting and coordinating with Owner in tuning various control loops finalizing protection and control requirements of all boiler auxiliaries.
- (xvi) Insurance for all items / activities in line with the provisions of General Condition of Contract of Volume-I.
- (xvii) Civil / Mechanical work (such as grouting, cutting, welding etc.) related to mounting of New Cabinets, CRT / Keyboards, laying & termination of associated Cables.

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- (xviii) Supply of all necessary tools, tackles, commissioning spares, test instruments and deputing of experienced personnel for completion of the above erection, testing and commissioning work.
- (xix) Dismantling of existing C&I cabinets along with associated cabling, for Boiler & Auxiliaries related to the unit for retrofitting the new C&I systems, based on requirement as described in clause No. 4.5.
- (xx) Providing all site execution and supervision by qualified and experienced engineering personnel during execution of all works under the scope of Bidder. Also providing all facilities and qualified personnel for implementing the approved quality assurance programme.
- (xxi) Dismantling of the existing Instrumentation Cables and relaying of new cables as may be required.
- (xxii) The Bidder shall conduct all shop and site tests as per the requirements of this Specification and Owner approved "Quality Assurance Program" to be finalised before the award of this Contract. Facilitating inspection, witness of shop and site tests by the representatives of Owner shall be in the scope of the Bidder.
- (xxiii) Performance Guarantee tests after successful completion of initial operation.
- (xxiv) Electrical

The scope of electrical system of Boiler and auxiliary's package will include all electrical equipment listed below (if applicable).

[Note: Scope of work of auxiliary system for SG shall be suitably modified with respect to specific project and accordingly list of attachments as given in 'Volume-II, Section-II, Part B' shall be enclosed]

- a) *[All 415 V MCCs for SG package (Boiler. MCC, Boiler valve MCC etc.) as required and ACDBs/PDBs and DCDBs for drives and equipment covered in SG package.*
- b) *6.6 / 0.433 kV transformers, 415 V non segregated phase bus ducts.*
- c) *Welding sockets in SG area with necessary Welding DBs.*
- d) *Control stations / Local Push Button stations.*
- e) *HV/LV A.C. motors and actuators for all the drives in the scope of SG package and DC Motors and DC starters as required in SG area.*
- f) *Installation, Interconnection laying and termination of all Bidder supplied HV/LV power and control cables with termination kits for all auxiliaries in TG area.*
- g) *Illumination System including Lighting Transformers, MLDBs, Lighting DBs/ Lighting Panels for the Steam Generator Island.*
- h) *Grounding system for the SG Island and grounding connection to all equipment in SG area. Making arrangement for proper electrical grounding of all systems, supplied by him as required by the system design. All required accessories including grounding cables.*

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- i) *Lightning Protection system for SG Building and other equipment/building covered in SG Island.*
- j) *Complete cable racks with necessary supporting structures and foundations within SG area, cable Trays with support system, cable trenches and accessories in SG area. Fire proof sealing system in SG area.*
- k) *Variable frequency drives for HV and LV system of SG package].*

(xxv) Construction Water:

[Construction water shall be made available to Bidder at a single point in a suitable location. The Bidder shall arrange at his own cost the required pumps, distribution pipe line network for further distribution as required to carry out construction work.]

(xxvi) Construction Power

[Construction power shall be made available to bidder at single point at [...] kV level. Further distribution as required to carry out the construction work shall be carried out by Bidder at his own cost.]

(xxvii) Providing all other services necessary for meeting the intent and requirement of this Specification. This shall include but not limited to system engineering, furnishing drawings, data, information for Owner's review, participation in meeting & reviews, System warranty, revision of O&M Manuals etc.

4.2 Tools & Tackles

One (1) set of special tools and tackles required for the maintenance of equipment/systems have to be supplied by the Bidder. These tools and tackles shall be separately packed and brought to site. These shall not be used for erection/commissioning purposes and shall be in an unused and new condition, when they are handed over to the Owner. A list of all such special tools and tackles shall be submitted along with the offer.

For C&I system, Bidder shall supply one set for each unit of special non standard tools, module testing kit, cables, and any other equipment required for erection commissioning, testing, trouble shooting, calibration, maintenance and inspection of all systems / equipment provided. Any tools required to make changes (DIP shunt cutter, soldering irons, tips, wire wrap guns and bit unwrapping tools, strippers, terminal guard, connector repair tool, dies etc.) shall also be supplied.

Bidder's scope shall also include supply of all Cranes, welding sets and NDT testing equipment, scaffolding, special tools and tackles, jigs and fixtures as may be required during modification / erection and commissioning. Those items specifically brought to site solely for erection / modification purpose and if no more needed for regular maintenance of the equipment, can however, be taken back by the Bidder after completion of the work at site, subject to the approval of Owner.

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4.3 Safety

4.3.1 The design of the equipment shall incorporate every reasonable precaution and provision for the safety of all personnel and for the safety and security of all persons and property. The design shall comply with all appropriate statutory regulations relating to safety.

Newly constructed structures and equipment shall be designed and constructed to withstand every foreseeable static and dynamic loading condition, including loading under earthquake conditions, with an adequate margin of safety.

Ready and safe access with clear head room shall be provided to all the newly supplied parts of the plant for operation, inspection, cleaning and maintenance.

4.3.2 While carrying out the R&M work as per this Specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items/ equipment supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipment / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipment / foundations / structure and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

4.4 Training Requirements

Bidder shall include in his offer the training programme for Owner's Operation & Maintenance staff in view of introduction of new systems/ equipment. This training shall be organized before handing over the unit.

In case there is any difference in scope of work and services as described in this section of the Specifications and individual Specification volumes, then more stringent of the Scope of work and services shall prevail.

4.5 Detail Scope of Work:

4.5.1 Boiler & Its Auxiliary System

{Describe in this chapter, all the equipment/components which need to be replaced/refurbished/retrofitted as finalized in the DPR on the basis of RLA/CA and EA report. Scope with regard to Civil, structural and architectural work as required for the Power Plant due to incorporation of new equipment/components shall also be incorporated in this chapter.

Generally there is a considerable time elapsed between the 'RLA/CA & EA Studies' and the 'Award of R&M Contract'. Due to this time gap, the unit suffers further deterioration which is not factored into the bidding document. To ensure that the Renovation & Modernization Project goals are successfully achieved, it is advisable to convey to the bidders the real health condition of the unit, while issuing the bidding documents. The utilities are therefore advised to get a Baseline Test conducted before

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issuing the bidding documents. Such Baseline Test may be conducted through an Independent Consultant for the Performance Evaluation of Boiler, TG and the Major BOPs of the Unit. Parameters to be evaluated during the Baseline Test are being enclosed separately.}

The Bidder shall include in his scope the following works for the R&M of the Unit, which are based on RLA/CA and EA studies. The overall scope of work shall include but shall not be limited to the scope of work mentioned below. DCS & other common system/items, if applicable, procured by owner separately, shall not be considered under SG package. Any other items not specifically mentioned but considered necessary by the Bidder for carrying out the R&M work, shall also be included in his scope so as to meet the intended performance of Boiler & Auxiliaries as specified in Clause No. 1.1

Table: 4.1

Equipment	Scope of Work	Quantity
PF Boiler/ CFBC Boiler <i>{The template provided below is common for PF Boiler as well as CFBC Boiler. Typical Equipments/Components which are applicable only for one kind of boiler and not for the other type of boiler have been specifically highlighted. }</i>		
[Drum]	[.....]	[.....]
	[.....]	[.....]
[Water Walls]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Low Temperature Super Heater]	[.....]	[.....]
	[.....]	[.....]
[Platen Super Heater]	[.....]	[.....]
	[.....]	[.....]
[Pendant Super Heater]	[.....]	[.....]
	[.....]	[.....]
[Ceiling Super Heater]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Reheater-Front Assembly]	[.....]	[.....]
	[.....]	[.....]
[Reheater-Rear Assembly]	[.....]	[.....]
	[.....]	[.....]
[Economiser]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Wind Box]	[.....]	[.....]
	[.....]	[.....]
[Oil Burners]	[.....]	[.....]
	[.....]	[.....]
[Low NOx Burners] {Applicable only for PF Boilers}	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Igniters]	[.....]	[.....]
	[.....]	[.....]
[Refractory]	[.....]	[.....]
	[.....]	[.....]
[Insulation]	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Buckstays]	[.....]	[.....]
	[.....]	[.....]
[Ducting]	[.....]	[.....]
	[.....]	[.....]
[Wall Blowers / LRSBs]	[.....]	[.....]
[Pent House]	[.....]	[.....]
	[.....]	[.....]
[Attemperators]	[.....]	[.....]
	[.....]	[.....]
[Any other systems]	[.....]	[.....]
	[.....]	[.....]
Air Pre-Heater		
[Air Pre- Heater Tubes for tubular Air Heaters]	[.....]	[.....]
[Air Pre- Heater Tube Plates for tubular Air Heaters]	[.....]	[.....]
[Sector Plates for regenerating air Pre-heater] <i>{Applicable only for PF Boilers}</i>	[.....]	[.....]
[Rubber Seals for regenerating air Pre-heater] <i>{Applicable only for PF Boilers}</i>	[.....]	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Any other Component]	[.....]	[.....]
	[.....]	[.....]
Coal Feeders {Applicable only for PF Boilers}	[.....]	[.....]
Fuel Feeding System (As applicable for specific CFBC Boiler)	[.....]	[.....]
Coal Mills {Coal Mills and their components indicated below are applicable for PF Boilers only}		
[Enhancement of Mill (Model No.)]	[.....]	[.....]
	[.....]	[.....]
[Mill Classifier]	[.....]	[.....]
	[.....]	[.....]
[Grinding Elements]	[.....]	[.....]
	[.....]	[.....]
[Rotary Throat & Ventury]	[.....]	[.....]
	[.....]	[.....]
[Loading Cylinder]	[.....]	[.....]
	[.....]	[.....]
[Mill Inner Cone]	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Drive Motor, Gear Box, Lubrication System etc].	[.....]	[.....]
	[.....]	[.....]
[Pulverized Fuel Piping System]	[.....]	[.....]
[Any other Component]	[.....]	[.....]
	[.....]	[.....]
Combustor Bed <i>{Combustor bed components indicated below are applicable for CFBC Boilers only}</i>		
[Distribution Grid]	[.....]	[.....]
[Air Fluidizing Nozzles]	[.....]	[.....]
[Combustor Refractory]	[.....]	[.....]
[Bed Drains]	[.....]	[.....]
Cyclones <i>{Cyclones and its components indicated below are applicable for CFBC Boilers only}</i>		
[Cyclone Tubes]	[.....]	[.....]
[Erosion Protection Refractory]	[.....]	[.....]
[Insulation]	[.....]	[.....]
[Lagging]	[.....]	[.....]
LOOP SEAL <i>{Loop Seal and its components indicated below are applicable for CFBC Boilers only}</i>		
Stand Pipe	[.....]	[.....]
Loop Seal bed	[.....]	[.....]
Fluidizing Air Nozzles	[.....]	[.....]
Loop Seal Blower	[.....]	[.....]
External Fluidized Bed Heat Exchanger		

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Equipment	Scope of Work	Quantity
{External Fluidized Bed Heat Exchanger and its components indicated below are applicable only for CFBC Boilers only}		
Heat Exchanger Tubes	[.....]	[.....]
Distribution Grid	[.....]	[.....]
Fluidizing Air Nozzles	[.....]	[.....]
Heat Exchanger Blower	[.....]	[.....]
Primary Air Fan		
[Impellers]	[.....]	[.....]
	[.....]	[.....]
[Drive Motor]	[.....]	[.....]
	[.....]	[.....]
[Any other Component]	[.....]	[.....]
	[.....]	[.....]
Induced Draft Fan		
[Impellers]	[.....]	[.....]
	[.....]	[.....]
[Hydraulic Coupling]	[.....]	[.....]
	[.....]	[.....]
[Drive Motor]	[.....]	[.....]
	[.....]	[.....]
[Lubrication Systems]	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Any other Component]		
Forced Draft Fan		
[Impeller]	[.....]	[.....]
	[.....]	[.....]
[Drive Motor]	[.....]	[.....]
	[.....]	[.....]
[Lubrication Systems]	[.....]	[.....]
	[.....]	[.....]
[Any other Component]	[.....]	[.....]
	[.....]	[.....]
[Seal Air Fan]	[.....]	[.....]
	[.....]	[.....]
Electro Static Precipitator		
[ESP Retrofitting]	[.....]	[.....]
	[.....]	[.....]
[ESP controller & HV Rectifier Transformer]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[80]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment		Scope of Work				Quantity	
[Insulation & Metal Cladding]		[.....]				[.....]	
		[.....]				[.....]	
[Ammonia injection system]		[.....]				[.....]	
		[.....]				[.....]	
[Fly Ash Hoppers]		[.....]				[.....]	
		[.....]				[.....]	
[Any other Components]		[.....]				[.....]	
		[.....]				[.....]	
[Equipment Cooling Water Pumps & its associated system for Boiler]		[.....]				[.....]	
		[.....]				[.....]	
[Replacement and Retrofitting of Motors]		[.....]				[.....]	
		[.....]				[.....]	
		[.....]				[.....]	
[Any other systems]		[.....]				[.....]	
		[.....]				[.....]	
		[.....]				[.....]	
[High Pressure & Low Pressure Piping and Fittings]							
Tag	Description	Flui	Size	Schedule /	Class	Material	Qty

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[81]	15.01.2016

Equipment		Scope of Work				Quantity	
No.		d		Thickness			
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Pneumatic Dampers]							
Tag No.	Description	Drive Type	Design Torque	Lever Radius	Duct Size	Angular Movement (Degree)	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Electric Actuators Operated Dampers]							
Tag No.	Description	Drive Type	Design Torque	Lever Radius	Duct Size	Angular Movement (Degree)	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Expansion Joints]							
Sl. No. / Tag No.		Service Description		Location	Size	Qty	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[82]	15.01.2016

Equipment		Scope of Work				Quantity	
[...]		[...]		[...]		[...]	[...]
[...]		[...]		[...]		[...]	[...]
[...]		[...]		[...]		[...]	[...]
[Motorized Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Travel time	Drg. No.	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Manually Operated Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Qty	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	
[Non Return Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Qty	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[83]	15.01.2016

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment		Scope of Work			Quantity	
[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Relief Valve]						
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Qty
[...]	[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	[...]	
[Electric Actuator for Valve]						
Tag No.	Description & Service	Torque (Nm)		Wattage (W)		Qty
[...]	[...]	[...]		[...]		[...]
[...]	[...]	[...]		[...]		[...]
[...]	[...]	[...]		[...]		[...]
[Control Valve]						
Replacement/ Retrofitting of Control Valves		[.....]			[.....]	
		[.....]			[.....]	
		[.....]			[.....]	
[Electrical Works]						

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[84]	15.01.2016

Equipment	Scope of Work	Quantity
HV & LV motors		
[Motor terminals box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor stator winding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor Rotor winding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor cooling system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of motors]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[85]	15.01.2016

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Motorized Actuator]		
[Motor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Position indicator/Transmitter]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Limit switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of motor actuators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[LT Transformers]		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[86]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Transformer HV/LV coil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Tap changer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of 6.6 / 0.433 kV transformers(oil type/dry type)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[415V NSPBD]		
[Bus duct enclosure]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[87]	15.01.2016

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Bus duct conductor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Support insulators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Disconnecting link/flexible]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[support structure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of NSPBD]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[415V LV Switchgear (PMCC/MCC)]		
[Air circuit breaker/MCCB/SFU/M CB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT/PT]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[88]	15.01.2016

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Numerical relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[AC/DC Starters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Electronic over load relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transducers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ground bus]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Switch socket]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[89]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Push button station]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Terminal block]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of LV Switchgear (PMCC/MCC)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HV Cables]		
[Joint and termination kit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of NSPBD]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[LV Power & Control cables]		
[Lugs and Glands]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[90]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Any other part/system of 415V NSPBD]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Illumination]		
[Distribution boards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting transformer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Aviation warning light system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Emergency light with self contained batteries]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lamps and fixtures]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Industrial socket]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[91]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	--------------------------

Equipment	Scope of Work	Quantity
outlet]	[.....]	[.....]
	[.....]	[.....]
[Fan and regulators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Switches and switchboards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Street or road light poles]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[High mast tower]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting junction box and conduits]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of lighting system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Grounding & Lightning Protection]		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[92]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
<i>[Electrode]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[GI flat/wire]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Air terminals]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Clamp/test links]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Shielding mast]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Any other part/system of earthing and lightning protection]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
Control & Instrumentation Works		
<i>[Soot Blower Instrumentation]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[93]	15.01.2016

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[SADC & Burner TILT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Boiler Temperature MI Thermocouple (K-Type)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Combustion Controls (Coal & Oil)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Flame Monitoring and furnace temperature]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Boiler Protections]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air and Flue gas dampers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Furnace Draft Instrumentation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[94]	15.01.2016

Equipment	Scope of Work	Quantity
[Air Flow Elements (Venturi or Aerofoil)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Acoustic Steam Leak Detector (ASLD)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Mill and Fans Lube oil instruments]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Super Heater Steam Temperature]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Re-Heater Steam Temperature]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Drum Level Gauges and Electronic Water Level indicator (EWLI)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Junction Boxes/ LIE/ LIRs]		
[Pressure/ Diff.]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[95]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	--------------------------

Equipment	Scope of Work	Quantity
[Pressure Transmitters]	[.....]	[.....]
	[.....]	[.....]
[Pressure / DP Gauges]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Temperature Gauges]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pressure / DP Switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Temperature Switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[RTD / TC 's]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Instrumentation and Control Cables]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Flow Measurement & Primary Flow Sensors]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[96]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	--------------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Fuel Flow Measurement]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Flue Gas Analyzers (O ₂ and CO)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Control Panels (Soot blowers/ FSSS)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Impulse Pipeline and Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other systems]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Station C&I (if applicable)		
[DCS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Station LAN]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[97]	15.01.2016

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Master Clock]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Panel Earthing / Grounding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[PLC System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CMMS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[STMS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[SWAS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Machine Condition Monitoring System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[98]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	--------------------------

Equipment	Scope of Work	Quantity
Civil Works		
<i>[Boiler Superstructure]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Boiler Foundation]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Bunker Building / Bay]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Coal Mill Foundation]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[PA Fan Foundation]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[FD Fan Foundation]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[ID Fan Foundation]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I	[99]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	--------------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[ESP Structure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[ESP Foundation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other Civil / Structural Work]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

In addition to the above listed works, scope of civil / structural / architectural works and supplies shall be as detailed below.

Bidder shall carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions of the buildings, structures, foundations & facilities mentioned in this Specification and identification of modification requirements in any other structure or foundation not included here.

Subsequently Bidder shall prepare and submit for approval by Owner, a detailed scheme including methods techniques, requirements etc. for carrying out civil/structural/architectural R&M works to executed in the plant.

Bidder shall be provided with the existing drawings and documents as listed in Annexure-I by the Owner to facilitate the civil / structural / architectural refurbishment and replacement works.

The scope of Civil / Structural / Architectural works to be carried out by the Bidder under this package shall generally cover the following:

- Inspection and checking the design adequacy of the existing structure foundations like *[boiler, ESP, bunker bay/building, fans and mill foundations, flue gas duct support foundations etc.]* for all the applicable loads and construction of new foundations / modification of existing, wherever required.
- Inspection and checking the design adequacy of existing structures *[such as boiler structures, ESP structures, duct support structures, bunker bay / building structures,*

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pipe & cable racks etc.] for any corrosion/damage and rectification / strengthening of the same.

- Carrying out all interior / exterior architectural replacement works *[such as flooring, painting, plastering, door/windows, roof finishing, water proofing, new false ceiling, glass partitions, lighting works replacement or modification of AC duct where ever applicable]* is also included in Bidders scope. etc.
- Any other civil related work required in buildings / structures of the package from aesthetics ambience & ease of operation point of view.

In addition to this any other modification/alteration to existing nearby foundation/structural steel/concrete/underground pipes work if required for satisfactory execution of intended work covered under this Specification shall be carried out by the Bidder. Supply of all material required for the above work is included in Bidder's scope

Supplies for Civil/Structural Work

The Bidder shall supply all material needed for completion of all civil, structural and Architectural works as per this Specification. The Bidder's scope of supply generally includes but is not limited to the following:

- Supply of cement, steel (for reinforcement as well as for any other use), grout, admixture for RCC work, sand and all other construction/architectural / building materials as may be required for any modification of existing civil works / foundation or for construction of new foundation / civil works.
- Supply of structural steel for all structural erection / modification / strengthening.
- Supply of all foundation bolts, and nuts base plates, embedments with lugs, miscellaneous steel where ever needed
- Supply of steel helical springs and viscous dampers for new equipment (if any).

Construction Enabling Works

Following facilities shall be made available / constructed as per the requirements for successful completion of the R&M works.

a) Temporary Site Buildings

The Bidder shall provide at his cost the following buildings/facilities for proper execution and quality control of the job, while meeting the provision stipulated by Factory Rules regarding staff welfare facilities. All these buildings shall have brick / metal cladding. GI/Colour coated metal sheet roofing over steel structure with cement concrete flooring and false ceiling with air conditioning, as required.

- **Temporary Stores**

A covered store shall be provided with brick cladding and / or GI/Colour coated metal sheeting to store at least one-month requirement of cement. Cement in bags shall be stored on a raised floor well away from outer walls and insulated from the floor to avoid moisture. Not more than 15 bags shall be stacked in any tier. Each consignment of cement shall be stored separately and consumed in its order of receipt.

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Covered storage area may also be provided to store other construction material, which will be affected on exposure to wind, sun and rain.

Reinforcement shall be stacked on top of timber sleepers to avoid contact with ground / water.

Suitable paving / flooring shall be provided in storage yard for storage of material. Proper lighting arrangement shall also be provided for the store complex. Proper fencing and security arrangement shall be provided for the stores complex.

- **Temporary Workshop and Garage**

The Bidder shall provide for a temporary workshop and garage to attend to routine maintenance and repair of the construction equipment as well as his fleet of vehicles used for construction activities.

- b) Fabrication Yard**

Depending on the extent of fabrication envisaged at site, the Bidder shall establish a full fledged structural fabrication yard with adequate handling facility during and after the fabrication. A fully equipped testing laboratory providing radiography, ultrasonic, dye penetration, magnetic particle test facilities shall be ensured adjacent to the fabrication yard to enforce strict quality control. Portion of the yard shall have covered shed with H.O.T / E.O.T cranes so that fabrication work can proceed even during inclement weather.

- c) Quality Control Laboratory**

A fully equipped quality control laboratory shall be established at site with qualified personnel to conduct acceptance test on all construction material, weldments, concrete cubes etc. This laboratory shall be housed in a covered building with A/C facility as required by the testing facility. All testing equipment shall be periodically calibrated to the satisfaction of the Owner.

- d) Fuel Storage area**

The Bidder shall obtain necessary permission from competent authorities and establish and operate a POL outlet with proper storage, dispensing and adequate fire fighting facility.

- e) Staff Welfare facility**

The Bidder shall provide adequate facility for his staff inside the plant boundary such as toilets for both gents and ladies, canteens, drinking water facility, rest places, creches etc.

The Bidder shall also provide for proper disposal of sewage and other wastewater arising from his construction team and his other temporary facilities, to meet with the requirement of Pollution Control Board.

The Bidder shall identify sufficient area inside the plant boundary to locate his staff and labour colony. Construction and maintenance of the staff and labour colony to satisfy all statutory requirement is the sole responsibility of the Bidder.

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The Bidder shall be preliminary responsible for all statutory deductions and contributions on account of CPF/EPF as per rules/act in force and subsequent amendments during Contract period.

f) Construction Tools & Materials Supplied By the Bidder

The Bidder shall provide and maintain at the site necessary number and type of machinery and equipment including survey instruments in good working condition for proper setting out and timely completion of the various works covered under this Specification and scope of the work. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expense. No claim shall be entertained for mobilizing additional equipment and / or personnel to complete the work within the stipulated time.

The Bidder shall provide all fuels and lubricants required for the operation and maintenance of construction machinery and equipment as well as his transport vehicles at his own cost.

It shall be ensured by the Bidder that work shall proceed uninterrupted even in the event of power failure. As such, adequate number of liquid fuel operated power generating equipments shall be provided by the Bidder at his own cost as an alternative arrangement.

The Bidder shall ensure continuous supply of coarse and fine aggregate conforming to the Specification.

All materials supplied by the Bidder shall be of the best quality and shall conform to the given Specifications. Approval in writing shall be obtained from the Owner before any alternative or equivalent material is used other than what is specifically mentioned in the drawings / Specification / Bid document.

The Bidder shall furnish manufacturer's test certificate for all the manufactured items supplied by him. Representative specimens of the material shall also be submitted to the Owner and shall be tested at a recognised testing laboratory at the Bidder's cost in case Owner so desire.

The Owner reserves the right to get any construction material supplied by the Bidder tested in a recognized testing laboratory at the Bidder's cost. In case the sample materials do not meet the Specification requirements, he shall replace the defective material at his own cost.

g) Work Execution and Supervision:

The Bidder shall have at the site accredited and qualified engineers and foremen / supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the works.

The Bidder's Engineer-in-charge of the work at site shall be capable of interpreting the Specification and drawings and make adequate site decisions as and when required.

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He shall also take instructions from the Owner and be responsible for carrying out the instructions.

The Bidder shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner with full understanding of the importance of work for a R&M project of this magnitude.

In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accident. He shall also report such accidents to all the competent authorities wherever such reports are required by those authorities.

Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner is not in accordance with the Specification / Bid document.

During inclement weather, rains etc., the Bidder shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at the Bidder's cost and any damage to works shall be made good by the Bidder at his own expense.

During the course of the Bidder's work, other works, either by the Owner or by other Bidders or by both simultaneously will be in progress within the Plant area. The Bidder shall make his best effort to work in harmony with others in the best overall interest of the project and towards its speedy completion.

h) Mobilisation

All mobilisation costs shall be the Bidder's responsibility and shall include all activities as described below.

- **Areas Allocated for the Bidder**

The Owner will provide the Bidder with uncovered area at the site for the storage of plant equipment and materials. The Bidder shall be responsible for preparation of the site to suit the required purposes.

The areas allocated to the Bidder shall be used solely for construction purposes such as site offices, prefabrication, maintenance, storage or similar activities. The Bidder shall not erect in these areas any form of residential or messing facilities.

- **Transport Conditions**

It is the Bidder's responsibility to ensure safe delivery of material upto the work-site. The Bidder shall make good all damages caused to public, private or government property e.g. roads etc. caused while transporting equipment etc. up to the work-site.

- **Temporary Site Services**

Prior to erecting any temporary facilities, the Bidder shall submit the detailed drawings of the proposed temporary facilities and the number of personnel using these facilities, to the Owner, for approval.

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The Owner shall then decide as to whether the Bidder's proposals comply with the Owner's requirements.

- **Communications at Site**

- Telefax, E-mail and Telephone:

The Bidder shall make his own arrangements for installation of telefax, email and telephone facility at the Site office and temporary facilities. Where possible, the Owner's representative may assist the Bidder in obtaining suitable connection. The Bidder shall pay all associated bills and costs.

- Signboards

The signboards shall be approved by the Owner and shall be in Hindi and English. The signboards shall be removed upon demobilisation.

- Medical Facilities

The Bidder shall, within a period of 14 days after mobilisation at work site, provide and maintain first aid facilities for emergency treatment. The Bidder shall also arrange with nearby hospital for dealing with emergency cases. The Bidder's staff shall be made aware of the available first aid facilities and emergency treatment arrangements.

- Maintenance

The Bidder shall be responsible for the proper maintenance of all temporary facilities erected within the allocated areas including the fences, gates, generators, access roads, etc. constructed by the Bidder. The Bidder shall be responsible for preventing dust from affecting the existing facilities.

i) Demobilisation of Temporary Facilities:

The Bidder shall demobilise all Bidder's site facilities including, but not limited to, office buildings, covered areas, workshops, prefabrication shops, storage facilities, toilet facilities, electrical and water distribution systems, camping upon the completion of work after intimating the Owner in advance. The Bidder shall reinstate the area to a clean and tidy condition to the satisfaction of the Owner. The Bidder shall demobilise within a reasonable period when advised by the Owner.

Safety of Adjacent Plant/Equipment and Civil Structure

While carrying out the R&M work as per this Specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items / equipments supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipments / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipments / foundations / structures and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

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4.5.2 Spares

All spares as specified in Annexure-II of this Specification in accordance with Clause No. 9.

4.5.3 Consumable, Oil & Lubricants

All the first fill and consumables such as greases, oil, lubricants, servo fluids/control fluids, gases and essential chemicals etc. as required up to the complete commissioning of the Boiler & Auxiliaries, are covered in the scope of Bidder. Suitable standard lubricants as available in India are preferable. Efforts should be made to limit the variety of lubricants to minimum.

4.5.4 Embedded Parts & Fixture

All fixtures, embedded parts, steel embedment including fixing lugs and welding between them, foundation plates, grouting, nuts, bolts etc. for fixing all the equipment, piping on civil works shall be included in scope work of this package. All structures which would be required by the Bidder for supporting the piping shall also be included in scope of work of this package.

4.5.5 Other Services

The scope of Erection, Commissioning and Testing shall include the following:

- a) Complete pre-commissioning work including tests of facilities such as line flushing, hydraulic testing of Boiler pressure parts, air and gas tightness tests of Boiler enclosure, electrostatic precipitators and duct work, chemical cleaning of pressure parts, steam blowing, gas distribution tests of electrostatic precipitators etc. and all other tests as mutually agreed in the Bidder's quality assurance programme as well as those identified in the Specification.
- b) Supply of all consumables (except coal and fuel oil for firing) like chemicals for chemical cleaning, passivation, inhibition etc., oil for line flushing, nitrogen for blanketing, consumables for air/gas tightness tests and any other consumable as required for above pre-commissioning/ commissioning activities.
- c) Necessary arrangement as requires for the start up of Boiler & Auxiliaries. However, Owner will arrange start up power, coal & fuel oil, instrument & service air and DM water as required for the star up purpose of the Boiler & Auxiliaries system.
- d) Supply of all temporary equipment such as tanks, piping, including supports, valves, nitrogen blanketing equipment including nitrogen cylinders, pumps and all necessary instrumentation for successful conductance of pre-commissioning and commissioning activities. All temporary equipment and instruments shall be clearly listed out in the Bid.
- e) Providing safety barricades and signage during dismantling, erection and testing etc.
- f) Supply of all labour, skilled/semi skilled supervisors, engineers and any other manpower.

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- g) All the erection materials and consumables like shims, welding rods, soldering and brazing alloys, industrial gases, insulating tapes, compounds, chemicals etc. required for the erection and commissioning works.

Note: The temporary equipment specifically brought by the Bidder solely for the pre-commissioning and commissioning work shall, on completion of these activities, remain the property of the Bidder. Nitrogen blanketing equipment including nitrogen cylinders shall get included in the Bidder's permanent scope of supply and become property of the Owner.

The selection of material of all the temporary equipment/instruments shall be compatible with the service conditions expected during pre-commissioning/ commissioning activities.

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5 TERMINAL POINTS & EXCLUSIONS

5.1 Terminal Points

{ Terminal points are project specific }

For all terminal points, scope of this Contract shall include supply of matching flanges, gaskets, bolts, nuts etc including any isolation valve. Terminal Points mean Engineering, Procurement and Erection in entirety. The terminal points of the complete package to be supplied shall be as follows.

(a) Steam & Feed water System

- (i) *[Main Steam: Inlet of Main Steam Stop Valve at Turbine hall]*
- (ii) *[Cold Reheat: Outlet of HP turbine]*
- (iii) *[Hot Reheat: Inlet of Reheat Steam Stop Valve.]*
- (iv) *[HP/LP turbine Bypass: Inlet of HP Turbine Bypass Valve and Outlet of HP Turbine Bypass Valve (Entire upstream and downstream piping of HPTB & LPTB Valve is in the scope of Bidder).]*
- (v) *[Blow Down: Boiler blow down tank outlet up to drain pit.]*
- (vi) *[Feed Water: At Economiser Inlet stop valve.]*

(b) Fuel Firing System:

[Coal-Raw Coal Bunker Inlet Flange, Fuel Oil-20 m from Discharge Flange of pressurizing pump]

(c) Mill Reject Handling System:

[Outlet Flange of Mill Spout.]

(d) Flue Gas Duct

[Inlet Flange of Chimney Flue]

(e) Ash Handling System:

[Up to Furnace Bottom Ash Hopper, Economiser, Air preheater and ESP Hopper outlet flanges.]

(f) Electrical

- (i) *[6.6 kV Supply: At the terminal of 6.6kV Unit/Station switchgears for power supply to 6.6 / 0.433 kV transformers and 6.6kV Motors of Boiler package. All Power and control cables from the terminals of 6.6 kV Unit/Station Switchgears are included in the scope of Boiler package. 6.6kV Unit/Station Switchgear is in scope of TG package.]*
- (ii) *[ESP system terminal point is the outgoing at 6.6 kV Unit switchgear: For ESP system electrical scope of work shall start from 6.6k V Unit switchgear outgoing and shall include HV cable termination, HV cable, LV transformer, 415 V NSPBD, 415 V LV switchgear and further distribution]*

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- (iii) *[Power Supply to Boiler MCC, Boiler Valve MCC, Soot Blower MCC, Boiler Emergency MCC, Boiler ACDB: Power supply at 415 V level at the outgoing terminals of 415 V Unit Service Switchgear / 415 V Unit Emergency Switchboard. All cables from the above terminal points are included in the scope of Boiler package. 415 V Unit Service Switchgear and 415 V Unit Emergency Switchboard are in the scope of TG package.]*
 - (iv) *[Power Supply to Illumination System of Boiler area: Power supply at 415 V level at the outgoing terminals of 415 V LV Switchgear. All cables from the above terminal points are included in the scope of Boiler package. Main Lighting Distribution Board (MLDB) and further distribution up to and including lighting fixtures is in the scope of TG Package.]*
 - (v) *[Power Supply to Welding System of Boiler area: Power supply at 415 V level at the outgoing terminals of 415 V Welding Service Switchgear. All cables from the above terminal points are included in the scope of Boiler package. Welding Service switchgear is in the scope of TG Package.]*
 - (vi) *[Power Supply to Bottom Ash Handling System MCC: Power supply at 415V level at the outgoing terminals of 415 V Ash Handling Service Switchgear. All cables from the above terminal points are included in the scope of Boiler package. Ash Handling Service switchgear is in the scope of BOP Package.]*
 - (vii) *[Grounding: Above grounding earthing from riser up to all the equipment under the scope of Boiler package in scope of Boiler package. Main ground grid and grounding conductor ring along with two test link at opposite corner of the Boiler switchgear building/structure shall be in BOP package. Suitable nos. of riser shall be provided by Bidder.]*
 - (viii) *[For all the inputs required by Boiler Bidder from other packages, the required relay contacts (1 NO/1 NC) will be provided by the other package Bidder. The required auxiliary relays, control cables including their laying & termination shall be in the scope of Boiler package Bidder. Similarly, necessary contact (1 NO/1 NC) required by other package Bidders shall be provided by Boiler package Bidder.]*
 - (ix) *[Wherever Power is tapped from Owner's board or any other package boards, Bidder's scope starts from the outgoing terminals of the respective board. Bidder has to include all necessary termination materials, cables, trays, conduits, supporting structure, terminations, and necessary earthing accessories in his scope.]*
- (g) Control & Instrumentation**
- (i) *[Inst. & Control Cabling: Up to BMS/FSSS panel for SG integral control systems and for rest up to Junction Boxes.]*
 - (ii) *[Instruments upto HP turbine Inlet & Outlet (MS & CRH line), IP turbine Inlet (HRH Line) and HP-LP Bypass systems instruments.]*

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5.2 Exclusions

Following are to be excluded from the scope of work under R&M Works for Boiler & Auxiliaries:

- (a) *[Turbine Generator & Its Auxiliary Equipment including HPTB & LPTB Valve and all Feed Cycle Equipment]*
- (b) *[Turbine Extraction piping and Feed Water Piping]*
- (c) *[Plant Water System including DM plant]*
- (d) *[Air Conditioning System]*
- (e) *[Fuel Oil Unloading, Storage & Forwarding System]*
- (f) *[Compressed Air System]*
- (g) *[Coal Handling System]*
- (h) *[Ash Handling System]*
- (i) *[Distributed Control System (DCS)]*
- (j) *[Vibration Monitoring System.]*
- (k) *[6.6kV Unit / Station Switchgears & Unit Auxiliary Switchgears]*
- (l) *[6.6kV/ 433 V Unit Transformers and 415 V Unit Service Switchgears.]*
- (m) *[6.6kV / 433 V Lighting Transformers and 415 V Switchgears for lighting]*
- (n) *[6.6kV / 433 V Welding Transformers and 415 V Welding Service Switchgear.]*
- (o) *[415 V Ash Handling Service Switchgear]*
- (p) *[220 V Battery, Battery Charger and Unit DCDB.]*
- (q) *[Unit UPS and its ACDBs.]*
- (r) *[Emergency DG sets and 415 V Unit Emergency Switchboard.]*
- (s) *[Plant communication system]*

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6 GENERAL TECHNICAL REQUIREMENTS

6.1 Codes & Standards

- 6.1.1 Apart from some specific application, the proposed R&M equipment shall comply with the appropriate Indian Standard / DIN or equivalent international Standard. Specification as listed below in this section and mentioned in detailed Specifications, each incorporating the latest revisions at the time of tendering.
- 6.1.2 Wherever specified or required the Plant & Equipment shall conform to various statutory regulations such as Indian Boiler Regulations, Indian Electricity Rules/Act, Factories Act, etc.
- 6.1.3 In the event of any conflict between the codes and standards referred above, and the requirements of this Specification, the requirements, which are more stringent, shall govern.
- 6.1.4 In case of any change of code, standards and regulations between the date of purchase order and the date, the Bidder proceeds with manufacturing, the Owner shall have the option to incorporate the changed requirements.
- 6.1.5 List of Reference Codes/Standard
- a)** American Society of Mechanical Engineers (ASME).
 - b)** American National Standards Institute (ANSI).
 - c)** American Society for Testing and Materials (ASTM).
 - d)** American Institute of Steel Construction (AISC).
 - e)** American Welding Society (AWS).
 - f)** Architecture Institute of Japan (AIJ).
 - g)** Bureau of Indian Standards Institution (BIS).
 - h)** British Standards (BS)
 - i)** Central Board of Irrigation and Power (CBIP) Publications.
 - j)** Deutsches Institut für Normung (DIN).
 - k)** Electric Power Research Institute (EPRI).
 - l)** Electricity Act 2003.
 - m)** Emission regulation of Central Pollution Control Board (CPCB)
 - n)** Federal Occupational Safety and Health Regulations (OSHA)
 - o)** Heat Exchanger Institute (HEI).
 - p)** Hydraulic Institute (HIS).
 - q)** Indian Electricity Rules.

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- r)** Indian Boiler Regulations (IBR).
- s)** Indian Explosives Act.
- t)** Indian Factories Act.
- u)** Institute of Electrical and Electronics Engineers (IEEE).
- v)** International Electro-Technical Commission Publications.
- w)** Instrument Society of America (ISA).
- x)** International Organization for Standardization (ISO).
- y)** International Electro-technical Commission (IEC).
- z)** Japanese Standards (JIS).
- aa)** Japanese Electro-technical Committee (JEC).
- bb)** National Fire Protection Association (NFPA).
- cc)** National Electrical Manufacturer's Association (NEMA).
- dd)** National Electric Code (NEC).
- ee)** Power Test Code for Steam Turbines (PTC).
- ff)** Pollution Control regulations of Dept. of Environment, Govt. of India
- gg)** Regulations of CEA.
- hh)** Standards of Manufacturer's Standardization Society (MSS).
- ii)** Tariff Advisory Committee (TAC) rules.
- jj)** Tubular Exchanger Manufacturer's Association (TEMA).

6.2 Name Plates

- 6.2.1** Instruction plates, nameplates or labels shall be permanently attached to each main and auxiliary item of plant in a conspicuous position. These plates shall be engraved with the identifying name, type and manufacturers serial number, together with the loading conditions under which the item of plant has been designed to operate.
- 6.2.2** Items such as valves, which are subject to hand operation, shall be provided with nameplates so constructed as to remain clearly legible throughout the life of the plant giving due consideration to the difficult climatic conditions to be encountered. Nameplates shall be securely mounted where they will not be obscured in service by insulation, cladding, actuators or other equipment. Direction of flow is also to be engraved.
- 6.2.3** All trade nameplates and labels shall be in Bilingual language. All measurements shall be in M.K.S. Units.
- 6.2.4** The size and location of nameplates shall be subject to Approval of the Owner.

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6.3 Guards and Fences

- 6.3.1 Effective guards and fences must be provided to prevent injury to operators.
- 6.3.2 Mesh guards which allow visual inspection of equipment with the guard in place are generally preferable. The guards shall be constructed of mesh attached to a rigid framework of mild steel rod, tube, or angle and the whole galvanized to prevent loss of strength by rusting or corrosion. The guards shall be designed to facilitate removal and replacement during maintenance.
- 6.3.3 Guards for couplings and rotating shafts shall be in accordance with BS 5304-1975 or similar approved standard. All rotating shafts and parts of shafts must be covered.

6.4 Operation, Maintenance & Availability

- 6.4.1 Equipment/works offered shall be designed for high availability, high reliability, low maintenance and ease of operation & maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability, availability, operability and ease of maintenance. He shall also furnish details of availability records in plants stated in his experience list.
- 6.4.2 Wherever required platforms and walkways with access ladders having hand rails shall be provided to facilitate operation and maintenance.

6.5 Materials

- 6.5.1 In selecting materials of construction of equipment, the Bidder shall pay particular attention to the atmospheric conditions existing at the Site and the nature of material/fluid handled. Wherever deviations are taken in respect of materials specified, the reasons shall be spelt out clearly in the proposal.
- All materials shall be new, and shall be of the quality most suited to the proposed application.
- 6.5.2 As far as possible; materials shall be in accordance with Indian or international standard Specifications. Where such standards are not available, sufficient information shall be provided to allow the Owner to assess the suitability of the material for the particular application.
- All materials used shall have performed lengthy satisfactory service in similar or more arduous conditions to those proposed by the Bidder.
- 6.5.3 All parts which could deteriorate or corrode under the influence of the atmospheric, meteorological or soil conditions at the Site, or under the influence of the working conditions shall be suitably and effectively protected so that such deterioration or corrosion is a minimum over the life of the plant.

6.6 Lubricants, Control Fluids and Chemicals

- 6.6.1 Provision shall be made for suitable efficient lubrication where necessary to ensure smooth operation free from undue wear.
- 6.6.2 Non ferrous capillary tubing shall be used throughout.

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- 6.6.3 Oil baths shall be provided with filling and drain plugs, both of adequate size. An approved means of oil indication including level switches and temperature indication shall be provided.
- 6.6.4 Lubrication points shall be conveniently situated for maintenance purposes. It must be possible to carry out lubrication from a gangway or landing and without the removal of guarding or having to insert the hand into it. Where accessibility to a bearing for oiling purposes would be difficult a method of remote lubrication shall be fitted.
- 6.6.5 The Bidder shall provide a detailed and comprehensive Specification for all lubricating oils, greases and control fluids required for Boiler & Auxiliaries. A sufficient supply of these shall be provided by the Bidder for initial commissioning, first fill and till handing over of the unit.
- 6.6.6 Chemicals for Boiler Water conditioning for operation of the Boiler shall be provided by the Owner. However, chemicals for Boiler cleaning shall be arranged by Bidder.
- 6.6.7 The Bidder shall supply a detailed schedule giving the lubricant testing, cleaning and replacement procedures. All equipment and facilities necessary for the testing, cleaning and changing of lubricants and control fluids shall be provided. The Bidder shall endeavour to reduce the varieties and grades of required lubricants, chemicals and control fluids to a minimum, matching them where possible to those already in use in the generating station in order to simplify procurement and minimize storage requirements. All lubricants, chemicals and control fluids shall be of internationally recognized standards and shall be easily obtainable from a large number of Indian suppliers. Bidder shall also indicate the equivalent Indian Standard for the above for easy procurement in future.
- 6.6.8 No lubricant or control fluid shall have toxic or other harmful effects on personnel or on the environment.

6.7 Plant Life and Modes of Operation

- 6.7.1 On completion of the R&M project, the plant/equipment and systems individually and collectively shall be possible to operate continuously with routine maintenance and overhauls for an economic service life of not less than **[20/25 years]** under the prevailing site conditions and for the type of duty intended.
- 6.7.2 After R&M of Boiler and associated auxiliaries, the unit shall be able to operate to its rated capacity continuously and there shall be no restriction of the operation of the unit during Base Load, Peak Load & Cyclic Load operation.
- 6.7.3 The capability of the unit operations including Cold, Hot & Warm Startups shall be in no way inferior to its original design capabilities. Accordingly, Bidder shall indicate the operation capabilities in various regime of operation in his Bid.

6.8 Packaging & Marking

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing all the materials, the limitations from the point of view of

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availability of railway wagon sizes in India should be taken account of. The details of various wagons normally available with Indian Railways for transportation of heavy equipment shall be considered by the Bidder. The Bidder shall be responsible for all loss or damage during transportation, handling and storage due to improper packing.

The identification marking indicating the name and address of the consignee shall be clearly marked in indelible ink on two opposite sides and top of each of the packages. In addition the Bidder shall include in the marking gross and net weight, outer dimension and cubic measurement. Each package shall be accompanied by a packing note (in weather proof paper) quoting specifically the name of the Bidder, the number and date of Contract and names of the office placing the Contract, nomenclature of contents and Bill of Material.

6.9 Protection

Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures. Coated surfaces shall be protected against impact, abrasion, discoloration and other damages. Surfaces that are damaged shall be repainted.

Electrical and C&I equipment shall be protected against moisture and water damages. All external gasket surfaces and flange faces, couplings, rotating equipment shafts, bearings and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection. All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors.

All piping, tubing and conduit connections on equipment and other equipment openings shall be closed with rough usage covers or plugs. Male threaded openings shall be closed with rough usage covers or plugs. Female threaded openings shall be closed with forged steel plugs. The closures shall be taped to seal the interior of the equipment. Open ends of piping, tubing and conduit shall be sealed and taped.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Bidder's expense.

6.10 Painting

6.10.1 General

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. Surfaces not easily accessible after shop assembly shall be treated before-hand and protected for life of the equipment. Surfaces to be finish painted after installation shall be shop painted with at least two (2) coats of primer. Steel surfaces, which are not to be painted, shall be coated with suitable rust preventive compound subject to the approval of the Owner.

All paints shall be used in accordance with the manufacturer's instructions. No thinners or other substance shall be added to the coating material without the approval of the Owner. The quality and vendor of the paints shall require approval of the Owner.

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All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

All primers shall be well marked into the surface, particularly in areas where pitting is evident, and the first priming coat shall be applied as soon as possible after cleaning, within four hours maximum. If the drying interval between successive coats, which should not exceed one week, has been so long as to endanger the adhesion of the following coat, the paint already applied shall be lightly rubbed down with fine abrasive paper before putting on the next coat.

Paint spraying on large surfaces shall not normally be done indoors, except with the approval of the Owner. Spray guns shall not be used outdoors in windy weather or near unprotected surfaces of a contrasting colour and under no circumstances shall spray guns be used where spray may be carried into or onto exposed electrical equipment.

Paint containers shall not be opened until required and the paint shall be mechanically mixed thoroughly before use, and agitated occasionally during use.

Electrical equipment shall be shop finished with one or more coats of primer and two coats of high-grade oil resistant enamel. The interior of all panels' cabinets and enclosures shall be finished with gloss white enamel.

The Bidder shall furnish sufficient touch up paint for one complete finish coat on all exterior factory surfaces of each item of equipment. The touch up paint shall be of the same type and colour as the factory applied paint and shall be carefully packed to avoid damage during shipment. Complete painting instructions shall be furnished.

Shop primer for steel and iron surfaces which will have a continuous operating temperature below 35 °C shall be selected by the Bidder, in accordance to the relevant standard. Special high temperature primer shall be used on surface exposed to operating temperature above 35 °C.

The colour scheme shall be submitted during execution of Contract for approval by the Owner.

6.10.2 Preparation

Oil and grease shall be removed from the surface by washing with a suitable detergent, rinsing with clean water, and drying.

Surfaces to be shot blasted shall be cleaned to Swedish Standard SA 2.5 or equivalent, and all dust remaining after cleaning shall be removed.

The priming coat shall be applied without delay.

6.10.3 Damaged Paintwork

Any damaged paintwork shall be corrected / modified as follows:

- a) The damaged area, together with an area extending 25mm around its boundary, shall be cleaned down to bare metal.

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- b) A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm around the perimeter of the original damage.
- c) The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

6.10.4 Painting Systems

The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as stated below, unless otherwise specified elsewhere in this Specification.

a) Surfaces Subject to Weathering

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	35 micron DFT per coat

The total minimum DFT shall be 140 micron.

b) Surfaces Inside Buildings

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	25 micron DFT per coat

The total minimum DFT shall be 120 micron.

The type and colour of primer & finish coat shall be selected by the Bidder after approval by the Owner.

6.11 Environment Protection

6.11.1 Environment Protection

The plant & equipment under this R&M project shall be designed for installation and operation in harmony with the surrounding environment and all measures of pollution control shall be ensured by the Bidder to restrict pollution from the liquid effluent and stack emission within the limits as given below with due consideration of Environment (Protection) Rules.

6.11.2 For Liquid Effluent

During construction activities, Bidder shall maintain the statutory compliance of State Pollution Control Board and MoEF in respect of pollution control and environmental protection within and around plant boundary. Any specific requirement of State Pollution Authorities over and above shall be maintained.

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6.11.3 For Air Quality

{Utilities to mention the Limit for SPM and NOx at Stack emission and Ground level concentration for SOx, NOx, SPM, RPM as stipulated by State Pollution Control Board.}

- a) Suspended Particulate Matter i.e. dust burden at chimney outlet – Maximum [...] mg/Nm³ (with worst coal and one field out in each path).
- b) NOx - Shall not exceed [...] gm/GJ at 6% excess O₂ dry at chimney outlet.

In absence of Indian Standard for emission from power plants as on date, for certain gaseous effluents, the internationally accepted World Bank Standard is to be followed.

6.11.4 Noise Level Requirement

The plant & equipment under this R&M project will be designed, constructed and provided with suitable acoustic measures to ensure the noise level criteria as per the following stipulations of MoEF & State Pollution Control Board.

- a) Maximum noise level shall not exceed 85 dB (A) when measured at 1.0 m away from the noise emission source.
- b) Maximum noise level from its source within the premises shall not exceed 70 dB (A) as per Environment (Protection) Rules 1986, Schedule-III, 'Ambient Air Quality Standards' in respect of noise.
- c) Any statutory changes in stipulations regarding noise limitation that may occur in future according to State Pollution Control Board or Central pollution Control Board or Ministry of Environment & Forest regulation during tenure of the Contract, the Bidder shall comply with the updated/amended requirement.

An exception will be made for the plant at startup operations of other big pressure reducing devices operating during emergency periods and for the safety valves.

6.12 Inspection and Testing

6.12.1 Inspection and Tests during Manufacture

- 6.12.1.1 The method and techniques to be used by the Bidder for the control of quality during manufacture of all plant and equipment shall be agreed with the Owner prior to the Award of Contract.
- 6.12.1.2 The Owner's general requirements on quality control and shop tests as mentioned in Section II of Volume-II.
- 6.12.1.3 Owner shall be informed for witnessing the shop tests of any item of the plant or equipment for checking the compliance with the Specification requirement and or related standards prior to leave place of manufacturing.
- 6.12.1.4 Advance notice shall be given to the Owner as agreed in the Contract, prior to the stage of manufacture being reached, and the piece of plant must be held at this stage until the Owner has inspected the piece, or has advised in writing that inspection is waived. If having consulted the Owner and given reasonable notice in writing of the

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date on which the piece of plant will be available for inspection, the Owner does not attend, the Bidder may proceed with manufacture having forwarded to the Owner duly certified copies of his own inspection and test results.

- 6.12.1.5 The Bidder shall forthwith forward to the Owner the Test Certificates in [...] copies for approval..
- 6.12.1.6 Under no circumstances any repair or welding of castings be carried out without the consent of the Owner. Proof of the effectiveness of each repair by radiographic and/or other non destructive testing technique, shall be provided to the Owner.
- 6.12.1.7 All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.
- 6.12.1.8 Where accurate alignment is necessary for component parts of machinery normally assembled on site, the Bidder shall allow for trial assembly prior to dispatch from place of manufacture.
- 6.12.1.9 All materials used for the manufacture of equipment covered under this Specification shall be of tested quality. Relevant test certificates shall be made available to the Owner. The certificates shall include tests for mechanical properties and chemical analysis of representative material.
- 6.12.1.10 All pressure parts connected to pumping main shall be subjected to hydraulic testing at a pressure of 150% of design pressure. The duration of the pressure tests shall be sufficient, as approved by the Owner, to show any leakage paths and to permit a thorough examination of the component whilst under pressure.
- 6.12.1.11 All necessary non destructive examinations shall be performed to meet the applicable code requirements.
- 6.12.1.12 All welding procedures adopted for performing welding work shall be qualified in accordance with the requirements of Section-IX of ASME code or IBR as applicable. All welded joints for pressure parts shall be tested by liquid penetrant examination according to the method outlined in ASME Boiler and Pressure Vessel code. Radiography, magnetic particle examination magnuflux and ultrasonic testing shall be employed wherever necessary/ recommended by the applicable code. At least 10% of all major butt welding joints shall be radio graphed. Payments in respect of IBR approvals including inspection shall be made by Owner. Bidder scope shall be limited to preparation of all necessary documents, coordination and follow up for above approvals.
- 6.12.1.13 The Bidder shall furnish the quality procedures to be adopted for assuring quality from the receipt of material at site, during storage, erection, pre-commissioning to tests on completion and commissioning of the complete system/equipment.

6.12.2 Performance Tests at Site

- 6.12.2.1 The full requirements for testing the system shall be agreed between the Owner and the Bidder prior to Award of Contract. The completely erected System shall be tested by the Bidder on site under normal operating conditions. The Bidder shall also ensure

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the correct performance of the System under abnormal conditions, i.e. the correct working of the various emergency and safety devices, interlocks, etc.

- 6.12.2.2 The Bidder shall provide complete details of his normal procedures for testing, for the quality of erection and for the performance of the erected plant. These tests shall include site pressure test on all erected pipe work to demonstrate the quality of the piping and the adequacy of joints made at site.

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7 LAYOUT CONSIDERATION

{Effort should be given to keep the Layout of the newly equipped system / packages under the R&M project unchanged to the extent possible with respect to existing layout to avoid disturbance to the existing equipment & facilities for which any modification/changes are not envisaged based on RLA/LA and EA assessment. However general guidelines, which need to be followed, as required, are given below :}

The broad salient features of the existing and expected layout arrangements of various equipment in the main plant building housing the turbine generator and its auxiliaries and Boiler area are given as hereunder:

- 7.1 The arrangement of the turbine- generator in the main plant building is of [longitudinal type]. The boiler centre line is in the [same as that of TG condenser]. Unit pitching distance between centre lines of two boilers is [approximately 120m]. The column spacing of main plant building is [about 10 m].
- 7.2 [The conventional arrangement of AB, BC and CD longitudinal bays with D row as first row of boiler columns is adopted with their respective widths of about 30m, 10m and 11m. The mill bunker buildings shall be about 12m wide on each side of the boiler].
- 7.3 [Two transverse bays at 0.0 m elevation equivalent to minimum area ofm² has been provided for unloading and maintenance at one end of main plant building].
- 7.4 [The location of control room (common for two units) is in BC bay at the operating floor level. Adjoining the control room, there is a control tower which accommodates control equipment room, AC plant room, battery room and UPS for C&I system, cable vault etc. at its different floor levels].
- 7.5 The local pits/trenches in main plant building/ mill bunker bay building/ boiler/ ESP area is to be avoided as far as possible.
- 7.6 Clear walk ways of minimum 1.5 m width at all the levels shall be provided in the main plant building. Adequate fire escape staircases shall be provided with fire doors at each landing.
- 7.7 [Interconnecting walkways (minimum 2.0 m clear) shall be provided between main plant building and boiler on either side of boiler at three elevations viz. mezzanine, operating and deaerator floor levels. Two nos. walkways each shall be provided on either side of the boiler between boiler and mill bunker building at feeder floor level, tripper floor level and roof of mill bay].
- 7.8 [The layout arrangement of critical piping connecting the Boiler and steam turbine shall be developed in such a way as to optimize the use of materials and resulting in minimum pressure losses in the steam flow].
- 7.9 In the boiler area, facility of crane/ chain pulley block/ monorail hoist etc. shall be provided along with provision of space for maintenance/ overhauling of equipment such as mills, coal feeders, boiler circulation pumps, fans, motors, and handling of APH baskets and coils of economizer and SCAPH etc.

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- 7.10 Clear approach width of minimum 10m with 8m clear height shall be maintained at the front and rear of ESP.
- 7.11 *[The VFD control equipment and transformers for radial type ID fans, if provided, shall be located along with the ESP control equipment in the ESP control room].*
- 7.12 Trestles to be provided for routing of cables, pipes etc. shall have a clear height of 8.0m at road crossings so as to clear the road spaces, approach to maintenance bays of different equipment. A walkway with hand rails and toe guards of 750mm (minimum) width shall be provided all along length of the trestle for maintenance of cables and pipes. Ladders for approach to these platforms shall be provided near roads, passage ways.
- 7.13 Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized taking into account the fire water sprinkler system wherever provided.
- 7.14 Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 2.5 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment and clear headroom within main structures and cable trays etc.
- 7.15 Fire water pipes in main plant area may be routed in trenches filled with sand and covered with pre-cast RCC covers.
- 7.16 The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards etc. shall be observed while developing the layout.
- 7.17 The available existing layout details of the plant are indicated in the enclosed drawings as Annexure-I. However, Bidder to suggest his own modified layout arrangement which shall be subject to approval of the Owner.

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8 PERFORMANCE GUARANTEES

The term "Performance Guarantees" wherever appears in this Section shall have the same meaning and shall be synonymous to "Functional Guarantees".

Similarly the term "Performance Tests" wherever appears in this Section shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

The term "BMCR" (Boiler Maximum Continuous Rating) appearing in the Technical Specification shall mean the maximum continuous steam output at super heater outlet of Boiler at rated parameters.

The term "TMCR" (Turbine maximum continuous rating) appearing in the Technical Specification shall mean [210/215/220/250] MW electrical power output at generator terminals under 0% cycle make-up and [76] mm Hg (abs) condenser pressure, unless used in conjunction with a different cycle make-up.

8.1 General Requirements

- 8.1.1 The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in this technical Specifications.
- 8.1.2 The guaranteed performance parameters furnished by the Bidder in the Bid proposal, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.
- 8.1.3 The Bidder shall demonstrate all the guarantees covered herein under Category I, II & III during functional guarantee / acceptance test. The various tests which are to be carried out during performance guarantee/acceptance test are listed elsewhere in this -Section. The guarantee tests shall be conducted by the Bidder at site in presence of Owner on the unit.
- 8.1.4 All costs associated with the tests including the cost associated with the supply, calibration, installation and removal of test instrumentation shall be included in the price offered by Bidder.
- 8.1.5 At all times during the Performance Tests the emissions and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.
- 8.1.6 It shall be the responsibility of the Bidder to make the plant ready for the performance guarantee tests.
- 8.1.7 All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Bidder shall get these instruments calibrated in an independent test institute approved by the Owner. All test instrumentation required for performance tests shall be supplied by the Bidder and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subjected to the approval of the Owner. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.

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- 8.1.8 Tools and tackles, thermo wells (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the Bidder free of cost.
- 8.1.9 The Performance/ Acceptance test shall be carried out as per the agreed procedure. The PG test procedure including demonstration tests shall be submitted within **[90 days]** of the date of Notification of Award and finalization of the PG test procedure shall be done within **[180 days]** from the date of Notification of Award. After the conductance of Performance test, the Bidder shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. However, preliminary test reports shall be submitted to the Owner after completing each test run.
- 8.1.10 The PG test procedures shall be submitted for equipment/ system & subsystem under Bidder's scope for all Guarantees under category I, II & III as mentioned below, as per latest International codes & standard including correction curves, meeting the Specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.
- 8.1.11 The Bidder shall submit for Owner's approval the detailed Performance Test procedure containing the following:
- Objective of the test.
 - Various guaranteed parameters & tests as per Contract.
 - Method of conductance of test and test code.
 - Duration of test, frequency of readings & number of test runs.
 - Method of calculation.
 - Correction curves.
 - Instrument list consisting of range, accuracy, least count, and location of instruments.
 - Scheme showing measurement points.
 - Sample calculation.
 - Acceptance criteria.
 - Any other information required for conducting the test.
- 8.1.12 In case, during performance guarantee tests, it is found that the equipment/systems has failed to meet the guarantees, the Bidder shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Owner. However, if the Bidder is not able to demonstrate the guarantees, even after the

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above modifications/replacements within *[ninety (90) days]* or a reasonable period allowed by the Owner after the initial performance guarantee tests have been completed, the Owner will have the right to impose the stipulated clauses under Guarantee Category I, II & III as specified in this Specification:

8.1.13 For Category-I Guarantees

Reject the equipment/system/plant and recover from the Contractor payments already made.

(OR)

Accept the equipment/system/plant after levying Liquidated Damages (LD) as specified in Clause No. 5.6 of Volume I. The LDs shall be prorated for the fractional parts of the deficiencies.

8.1.14 For Category-II Guarantees

Reject the equipment/plant/system and recover, from the Contractor, the payments already made. Conformance to the performance requirements under Category-II is mandatory.

8.1.15 For Category-III Guarantees

Reject the equipment/system/plant & recover, from the Contractor, the payments already made.

(OR)

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the Contract price an amount equivalent to the damages as determined by the Owner. Such damages shall however be limited to the cost of replacement of the equipment/systems replacement of which shall remove the deficiency so as to achieve the guaranteed performance.

8.2 Performance Guarantees under Category-I

The performance guarantees which will attract liquidated damages shall be as follows:

- (i) Boiler steaming capacity in Tons per Hour (TPH) of steam at 100% BMCR at rated steam parameters at superheater outlet and at rated steam temperature at reheater outlet (with any combination of mills working as per Owner's discretion) with the coal being fired from within the range specified in the Technical Specifications.
- (ii) Efficiency of the Boiler at 100%TMCR unit load at 0% Make-up with site design ambient condition, while firing the design coal, at rated steam parameters at superheater outlet and at rated steam temperature at reheater outlet, and rated excess air.
- (iii) Auxiliary Power Consumption for Boiler & its Auxiliaries at 100% TMCR unit load at condenser pressure of *[76]* mm Hg (abs) with 0% make-up and with design ambient air condition.

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Note: Power consumption of each of the pump/fan/compressors etc. wherever mentioned shall be measured with its own drive.

8.2.1 Limit of Technical Parameters under Liquidated Damages Applicable For Category-I Guarantees:

Table: 8.1

S.No.	Parameter	Performance Limit
1	Boiler Capacity in TPH at rated parameters at superheater outlet, the coal being fired from the range specified.	Shortfall beyond [1%] of guaranteed value [(i.e. – 1.0 %)]
2	Boiler Efficiency at 100% TMCR	Shortfall beyond [0.5%] of guaranteed value [(i.e. – 0.5 %)]
3	Auxiliary Power	Increase beyond [5%] of guaranteed value/. [(i.e. + 5.0 %)]

8.2.2 Specific and Limiting Requirements For Boiler Efficiency

{Efficiency of the Boiler should be determined by Heat Loss Method as per the ASME Code PTC – 4 discussed below.}

The efficiency quoted by the Bidder shall comply with following limiting parameters with design coal firing:

Table: 8.2

S.No	Detail	Description
1.	Excess air at economizer outlet at [105% & 100% TMCR load]	[20%] (min.)
2.	Corrected flue gas temperature at air preheater outlet at [105% & 100% TMCR]	[135 degree C] or as predicted by the Bidder whichever is higher
3.	Boiler Efficiency Loss due to unburnt carbon	[1.0%] (min.)

Bidder to note that no credit shall be given in the Bid evaluation or in the

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evaluation of the results of the guarantee tests for performance predictions/ guarantees etc. if the values considered by the Bidder for parameters indicated above are lower than those specified above.

For the purposes of guarantees the ambient air temperature and relative humidity shall be taken as *[27 degree Celsius and 60%]* respectively.

Unless otherwise specified, the guarantees shall be based on design coal firing with coal/ ash analysis as given with this Technical Specification.

The performance guarantee test will be carried out within three months after the successful completion of Initial Operation of facilities or as per the time frame specified for a particular equipment/ plant/ system in the Technical Specifications. Delay in conductance of the test beyond this period will not be normally permitted by the Owner. In the event of Owner agreeing to conductance of such tests after three months, for reasons not attributable to the Owner, as assessed by the Owner, no factor for ageing shall be considered for computing performance of the equipment.

Note: In addition to above, major requirements/ method of Boiler Efficiency Tests

- i) Ambient air condition : *[27 degree Celsius temperature (Dry bulb) and 60% relative humidity]*. The reference air temperature for the Boiler efficiency guarantee / testing shall be taken as the temperature of air (i.e. *[27 degree Celsius]*) entering PA and FD fans.
- ii) No. of readings : Two sets of consistent readings for each of test loads. Average of the test efficiencies based on above two readings for each load shall be considered for Boiler efficiency.
- iii) Measurement and computation of heat losses will include but not be limited to the following:

A. ASME Code PTC – 4 Guidelines

Boiler Efficiency should be worked out by determining the total heat loss.

Total Heat Loss consists of the following items:

- i) *Heat Loss due to dry flue gases.*
- ii) *Heat Loss due to evaporation of moisture in fuel.*
- iii) *Heat Loss due to hydrogen in fuel.*
- iv) *Heat Loss due to moisture in Air.*
- v) *Heat Loss due to incomplete combustion to CO.*
- vi) *Heat Loss due to un-burnt carbon.*

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- vii) Heat Loss due to mill (pulveriser) rejects.
- viii) Heat Loss due to Radiation and convection (Difficult to evaluate. Hence Design Value [normally 0.18%] should be considered.)

The Efficiency of Steam Generator should be worked out by the following equation.

$$\text{Efficiency} = 100 - \% \text{ Losses of Heat Input.}$$

Locations of Installing Measuring Instruments:

For conducting the Boiler Efficiency Test, following locations should be used for installing the measuring instruments and for collecting the samples:

- Flue gas analysis at the air pre-heater inlet and outlet for measuring O₂, CO & CO₂.
- Temperature of flue gas at air pre-heater inlet and outlet.
- Fly ash sampling at Economizer outlet and ESP Hoppers for unburnt carbon in fly ash.
- Sampling of bottom ash from hopper or scrapper.
- Sampling of raw coal from RC feeder of the mill for proximate and ultimate analysis of fuel and finding its Gross Calorific Value (GCV).
- Pulverised coal samples from each mill for sieve analysis.
- Sample of mill rejects for finding GCV.

Notes:

- (i) Before the Efficiency Test is conducted, the contractor will submit a detailed procedure for conducting the test which will be subject to the approval of the owner. Among other things, the procedure will also include the type of instruments to be used and the locations of various measuring instruments and sampling points.
 - (ii) During the Efficiency Test, the Steam Generator blow downs and the use of auxiliary steam for purposes like soot blowing should be stopped, since, accurate evaluation of heat loss due to these items is difficult.
 - (iii) Test Instruments should have 0.5% accuracy. Calibration of the instruments should not be more than six months old. Instruments calibration should be certified by Govt. Accredited Laboratories i.e. NABL approved laboratories.
 - (iv) During the test, the operating parameters should be kept stable and close to design parameters.
 - (v) During the Boiler Efficiency Test, quality of fuel to be used should be as close as possible of the design quality.
- iv) Correction to tested efficiency shall be applicable for variation in following parameter only:
- Ambient air temperature.

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- Relative humidity of ambient air.
- Hydrogen in coal.
- Moisture in coal.
- GCV of coal.

8.2.3 Auxiliary Power Consumption

The respective auxiliary power consumption as is illustrated hereunder:

a) Auxiliary Power Consumption

The auxiliary power consumption shall be calculated using the following relationship.

$$P_{au} = \sum P_u$$

P_{au} = Guaranteed Unit Auxiliary Power Consumption.

P_u = Power consumed by each of the continuously running equipment of Boiler & Auxiliaries.

While guaranteeing the auxiliary power consumption, the Bidder shall necessarily include all continuously operating equipment of Boiler & auxiliaries. The auxiliaries to be considered shall include but not be limited to the following:

- Mills (Number of Mills to be considered in operation will correspond to the number of mills required to be operated for design coal).
- PA Fans
- FD Fans.
- ID Fans.
- Air Heaters.
- Coal Feeders.
- Boiler Start up drain recirculation Pumps (If applicable).
- Seal Air Fans.
- Lube oil pumps for fans/ Air heaters & mill system etc.
- Scanner air fans.
- Electrostatic Precipitator with all ESP fields of all ESP passes working and rapping system in normal operation (as measured at the input terminals of the TR set. Refer Note 3 below).
- Gas Recirculation Fan (if applicable)
- DM Cooling (normally working) Water pumps to supply cooling water on the primary (DM) side of the plate type heat exchangers in the closed loop Equipment cooling dedicated to Boiler & Auxiliaries.

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- n) Auxiliary Cooling (normally working) water pumps to supply cooling water on the secondary side of the plate type heat exchangers in the closed loop Equipment cooling dedicated to Boiler & Auxiliaries.
- o) Power consumption of any other continuously operating auxiliary for Boiler and its Auxiliaries operation at 100% TMCR.

Note:

1. The Bidder shall furnish a list of equipment to be covered under Unit auxiliary power consumption, which shall be subject to Owner's approval.
2. The Bidder shall ensure that power supply to all such equipment to be covered under auxiliary power consumption is fed from unit board.
3. Method of Computation of Auxiliary Power consumption for ESP:-

For guarantee purpose, total maximum continuous Auxiliary power consumption will be the power consumption of corona power (excluding power consumption by hopper heaters, insulator heaters, rapping system, ventilation fans etc.) of all fields of all passes of ESPs for one unit. Corona power of TR sets will be computed at the input terminals of the TR sets when all ESP fields of all ESP passes are working and rapping system is in normal operation at the guarantee point condition. The measurement for guaranteed auxiliary power consumption shall be carried out during ESP collection efficiency test. The method for computing the corona power shall be as described below:-

- a) Power consumption of TR sets will be measured pass wise and for one pass (Say ESP-A) at a time with the help of energy meter in ESP MCC.
- b) Energy meter reading will be taken before starting the collection efficiency test and after completion of collection efficiency test.
- c) Before starting collection efficiency test, switch off all the TR sets serving to one pass (ESP-A) temporally and note down energy meter readings for period t1 i.e. E1. Power consumed by hopper heaters, shaft and support insulator heaters and rapping systems shall be $W1 = E1/t1$. The time period t1 shall be minimum 4 hours.
- d) During the collection efficiency test the total energy fed in to ESP MCC of one pass (say ESP-A) will be measured during entire period of collection efficiency test i.e. E2. Total time period (t2) of test shall be noted. The power consumption shall be $W2=E2/t2$. During this period, no change in the status of hopper heaters, insulator heaters, rapping system, ventilation fans etc. will be allowed w.r.t. the condition at clause c) above. In case there is any change in the status of hopper heaters, insulator heaters, rapping system, ventilation fans etc., then auxiliary power consumption test will be repeated again.
- e) Measured corona power consumption for one pass (say ESP-A)= $(W2-W1)$
- f) Measured corona power of one unit= Corona power of (ESP-A + ESP-8 + ESP-C +ESP-D + ESP-E + ESP-F).

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8.3 Guarantees under Category-II

The Performance Guarantees, conformance to which is mandatory are as follows:

i. Particulate Emission/ ESP Efficiency

Maximum [...] mg/Nm³] (With worst coal and one field out in each path)

The performance test on electrostatic precipitator will commence after a minimum period of fifteen hundred (1500) hours of continuous operation after completion of initial operation. During the interval between the commencement of initial operation and the commencement of performance test only routine maintenance shall be carried out. No physical or chemical cleaning of ESP shall be permitted during this period or immediately before the conductance of the performance tests.

The test efficiency shall be based on the overall performance of the electrostatic precipitator over a mutually agreed period of operation under the conditions given in this Specification and allowing the normal operation of the unit including rapping and normal soot blowing and/or when fuel oil is being fired in the igniters and/or warm up guns.

The overall test efficiency and test temperature/inlet dust burden for one set of ESP passes (streams) serving one Boiler shall be worked out as follows:-

- a) Vm (guarantee point test flow) shall be the total of inlet gas flows to, say six gas streams at the time of test.
- b) Test inlet dust burden (Di) shall be weighted mean of the inlet dust burdens for the individual streams i.e.:

$$\{(Vm1*Di1)+(Vm2*Di2) + (Vm3*Di3)+(Vm4*Di4)+(Vm5*Di5)+(Vm6*Di6)\}$$

$$Di = \frac{\{(Vm1*Di1)+(Vm2*Di2) + (Vm3*Di3)+(Vm4*Di4)+(Vm5*Di5)+(Vm6*Di6)\}}{(Vm1+ Vm2 + Vm3 + Vm4+ Vm5 + Vm6)}$$

$$(Vm1+ Vm2 + Vm3 + Vm4+ Vm5 + Vm6)$$

Where suffix 1, 2,3,4,5 & 6 represents the six gas streams.

Similarly the test outlet dust burden (Do) will be calculated based on outlet gas flow.

- c) The weighted test inlet gas temperature (Ti) shall also be worked out in a similar manner i.e.

$$(Ti1*Vm1)+(Ti2*Vm2)+(Ti3*Vm3)+(Ti4*Vm4)+(Ti5*Vm5)+(Ti6*Vm6)$$

$$Ti = \frac{(Ti1*Vm1)+(Ti2*Vm2)+(Ti3*Vm3)+(Ti4*Vm4)+(Ti5*Vm5)+(Ti6*Vm6)}{(Vm1+ Vm2 + Vm3 + Vm4 + Vm5 + Vm6)}$$

$$(Vm1+ Vm2 + Vm3 + Vm4 + Vm5 + Vm6)$$

- d) The measured test efficiency shall be :

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(Di-Do)

$$Em = \frac{Di - Do}{Di} \times 100\%$$

- e) The corrections for the flue gas flow and ESP inlet flue gas temperature in excess of the values for these parameters under guarantee point conditions, shall be allowed only in case and to the extent such variations are caused solely due to changes in specified coal properties and ambient conditions. Further, the corrections for the flue gas flow and temperature lower than the guarantee point values shall be applied based on actually measured test values. Subject to the above, the corrections for the variation in flue gas flow, inlet dust burden and ESP inlet flue gas temperature shall be based on the above computed test values and the procedure given below:
- f) At the time of performance testing if the inlet flue gas conditions are not consistent with the specified conditions, due to variation in coal characteristics from the design coal and boiler operating conditions the precipitator performance conforming to this Specification, shall be determined using performance curves and correction factors accepted at the time of award of Contract. However, the test efficiency shall be corrected to the guarantee point conditions in the following manner:

1. $Ec = 1 - eZ$

Where Ec = Corrected test efficiency to guarantee point conditions.

$$Z = C \ln \frac{1}{1 - Eg}$$

1

and $C = \frac{Ca \cdot Cb \cdot Cc \cdot \text{etc.}}{Ec}$

Ca. Cb. Cc. etc.

Ca.Cb.Cc etc. are Correction factors for flue gas at temperature, moisture content in flue gas, ESP inlet dust loading, sulphur and sodium contents of coal ash based on correction curves furnished by the Bidder and approved by the Owner.

2. $Eg = 1 - eY$

Where $Y = \{(Vm/Vg)^{0.5}\} \cdot \ln (1 - Em)$

Eg = Measured test efficiency corrected to the specified guarantee point flow

Vg = Specified Guarantee point gas flow (m³/sec)

Vm = Measured gas flow (m³/sec)

Em = Measured test efficiency

\ln = Logarithm, natural base.

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The correction curves should be realistic for expected range of operation and variation in characteristics specified.

The test efficiency shall be the average of at least three corrected test efficiencies.

The Performance tests shall be carried out in accordance with method-17 of EPA (Environmental Protection Agency of USA) code. The details of the test shall, however be mutually agreed upon between the Owner and the Bidder.

Further, during the performance test of the Electrostatic Precipitator, if the Bidder establishes that the average of three tested outlet dust burden (Do) values (uncorrected) are either equal to or less than [...] mg/Nm³], then the Bidder shall also be deemed to have successfully met the guaranteed ESP efficiency.

ii. Liquid Effluent

Liquid Effluent discharge to an outside body, from the plant battery limit, shall meet statutory requirements State Pollution Control Board.

8.4 Guarantees under Category-III

The parameters/capabilities to be demonstrated for various systems/ equipment shall include but not be limited to the following:

8.4.1 Noise

All the plant, equipment and systems covered under this Specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency specified.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.

Equivalent "A" weighted Sound pressure shall be measured all around the equipment at a distance of 1.0 m from the Noise emitting source.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A - weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed the guaranteed value. Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests.

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If the noise level recorded is beyond the limits specified above, the Bidder should provide suitable acoustic cladding to mitigate the noise level to within allowable limits.

8.4.2 Start-up, loading, Unloading and Shutdown Capabilities

a) Boiler Start-up

Start-up time (up to full load), and loading capabilities for the Boiler for cold start conditions [(greater than 36 hours shutdown)], warm start conditions [(between 8 and 36 hours shutdown)] and hot start conditions [(less than 8 hours shutdown)] as indicated by the Bidder in the offer and accepted by the Owner shall be demonstrated, ensuring various parameters like tube metal temperature, excess air level etc is within design limits.

b) Sudden Total Loss of External Load

When the steam turbine generator unit experiences sudden total loss of all external load, the steam turbine generator unit shall not trip on over speed but shall continue to be in operation (house-load conditions) under the control of its speed governor to supply power for the plant auxiliary load and during such condition Boiler shall be capable of producing steam as per the requirement of Turbo Generator. The same shall be demonstrated.

8.4.3 Other Parameters for Boiler and Auxiliaries

a) Mill Capacity at Rated Fineness {Applicable for PF Boilers but not for CFBC Boilers}

Performance testing shall be done on each mill towards establishing its capacity specified at the rated fineness, applying corrections for the variation in coal characteristics i.e. HGI & total moisture. The Bidder shall guarantee the capacity output not less than the offered value for each mill with following conditions occurring simultaneously during testing with the available coal from the specified range:

- Coal fineness: Not less than [70% through 200 mesh] and not less than [99% through 50 mesh] screen.
- Mill loading: Not to exceed [90%] of maximum load for worst coal.

The Bidder shall guarantee that the above capacity shall be maintained and demonstrated with the installed grinding elements in nearly worn-out condition as mutually agreed for the purpose of ascertaining wear life of any of the wear parts. During the above mentioned operating period of the mill, manufacturer's operating instructions shall be followed and mill shall be operated with the specified range of coals without any such readjustment that requires a shutdown of the mill or reduction of the load and/or any replacement of any mill wear parts.

For the purpose of testing to demonstrate the capacity, if HGI and total moisture vary from those given in coal characteristics, the above pulverizer measured capacity shall be corrected using the capacity correction curves furnished by the Bidder and approved by the Owner. HGI versus mill capacity curve shall be furnished for HGI variation up to a

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value above which the capacity remain constant. Capacity guarantee shall be conducted and demonstrated on each coal pulverizer individually.

b) Coal Mill Wear Parts Warranty {Applicable for PF Boilers but not for CFBC Boilers}

Life of mill wear parts, in hours of operation, for the entire range of coal characteristics specified.

The Bidder shall warrant the wear life of all wear parts of the pulveriser when grinding the specified range of coal. Pulveriser wear parts are defined as those parts of the pulveriser which are in contact with coal or coal dust and are likely to wear out during the operation of the pulveriser. The guarantee/warranty shall be demonstrated on each pulveriser during the Guarantee Trial Period commencing after establishing successful operation of the pulveriser continuously for a period of not less than [24 (twenty four)] hours, at or near its warranty rated capacity. The Guarantee Trial Period for the respective wear part(s) shall be at least three years or the wear life of any wear part that wear part(s), whichever occurs later. The establishment of the warranty will be based on actual total hours of operation of the pulveriser, regardless of the specified fuel or fuel loading of the pulveriser. The wear parts shall be considered to have passed their warranted operating life when they have successfully demonstrated their capability to meet the full load rated capacity of the pulveriser during the guaranteed life of the wear part. In case any of the wear part has worn out to such an extent that either the normal or safe operation of the pulveriser is jeopardised if this part is not replaced/repared, or continuous use with this part may lead to exposure or wear of other parts which are not meant for the purpose of checking the shortfall in wear life, even if there is no reduction in pulveriser rated capacity, then the part shall be deemed to have outlived its wear life. The rated capacity of pulveriser is as per manufacturer standard supplied mills. If any of the wear parts fail to meet the warranted life, additional quantities of these wear parts shall be supplied on prorata basis.

Pulveriser Warranty Shortfall Settlement Procedure (With Example)

For all wear parts of each pulveriser:

Table: 8.4

S.No.	Description	Example	Remarks
1	Guaranteed wear life of the part is (say=Y)	15,000 hrs	
2	Actual wear life achieved by failed part with replacement is (say Y1 & Y2)	13,000 and 11,000 hrs	Life of wear part replaced during 5 year guarantee trial period
3	Average wear life of failed wear parts is(AWL)	$= (Y1+Y2)/2$ $=12000$	

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S.No.	Description	Example	Remarks
4	Total shortfall in hours for wear part during 5 years of guarantee trial period is S	$= (Y-Y1)+(Y-Y2)$ $= 2000+4000$ $= 6000$	
5	Shortfall settlement	$= [S/AWL] \times [(20-GTP)/ (guarantee trial period)]$ $= 2.0$	If the value works out to 1.6, then in that case the same can be rounded off to the next higher whole number.

The Bidder shall provide to Owner either the wear parts of original or better quality/material number equivalent to one and a half times the quantity worked out based on the method explained in the above example so as to compensate for the shortfall in wear life for a extended plant life of [20/25] years as has been established above, or the cost of such number (i.e., one and a half time the quantity worked out as per the above example) of wear parts based on the prices agreed for mandatory spares. The final mode of compensation for such shortfall viz., by means of additional quantities of spares worked out or by cost thereof shall be as per Owner's discretion. The total cost of such replacements shall be without any limit to the maximum amount recoverable.

Average Wear Life (AWL) during guarantee trial period, to be considered for pulveriser wear part warranty shall be as arrived at from the station record for each pulveriser, and as corrected for variation in YGP index of the coal being fired during guarantee trial period. For this purpose the coal YGP shall be the average tested value during guarantee trial period. The Bidder shall collect the coal samples and get them tested for YGP index at recognised, Owner's approved test lab, periodically. (The frequency of sampling and testing shall be mutually agreed between Bidder & Owner). The YGP index testing shall be done as per the BS Standard specified. A jointly signed record shall be maintained during guarantee trial period.

c) Furnace Exit Gas Temperature (FEGT) {Applicable for PF Boilers but not for CFBC Boilers }

The Bidder shall conduct a comprehensive thermal performance test (TPT). Through such TPT the Bidder, by indirect measurement, shall demonstrate that the Furnace Exit Gas Temperature (FEGT) does not exceed the specified maximum temperature limit, with coal pulverizer combinations to Owner's choice and all other requirement in line with Specification requirements. The demonstration shall be done by backward calculations method, after having measured/tested/calculated the economizer outlet gas temperature (average), excess air (average), unit heat load (based on turbine flow and reheater flow), characteristics of coal being actually fired during testing, heat

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absorption in different stages of heat transfer equipment (based on steam/water temperature and pressure measurements) etc. FEGT for the specified design and worst coals shall be calculated using the measured FEGT (with test coal) as above and using computer modeling technique for necessary conversion of the results to the specified design and worst coals. The FEGT demonstration using computer modeling technique shall involve following steps:

Development of a computer field model (FM) (backward) using above measured/computed field data. This will be used to calculate the surface effectiveness factor (SEF) for each of heat transfer banks including furnace water walls with test coal.

The above field model shall have to be validated by various tests (loads, coal pulverizer combination etc. with test coal) to ensure SEFs for each bank are consistent (within: 1.5%) for all tests.

Using above SEFs, for each heat transfer bank Bidder's original boiler design model will be changed.

The validity of the above model shall be checked for each test by feeding the test coal both from backward direction FM and the calibrated Unit Specific model as per step-(c) above. The model validity is established if the results for flue gas temperature profile in the boiler, zonal assumptions etc are identical in both the 'BACKWARD' and 'FORWARD DIRECTION'.

The validated Unit Specific model shall have "Fuel Switching" capability i.e. it shall be able to appropriately vary the furnace absorption with changes in the coal properties. Validation of the above fuel switching capability will also have to be established to the satisfaction of Owner.

Having established and demonstrated FUEL SWITCHING capability, the Contractual FEGT can be demonstrated by using the SITE SPECIFIC calibrated model as per step-(d) and plugging in the specified coal(s).

The detailed procedure and the correction curves for the above test shall be to Owner's approval.

The Bidder through thermal performance test (TPT) as per above shall also demonstrate that the flue gas temperature (Actual/MHVT values) at the entry and exit of various boiler heating surfaces and also the variations across the cross section perpendicular to gas flow do not exceed the values indicated in the data sheets for 100% TMCR Load.

d) Flue gas Temperature (Actual/MHVT)

The Bidder shall also demonstrate that the flue gas temperature at the entry and exit of Boiler heating surfaces and also the variations across the cross section perpendicular to gas flow do not exceed the values indicated in the Technical Specification Section-II of Volume-II at 100% TMCR load.

e) Fuel Oil Support [(Not above 30% BMCR)] {Applicable for PF Boilers but not for CFBC Boilers}

The Bidder shall demonstrate that with any combination of mills in service (to Owner's choice) the Boiler does not require any oil firing for stable and efficient Boiler operation at and above [30% BMCR load].

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f) Steam Temperature Imbalance

The Bidder shall demonstrate that at SH and RH outlets (in case of more than one outlet) the temperature imbalance between the outlets does not [exceed 5°C] under all loads including transients.

Also Bidder to demonstrate the rated temperature at ESV & ICV of HP turbine & HP turbine respectively.

g) Rated SH/RH Imbalance

The Bidder shall demonstrate the Boiler capability to operate on continuous basis with rated SH/RH outlet steam temperature within the complete control range of the Boiler and with the whole range of specified coal(s). This demonstration test shall be conducted for at least 72 (seventy-two) hours and the metal temperature and various operating parameters of Boiler such as excess air etc shall not exceed their design/predicted values.

h) SH/RH attemperation System

The Bidder shall demonstrate that for all Boiler loads, the spray water flow for SH attemperation system does not exceed [8% of main steam flow], at superheater outlet and spray water flow for RH attemperation system does not exceed [3% of reheat flow] at reheater outlet, while firing any coal from within the range specified with HP heaters in service (to be indicated in the Bid) while maintaining the rated SH/RH steam temperatures at all loads within the control range of the Boiler up to an including BMCR.

i) Fans & Drives

- Satisfactory operation without undue noise and vibration while operating in isolation as well as parallel operation shall be demonstrated.
- Each Fan Set shall be capable of operating within the entire range i.e. from minimum flow to the design head-capacity point.

j) Air Heater Leakages

The Bidder shall demonstrate that the air heater air-in-leakage and maximum drift in air leakage do not exceed the guaranteed or specified value as per technical Specification. Above requirement needs to be combined even with recirculation of flue gas from downstream of ESP.

k) Boiler Capability with HP Heater out of service

The Bidder shall demonstrate steam generating capacity of Boiler when one and/or both or all strings of HP heaters are out of service, as offered. The metal temperature margins over the design value shall also be demonstrated for the most adverse operating conditions.

l) Integration among Boiler C&I and Turbo Generator C &I and BOP C&I

Boiler and its auxiliaries along with its control system (BOILER C&I), TG and its auxiliaries along with its control system (TG C&I) when integrated with Balance of

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Plant (BOP) C&I systems shall meet the permissible limits for important parameters, under various operating conditions specified.

m) ESP air leakage

ESP air-in leakage shall not be more than 1% of total gas flow at ESP inlet at the guarantee point condition.

n) ESP Test

Test to demonstrate for pressure drop across ESP not to exceed the applicable value.

8.4.4 Auxiliary Water System Pumps

Capacity and head and power consumption of all the pumps dedicated to Boiler & its Auxiliaries at the rated duty point (to be demonstrated and proved at shop with the respective job motors).

Vibration, noise level and parallel operation of all the pumps at the rated duty point shall be demonstrated at site.

8.4.5 Power Cycle Piping

Actual hanger readings, under cold and hot condition (at rated parameters) to match with those of design cold and hot hanger readings for MS/CRH/HRH / HP & LP by pass piping system.

8.4.6 Equipment Cooling Water System

Following parameters for ECW pumps dedicated to Boiler and its Auxiliaries:

- a) Parallel operation of pumps to be demonstrated at site
- b) Further pressure drop across the heat exchanger on the primary & secondary water circuit to be demonstrated at site.

Note: The Bidder needs to demonstrate performance parameters for the above auxiliaries, only if, any replacement / refurbishment / retrofitting are carried out by the Bidder in the respective Equipment/Systems in line with the scope of work. Nevertheless, Bidder shall demonstrate performance of Boiler & Auxiliaries closest to the predicted performance and within the safe limit of parameters.

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9 SPARE PARTS

The Bidder shall include in his scope of supply all the necessary mandatory spares, start up and commissioning spares and recommended spares and indicate these in the relevant schedules. The general requirements pertaining to the supply of these spares is given below:

9.1 Mandatory Spares

The list of mandatory spares considered essential by the Owner is enclosed in Annexure-II of this Specification. The Bidder shall indicate the prices for each and every item (except for items not applicable to the Bidders design) in the 'Schedule of mandatory spares' whether or not he considers it necessary for the Owner to have such spares. If the Bidder fails to comply with the above, the cost of such spares shall be deemed to be included in the Contract price. The Bidder shall furnish the population per unit of each item in the relevant Schedules. Whenever the quantity is mentioned in "sets" the Bidder has to give the item details and prices of each item.

Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the R&M Contract unless specified otherwise, and the fraction will be rounded off to the next higher whole number. Wherever the requirement has been specified as a 'set', it will mean as applicable for one complete Unit or each type & size of the Equipment being taken up for refurbishment or replacement. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.

All mandatory spares shall be delivered at site at least two months before scheduled date of initial operation of the first unit. However, spares shall not be dispatched before dispatch of corresponding main equipment.

Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise. Price of mandatory spare parts will also be evaluated.

9.2 Recommended Spares

In addition to the mandatory spare parts mentioned above, the Bidder shall also provide a list of recommended spares for [five (5)] years of normal operation of the plant and indicate the list and total prices in relevant schedule. The list shall take into consideration the mandatory spares specified and should be independent of the list of the mandatory spares. The Owner reserves the right to buy any or all of the recommended spares. The recommended spares shall be delivered at project site at least two months before the scheduled date of initial operation of first unit. However, the spares shall not be dispatched before the dispatch of the main equipment.

Prices of recommended spares will not be used for evaluation of the Bids. The price of these spares will remain valid upto execution of the Contract. However,

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the Bidder shall be liable to provide necessary justification for the quoted prices for these spares as desired by the Owner.

9.3 Start-up & Commissioning Spares

Start up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system till the handing over of the Plant. The Bidder shall provide all such start up and commissioning spares and keep an adequate stock of the same to be brought by him to the site for the plant erection and commissioning. These must be available at site before the equipment are energized. The unused spares, if any, should be removed from there, only after handing over of the plant. All start up spares which remain unused at the time shall remain the property of the Bidder.

9.4 General Requirements

The Bidder shall indicate the service expectancy period for the spares parts (both mandatory and recommended) under normal operating conditions before replacement is necessary.

All spares supplied under this Contract shall be strictly inter-changeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desiccators packs as necessary.

All the spares (both mandatory and recommended) shall be manufactured along with the main equipment components as a continuous operation as per same Specification and quality plan.

The Bidder will provide Owner with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the Owner to identify and finalize order for recommended spares.

Each spare part shall be clearly marked or labeled on the outside of the packing with its description. When more than one spare part is packed in a single case, a general description of the content shall be shown on the outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.

All cases, containers or other packages are to be opened for such examination as may be considered necessary by the Owner.

The Bidder will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on Vendors for items/ components/ equipment covered under Contract and will further ensure with his Vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such Vendors.

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The Bidder shall warrant that all spares supplied will be new and in accordance with the Contract documents and will be free from defects in design, material and workmanship.

In addition to the recommended spares listed by the Bidder, if the Owner further identifies certain particular items of spares, the Bidder shall submit the prices and delivery quotation for such spares within 30 days of receipt of such request for consideration by the Owner and placement of order for additional spares if the Owner so desires.

The Bidder shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered in the Contract. The Bidder shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the Owner at least 2 years advance notice so that the latter may order his bulk requirement of spares, if he so desires. The same provision will also be applicable to Sub-Bidders. Further, in case of discontinuance of manufacture of any spares by the Bidder and/or his sub-Bidders, Bidder will provide the Owner, two years in advance, with full manufacturing drawings, material Specifications and technical information including information on alternative equipment makes required by the Owner for the purpose of manufacture/procurement of such items.

The prices of all future requirements of spares beyond [five (5)] years shall be derived from the corresponding FOB/Ex-works price at which the order for such spares have been placed by the Owner as a part of the mandatory spares or recommended spares. FOB/Ex-works order price of future spares shall be computed in accordance with the price escalation formula to be furnished by Bidder indicating base price reference variation indices for material, labour etc. Based on the formula and considering escalation indices prevailing at the time of order of spares, order price shall be worked out. The base indices will be counted from the scheduled date of successful completion of trial operation of the last plant/equipment under the project. The above option for procuring future recommended spares by the Owner shall remain valid for the period of fifteen [fifteen (15)] years from the date of successful completion of trial operation of the last plant/equipment. In case the spare parts from the same sub-Vendor are not available due to obsolescence or any other reason, the Bidder shall supply the spares for a period of [fifteen (15)] years from an alternative source.

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10 ANNEXURE

10.1 Annexure-I (List of Existing Drawing)

{Available as Build/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned in Annexure-I for their information & familiarization of the existing Unit}

10.2 Annexure-II (Mandatory Spares)

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II}

10.3 Annexure-III (List of Sub-Vendor)

{List of Sub-vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the format in Annexure-III}

10.4 RLA/CA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.5 EA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.6 Baseline Study Report

{Not attached with this document. This is to be provided by Utilities}

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-I, ANNEXURE-I
LIST OF EXISTING DRAWING**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-I

List of Existing Drawing

{Available as Build/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned below for their information & familiarization of the existing Unit.}

i) MECHANICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[General Layout (Plot Plan)]
2	[.....]	[Main plant Layout at + 0.00 M]
3	[.....]	[Main Plant Equipment Layout Plan at Different Elevations]
4	[.....]	[Main plant Layout – Cross Section]
5	[.....]	[General layout battery limit]
6	[.....]	[Symbol /Legends]
7	[.....]	[P&ID for Main Steam, CRH & HRH Steam System]
8	[.....]	[Flow Diagram for Boiler Proper]
9	[.....]	[Flow Diagram Air and Flue gas path]
10	[.....]	[Flow Diagram Fuel oil System]
11	[.....]	[Flow Diagram Chemical feed system]
12	[.....]	[Flow Diagram Auxiliary Steam System]
13	[.....]	[Flow Diagram DM Cooling Water System]
14	[.....]	[Flow Diagram Compressed Air System]
15	[.....]	[Arrangement of Bunker Bay Section]
16	[.....]	[Boiler Sectional Drawing]

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S.No.	Drawing/Document No.	Title
17	[.....]	[Boiler Plan/Foot Print]
18	[.....]	[ESP Elevation].
19	[.....]	[ESP Foot Print]

ii) ELECTRICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[Key Single line diagram]

iii) CONTROL & INSTRUMENTATION

S.No.	Drawing/Document No.	Title
1	[.....]	[Plant DCS Configuration Drawing]
2	[.....]	[SG Integral Control System Configuration Drawing]
3	[.....]	[Instrument Installation Diagram (Pressure Transmitter)]
4	[.....]	[Instrument Installation Diagram (Flow Measurement)]
5	[.....]	[Instrument Installation Diagram (Pressure Gauge)]
6	[.....]	[Instrument Installation Diagram (DP Measurement)]
7	[.....]	[Instrument Installation Diagram (Level Measurement using gauge & switch)]
8	[.....]	[Instrument Installation Diagram (Level Measurement using DP Transmitter & Displacer type Transmitter)]
9	[.....]	[Instrument Installation Diagram (Level Measurement for Open/Close Vessels)]
10	[.....]	[Instrument Source Connection Details – Pressure Measurement on Pipe]
11	[.....]	[Instrument Source Connection Details – Pressure Measurement on Duct]

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S.No.	Drawing/Document No.	Title
12	[.....]	[Instrument Source Connection Details – Temperature Measurement on Pipe]
13	[.....]	[Instrument Source Connection Details – Temperature Measurement on Duct]
14	[.....]	[Instrument Source Connection Details – Flow Measurement]
15	[.....]	[Instrument Source Connection Details – Flow Measurement]
16	[.....]	[Instrument Source Connection Details – Level Measurement]
17	[.....]	[Instrument Source Connection Details – Level Measurement]
22	[.....]	[Grounding Scheme for Cabinets/Panels]
23	[.....]	[C&I Power Supply distribution cabling Philosophy & Scope Diagram]
24	[.....]	[C&I Instrumentation cabling Philosophy & Scope Diagram]
25	[.....]	[Typical PLC based Control System Configuration Diagram]
26	[.....]	[Boiler Protection System Configuration Diagram]
27	[.....]	[Drive Control Philosophy-Bidirectional drive (ON-OFF Type MOV)]
28	[.....]	[Drive Control Philosophy-Bidirectional drive (Inching Type MOV)]
29	[.....]	[Drive Control Philosophy- LT drive]
30	[.....]	[Drive Control Philosophy- HT drive]
31	[.....]	[Drive Control Philosophy-Solenoid Valve]
32	[.....]	[Typical Block Diagram for Furnace Flame Viewing System]
33	[.....]	[Drive Control Philosophy- VFD]

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iv) CIVIL

S.No.	Drawing No.	Description
1	[.....]	[Geotechnical Investigation Report of the site]
2	[.....]	[Road, drains, trench layouts etc., as available]
3	[.....]	[Design documents of the existing structures]
4	[.....]	[Drawings for loading data of the existing structures & foundations]

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OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-I, ANNEXURE-II
MANDATORY SPARES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-II

Mandatory Spares

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II. Available Mandatory spares of the existing Unit, which can be used after completion of R&M work, shall also be verified before finalization of the below mentioned Spare List. Mandatory Spares shall be defined as for each Unit. The unit, 'set', indicated in the table below will mean as applicable for one complete Unit or each type & size of the Equipment being taken up for refurbishment or replacement.}

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1. MECHANICAL

1.1 [Boiler and Auxiliaries – Mechanical Spares]

1.2.1 Pressure Parts

A. Economiser

- i) Straight tube : 200m for each size, type, thickness and material
- ii) Coil end bends : 50 nos. of each size, type, radius and material.

B. Water wall

- i) Straight tube and spiral tube : 200m quantity for each thickness, size and material.
- ii) Bends for burner elevation : 20 nos. for each size, type, thickness, radius and material.
- iii) Bends for Furnace opening : 10 nos. for each size, type, thickness, radius & material.

C. Low temperature super heater (LTSH)

- i) Straight tube of 8-10 m length : 300m length for each size, thickness, and material.
- ii) Bends : 20 nos. of each size, type, thickness, radius and material.
- iii) bends/offsets for supply tubes : 20 nos. each

D. Intermediate temperature superheater (ITSH)/ Platen superheater

- i) Straight tube : 60 m length of each size, thickness, and material.
- ii) Bends : 10 nos. of each size, thickness, radius, type and material.

E. High temperature superheater/ Final superheater

- i) Straight tube : 75m length of each size, thickness, and material.
- ii) Bends : 10 nos. of each size, thickness, type, radius and material

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iii) Dissimilar metal weld joint spot piece : 25 nos. of each size, radius and thickness, types & materials

F. Reheater

i) Straight tube : 100m length of each size, type and material

ii) Bends : 10 nos. of each size, thickness, type, radius and material

iii) Dissimilar metal weld joint spot piece : 25 nos. of each size, radius and thickness, types & materials

1.2.2 Headers

A. Water wall headers

i) Hand hole plate : 4 nos.

ii) Yoke plate with fasteners : 4 sets

B. Superheater headers

i) Hand hole plate assembly : 2 nos. of each type

i) Radiographic plug : 6 nos.

C. Reheater headers

i) Hand hole plate assembly : 2 nos. of each type

ii) Radiographic plug : 6 nos.

1.2.3 Superheater and Reheater Attenuation System

Desuperheater liners : 2 sets of each type

1.2.4 Steam Drum (if applicable)

i) Manhole gasket for drum : 12 nos.

ii) Local water level gauge : 1 set
glass assembly

iii) Spares for direct water : 1 set
level gauge

(such as port assembly,
glass strip lamps spring cones, gaskets etc.)

iv) Spares for remote level indicator
(such as seal ring bull deflector
plate, gasket and diaphragm) : 1 set

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- v) Spare isolating valve assembly for
above gauge glass : 1 set
For separator (if applicable) spares list to be furnished by the bidder along with the bid document.

1.2.5 Boiler Water Forced Circulation Pumps

- i) Complete pump and motor
assembly : 1 no.
- ii) Motor stator winding : 1 no.
- iii) Journal bearing : 2 no
- iv) Thrust bearing : 2 no
- v) Casing wear rings : 2 no
- vi) Impeller wear rings : 3 no
- vii) Set of gaskets : 5 sets
(All gaskets including
heat exchanger)
- viii) Set of 'O' rings : 5 sets
- ix) Gland packings : 5 sets
- x) Motor heat exchanger : 1 set
- xi) Thermocouples : 1 set
- xii) Temperature switches : 1 set
- xiii) Pressure switches : 1 set
- xiv) Flow switches : 1 set

1.2.6 Fans

A. ID Fans

- i) Radial/Axial type (as applicable)
- a) Fan rotating element (complete assembly) : 1 set
- b) Impeller liners : 2 sets
- c) Casing liners : 2 set
- d) Motor bearings : 2 sets
- e) Fan bearings : 2 sets
- f) Bearing Housing : 1 No
- g) Seals, 'O' rings oil rings for
all the fan bearings : 6 sets
- h) Lube oil system

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- Pump assembly : 1 no.
- Pressure regulator : 2 nos.
- Filters : 8 nos.
- Coupling between oil pump and motor : 2 nos.
- Coolers : 1 set
- i) Inlet guide vanes (IGV)if applicable : 1 set
- j) Fan blades : 1 set
- k) Spares for blade bearing assembly
 - i) Bearing : 2 sets
 - ii) 'O' rings : 2 sets
 - iii) Bushes : 2 sets
 - iv) Metallic rings : 2 sets
 - v) Intermediate piece (if applicable) : 2 sets
 - vi) Hydraulic servomotor : 2nos
 - vii) Fan Bearing Housing : 1 set
- l) ID Fan Motor complete : 1 no.

B. FD fans

- i) Fan rotor complete (including impeller and shaft) : 1 no.
- ii) Fan bearings : 1 set
- iii) Bearing Housing : 1 no
- iv) Motor bearings : 1 set
- v) Fan blades : 2 sets
- vi) Spares for blade bearing assembly
 - a) Bearings : 2 sets
 - b) 'O' rings : 2 sets
 - c) Bushes : 2 sets
 - d) Metallic rings : 2 sets
 - e) Intermediate piece : 3 sets
- vii) Lube oil system
 - a) Pump assembly : 1 no.
 - b) Pressure regulator : 3 nos.
 - c) Filters : 8 nos.
 - d) Coupling between oil pump and motor : 2 nos.
 - e) Coolers : 1 set
- viii) Couplings between fan

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- and motor : 2 nos.
ix) Hydraulic servomotor : 2 nos.
x) FD fan Motor complete : 1 no.

1.2.7 Coal Pulverizers

i) Grinding elements

- Rollers/ tyres/ grinding balls : 2 sets
Bull ring segments/ bowl/ rings : 1 set

Note: One set of grinding element above is defined as under

1 set = (Grinding elements needed for complete replacement of one mill) x A

Where

A = [(8000 x N)/ GWL. Rounded off to nearest whole number]

GWL = Guaranteed wear life of grinding element as offered by Bidder

N = Number of mills installed for one Boiler unit

- ii) Gear box internals (expect bearings and seals) : 1 sets*
iii) Mill motor complete : 1no
iv) Mill motor bearing : 1 set
v) Complete gear box : 2 sets*
vi) Bearings for mills : 2 sets*
vii) Seals and rings for gear box : 2 sets*
viii) Liners with brackets & fasteners : 3 sets*
ix) Discharge valve assembly : 2 sets*
x) Multiport outlet & liners : 2 sets
xi) Mill main shaft/ yoke : 1no.
xii) Journal & Spring : 2nos.
xiii) Hydraulic loading cylinder : 3nos.
xiv) Filter cartridges : 6nos.
xv) Actuators (pneumatic/hydraulic) (complete) : 1no. of each type
xvi) Actuators (pneumatic/ hydraulic) spare kits : 1 set of each type
xvii) Mill bottom : 2nos.
xviii) Bowl hub assembly/Ring seat : 1nos.
xix) Lube oil system

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- a) Pump and motor coupling : 3nos.
- b) Pump assembly : 2nos.
- c) Motor assembly : 2nos.
- d) Filters : 12 nos.
- e) Pressure regulator : 2nos.

xx) Oil cooler assembly for coal mills : 2 nos.

xxi) Bearings for gear box : 3 sets*

*One set means complete replacement of one mill

1.2.8 Feeders

- i) Belt : 6 sets*
- ii) Belt drive feeder motor : 2nos.
- iii) Belt drive reducer : 2nos.
- iv) Clean out conveyor motor : 2nos.
- v) Clean out conveyor reducer : 2nos.
- vi) Counter assembly (complete): 2nos.
- vii) Head pulley assembly (complete) : 2nos.
- viii) Weight sensing system

- a) Weighing oil : 2nos.
- b) Weighing spare roller assembly : 2nos.
- c) Drag link assembly : 2nos.

- ix) Tension roll : 2nos.
- x) Worm : 2nos.
- xi) Worm wheel : 2nos.
- xii) Feeder gate : 2nos.
- xiii) Actuator : 1no. of each type

1.2.9 Coal Burners and Coal Pipe Bends

Bidder to provide the complete list of spares as required.

1.2.10 Seal Air Fan

- i) Impeller with shaft : 1 no.
- ii) Bearings and seals : 2 sets
- iii) Motor bearings : 2 sets
- iv) Seal Air Fan Motor complete : 1 no.

* One set means complete replacement of one fan

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1.2.11 Regenerative Air Preheaters (RAPH)

- i) Support bearing : 2 nos.
- ii) Guide bearing : 2 nos.
- iii) Lubricating system of support and guide bearing
 - a) Pump assembly : 1 no.
 - b) Pressure regulator : 1 no.
 - c) Filters : 6 nos.
 - d) Pump motor coupling : 3 nos.
 - e) Coolers : 1 set
- iv) Radial seals : 4sets
- v) Axial seals : 4 sets
- vi) Circumferential or bypass seals : 2 sets
- vii) Rotor post seals : 4 sets
- viii) Speed reducer
 - a) Complete speed reducer(gear box) : 1 set
 - b) Speed reducer gears, pinions and shaft : 1 set
 - c) Speed reducer bearings : 1 set
 - d) Speed reducer seals and gaskets : 2 sets
 - e) Speed reducer clutch assembly : 2 nos.
- ix) Fluid coupling 3 nos.
- x) Other couplings with inserts and fasteners : 2 nos.
- xi) Solenoid valves : 2 nos.
- xii) Spare kit for rotor stoppage alarm : 1 set
- xiii) Spare kit for fire sensing device 1 set
- xiv) Spares for cleaning device
 - a) Worm and worm wheel for gear reducer : 1 set
 - b) Coupling : 1 set
 - c) Bearing and seals for speed reducer : 1 set
 - d) Bearing for cleaning device : 2 sets

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- xv) Bushings for worm gear reducer : 1 set
 - xvi) Actuators for isolation dampers : 2 no.
 - xvii) Cold, intermediate and hot end baskets : 1set for each type and size
 - xviii) RAPH motor complete : 1 no. of each type
- *One set means complete replacement for one APH*

1.2.12 Fuel Oil System

A. Heavy fuel oil system

- i) Fuel oil guns : 2nos
- ii) Oil gun nozzle (with back plate, mixing plate and cap nut) : 4 sets
- iii) Oil gun flexible hoses (including for guide pipe, air line) : 4 sets
- iv) Burner isolation valves
 - a) Isolation valves : 12 nos. or 10% whichever is higher
 - b) Gaskets for above valves : 2 sets
 - c) Gland packings for above valves : 2 sets
- v) Atomizing steam pressure reducing valve : 1 no.
- vi) Electro pneumatic quick closing valves used in oil burner area, each type size & model (complete valve with servo motors, solenoid & its limit switches for ol, air, steam : each 1 no
- vii) Oil shut off valve of each type, size & model : 1 no
- viii) Check valve of each type, size & model : 1 no
- ix) Limit switches for the displacement: device : 2 nos
- x) Steam traps : 4 nos
- xi) Heavy oil temperature control valve : 1 no.

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xii) Actuators of above valves : 1 no. of each type and rating

1.2.13 Light oil system

i) Light oil gun : 1 set
 ii) Oil gun nozzle (with back plate, mixing plate and cap nut) : 2 sets
 iii) Burner isolation valves
 a) Isolation valves : 4nos
 b) Gaskets for above valves : 2 sets
 c) Gland packings for above valves : 2 sets
 iv) Light oil pressure control valve : 1 no.
 v) Light oil main trip valve complete : 1 no.

1.2.14 HEA Igniters

i) HEA retractor : 2 sets
 ii) HEA spark rod : 2 sets
 iii) HEA spark tip : 2 sets
 iv) HEA exciter : 4 nos. of each type and rating
 v) Solenoid valves : 4 nos. of each type and rating
 vi) Limit switch : 4 nos. of each type and rating
 vii) Solenoid valve coil : 8 nos. of each type and rating
 viii) HEA spark gap : 8 nos.
 ix) HEA transformer : 8 nos.
 x) HEA rectifier : 8 nos.
 xi) HEA inductor : 8 nos.
 xii) Resistor : 8 nos. of each type and rating
 xiii) Capacitor : 4 nos. of each type and rating

* One set means one complete replacement of one HEA igniter

1.2.15 Soot Blowers

i) Complete assembly of water wall Deslaggers (water lances) : 2 nos.
 ii) Motor for water wall deslaggers
 a) For each drive : 3 nos.
 iii) Complete valve assembly for water wall deslaggers : 4 nos.

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- iv) Motor for long travel retractable soot blower(Steam soot blowers in convective pass)
 - a) For rotary motion : 2 nos.
 - b) For traverse motion : 2 nos.
- v) Complete valve assembly for long retractable soot blower : 2 nos.
- vi) motors for air preheater soot blower : 1 no. of each type
- vii) Reduction gear box and motor for air preheater soot blower oscillation : 1 no of each type
- viii) Complete valve assembly for air preheater soot blower : 1 no. of each type
- ix) Bearing and oil seals for
 - a) Long retractable soot blower : 2 sets
 - b) Water wall deslagger : 3 sets
- x) Complete steam safety valve assembly for soot blowing system : 1 no.
- xi) Steam pressure control valve assembly : 1 no.
- xii) Steam pressure control valve spares
 - a) Stem and disc assembly : 2 sets
 - b) Gaskets : 6 sets
 - c) Gland packings : 4 sets
 - d) Seat rings : 2 sets
- xiii) Long retractable soot blower assemblies complete : 1 no. of each type
- xiv) Limit switches : 2 nos. of each type and rating
- xv) Complete power pack assembly for long retractable soot blower : 2 nos. (1 no. for rotary no. for transverse)
- xvi) Spare set of rotary and transverse chain for long retractable soot blowers : 1 no. of each type and size
- xvii) Spares for rack gear assembly
 - a) Set of gears and shaft (Spur and worm) : 1 set
 - b) Rack and pinion : 1 set
- xviii) Thermocouples for temperature probes : 1 no. of each type and size

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- xix) Soot blower nozzle : 10 % of populaaton
xx) Soot blower lance tube : 10 % of population

1.2.16 Valves

A. Steam drum (if applicable) safety valves

- i) Upper adjusting ring : 2 nos. of each type
ii) Lower adjusting ring : 2 nos. of each type
iii) Locking pin set : 2 nos. of each type
iv) Safety valve disc : 2 nos. of each type
v) Safety valve stem : 1 no.
vi) Valve spindle : 2 nos.
vii) Guide : 1 no.

B. SH safety valves

- i) Disc : 2 nos. of each type
ii) Upper adjusting ring : 2 nos.
iii) Lower adjusting ring : 2 nos.
iv) Valve spindle : 1 no.
v) Set of washers : 2 sets of each type
vi) Guide : 1 no. of each type
vii) Set of locking pins : 2 sets of each type

C. Hot RH safety valves

- i) Disc : 1 no. of each type
ii) Upper adjusting ring : 1 no. of each type
iii) Lower adjusting ring : 1 no. of each type
iv) Valve spindle : 1 no. of each type
v) Set of washers : 1 set of each type
vi) Set of pins : 1 no. of each type
vii) Guide : 1 no. of each type

D. Cold RH safety valves

- i) Disc : 1 no. of each type
ii) Upper adjusting ring : 1 no. of each type
iii) Lower adjusting ring : 1 no. of each type
iv) Valve spindle : 1 no. of each type
v) Locking pin set : 1 set of each type
vi) Guide : 1 set of each type
vii) Set of washers : 1 set

E. Electromatic relief valve

- i) Complete electromatic relief valve : 1 no. of each type

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ii) Spares for above:

- a) Disc for main valve : 2 nos. of each type
 - b) Spring for main valve : 2 nos. of each type
 - c) Seal rings for main valve : 2 nos. of each type
 - d) Seal bushing for main valve : 2 nos. of each type
 - e) Disc and steam assembly
for pilot valve : 2 nos. of each type
 - f) Bushing for pilot valve : 2 nos. of each type
 - g) Spring for pilot valve : 2 nos. of each type
 - h) Seal ring : 2 nos. of each type -
- If air assisted safety valves are envisaged, necessary spares to be added..*

F. Superheater spray control valve

- i) Complete superheater spray control valve : 1 nos. of each size and type

ii) Spares for the above:

- a) Gland packings set : 4 sets
- b) Pressure seal gasket : 4 sets
- c) Stem : 2 nos.
- d) Plug valve : 2 nos.

G. Reheater spray control valve

- i) Complete reheater spray control valve : 1 nos. of each size and type

ii) Spares for the above:

- a) Gland packings set : 6 sets
- b) Pressure seal gasket : 6 sets
- c) Stem : 2 nos.
- d) Plug valve : 2 nos

H. Superheater Spray Block Valve

- i) Gland packing set : 2 sets of each type
- ii) Pressure seal gasket : 2 nos. of each type
- iii) Stem : 2 nos. of each type
- iv) Valve plug : 2 nos. of each type

I. Reheater Spray Block Valve

- i) Gland packing set : 2 sets of each type
- ii) Pressure seal gasket : 2 nos. of each type
- iii) Stem : 2 nos. of each type

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iv) Valve plug : 2 nos. of each type

1.2.17 Boiler Main Steam Stop Valve

- i) Set of gland packings : 6 sets
- ii) Pressure seal gaskets : 8 nos.
- iii) Stem : 1 no. of each type (1 no. for main valve and 1 no. for integral bypass valve)
- iv) Disc : -do-
- v) Seat rings : -do-
- vi) Fasteners : -do-
- vii) Actuator : -do-

1.2.18 Start Up Vent Valves

- i) Stem : 1 no.
- ii) Disc : 1 no.
- iii) Body seat rings : 2 sets
- iv) Gland packings : 3 sets
- v) Pressure seal rings : 3 nos.
- vi) Fasteners : 1 set

1.2.19 Economiser Recirculation Valve

- i) Valve Stem : 1 no.
- ii) Disc : 1 no.
- iii) Body seat rings : 1 set
- iv) Gland packings : 2 sets
- v) Pressure seal rings : 2 sets.
- vi) Boiler Feed Check Valve
 - (i) Body seat rings : 2 nos.
 - (ii) Flap : 2 nos.
 - (iii) Pressure seal ring : 2 nos.
 - (iv) Gland packings : 4 sets
 - (v) Fasteners : 1 set

1.2.20 Auxiliary Steam Pressure Reducing and Desuperheating (PRDS) System

A. High capacity PRDS system (MS)

- i) Desuperheater liners : 1 set
- ii) Pressure reducing cum desuperheating valves
 - a) Stem : 1 no.

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- b) Disc : 1 no.
- c) Body seat rings : 2 nos. for each type, size and rating of valves
- d) Gland packings : 3 nos. for each type, size and rating of valves
- e) Pressure seal ring : 3 nos.
- f) Gasket : 3 nos.
- iii) Spray water line control valves
 - Valve trim including cage : 1 no. for each size, type and rating of valves
 - plug, stem, seat rings, guide
 - bushings, stem packing
- B. Low capacity PRDS system (CRH)
 - i) Desuperheater liners 1 set
 - ii) Pressure reducing cum desuperheating valves
 - a) Stem : 1 no.
 - b) Disc : 1 no.
 - c) Body seat rings : 2 nos. for each type, size and rating of valves
 - d) Gland packings : 3 nos. for each type, size and rating of valves
 - e) Pressure seal ring : 3 nos.
 - f) Gasket : 3 nos.
 - iii) Spray water line control valves
 - Valve trim including cage : 1 no. for each size, type and rating of valves
 - plug, stem, seat rings, guide
 - bushings, stem packing

1.2.21 Bottom ash removal system

- 1. Furnace bottom ash removal system
 - a. Wet type slag removal equipment
 - i) Round chain : 2 sets
 - ii) Nylon rings : 8 sets
 - iii) Shaft seals : 8 sets
 - iv) Round core packing : 8 sets
 - v) PIV Spare chains : 1 no.
 - vi) Roller chain between gearing

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- and driving shafts* : 1 set
- vii) Bearings of various type* : 2 nos. of each type
- viii) Drive motor* : 1 no. of each type
- ix) Wear plates* : 1 set
- x) Tension pulley with bearing* : 1 no.
- xi) Deflection station* : 1 no.
- xii) Central sprocket wheel discs* : 1 no.
- xiii) Water proof bin assembly* : 8 nos.

1.2.22 Chemical dosing system(if applicable)

1. HP chemical dosing system

- i) Drive shaft cum worm* : 1 no.
- ii) Drive worm wheel* : 3 nos.
- iii) Connecting rod plate* : 1no.
- iv) Cross head* : 1no.
- v) Cross head guide bush* : 3 nos.
- vi) Plunger* : 1no.
- vii) Discharge NRV* : 1no.
- viii) Plug* : 1no.
- ix) Oil seal* : 1no.
- x) Suction NRV* : 1no.
- xi) Washer* : 2nos.
- xii) Gland nut* : 2nos.
- xiii) HP dosing pump assembly* : 1no.

1.2.23 Scanner (Cooling air fans)

- i) Filter screens for cooling air fans* : 1 no
- ii) Fan impeller* : 1 no
- iii) Motor AC* : 1 no
- iv) Seal* : 2 nos. of each type
- v) Bearings* : 1 no. of each type

1.2.24 Power Cycle Piping

- i) Spare gasket for all the gate valves of sizes 15mm NB to 500mm NB* : 5% of each type & size per unit.
- ii) Spare set of gland packings of all the gate valves for all sizes* : -do-

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- iii) Spare gasket for all the globe valves for sizes 15mm NB to 500 mm NB : -do-
- iv) Spare set of gland packings of all the globe valves for all sizes : -do-
- v) Spare gaskets for NRV for all the valves : -do-
- vi) Spare set of gaskets for safety relief valves for all sizes : -do-
- vii) Complete gate valves assembly upto the size of 50NB : -do-
- viii) Complete angle valves upto the size of 50 NB : -do-
- ix) Complete globe valves upto the size of 50 NB : -do-
- x) Complete NRV's upto the size of 50 NB : -do-
- xi) Complete needle valves upto the size of 50 NB : -do-
- xii) Spring hangers : 5% of each type & stiffness of quality
- xiii) Gasket for each flanged connection on HP steam and feed line, jacking oil lines : 2 nos.
- xiv) Steam traps and Y-strainers for each size, type and rating : 10% of total population
- xv) SH spray valve (control) : 1no.
- xvi) RH spray valve (control) : 1no.
- xvii) Other valves
 - Each type, size & class 100mm below : 1no.
 - Each type, size & class 100mm above : 10% or 2nos. whichever is lesser
- xviii) Critical piping

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For MS, HRH, CRH, BFD, HP-LP Bypass, Aux PRDS Systems, Spray Water and all Miscellaneous Piping including Drains (of boiler scope) as follows:

- *Pipes of dimension 100Nb and : 6 meters
above with IBR certification in
form IIIA*
- *Pipes of dimension below
100 NB with IBR certification : 6 meters
in Form III B.*
- *Gaskets for the system including
all types of metal gaskets, grafoil : 10%*

1.2.25 After Burning Grate (ABG)

ABG (1 set = requirement of one ABG)

- i) Drive shaft : 2 nos.*
- ii) Return shaft : 2 nos.*
- iii) Louvre plates : 1 set*
- iv) Side supports : 1 set*
- v) Intermediate supports : 1 sets*
- vi) Rollers : 1 set*
- vii) Lower support bar : 1 set*
- viii) PIV Gear box : 1 no*
- ix) Constant speed Gear box : 1no*
- x) Clutch assembly : 1no*
- xi) Coupling motor to PIV : 4 nos*
- xii) PIV chain assembly : 4 nos.*
- xiii) Plummer block with bearing-*
 - a) For drive shaft : 2 nos.*
 - b) For return shaft : 2 nos.*
- xiv) Drive sprocket : 1 set*
- xv) Return shaft pulley : 1 set*
- xvi) ABG Motor complete : 1 no.*

1.2.26 Electrostatic Precipitator (ESP)

- i) Support insulator : 6 nos.*

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- ii) Shaft insulator : 6 nos.
- iii) Bushing insulators assembly : 4 nos.
- iv) Emitting electrodes
 - a) Helical wire type : 5% of the installed quantity in one ESP
 - b) Wire pipe in rigid frame : 10% of the installed quantity in one ESP
 - c) Mast type : 2% of the installed quantity in one ESP
- v) Collecting electrode : 2% of the installed quantity in one ESP
- vi) Inner arm assembly : 20 nos. each for collecting and emitting system
- vii) Outer arm assembly : 10 nos. each for collecting and emitting system
- viii) Plain bearing : 20 nos. of each type and size
- ix) Shock bar/ anvil : 60 nos. of each type and size
- x) Rappers
 - a) For electric rappers
 - Assembled rapper/ drop rods : 20 nos. of each size and type
 - Coil assembly along with sleeve : 4 nos.
 - Casing : 4 nos.
 - Gaskets and packing : 10 nos. of each size and type
 - b) For tumbling rappers
 - Hammers : 20 nos. of each size and type
 - Bearing components : 4 nos.
 - Shafts : 4 nos.
 - Gear motors : 4 nos.
- xi) Transformer rectifier set
 - a) Complete set : 2 nos.
 - b) High voltage insulator : 4 nos.
 - c) Switches and gaskets : 1 set

(One set means one complete replacement for all the TR sets)

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of one ESP)

xii) Control system

- a) *Transformer-rectifier set controller: 2 nos.*
- b) *Rapper controller complete : 2 nos.*
- c) *Communication controller complete : 2 nos.*
- d) *Electronic cards*
 - *For rapper controller and ESP management system : 1 set*
 - *For transformer rectifier controller : 2 sets*
- e) *Display unit : 2 nos. of each type*
- f) *Keyboard : 2 nos. of each type*
- g) *Push buttons for:*
 - *TR set controller: 2 sets*
- h) *Indicator lamps : 1 set*
- i) *Control fuse : 1 set*
- j) *Power fuse : 1 set*
- k) *Thyristor fuse : 1 set*
- l) *Thyristor of transformer rectifier controller : 2 sets*

xiii) Rapping motor complete : 5 nos. of each type and rating]

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2. ELECTRICAL

S.No / Cl. No.	Item	Quantity	Remarks		
2.1 General (VENTILATION & AIR CONDITIONING) (To be repeated for each type & rating)					
2.1.1	Contactors	Min. 1 no. of each type			
2.1.2	Over load relay	2 nos. of each type			
2.1.3	Relay/ Timers	3 nos. of each type			
2.1.4	Fan motor	30 % of each rating			
2.1.5	Switch fuse unit/MCCB/ELCB	2 nos. of each rating			
2.1.6	Blower motor	30% of each rating			
VFD System (To be repeated for each type & rating)					
2.1.7	Electrical Cards				
2.1.8	Control modules	1 No of each type & rating			
2.1.9	I/o modules	2 Nos. of each type & rating			
2.1.10	Power supply modules	2 Nos. of each type & rating			
2.1.11	Thyristor gate module including gate transformer	10% of installed quantity			
2.1.12	Exciter module	1 No.			
2.1.13	Thyristor bridge leg	10%			
2.1.14	Over voltage limiter and surge suppressor network	1 set			
2.1.15	Power & Control fuse	100% of installed quantity			
2.1.16	Control transformer	1 no. of each type & rating			
2.1.17	Contractor/load break switch	1 No.			
2.1.18	CT/VT	1 No. of each type & rating			
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S.No / Cl. No.	Item	Quantity	Remarks
2.1.19	Indicating lamps	100% of installed quantity	
2.1.20	Auxiliary contractors & relays	10% of installed quantity	
2.1.21	Panel mounted meters	1 No. of each type & rating	
2.1.22	Panel mounted printer	1 No.	
2.1.23	Hand held unit	2 Nos.	
415 V NON-SEGREGATED PHASE BUS DUCT (To be repeated for each type & rating)			
2.1.24	Bus support Insulator	15 Nos. each type and rating	
2.1.25	Rigid joint	5 Nos. each type and rating	
2.1.26	Copper/Aluminum flexible for main run and tap offs bus ducts	1 Set of each type and rating per phase	
2.1.27	Seal of bushing for main run and tap offs bus ducts	1 Set of each type and rating per phase	
2.1.28	Jumpers, if any	2 No. of each type	
2.1.29	Drain Plugs with cap	3 Nos.	
2.1.30	Gaskets	3 sets of each type and rating	
2.1.31	Rubber bellow for main run and tap offs bus ducts	1 Set of each type and rating per phase	
2.1.32	Belleville washers	5 Nos.	
2.1.33	Densal or equivalent compound	1 kg.	
2.1.34	Space Heaters	1 set	
2.1.35	Silica gel breather	1 No.	
TRANSFORMER (Dry Type) (To be repeated for each type & rating)			
2.1.36	Complete winding temperature equipment	1 set	
2.1.37	CTs of each type and rating	1 set	

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S.No / Cl. No.	Item	Quantity	Remarks
2.1.38	<i>Thermistor</i>	<i>2 sets</i>	
2.1.39	<i>Temperature surveillance unit</i>	<i>2 nos.</i>	
2.1.40	<i>Tap changer contact</i>	<i>1 set</i>	
2.1.41	<i>Set of gaskets (other than that with the bushing)</i>	<i>1 No.</i>	
2.1.42	<i>PRV</i>	<i>1 No.</i>	
2.1.43	<i>Support insulators</i>	<i>2 sets</i>	
<i>TRANSFORMERS (ONAN) (If applicable for VFD drives) (To be repeated for each type & rating)</i>			
2.1.44	<i>HV bushing</i>	<i>4 nos.</i>	
2.1.45	<i>LV Bushing</i>	<i>4 Nos.</i>	
2.1.46	<i>LV Neutral Bushing</i>	<i>2 nos.</i>	
2.1.47	<i>Bushing CT (LV) of each rating</i>	<i>2 nos.</i>	
2.1.48	<i>Complete set of gaskets</i>	<i>2 sets</i>	
2.1.49	<i>Valve of each type</i>	<i>4 nos.</i>	
2.1.50	<i>Magnetic oil level indicator</i>	<i>2 nos.</i>	
2.1.51	<i>Buchholz Relay</i>	<i>1 no.</i>	
2.1.52	<i>Winding temperature indicator</i>	<i>2 nos.</i>	
2.1.53	<i>Dial type oil temperature indicator</i>	<i>2 nos.</i>	
2.1.54	<i>Silica gel breather</i>	<i>2 nos.</i>	
2.1.55	<i>Buchholz Relays</i>	<i>2 nos.</i>	
2.1.56	<i>Radiator unit</i>	<i>1 no.</i>	
2.1.57	<i>Pressure relief device</i>	<i>2 nos.</i>	
2.1.58	<i>Tap changer contact</i>	<i>1 set</i>	
<i>415 V Switchgear (To be repeated for each type & rating)</i>			
2.1.59	<i>Busbar support insulators</i>	<i>10 Nos. of each type</i>	
2.1.60	<i>Current transformers</i>	<i>1No. of each type & rating</i>	
2.1.61	<i>Potential transformers 415/110V</i>	<i>1 No.</i>	
2.1.62	<i>Male contact of ACB (main and aux.)</i>	<i>1 set</i>	
2.1.63	<i>Female contact of ACB (main and aux.)</i>	<i>1 set</i>	

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S.No / Cl. No.	Item	Quantity	Remarks
2.1.64	Limit switch of ACB	3 Nos.	
2.1.65	Spring charging motor of ACB	3 Nos.	
2.1.66	Closing coil of ACB	2 Nos.	
2.1.67	Tripping coil of ACB	2 Nos.	
2.1.68	Breaker control switch	2 Nos.	
2.1.69	Protection Relays	1No. of each type	
2.1.70	Electronic overload relays with single phase preventers	1 no. of each type	
2.1.71	Relays of each type and rating	1 no.	
2.1.72	Auxiliary relay	2 Nos. of each type	
2.1.73	Load break switch	1 no. of each type	
2.1.74	Auxiliary contact assembly of breaker		
	i) Test position	3 sets of each type	
	ii) Service position	3 sets of each type	
2.1.75	Arc chute for CBs	5 nos. of each type	
2.1.76	Arching contacts (for fixed)	3 nos. of each rating	
2.1.77	Arching contacts (for moving)	3 nos. of each rating	
2.1.78	Check synchronizing relay	1no	
2.1.79	MCB/MCCB	1no. of each rating	
2.1.80	Timers	2 nos. of each type per board	
2.1.81	Fuse base	10 nos of each type	
2.1.82	Switch Fuse Assembly	1 no. of each type and rating	
2.1.83	Power and control circuit fuses	10 Nos. of each type	
2.1.84	Selector switch	5 nos. of each type	
2.1.85	Voltmeter selector switch	5 nos. of each type	
2.1.86	Ammeter selector switch	5 nos. of each type	
2.1.87	Local-Remote selector switch	3 nos. of each type	
2.1.88	Terminal blocks	10 sets	
2.1.89	Aux & Power Contactors	5 nos of each type	
2.1.90	Indicating Lamp assembly (LED LVGP	10 Nos. of each type & colour	

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S.No / Cl. No.	Item	Quantity	Remarks
	<i>type)</i>		
2.1.91	<i>Phase sequence meter</i>	<i>2 Nos.</i>	
2.1.92	<i>MPCB</i>	<i>1no of each type and rating</i>	
2.1.93	<i>MCCB</i>	<i>1no of each type and rating</i>	
2.1.94	<i>Single phase control transformer (415/110V)</i>	<i>1 no. of each type</i>	
2.1.95	<i>Interposing relay</i>	<i>1 no. of each type</i>	
2.1.96	<i>Push button with contact element</i>	<i>1 no. of each type</i>	
2.1.97	<i>Meters</i>	<i>1 no. of each type</i>	
2.1.98	<i>Intelligent control modules</i>	<i>2 nos of each type.</i>	
<i>MOTORS (To be repeated for each type & rating)</i>			
2.1.99	<i>Bearing (driving end)</i>	<i>1 No. of each type</i>	
2.1.100	<i>Bearing (Non-driving end)</i>	<i>1 No. of each type</i>	
2.1.101	<i>End shield (DE and NDE)</i>	<i>1 set of each type</i>	
2.1.102	<i>Cooling fan of motors</i>	<i>1 No. of each type</i>	
2.1.103	<i>Fan cover</i>	<i>1 No. of each type</i>	
2.1.104	<i>Lubrication oil pump motor</i>	<i>1 No. of each type and rating</i>	
2.1.105	<i>Bearing puller</i>	<i>1 Nos. of each type</i>	
2.1.106	<i>Grease gun</i>	<i>2 Nos.</i>	
2.1.107	<i>Special spanners/tools</i>	<i>1 Set</i>	
<i>ELECTRICAL MOTORIZED ACTUATORS (To be repeated for each type & rating)</i>			
2.1.108	<i>Actuator motor</i>	<i>1 No. of each type and rating</i>	
2.1.109	<i>Torque switch with potential free contact</i>	<i>2 Nos. of each type</i>	
2.1.110	<i>Limit switch with potential free contact</i>	<i>2 Nos. of each type</i>	
2.1.111	<i>Mechanical position indicator</i>	<i>1 No.</i>	

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

S.No / Cl. No.	Item	Quantity	Remarks
2.1.112	Hand wheel for manual operation	1 No.	
ACDB/PDB/LDB/SLDB/AUX. PDB/ DISTRIBUTION PANELS(To be repeated for each type & rating)			
2.1.113	Busbar support insulators	3 Nos. of each type	
2.1.114	MCCB / SFU	2 Nos. of each rating	
2.1.115	MCB	2 Nos. of each rating	
2.1.116	Control switch	2 Nos. of each type	
ILLUMINATION			
2.1.117	Lamps	10 Nos. of each type	
2.1.118	Fittings	2 Sets of each type	
2.1.119	Control gear box complete	5 Sets of each type	
2.1.120	Timer/photo cell (wherever applicable)	2 Nos.	

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3. CONTROL & INSTRUMENTATION

S.No	Item	Quantity / Unit	Remarks
3.1	<i>Boiler Integral Control System</i>		
a	<i>Power Supply module/Cards</i>	<i>10% of each type & model no.</i>	
b	<i>Network modules</i>	<i>10% of each type & model no.</i>	
c	<i>Communication Interface modules</i>	<i>10% of each type & model no.</i>	
d	<i>Input/Output modules</i>	<i>10% of each type & model no.</i>	
e	<i>Controller module</i>	<i>10% of each type & model no.</i>	
f	<i>SOE Module</i>	<i>10% of each type & model no.</i>	
g	<i>Net work components like switch/repeaters/hubs etc</i>	<i>10% of each type & model no.</i>	
h	<i>Printer Paper</i>	<i>1000 sheets of each type</i>	
i	<i>Printer Cartridge</i>	<i>10 Nos. of each type</i>	
j	<i>Data Bus Cable</i>	<i>1 no. of each type & Length</i>	
k	<i>Fibre Optic Patch Cords (if applicable)</i>	<i>1 no. of each type & Length</i>	
l	<i>Prefab interconnecting cables with connectors</i>	<i>1 no. of each type & Length</i>	
m	<i>System bus cable with connectors</i>	<i>1 no. of each type & Length</i>	
n	<i>Loose Connectors</i>	<i>5 nos. (set) of each type</i>	
o	<i>Batteries used for battery backup of RAMs</i>	<i>10%</i>	
p	<i>Panel/Cabinet cooling fans</i>	<i>10% of each type & model</i>	
q	<i>Fuses</i>	<i>200% of each type & rating</i>	
r	<i>Relays</i>	<i>20% of each type</i>	

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S.No	Item	Quantity / Unit	Remarks
3.2	<i>Boiler Related Instruments</i>		
a	<i>Flame Monitoring System</i>		
a1	<i>Complete Flame Scanner Assembly including scanner head assembly, scanner housing and cables</i>	<i>2 nos. each/2 sets</i>	
a2	<i>Flame scanner lens</i>	<i>10 nos.</i>	
a3	<i>Flame monitoring electronic unit</i>	<i>2 nos. of each type & model no.</i>	
a4	<i>Power Supply modules/unit</i>	<i>2 nos. of each type & model no</i>	
b	<i>Lignite Feeders</i>		
b1	<i>Motion Monitor/Speed transmitter/switch</i>	<i>10% of each type & model no.</i>	
b2	<i>Speed pick-up</i>	<i>10% of each type & model no.</i>	
b3	<i>Torque Switch</i>	<i>10% of each type & model no.</i>	
b4	<i>Load Cell</i>	<i>10% of each type & model no.</i>	
b5	<i>Electronics cards and power supply cards</i>	<i>10% of each type & model no.</i>	
b6	<i>Limit Switch assembly</i>	<i>10% of each type & model no.</i>	
c	<i>Not used</i>		
d	<i>Not used</i>		
e	<i>Acoustic Pyrometer</i>		
e1	<i>Electronic cards/PCB's/modules</i>	<i>2 nos. of each type & model no.</i>	
e2	<i>Sensors & transceivers</i>	<i>20% of each type & Model no.</i>	
f	<i>Furnace & Flame Viewing System</i>		
f1	<i>Flame Camera</i>	<i>1 No. of each type & Model</i>	
f2	<i>Electronic Modules/PCB's</i>	<i>2 Nos. of each type &</i>	

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S.No	Item	Quantity / Unit	Remarks
		<i>model</i>	
g	<i>Mill & Air heater Fire detection system</i>		
g1	<i>Thermocouples</i>	<i>10% of each type & Length</i>	
g2	<i>Process actuated switch</i>	<i>10% of each type</i>	
h	<i>Electronic Drum Level Indicator</i>		
h1	<i>Probes</i>	<i>20%</i>	
h2	<i>Electronic Cards</i>	<i>20% of each type</i>	
h3	<i>Display indicator for local & remote including cables</i>	<i>1 nos. each</i>	
3.3	<i>Local Measuring Instruments</i>		
a	<i>Electronic Transmitter</i>		
a1	<i>Transmitters of all types, range and model no. (for the measurement of pressure, differential pressure, flow, level etc.)</i>	<i>10% of each type & model</i>	
a2	<i>Electronic cards / PCB's for each type and model of transmitters</i>	<i>10%</i>	
b	<i>Complete RTD assembly along with thermowell</i>	<i>10% of each type & length</i>	
c	<i>Complete Thermocouple assembly along with thermowell</i>	<i>10% of each type & length</i>	
d	<i>Metal Temperature Thermocouple</i>	<i>10% of each type & length</i>	
e	<i>Proximity switch along with sensor</i>	<i>10% of each type</i>	
f	<i>Temperature Transmitter</i>	<i>10% of each type</i>	
g	<i>Gauges (Pressure, DP, Temperature)</i>	<i>10% of each type & Range</i>	
h	<i>Switch (Pressure, DP, Temperature, Level, Flow)</i>	<i>10% of each type & Range</i>	
i	<i>Ultrasonic Level Transmitter (Complete assembly)</i>	<i>1 no. of each type & model</i>	

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S.No	Item	Quantity / Unit	Remarks
j	<i>Radar Type Level Transmitter (Complete assembly)</i>	<i>1 no. of each type & model</i>	
k	<i>Rotameters</i>	<i>1 no. of each type & model</i>	
l	<i>Coriolis Flow Meter</i>	<i>1 no. of each type & model</i>	
p	<i>Oxygen Analyzer</i>		
p1	<i>Standard gas for Zero & Span</i>	<i>2 Cylinders with Pressure regulator & Connector</i>	
p2	<i>Complete Probe assembly</i>	<i>1 no. for each type & model no.</i>	
p3	<i>Complete Electronic unit</i>	<i>1 no. for each type & model no</i>	
p4	<i>Sensing element, O-rings, gaskets,</i>	<i>2 no. for each type & model no</i>	
p5	<i>Heating Element & filter</i>	<i>1 no. for each type & model no</i>	
q	<i>CO Analyzer</i>		
q1	<i>Standard gas for Zero & Span</i>	<i>2 Cylinders with Pressure regulator & Connector</i>	
q2	<i>Complete Probe assembly</i>	<i>1 no. for each type & model no.</i>	
q3	<i>Complete Electronic unit</i>	<i>1 no. for each type & model no</i>	
q4	<i>Sensing element, O-rings, gaskets,</i>	<i>2 no. for each type & model no</i>	
3.4	<i>Control Valves, Actuators & Accessories</i>		
a	<i>Valve trim (including cage, plug, stem, seat rings, guide bushings etc)</i>	<i>1 set for each type of control valve</i>	
b	<i>Packing & Gasket</i>	<i>5 no. of each type</i>	
c	<i>Actuator Diaphragm</i>	<i>1 no. of each type</i>	
d	<i>O-rings</i>	<i>5 nos. of each type for each positioner</i>	

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S.No	Item	Quantity / Unit	Remarks
e	Feedback linkage	1 no. of each type	
f	Pressure gauges of all types, range, make, rating etc	10%	
g	Air Filter Regulator	10% of each type & Range	
h	I-to-P Converter	10% of each type & Range	
i	Position transmitter	10% of each type & Range	
j	Limit Switch	10% of each type & model no.	
k	Solenoid Valves assembly with coil	10% of each type & model no.	
l	Not used		
m	Air lock relay	10% of each type & model no.	
n	Smart Positioner	10% of each type & model no.	
o	Not used		
p	Pneumatic Power Cylinder	1 complete set of each type & model no.	
p1	Feedback linkage	1 no. of each type	
p2	Packing & gaskets	1 no. of each type	
p3	O-rings	5 nos. of each type for each positioner	
3.5	Process connection Piping		
a	2 way, 3 way Valves for instruments	10% of each type, size, rating, class, material & model no.	
b	Fittings	10 Nos. of each type, rating, material & size	
c	Valve manifolds	10 % of each type, rating & model no.	
d	Air Filter regulator	10 % of each type, rating & model no.	
e	Impulse piping & tubing	5 nos. of standard	

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S.No	Item	Quantity / Unit	Remarks
		<i>Length of each size, rating & material</i>	
3.6	<i>Instrumentation cables & Accessories</i>		
a	<i>Cables (including compensating cable)</i>	<i>5% of total installed Length (In running meter) of each type, pair & size (if total installed length < 500 mtrs.), 1 no. of 500 mtr. Drum (if total installed length > 500 mtrs.)</i>	
3.7	<i>Cabinets, Panels & Junction Box</i>		
a	<i>Terminal Blocks</i>	<i>100 Nos. of each type & rating (for type exceeding 100 nos.)</i>	
b	<i>MCB's</i>	<i>10% of each type & rating</i>	
c	<i>Fuse</i>	<i>10 nos. of each type & rating</i>	
d	<i>Junction box</i>	<i>1 no. of each size & material</i>	
e	<i>LED Indicators</i>	<i>10% of each type & Colour</i>	
3.8	<i>Programmable Logic controller (PLC)</i>		
a	<i>Power Supply Unit/Module</i>	<i>1 no. of each type & Model</i>	
b	<i>Input/ Output modules</i>	<i>10 % of each type & Model</i>	
c	<i>Central processor Unit</i>	<i>1 no. of each type & Model</i>	
d	<i>Interface Units/ Communication module</i>	<i>1 no. of each type & Model</i>	
e	<i>Interconnecting Cables</i>	<i>1 no. of each type</i>	
f	<i>Batteries for RAM battery back-up</i>	<i>1 set of each type</i>	
3.9	<i>Compressed Air System</i>		

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S.No	Item	Quantity / Unit	Remarks
a	<i>Complete control unit with display/operating unit</i>	<i>1 no. of each type & Model</i>	
b	<i>Interface/communication hardware for interfacing with other control systems</i>	<i>1 no. of each type & Model</i>	
c	<i>Local instruments including gauge, switch, transmitter etc.</i>	<i>1 no. of each type, range & model</i>	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-I, ANNEXURE-III
LIST OF SUB-VENDOR**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-III

List of Sub-vendor

{List of approved vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as in the given format.}

A. MECHANICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

B. ELECTRICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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C. CONTROL & INSTRUMENTATION

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

D. CIVIL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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LII-GETS12021-G-00129-001	02	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-I, Annexure-III	[3]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-A
DETAILED TECHNICAL SPECIFICATION-
MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-II, Part-A	[i]	15.01.2016

VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-II, Part-A	[ii]	15.01.2016

VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-II, Part-A	[iii]	15.01.2016

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-II, Part-A	[iv]	15.01.2016

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ABBREVIATIONS

{The utilities are advised to use the following standard abbreviations while preparing Model Tender Document for their power plant.}

AAQ	Ambient Air Quality
AC	Alternating Current
ACB	Air Circuit Breaker
ACDB	AC Distribution Board
ACG	Automatic Control Gear
AHP	Ash Handling Plant
AHU	Air Handling Unit
ASME	American Society of Mechanical Engineers
ATRS	Automatic Turbine Run up System
ATT	Automatic Turbine Testing
AVR	Automatic Voltage Regulator
BHEL	Bharat Heavy Electricals Ltd.
BFP	Boiler Feed Water Pump
BMCR	Boiler Maximum Continuous Rating
BOD	Biochemical Oxygen Demand
BOP	Balance of Plant
BTD	Bearing Temperature Detector
CA	Condition Assessment
CAVT	Cold Air Velocity Air Flow Test
CBD	Continuous Blow Down
CCTV	Closed Circuit Television

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LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-II, Part-A	[vii]	15.01.2016

CEA	Central Electricity Authority
CEMS	Continuous Emission Monitoring System
CERC	Central Electricity Regulatory Commission
CFBC	Circulating Fluidized Bed Combustion
CHP	Coal Handling Plant
CRH	Cold Re-Heat
CRT	Cathode Ray Tube
CLCS	Closed Loop Control System
CMMS	Computerized Maintenance Management System
COC	Cycle of Concentration
COD	Chemical Oxygen Demand
CT	Cooling Tower, Current Transformer
CV	Control Valve
CW	Cooling Water
DB	Distribution Board
DC	Direct Current
DCDB	Direct Current Distribution Board
DCS	Distributed Control System
DDCMIS	Digital Distributed Control Monitoring Information System
DG	Diesel Generator
DGA	Dissolved Gas Analyser
DM	Demineralization
DMCW	Demineralized Cooling Water
DP	Differential Pressure

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E	Earthed
ECO	Economizer
EHC	Electro-Hydraulic Control
ELCID	Electromagnetic Core Imperfection Detection
EOT	Electrically Operated Travelling Crane
ESP	Electro Static Precipitator
ESV	Emergency Stop Valve
ETP	Effluent Treatment Plant
EWS	Engineer's Work Station
FD	Forced Draft
FEGT	Furnace Exit Gas Temperature
FO	Fuel Oil
FOPH	Fuel Oil Pump House
FSSS	Furnace Safeguard Supervisory System
GC	Gland Condenser
GCV	Gross Calorific Value
GA	General Arrangement
GT	Generator Transformer
HCA	Host Country Approval
HFO	Heavy Fuel Oil
HPS	Heavy Petroleum Stock
HPTB	High Pressure Turbine Bypass
HMI	Human Machine Interface
HP	High Pressure

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HRH	Hot Re-Heat
HT	High Tension
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
HVDC	High Voltage Direct Current
HVWS	High Velocity Water Spray System
IBD	Intermittent Blow Down
IBR	Indian Boiler Regulations
I&C	Instrumentation and Control
ICB	International Competitive Bidding
ID	Induced Draft
IGV	Inlet Guide Vane
I/O	Input / Output
IPT	Intermediate Pressure Turbine
IPR	Inter Posing Relay
ISA	Indian Standard Angle
ISMB	Indian Standard Medium Beam
ISMC	Indian Standard Medium Channel
IV	Interceptive Valve
LAN	Local Area Network
LDB	Lighting Distribution Board
LDO	Light Diesel Oil
LE	Life Extension
LP	Low Pressure

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LII-GETS12021-G-00129-001	04	Tender Document for Selection of R&M Contractors – Boiler & Auxiliaries Volume-II, Section-II, Part-A	[x]	15.01.2016

LP	Lighting Panel
LPA	Loss Prevention Association of India
LPT	Low Pressure Turbine
LPTB	Low Pressure Turbine Bypass
LRSB	Long Retractable Soot Blower
LSHS	Low Sulfur High Stock
LT	Low Tension
LTSH	Low Temperature Super Heater
LVS	Large Video Screen
MCC	Motor Control Centre
MCCB	Module Case Circuit Breaker
MHVT	Multi High Velocity Thermocouple
MOCB	Minimum Oil Circuit Breaker
MoEF	Ministry of Environment & Forest
MS	Main Steam
MSSV	Main Stream Safety Valve
NDT	Non Destructive Test
NABL	National Accreditation Board for Testing and Calibration Laboratories
NSPBD	Non Segregated Phase Bus Duct
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OPC	Object linked embedded Process Control
OWS	Operator Working Station

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PA	Primary Air
PDB	Power Distribution Board
PLF	Plant Load Factor
PCC	Power Control Centre
ppm	Parts Per Million
PLC	Programmable Logic Controller
PMCC	Power cum Motor Control Centre
PRDS	Pressure Reducing De-superheating Station
PTFE	Polytetrafluoroethylene
PVDF	Polyvinylidene Fluoride
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RH	Reheater
RLA	Residual Life Assessment
RO	Reverse Osmosis
RPM	Respirable Particulate Matter
rpm	Revolutions Per Minute
RMS/ rms	Root Mean Square Value
RSO	Recurrent Surge Oscillograph
RTD	Resistance Temperature Detector
SADC	Secondary Air Damper Control
SG	Steam Generator
SH	Super Heater

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SPM	Suspended Particulate Matter
STMS	Smart Transmitter Monitoring System
SWAS	Steam and Water Analysis System
TFT	Thin Film Transistor (Monitor)
TG	Turbo Generator
TMCR	Turbine Maximum Continuous Rating
TPS	Thermal Power Station
TR	Tons of Refrigeration
TC	Thermocouple
TSE	Turbine Stress Evaluator
TSI	Turbine Supervisory Instruments
TSS	Total Suspended Solids
UCR	Unit Control Room
UE	Unearthed
UPS	Uninterruptible Power Supply
VT	Voltage Transformer
VFD	Variable Frequency Drive
VVVF	Variable Voltage and Variable Frequency Drive

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1 DESIGN AND SIZING OF BOILER & AUXILIARIES

1.1 General

[The Boilers shall be drum or once through type unit, sub - critical, either a single pass (tower type) or two pass type gas path arrangement, dry bottom, balanced draft, natural or assisted circulation semi-outdoor type, top supported, pulverized coal fired, single reheat type with all auxiliaries. The Boiler shall have the super heater and reheat outlet indicative parameters as mentioned below in the table 1.1.]

[For CFBC Boiler & Auxiliaries, refer Annexure-M1]

1.2 Codes & Standards

The design, manufacture, erection, inspection and testing and materials of the Boilers shall comply with the Indian Boiler Regulations (IBR) and any other standards that are permitted by the IBR and are acceptable to the Chief Inspector of Boilers.

The Boilers shall also comply with those specification requirements that are in addition to those specified in IBR.

International Standards other than IBR that are considered to be equivalent or superior to the IBR shall also be acceptable subject to the approval of the Chief Inspector of Boilers. However, in the event of any conflict between the requirements of the equivalent codes and standards, and the requirements of the Indian Standards/ Regulations, the latter shall govern, unless, specified otherwise in this Specification.

It shall be responsibility of the Bidder to obtain such approvals of the Inspection Authority and Chief Inspector of Boilers on behalf of the Owner, as may be required for designing, manufacturing and erecting, and testing as required by the IBR. All such documentation submitted to statutory authorities shall also be submitted to the Owner/Consultant for his review. It shall also be the responsibility of the Bidder to furnish the requisite documentation as required by the Owner for registering the boiler under IBR.

1.3 Specific Design Criteria of Boiler & Auxiliaries

**Table 1.1
Boiler Rating (Tentative Indicative Parameters)**

S.No.	Description	Unit	Rated Parameter
1	Steam flow at superheater outlet at boiler maximum continuous rating (BMCR) when firing the worst coal	%	<i>[1.02 times the steam flow at turbine VWO condition plus continuous auxiliary steam requirement of unit at TMCR condition.]</i>
2	Steam temperature a) At superheater (SH) outlet	° C	<i>[540 (Correspond to HP turbine inlet parameters of 537°C)]</i>

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S.No.	Description	Unit	Rated Parameter
	b) At re-heater (RH) outlet	° C	<i>540 (Correspond to IP turbine inlet temperature of 537°C)]</i>
3	Feed water temperature at economizer inlet		<i>[247 °C]</i> The Boiler shall also be suitable for accepting feed water at lower temperature corresponding to HP heaters out of service condition without exceeding any design limits including the design metal temperature.
4	Steam pressure at superheater outlet	kg/cm ² (abs)	<i>[137 kg/cm² (a)]</i> [corresponding to turbine throttle steam pressure <i>[130 kg/cm² (a)]</i> at 100% TMCR]
5	Boiler control range		<i>[50% TMCR to 100% BMCR]</i> . However, the bidder to specify the feasible mill combinations below 60% TMCR

The above parameter shall be in line with finalized TG parameters (TG specification).

Note!

Pressure drop in reheater should not exceed *[2.5 kg/cm²]* under all operating conditions.

1.3.1 Limiting Parameters for Boiler Design

The Boiler design shall comply with the following limiting parameters with design coal firing, under stipulated air condition *[i.e. 27°C temperature and 60% relative humidity]*.

- Excess air at economiser outlet at TMCR load: *≥[20%] if (i) quoted* (ii) actual value during the PG test is higher than *[20%]* the higher value shall be taken.
- Flue gas temperature at air heater outlet at TMCR: *[135-150°C]* (minimum)

The Boiler guarantees shall however be as per the conditions stipulated in relevant section of the specification.

1.3.2 Quality Parameters of Steam

The quality parameters of steam shall be as per the requirement of the turbine manufacturer. However, the same shall not be inferior to the following under all operating conditions:

- [Silica as SiO₂ :<20ppb]*
- [Sodium + Potassium as Na + K :<10ppb]*
- [Copper as Cu :<3ppb]*

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d. [Iron as Fe : <20ppb]

e. [Conductivity at 25 deg C : <0.3 μ S/cm]

1.3.3 Boiler Water Quality

The quality parameters of the boiler water shall not be inferior to the following limits:

a) [Phosphate ions : 0.5 to 3 ppm]

b) [Silica_ : \leq 0.25 ppm]

c) [TDS_ : \leq 0.20 ppm]

d) [Conductivity at 25 deg C : \leq 50 μ S/cm]

e) [pH at 25 deg C : 9.2 to 9.4]

1.3.4 Minimum Load without Oil support for Flame Stabilization

The design of Boiler shall be such that it does not call for any oil support for flame stabilization [beyond 30% BMCR] load when firing any coal from the range specified, with adjacent mills in service and mill load not less than 50% of its capacity. This shall be guaranteed and demonstrated by the bidder.

1.3.5 Cyclic Load Capability and Adoptability for Sudden Load Changes/ Load Throw Off

- i) To match the desired plant operating capabilities, the Boiler shall also be designed for regular cyclic/ two shift operation. The total number of start-ups shall be as under

a Hot starts [(less than 8 hrs*)] : [4000]

b Warm starts [(between 8 and 36 hrs*)] : [1000]

c Cold starts [(greater than 36 hrs*)] : [150]

* The time specified is with respect to hours of unit shutdown.

- ii) Under the above conditions, no portion of the Boiler and the associated systems shall be stressed beyond acceptable safe stress and fatigue levels and the

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design of Boiler and its pressure parts shall take care of above without affecting the life of equipment and pressure parts adversely.

- iii) Boiler shall also be capable of satisfactory, stable and safe operation in case of rapid load changes in downward direction due to external disturbances or equipment malfunction. Under such conditions, the system shall stabilize itself through proven concepts and controls within the recommendation of National Fire Protection Association, USA (NFPA), and sections 85C, 8502 and 8503.
- iv) In case of sudden load throw off, in worst case from 100% TMCR, the Boiler shall be capable of automatically bringing down the steam generating capacity to match with HP-LP bypass capacity of [60% BMCR]. The bidder to indicate minimum load of Boiler to which it can be brought down under such condition, during short turbine outages or export load rejection, with a view to save fuel and reduce heat losses. The unit shall be capable of operating at house load conditions.
- v) In line with automatic run back capability of the unit load on loss of critical auxiliary equipments, the Boiler equipment and systems shall also ensure smooth and stable runback operation.

1.3.6 Operation without HP Heaters in Service

Boiler shall be designed for continuous operation with HP heaters out of operation. The Boiler heat output with HP heaters out of service shall be not less than that at 100% BMCR with all HP heaters in service. Under this condition the superheater and reheater outlet steam temperature shall be maintained at rated values within the whole control range of Boiler load. Further, during such operation the metal temperature of various pressure parts shall not exceed the limits stipulated in their design/ selection.

1.3.7 Operation with/ without Turbine HP- LP Bypass System

- i) As specified elsewhere, when unit trips under full load, HP-LP by-pass system shall come into service. This will call for boiler operation in HP-LP bypass mode, with SH flow of [60% BMCR] capacity and feed water temperature of [140°C] at economiser inlet. For such condition the economiser shall be suitably designed to take a thermal shock of sudden change of feed water temperature from the rated value to approx [140°C]. The superheater and reheater outlet steam temperatures, during such operation shall be maintained at the rated value without the metal temperature for various pressure parts exceeding the safe limits stipulated for their design/ operation.
- ii) Irrespective of the fact that HP-LP bypass system is provided for smooth start-up, fast loading and house load operation of the unit; the Boiler shall also be capable of start up without HP-LP bypass system in service, except in case of hot start-up.

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1.3.8 Mode of Boiler Operation and Rate of Loading

- i) In line with the plant operating capability requirements, the Boilers shall be designed for *[both constant as well as variable pressure operation]*. Thermal design of Boiler and the selection of materials shall be suitable for both the operational modes.
- ii) The Boilers shall be designed for minimum rate of loading/ unloading mentioned below from 50% to 100% (TMCR) loads without compromising on design life of pressure parts.
 - a. Step load change : Minimum $\pm 10\%$ per minute.
 - b. Ramp rate : Minimum $\pm 2\%$ per min (30% to 50% TMCR Load)

: Minimum $\pm 4\%$ per min (50% to 100% TMCR Load)

Bidder shall clearly bring out the max. rates of loading/ unloading achievable with steam generator offered and the corresponding limiting variations (+ %) of boiler parameters such as throttle pressure, oxygen in flue gas, drum level, SH steam temperature, RH steam temperature, furnace draft, etc.

1.3.9 Furnace

Furnace shall comply with following requirements at 100% BMCR with or without HP heaters out of service and with range of specified coal, under most stringent combination of operating conditions.

- i) Max heat input (NHI) per Unit plan area of furnace : $4-5 \times 10^6$ kCal/hr/m²
- ii) Max heat liberation rate : 110000 kCal/hr/m³
(Volumetric Loading)
- iii) Max burner zone heat release rate : Bidder to furnish kCal/hr/m³
- iv) Max heat input per burner : Bidder to furnish kCal/hr/m³
- v) Max furnace cooling factor : Bidder to furnish kCal/hr/m³
- vi) Max furnace exit gas temp(FEGT) : 60°C below minimum initial deformation temperature (IDT) of ash (FEGT measured at downstream of first stage Platen SH)
- vii) Minimum furnace residence time : *[1.8-2.0 seconds.(Coal specific)]*
- viii) Pressure withstanding capability : Minimum ± 660 mmwc at 67% yield strength or maximum conceivable head of fans, whichever is higher.
- ix) No. of coal burner elevation to be fed from one mill : Bidder to specify

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- x) Buckstay spacing : To ensure that its natural frequency is sufficiently away from the flame pulsation frequency.
- xi) Buckstay support : Self support from furnace walls with no interconnection from the flame pulsation frequency.

1.3.10 Pressure parts

- i) The design of all pressure parts (tubes, headers, vessels etc.) shall be as per IBR or other international codes with the approval of the Owner.
- ii) Design pressure of the boiler pressure parts shall be at least 1.05 times the maximum operating pressure, or as required by IBR/ other international codes, whichever is higher. For boiler drum, the design pressure shall be higher of the value as per (i) above or lowest drum safety valve set pressure for full discharge.
- iii) The thickness of the pressure parts (steam and water tubes/ headers, pressure vessel etc.) shall be calculated using IBR formulae/factor of safety etc (or as per codes/ formulae acceptable to IBR). Such thickness as per IBR formulae shall be arrived at after allowing for tube bend thinning, where ever applicable as per IBR/international codes. Additional erosion allowance on the calculated tube thickness shall be provided at specific locations as specified in this specification.
- iv) In line with IBR, the maximum permissible temperature/ metal temperature for design of different components of the boiler shall be considered as below:

Table 1.2
Design temperature values for different components

S.No	Components	Designed values
a	Economiser tubes	Maximum working water temperature plus 11 deg C
b	Furnace and boiler tubes	Saturation temperature corresponding to maximum working pressure plus 28 deg C
c	Superheater and reheater tubes in convection path	Maximum working steam temperature plus 39 deg C
d	Superheater and reheater tubes in radiation path	Maximum working steam temperature plus 50 deg C

Material for Design Metal Temperature is given below

Design Metal Temperature	Material
Upto & including 400°C	Carbon steel to ASME SA-106 Gr. B/C or SA 209 T1 or SA 210 Gr-A1 or approved equivalent

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Design Metal Temperature	Material
Upto & including 550°C	Alloy steel to ASME SA-335: P-11/P-12/P-22; ASME SA213: T-11/T-22 or approved equivalent.
Material above 550 °C & up to 600°C	Alloy steel ASME SA-335/213:P91/T-91 or approved equivalent

1.3.11 Superheaters and Reheaters

Table 1.3
Superheaters and Reheaters – Design Criteria

S.No	Components	Designed values
a	Maximum average flue gas velocity in section/ tube banks with transverse tube pitching 600 mm or less and with ≥20% excess air at economizer outlet	10 m/s (The maximum localized velocity across the cross section shall not exceed 12 m/sec)
b	Means of temperature control	
	Super heater	Spray water attemperation shall be tapped off from a suitable source upstream of HP heaters (from BFP discharge or Kicker stage outlet). The bidder can also tap off the spray water from a suitable location downstream side of HP heaters, provided bidder is having experience of such tapping, details of which shall be provided to Owner/Consultant.
	Reheater	Spray water attemperation (utilizing water tapped off from inter-stage of BFP)
	Maximum allowable spray water flow	<p><u>For Superheater:</u> 8% of TMCR flow, however the valve sizing shall be considered 12% of BMCR flow.</p> <p><u>For Reheater:</u> 3% of RH flow at TMCR (However, the control valve shall be sized for 6% of the BMCR flow.</p>

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1.3.12 Economiser

Table 1.4
Economiser – Design Criteria

S.No	Description	Design basis
a	Type	Non steaming type, with parallel cross flow or counter cross flow arrangement
b	Feed Water Approach temperature	17 deg C (min.) at BMCR load. However, there shall be no steaming at part load and/ sliding pressure operation
c	Maximum average flue gas velocity through inter-tube space of the economizer banks (the gas velocity shall be calculated considering 17% excess air at economiser outlet)	10 m/s (maximum localized velocities shall not exceed 12m/s)

1.3.13 Air Pre Heaters

Table 1.5
Air Pre Heaters – Design Criteria

S.No.	Description	Design basis
a	Type	<i>[Regenerative type Tri-sector air pre heaters with facility of steam coil heating on secondary air side to guard against low cold end temperature.]</i> OR <i>[Tubular type air pre heaters with facility of steam coil heating to guard against low cold end temperature.]</i>
b	Design ambient air	<i>[27°C and 60% RH]</i>
c	Boiler load to be	60% BMCR with worst coal and maximum moisture <i>[with one APH in service, as applicable for Regenerative type Tri-sector air pre heaters]</i>
d	Minimum average cold- end temperature at 100% BMCR (with SCAPHs out of service)	Bidder to calculate and specify.

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S.No.	Description	Design basis
	<p>APH sizing shall also ensure following (for whole range of specified fuels)</p> <ul style="list-style-type: none"> -Minimum flue gas temperature (corrected) at APH exit at 100% TMCR load with design coal firing - Air leakage - Minimum flue gas temperature at all loads 	<p>[135-150 deg C]</p> <p>Max 10% of the TMCR flue gas weight entering air-heater <i>[as applicable for Regenerative type Tri-sector air pre heaters]</i>.</p> <p>10 deg C above acid dew point of flue gas</p>

Sizing of air-preheater(s) shall also ensure that there is no need for economiser bypass to get the desired mill outlet temperature, for the whole range of specified coal.

1.3.14 Steam Coil Air preheater (SCAPH)

SCAPH shall be designed and sized to increase the air heater inlet temperature based on following criteria

- i) Design ambient temperature : [27 deg C]
- ii) Number of SCAPHs : One (1) per *[tri-sector type]* APH
- iii) Air temperature at the inlet of each air preheater (throughout boiler control range) : To keep average cold end metal temperature minimum 10 deg C above the acid dew point for flue gases.
- iv) Design SCAPH and connected duct work suitable to handle flows corresponding to 30% BMCR loads without any undue noise/vibration.

1.3.15 Auxiliary Steam PRDS

The sizing of the auxiliary steam PRDS shall be based on the following:

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Table 1.6

Auxiliary Steam PRDS - Particulars

S.No.	Description	High capacity auxiliary PRDS	Low capacity auxiliary PRDS
1	No. of aux. PRDS unit	1	1
2	Source of steam	Main steam line	Cold reheat steam line
3	Capacity	Bidder to specify depending on requirement as per Note-1	Bidder to specify depending on requirement as per Note- 2
4	Indicative parameters of steam on downstream sides	[16 kg/cm ² (abs.) and 310 deg C]	[16 kg/cm ² (abs.) and 210 deg C]

Note-1: The high capacity PRDS shall be sized for auxiliary steam requirement of the equipment specified in the bidders scope of supply with the normal unit running at TMCR rating *[plus start-up auxiliary requirement of another unit, if any]* plus the auxiliary steam requirement of equipments in Owner's scope.

Note-2: The low capacity PRDS shall be sized for auxiliary steam requirement of the equipment specified in the bidders scope of supply with the normal unit running at TMCR rating plus the auxiliary steam requirement of equipments in Owner's scope.

1.3.16 Coal Firing System

a) Coal Mill

Type - Vertical spindle mills type *[(like pressurized type bowl mills, ball and race mills, MPS type roller mills or approved equivalent)]*

Input coal size: 20-25 mm with excursion of 50 mm up to 15%

Maximum loading of the mill with worst coal and design coal (for sizing whichever is higher) - 90% or mill loading achievable corresponding to near wear out condition of mill grinding loss whichever is less for the range of specified coals.

Expected Mill out-put: 99% thru 50 mesh (300 microns) and 70% through 200 mesh (75 microns)

No. of Mills: At 100% BMCR worst coal firing – *[N+1]*

At 100% BMCR design coal firing – *[N+2]*

At 100% TMCR worst coal firing – *[N+2]*

(Where N is no. of Working Mills)

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Guaranteed life of different mill components:

Seals: 20000 hours

Grinding elements (Rolls/Balls and Rings/Race): 7200 hours

Mill Discharge Valves: 15000 hours

Classifier Cone and other ceramic lined components: 25000 hours

Classifier vane: 25000 hours

b) Coal pipes

S.No	Detail	Description
1	Velocity in coal pipe	<ul style="list-style-type: none"> Minimum 15m/s Maximum 28m/s
2	Continuous operating temperature for pipe design	110 deg C (Minimum)
3	Special erosion protection (on identified areas)	Ceramic lining/wear plate liner
4	Design Pressure	3.5 kg/cm ² (minimum) as per NFPA requirement

c) Raw Coal Feeders

S.No	Detail	Description
1	Type	Gravimetric type.
2	Maximum moisture	As per specified coal
3	Feeder capacity	Minimum 20% spare capacity over maximum mill capacity
4	Environment withstand capability as per NFPA norms	a) Operating pressure of 0.14 kg/cm ² b) Explosion pressure of 3.5 kg/cm ² (minimum) c) Ambient temperature 70 deg C Other environmental conditions envisaged

d) Coal burners

S.No	Detail	Description
1	Capacity	a) To be cater to 100% BMCR load b) To ensure stable operation at BMCR with coal having lowest volatile matter without oil support.
2	Turn down ratio of each set from one mill	To be decided by bidder as per stable operation criteria detailed above subject

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		to minimum of 2.5:1.
3	Special feature	a) Low NOx design. b) Total NOx emission (fuel as well as thermal NOx shall not exceed 260gms/giga joule of heat input to the boiler)
4	Control	Centralized automatic control with flame scanner and safety precautions.
5	Operation	Conforming to NFPA guidelines.

1.3.17 Fuel oil preparation and Firing System

- i) Type of fuel oil
 - Startup fuel for cold start : LDO
 - Startup fuel for normal start up, : HFO
 - low load operation, coal flame stabilization
- ii) Minimum fuel oil firing capacity
 - For LDO : [7.5% BMCR heat input capacity]
 - For HFO : [30%BMCR heat input capacity]
- iii) Oil burners
 - Type : Steam/air atomized with HEA igniters
 - Atomization medium : Air for LDO and steam for HFO
 - Capacity :
 - > To cater for [30% BMCR] heat input with HFO for load carrying and as oil support.
 - >To cater for [7.5% BMCR] heat input with LDO for startup at cold start conditions.
- iv) Turndown ratio : 4:1.
- v) Control : Centralized automatic scanner with flame scanner and safety protection.

1.3.18 Draft System

The forced draft (FD) fans and induced draft (ID) fans shall be capable of maintaining balance draft conditions in the furnace over the entire load range with any one or both FD fans and any one or both ID fans in operation while burning the specified range of fuels.

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Table 1.7
Draft System - Particulars

S. No.	Description	FD fans	ID fans
i)	Type of fans	Constant speed axial fans	Variable speed radial fans or constant speed axial fans with variable blade pitch control
ii)	Fan sizing criteria with all the following conditions occurring together	Each fan to be sized for 60% BMCR flow (one stream in operation) calculated taking into account following factors occurring together.	Each fan to be sized for 60% BMCR flow (one stream in operation) calculated taking into account following factors occurring together.
	a) Type of coal firing	Design/best/worst coal whichever gives maximum FD fan air requirement	Design/best/worst coal whichever gives maximum flue gas flow.
	b) Power supply frequency	47.5 Hz	47.5 Hz
	c) Excess air	≥20% over stoichiometric air requirement	≥20% over stoichiometric air requirement
	d) Fan inlet air/ flue gas temperature	[27 deg C with 60% RH]	150 deg C or actual which ever is higher, corresponding to ambient air temperature of [27 deg C with 60% RH]
	e) Air heater air-in leakage	10% or guaranteed value whichever is higher	Based on minimum 15% leakage from primary air and minimum 10% leakage from secondary air.
	f) Pressure drop through ESP	Not applicable	[25 mmwc]
	g) Air-in leakage through ESP	Not applicable	1% through ESP and 2% through duct or actual whichever is higher
	h) Pressure required at chimney inlet	Not applicable	+ 10 mmwc
	i) Air in leakage	Not applicable	+2%

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S. No.	Description	FD fans	ID fans
	through duct		
	j) Operating medium	atmospheric air	Flue gas
iii)	The fan shall also fulfil following sizing criteria in addition to that mentioned above (with both fans working):	Taking into account following conditions taken together:	Taking into account following conditions taken together:
	a) Margin over 100% BMCR flow	20%	20%
	b) Margin over 100% BMCR pressure	44%	44%
<p>(The sizing criteria specified above shall consider air heater and ducts in normally fouled up condition. The static pressure requirements only shall be considered without any credit for velocity pressure recovery.)</p> <p>Additional Points needs to be considered in design:</p> <ul style="list-style-type: none"> • Suction effect of the chimney to be neglected. • Pressure and temperature drop across ESP has to be considered. • Minimum efficiency of the ESP has to be considered. <p>Deterioration in the capacity of the fan due to wear on account of extended period of service.</p>			

1.3.19 Flue Gas Duct and Air Ducts

All necessary flue gas and air ducts shall be provided. Supply of the flue gas and air ducts shall include all access doors, inspection ports, test points and thermal insulation. The bidder shall supply all steelwork for supporting the ductwork together with all expansion joints and special supports necessary to accommodate thermal expansion. Expansion joints shall be designed so that dust or water cannot accumulate in them.

All necessary drains shall be provided to ensure complete draining of wash water. The duct design shall ensure that wash water does not accumulate on duct surfaces and cause off load corrosion. All ducts shall be designed for the most severe pressures.

- i) Maximum allowable flue gas velocity: 13 m/s (before ESP)
16 m/s (after ESP)
- ii) Maximum allowable air velocity : 16 m/s

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- iii) Design Pressure : ± 660 mmwc at 67% yield strength or maximum conceivable pressure of the relevant fans, whichever is higher.
- iv) Type of damper : a) Control damper: pneumatic
b) Isolation: Electric/pneumatic, where fast closing is desirable from process point of view.
- v) Duct Plate material : a) Minimum thickness 6 mm in the flue gas ducts. However, duct plate thickness of 5 mm can be considered, provided the duct stresses remain in normal range.
b) Minimum thickness of 5 mm in the air ducts.
c) A corrosion allowance of 1.5 mm shall be considered for stress calculation for gas ducts.
d) Resistance to flow is to be kept at an economically low value.
e) Equal distribution of flow to various portions of the unit is to be ensured.
f) Dust accumulation is prevented/minimized.
g) Wind load, dead weight and weight of insulation, lagging and cladding.
h) Proper drainage of ducts.
i) Extra thickness of flue gas duct plate at the portion where flue gas changes direction.
j) Adequate provision of access by providing gas tight access doors with bolted and hinged covers and ladders / platforms staging, etc for carrying out maintenance.
k) Provision of ash/dust hopper in the flue gas ducts, as may be

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required, especially in vertical portions or at the place where flue gas changes direction.

l) Suitable load factors shall be applied to the design loads to care of the higher temps.

m) Vibration aspects of ducts and respective fans so that resonance does not occur under any condition.

1.4 System Description

1.4.1 Boiler

Boiler shall be designed to produce maximum continuous output power with steam parameters of [137 kg/cm² (a)] pressure and [540 deg C / 540 deg C] temperature at the SH outlet. The power plant shall be designed to operate on unit basis [having no interconnection with other units either on the boiler feed water side or main steam side. Each generator shall be connected to its own generator transformer].

Table 1.8
BOILER Parameters

S.No	Parameter	Unit	Value
1.	Main Steam Flow at BMCR	TPH	[.....]
2.	Main Steam Flow at TMCR	TPH	[.....]
3.	Main Steam pressure at SH Outlet,	kg/cm ² (a)	[137]
4.	Main Steam temperature at SH Outlet	deg C	[540]
5.	Main Steam Pressure at HP Turbine inlet	kg/cm ² (a)	[130]
6.	Main Steam Temperature at HP Turbine inlet	deg C	[537]
7.	Hot Reheat inlet Temperature at IP Turbine	deg C	[537]

The above parameters are indicative only and the bidder has to size the Boiler as per their proven standard practice for optimized and efficient [210/215/220/250] MW units.

a) Considerations for Boiler Design

The Boiler design parameters shall comply with the following limiting parameters with design coal firing. The Boiler shall be designed to operate as a base load unit. However, continuous operation under two shift and cyclic modes during certain periods of the year is also envisaged. The design should cover adequate provision for quick startup and loading of the unit to full load at a fast rate and apart from constant pressure operation would also have the facility for sliding pressure operation.

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1. The Boiler design shall be such that the rated Reheater outlet temperature is achievable for the entire range of operation while firing the specified range of coal and under all the specified operating conditions of operation of Boiler with reduced feed water inlet temperature during the conditions of HP heaters out of operation and/or HP/LP bypass operation, at 100% TMCR load.
2. The unit and the auxiliaries shall be designed for maximum reliability and availability; operability and maintainability. The bidder shall specifically state the design features incorporated to achieve the high degree of reliability and availability.
3. The unit shall be suitably designed and provided with necessary instrumentation for rapid starting, loading and unloading without causing undue vibration, distortion, differential expansion or producing excessive thermal stresses. The design of the control system and relevant equipment shall adhere to the fail safe operation at all system conditions. The fail safe operation signifies that loss of signal/air/power supply, loss of excitation or failure of any component shall not cause hazardous conditions and at the same time prevent occurrence of false trips.
4. The work falling under the purview of Indian Boiler Regulations (IBR) shall completely meet or exceed all the requirements of the latest edition of IBR. Any other standard acceptable to IBR can also be considered, provided the requirements of that standard are equivalent or exceed IBR requirements.
5. It shall be the responsibility of the Bidder to furnish the requisite documentation as required by the Owner/consultant for ascertaining the adequacy of the design/soundness of the materials of construction /manufacturing methods adopted etc.
6. All materials used for the construction of the equipment shall be new and shall be in accordance with the requirements of this specification. Materials utilised for various components shall be those which have been established for use in such applications. It would be the responsibility of the bidder to furnish the relevant information in this regard, as required, at the time of detailed engineering.
7. All heavy parts of the plant must be provided with some convenient arrangement for aligning and for handling during erection and overhaul. Any item of plant required be stripping or lifting during period of maintenance and weighing one tonne or more shall be marked with its approximate weight. All equipment shall be designed to run satisfactorily without any undue noise and vibrations. Corresponding parts throughout shall be made to gauge and shall be interchangeable wherever possible. No welding, filling or plugging of defective parts shall be allowed without the permission in writing to the Owner.
8. The Boilers shall be supplied with all equipment and software necessary to monitor and record the fatigue and creep life usage (as appropriate) of major pressures parts which shall include but not limited to the drum, main steam and reheater outlet pipes and the superheater and reheater outlet headers.

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1.4.1.1 Boiler Furnace

- i. The furnace shall be designed to burn the specified fuels under all loads up to BMCR.
- ii. The furnace volume and residence time shall be sufficient to maintain efficient combustion at all loads without incurring any damage and there shall be no flame impingement on any part of the furnace walls, superheater or reheater, and no accumulation of slag or ash on the walls, tubes or hoppers that shall interfere with the continuous operation of the boiler or the easy removal of ash from the furnace hopper.
- iii. The thermal ratings of the furnace shall be selected based on previous successful operating experience with coal having similar slagging, fouling, combustion and erosion characteristics to those specified.
- iv. The design metal temperature for the boiler tubes shall not be less than the saturation temperature of the steam at the maximum allowable working pressure plus the following temperature margins:-
 - a. 39°C for tubes mainly subject to convective heat.
 - b. 50°C for tubes mainly subject to radiant heat.

Test ports shall be provided throughout the boiler for measuring temperatures, gas pressures and for gas sampling using portable instruments.

1.4.1.2 Boiler Casing

1. The furnace, superheater, reheater, convection passes and economiser shall be enclosed within a completely gas tight casing. The enclosure shall be formed using welded wall construction only. Where use of refractory is unavoidable, 4mm thick steel plate behind refractory shall be provided to form enclosure and any penetration(s) into the Boiler enclosure shall be sealed for gas tight integrity.
2. The boiler casing shall be designed and constructed to withstand the maximum internal positive or negative pressures produced by draught plant control, or explosion, and complete combustion trips. In addition, the furnace structural design pressures shall not be less severe than that required by NFPA 85.
3. Leak tests shall be carried out before commissioning the boiler and before fixing of external insulation. These tests shall prove the gas tightness of the boiler casings, associated fittings and flues. Defects shown by this test shall be made good and proved by a further test, at the bidder's expense before lagging.
4. No Dissimilar Metal Welds (DMW) between austenitic and ferritic steels, martensitic and austenitic steels, martensitic and ferritic steel shall be allowed inside the Boiler at site for the pressure parts which are exposed to hot flue gases.

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5. The casing/pent house and its supporting system shall be capable of taking additional loads due to accumulation of ash (300 mm thick) expected in between two overhauls of the units. This additional load is over and above the other loads considered for casing design.

1.4.1.3 Water Walls

Water/steam walls shall be of membrane wall construction and shall be made of seamless tubes.

A minimum allowance of 0.6 mm over and above the calculated thickness as per IBR shall be provided for entire water wall. An additional tube thickness of 1.0 mm over and above the tube thickness of water wall tubes calculated as per above shall be provided on all water wall tubes coming within a radius of one meter around each wall blower to guard against premature tube failure due to soot blowing steam erosion, if the soot blowing arrangement is so designed that there may be impingement of soot blowing medium on the water wall tubes.

Provide adequate nos. of furnace observation and tapping points for local instruments, gauges, switches, test pockets etc. In case water wall orifice are provided, these should be supplied with indexing holes and index pins

Important features of water walls shall be as given below:

1. Water walls made of seamless steel tubes with membrane welded construction.
2. Minimum refractory construction. Arrangement to ensure that there is no exposed refractory in the furnace except at the burner throat.
3. Water wall headers shall be sized generously and shall be located outside the gas path. These shall be provided with suitable openings with forged weld on caps for inspection and chemical cleaning. If under unavoidable circumstances it is required to locate the headers in the gas path, they shall be suitably shielded and protected from erosion due to ash impingement.
4. Water wall headers shall be completely drainable and shall be fed through down comers.
5. The water wall tubes and headers shall be provided with supports, stiffeners, etc. for carrying load, for permitting proper expansion / contraction and for protection against vibrations.

Lowest water wall header shall be at sufficient height to facilitate installation and easy access for maintenance of ash hoppers and bottom ash handling equipment. All bottom ash handling equipment shall be installed above ground level. Elevation of Furnace Bottom ring header shall be so chosen to accommodate all ash handling equipment like the Scraper Chain Conveyor and clinker grinder & bed ash transfer conveyor system equipments (by other bidder) below the header.

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In case of tower type design of the Boilers, necessary leak proof expansion joints shall be provided between the water walls enclosure and the flue gas duct to take care of any differential expansion.

1.4.1.4 Boiler Drum

The drum shall be provided with all necessary internals, mountings and fittings including but not limited to the following:

- i) Steam water separators
- ii) Moisture eliminators
- iii) Feed water distribution system
- iv) Chemical feed pipe
- v) Intermittent and continuous blow down pipes and vessels,
- vi) Saturated steam and water sampling probes
- vii) Nitrogen connections
- viii) Gauge Glass
- ix) Safety valves.
- x) All steam drum integral piping and associated fittings

The dissolved solids in the saturated steam shall not exceed 0.02 ppm when the total dissolved solids in the Boiler water are not greater than 15 ppm. The dryness fraction of steam leaving the drum shall not be less than 0.999

Adequate steam separators shall be provided together with a single drain collection vessel. The separators and drain collection vessel shall be of welded construction with all necessary internals, valves, mountings, fittings and accessories.

The drum dished ends shall be provided with properly sized manholes and hinged manhole covers of forged steel secured by forged steel yokes and bolts. Suitable sampling connections shall be provided to facilitate collection of representative samples of Boiler water from drum and of condensed steam from the saturated steam outlets.

The storage capacity of the drum shall be adequate so as not to cause trip out of the unit on low drum level, in case of tripping of a running boiler feed pump and cutting in of the standby pump automatically in 15 seconds. Storage capacity of drum shall also be adequate considering duration of 10 seconds to reach trip level in Boiler drum from the normal drum level at BMCR draw off condition with no inlet flow to drum.

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1.4.1.5 Superheater and Reheater

In the design of the superheaters and reheaters, due account shall be taken of the inaccuracies of predicting furnace exit gas temperatures to ensure that adequate surface area is provided in the superheaters and reheaters and that tube metal temperatures in excess of design are not encountered. Due account shall also be taken of the variations which shall occur in the characteristics of the specified fuels.

Measures shall be taken to prevent magnetite exfoliation of the internal surfaces of superheater and reheater tubes.

The transverse spaces between superheater and reheater elements shall be selected based on previous successful operating experience with coal having similar slagging, fouling, combustion and erosion characteristics to those specified. Bidder to ensure that the furnace exit gas temperature shall be at least 60 °C below the minimum ash deformation temperature in reducing conditions for any specified coal for all loads up to & including BMCR.

Spacing of superheater/reheater elements shall be selected with specific reference to ash quality in coal particularly in high temperature sections and accordingly the spacing shall be large. The transverse pitch of elements in heating surface meeting highest flue gas temperature region shall not be less than 800 mm and that of lowest flue gas temperature region shall not be less than 100 mm.

Design of the superheater elements shall be such that any individual tube or element can be easily repaired & replaced with or without removing it from the Boiler. Design / spacing shall also permit increase of surface area, if necessary. A minimum spacing of 1.2 m shall be provided between any two sections of super heater and reheater and between any horizontal tube banks of heat exchangers to allow personnel access for maintenance. For vertical surfaces, minimum clearance between two banks shall be 600 mm.

All the horizontal heat transfer surfaces shall be suitably supported using steam cooled tubes. The support tubes shall be designed to withstand direct radiation and shall not be subjected to distortion, erosion, corrosion and creep. The joint between the supporting tubes and the heating surfaces shall be designed so as so to permit free thermal expansion of both the supporting tubes and the heating surfaces. Necessary shielding shall be provided to prevent direct impingement of flue gases.

Necessary safety valves as per IBR shall be provided for superheater and reheater system. Test pressure gauges shall be provided on the super heater outlet pipes and the reheater inlet pipes to facilitate adjustment of the setting of safety valves.

The reheater shall be provided with isolators both at inlet and outlet to facilitate isolation of reheater during hydraulic tests. Reheater isolating devices shall be provided on cold reheat and hot reheat lines at Boiler outlet. Isolating device shall

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consist of a robust cast steel body with carbon steel (ASTM A216 GR WCB) material for cold reheat application and alloy steel (ASTM A217 GR WC 9) for hot reheat application suitable for pressure and temperature condition to which they shall be subjected. Isolating device shall be of welded type construction and will form part of the pipe line during normal operation without any leakage. Before hydrostatic test top cover and bonnets are removed and a separate test closure assembly with sealing rings are inserted to close the flow path. Drains shall be provided on both side of the device.

For superheater and reheater tubes, erosion allowance of one (1) mm shall be provided over and above the calculated thickness as per the IBR formula. In addition to the above, +10% minimum thinning allowance on bends shall be provided. Erosion shields for the tubes shall be provided for critical zones likely to encounter erosion due to ash or due to soot blower steam. The maximum average flue gas velocity in the convection pass shall be limited to 10 m/sec, however localized velocity of flue gas shall not be allowed to exceed 12 m/sec due to installation of such shields.

The maximum skin temperature to which the tubes shall be subjected shall be 40 deg C below the oxidation limit as applicable to the material.

1.4.1.6 Arrangement of Headers

Headers shall be located outside of the gas path and shall be fully drainable. If locating the headers in the gas path is unavoidable, then such headers shall be suitably protected with erosion shields. All headers shall be seamless and shall be provided with inspection and cleaning openings. All such openings shall be readily accessible and permit the convenient internal inspection by video-scope without removal of Boiler enclosure walls or nearby headers and tubes. The topmost header shall be provided with suitable stubs for nitrogen capping. It shall be ensured that the maximum steam side header unbalance is 6%

1.4.1.7 Economiser

An inline, bare tube economizer shall be provided with vents, recirculation system, drains and sampling connections etc. The support structure and hanger designs shall be suitable for loads due to these additional surfaces. The economiser shall be of the non steaming type.

The economizer shall be so designed as to keep the feed water temp. in all sections at least 17 deg C below the saturation temperature, under all conditions of Boiler operation.

In case of tower type Boilers, economiser shall be arranged for parallel cross flow of feed water and flue gases. In case of two pass design of Boilers, it shall be arranged for counter cross flow of feed water and flue gases.

Provision for recirculation of water (economiser recirculation system) while starting shall be provided.

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The maximum average flue gas velocity through economiser section (with $\geq 20\%$ excess air at economizer outlet) shall not exceed 10 m/s. However; the maximum localized velocities across the cross-section shall not exceed 12m/sec. The economiser tubes shall be arranged to permit the installation of soot blowers. The design shall ensure elimination of water hammering in economiser and feed line during cold start-up. Maximum skin temperature to which the tubes shall be subjected shall not exceed the oxidation limit as applicable to the material.

The erosion shields for leading tubes of each tube bank of economiser shall be provided. In addition sturdy cassette baffles shall be provided for all front side and rear side bends of economizer banks. The tube thickness erosion allowance of 0.5 mm over and above design tube thickness considering normal erosion allowance.

If the Boiler has the flue gas down flow section with horizontal economiser tube banks, the top most row shall be shielded to reduce erosion.

1.4.1.8 Furnace Sizing

Bidder shall furnish the details of their standard design practices for sizing furnaces which shall include but not be limited to the following:

- Maximum net heat input (NHI) per unit plan area of furnace
- Maximum heat liberation Rate
- Maximum burner zone heat release rate
- Maximum heat input per burner, maximum furnace cooling factor
- Maximum furnace exit gas temperature
- Minimum furnace residence time

1.4.1.9 Steam Temperature Control

1. The Boiler design shall ensure that rated superheater and reheater outlet temperatures are achieved for the entire control ranges while firing any coal within the specified range and all the operating conditions such as the following:
 - Operation of the Boiler with HP heaters out of service
 - Turbine bypass operation
 - Mills operating with all combinations
2. During steady operation the superheater and reheater outlet steam temperatures shall be maintained constant at all loads above 65% BMCR when operating in modified sliding pressure mode and shall be within the permissible limits stated in IEC 60045-Part 1, clause 6.2(b). The superheater outlet pressure shall be within $\pm 1\%$ of the set point.

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3. During major load changes and during start up when the Boiler is above 60% BMCR the superheater and reheater outlet temperatures shall be within the permissible limits stated in IEC 60045-Part 1, clause 6.2(b) and the outlet pressure within $\pm 3\%$ of the set point.
4. The permissible variations in temperature and pressure shall apply when the Boiler is operated in both modified sliding pressure and constant pressure modes.
5. Superheater de-superheating shall be provided by spray type attenuators. The spray water shall be from a location on the feed system selected in after the HP Heaters' outlet accordance with the bidder's experience.
6. Each superheater and reheater spray system shall be provided with all necessary valves and fitting.

1.4.1.10 Supporting & Enclosing Structure, Galleries, Walkways, Roofing, Platforms

1. Boiler supporting structure complete with girders, beam column base plates, foundation bolts, shims etc.
Galleries, walkways, platforms, hand rails, ladders, auxiliary steel for piping supports shall include base plates, foundation bolts, nuts, washers, 'U' bolts and hangers for Drum (if applicable), superheaters, reheaters, furnace rear pass tubes (if applicable) and grating.
2. Stair cases/platforms of minimum 1000 mm width with handrails 100 cm high and 2(two) rail safety handrails of 40 mm galvanised iron (GI) pipe, on either side of Boiler from 'O' ML to the roof.
3. The interconnecting platforms between the Boiler (operating floor) and main station building at 4 elevations (excluding ground floor) at two places per Boiler.
4. Storage platforms for storing of scaffoldings, APH baskets and other maintenance item during overhaul of Boiler. Platforms for removal, handling & storage of Economiser and Reheater/Superheater sections (all horizontal heating surfaces).
The above provision shall include but shall not be limited to the following locations:
 - a) Bunker outlet gate.
 - b) All maintenance hoist levels.
 - c) All dampers and their drives.
 - d) Furnace seal trough level.
 - e) All fans and associated motors.
(Continuous platforms shall be provided around the fans and their corresponding motors).
 - f) SCAPHs
 - g) Air preheaters
 - h) All valves.
 - i) All observation ports, access manholes etc.

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- j) All soot blowers and water lancers.
 - k) All Burner levels
 - l) All Control Stations
 - m) PRDS area
5. Access platforms, staircases and walkways for sootblowers, man holes/inspection doors, dampers/damper drives, valves of critical services, ID fans, FD fans, air preheater, transmitter racks, junction boxes etc.
6. Boiler roof shall be provided with an approach ladders and all round hand railings
7. All Operating platforms and main access walkways in boiler area shall have minimum width of 1200 mm. All interconnecting platforms (with side coverings and roof) between boiler galleries and elevators landings shall also have a minimum width of 2000 mm. In case it is not possible to provide width of the platforms / walkways as mentioned above due to layout constraints, lesser widths, in exceptional cases, may be accepted subject to Owner's /Consultant's approval.
- All Maintenance access walkways in boiler area shall have a minimum width of 1000 mm. The gap between the equipment / furnace casing and walkways shall not exceed 150 mm.
- All other walkways shall have a minimum width of 800 mm.

8. Floor Grating

Floor grating for floors, platforms, stair landings, any other locations shall have minimum 5 mm thick bearing bars on 40 mm centers, 32 mm deep. Cross bars shall be spaced 100 mm on centers and electro-forged into the bearing bars to provide a non-slip surface. The gratings shall be made of steel conforming to IS: 2062 and hot dip galvanized. Galvanization shall be done as per IS: 2629 and IS: 4759. Weight of galvanization shall not be less than 610 gm/m². Grating shall also be designed for a minimum live load of 500 kg/m².

Floor grating shall be neatly cut and banded around all openings. Unless otherwise indicated, banding shall from a 100 mm high curb. Grating to head of stair runs shall have an applied chequered plate or cast iron abrasive surfaced nosing similar to that specified for stair treads.

Grating panel shall be removable type and shall have the bars of adjacent panels aligned.

Grating shall be anchored to support with bent clip fasteners secured to threaded stud field welded to supporting members. Two clips at each end of each panel and one clip (staggered) at each intermediate support shall be provided.

Penetrations through grating and floor plates that are not shop fabricated (generally opening under 500 mm in nominal size pipes and for conduits etc.) are to be cut in the field as required. Such opening shall be neatly trimmed, concentric with penetration or as required for movements. Generally 50 mm

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clearance shall be left over insulation and 25 mm clearance at bare metal. Openings may be ganged where accepted by the Purchaser / Consultant.

Openings less than 150 mm in maximum dimension may be squared off. Large openings shall be suitably shaped. All grating opening shall be kick plates or banded to match the shop fabricated work. All grating for a given area shall be positioned and aligned before the stud bolts are located and welded to the supporting members.

1.4.1.11 Pipe & Cable Racks

The pipe and cable rack and support structure shall be provided for the pipes / cable racks with access and adequate working platform, crossovers for erection and maintenance. Certain portions of these pipe racks shall have to accommodate Purchaser's pipes /cables also, the details of which shall be furnished to the Bidder during detailed engineering of cable racks:

All other safety requirements as per the factories act, explosives act, etc. shall be observed while developing the layout.

No cable trenches, under-ground cable vaults are acceptable in main plant as well as interplant cable routing. In case it is unavoidable, it shall be provided only with prior written approval by the Purchaser / Consultant. In that case, trenches shall be finished to surrounding floor levels/ paved area.

To the extent possible, Bidder shall route all the cablings from the Boiler house to control rooms, MCC/PMCC only at the sideways. Care shall be taken not to route / pass the same through Boiler house area.

Bidder shall ensure that in the lay out, no C&I provisions shall be installed below any of the fire hydrant provision and is suggested that routes for A.C. & ventilation ducts, piping, cables, etc. be conceptualized at initial stage to avoid or to minimize any interference during execution / actual installation.

1.4.1.12 Maintenance

The Bidder shall provide adequate handling facilities & approach as for carrying out on-line and off-line maintenance of the Boiler and its auxiliaries. In order to carry out on-line maintenance, it shall be possible to readily disassemble, repair and reassemble the equipment supplied in the shortest period. A minimum of four accesses and clean out doors in each area shall be provided to permit access to the furnace, superheater, reheater, the area between tube bank, economiser and any other area requiring maintenance.

A vertical & straight chute of minimum 500 mm dia and made from minimum 10 mm thick mild steel pipe shall be provided for Boiler, from pent house level to ground level for disposal of debris & scrap generated during erection, operation and maintenance. The chute shall be provided with branch connections with doors and suitable access to the doors at all platform levels. Garbage collection trolleys shall also be provided at the ground level.

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1.4.1.13 Valves

The Boiler valves shall include all necessary isolating, control, regulating, check and relief valves and/or pneumatic valves, motorized valves including main steam stop valves, vent valves, drain valves, root valves, safety valves, mountings required for the safe, efficient, and reliable operation of the Boiler. Valves and accessories shall comply with all the requirements of the applicable standards. The Boiler drain system shall include emergency drain valves and appropriate noise reducing measures on the blowdown pipes and tanks. Any other valves not mentioned specifically but needed to complete the system with drives, wherever required shall be provided

1.4.1.14 Internal Cleaning of Boiler and Associated Pipe work

1. During the construction and commissioning, the bidder shall be responsible for the internal cleaning of the Boiler.
2. On completion of erection, and after the commissioning of all the auxiliary plant associated with the Boiler, Boiler shall undergo a chemical cleaning process throughout the economiser, and the water circulating spaces. The superheaters and reheaters shall be subject to thorough water flushing or blowing out procedure. In addition, the superheaters and reheaters and steam pipes connecting the superheaters and reheaters shall be steam purged to ensure all foreign debris is removed. The procedure for steam purging, including the target plate acceptance criteria shall be reviewed by the steam turbine supplier and the Owner/consultant.
3. All the necessary temporary equipment, pipes, connections and valves, together with chemicals, inhibitors and reagents necessary for the monitoring of the effectiveness of the process shall be provided by the bidder.
4. The method adopted for the chemical cleaning process shall be to the approval of the Owner/Consultant, including the disposal of any effluent. The bidder shall be responsible for the disposal of the effluent to a suitable site.
5. The procedures for chemical cleaning and steam purging shall be in accordance with VGB-R 513, "Internal Cleaning of Water-Tube Steam Generating Plants and Associated Pipe work".
6. Bidder shall be responsible for the monitoring and supervision of all stages of the process.

1.4.1.15 Fly Ash Hopper

Bidder to furnish all necessary boiler, air heater, fly ash hoppers including ESP hoppers as required. The capacity of each hopper shall not be less than 8 hrs of storage capacity when the boiler is steaming at 100% BMCR while firing the worst coal. All hoppers shall be equipped with proper flanged pipe connection including matching counter flanges for attaching to fly ash removal system. The outlet of the fly ash hoppers shall be at a height of 3.5 meters minimum above the floor level.

1.4.1.16 Soot Blowing System & Water Lancers

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Bidder to supply the fully automatic sequentially controlled micro-processor based steam soot blowers for the superheaters, reheaters, economizer and airheaters complete with all pipings and accessories, including valves, controls, control panels, motor control centre complete with starter and wiring. System offered shall be for long retractable soot blowers & water lancers for the boiler furnace.

Water Lancers for furnace shall be of proven design & reliability. 2 x 100% capacity high pressure pumps and drives complete with necessary valves, instruments & piping for supplying water to the water lancers and control systems. All control & interlocks necessary for sequential operation of water lancers (for deslagging of the furnace zone) shall be incorporated by the bidder in the soot blowing control panel.

For detailed control and operation philosophy of soot blowing and water lance system refer respective instrumentation system.

1. The steam used for the blowing should be taken from the appropriate auxiliary steam header or from saturated/superheater steam header directly.
2. For air heater blowing additional provision shall be provided to tap off the steam from auxiliary steam header to clean the elements during startup when steam may not be available from the main source.
3. Adequate no of motorised drain valves shall be provided to facilitate warmup the complete piping before starting the soot blowing operation. Suitable by-pass with orifice shall also be provided. Temperature detectors with drain valves shall also be part of the complete system.
4. The retractable blowers shall be located on both sidewalls of the boiler and each shall cover little more than half the effective width of the boiler, when fully extended in order to ensure through deslagging/cleaning. Provision of retracting back the blowers during emergencies like drop in steam pressure, low steam etc, shall also be provided.
5. Platform/galleries shall be provided around all the soot blowers to facilitate access and maintenance.
6. Provision shall also be kept for additional installation of blowers/lances in the boiler. Provision shall also be kept in the control panel, if required to be installed in future.

1.4.1.17 [Boiler Startup Circulation Pumps (If applicable)]

Assisted circulation, if applicable, shall ensure adequate circulation during start-up, normal operation and sudden load changes to prevent overheating of tubes.

The design shall ensure that with the circulation pumps in operation, all duty of the boiler can be met under all operating conditions. The design should envisage adequate stand by pumps or in case assisted circulation is not envisaged, and if as per the bidder's design only one pump (1 x 100%) is envisaged during start up and low load only, the Boiler design shall ensure adequate circulation during

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normal operation and sudden load changes to prevent overheating of boiler tubes.

Circulating water pump shall be hermetically sealed glandless type without requiring any external sealing arrangement. The pump and motor shall be submerged in boiler water and shall be mounted on the Boiler circulating system. The entire pump and motor shall be enclosed in the pressure tight casing, motor being protected from the high temperature fluid inside the pump casing by a suitably designed thermal throttle. The motor shall be of wet stator construction. The liquid inside the motor shall be circulated by an impeller mounted on the motor shaft in a closed cycle network and shall be cooled by indirect water/water heat exchanger. Cooling water for the heat exchanger shall be tapped off from cooling water system. The power and instrumentation leads shall be taken out of the motor through properly sealed glands with adequate provisions of differential expansion of pump body and conductor.

Pump design and installation shall be so as to ensure adequate NPSH under all operating condition of the boiler including cold start. The circulating water pumps shall be suitable for parallel operation throughout the entire operating range.

Adequately sized Journal and thrust bearings shall be provided for the common shaft of pump and motor assembly. Guide bearings shall be spherically seated journal guide bearings and thrust bearings shall be spherically seated tiling pad type double action thrust bearings. All bearings shall be lubricated by the liquid in the motor cavity. Bearing material shall preferably be Ferrobestos and leaded bronze impregnated with polytetra fluoro ethylene or FRP.

The material of construction of pumps & motors shall be suitable for continuous operation with chemically conditioned boiler quality water normally encountered in such service and shall ensure long service life. The circulation system shall be so designed that the boiler shall be capable of operating at 100% BMCR uninterruptedly when any one of the operating pumps undergoes sudden trip out.

Suitable isolating valves shall be provided in the circulating piping's so as to enable operation of Boiler with remaining pumps. Control valve shall be provided to ensure appropriate flow distribution/to prevent zonal overheating in the water walls.

Automatic cutting in feature of stand-by circulation water pump shall be provided by the bidder. Bidder shall indicate the safety protections and interlock scheme provided for the circulation water pumps.

1.4.1.18 Boiler Integral Piping

1. The integral piping shall comply with the Indian Boiler Regulations (IBR) and the requirements of the Boiler Specifications.
2. The scope shall include all necessary super heater outlet including the Main Steam Stop Valve (by-pass arrangement including valves and piping), HRH and CRH piping, HP- LP bypass system piping, complete drain collection piping from various headers and equipments, drum, safety valves, down comers, drain collection

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headers, all piping downstream of and including the NRV on the feed water piping at economizer inlet. All auxiliary steam piping to SCAPH, fuel oil atomisation, mill fire fighting etc. All vent pipes and safety valves escape pipes shall be taken to a level above boiler house roof. The vents on the headers and links shall be provided with drain lines connected to a common trough and further terminated at the drain trench at the ground level.

3. All hangers and supports shall be provided with auxiliary steel structure, including columns and beams, base plates, foundation bolts, nuts and washers.
4. All the above piping systems shall be complete with valves, specialities, stubs including instrument stubs pipe reducers/expanders, matching flanges and suitable gaskets, nuts and bolts.
5. Bidder to provide tapping points with root/isolation valve for sample points for SWAS.

1.4.2

Draft Plant

Complete draft plant for the balanced draft system shall be tested in accordance with ASME PTC11.

a) Forced Draft (FD) Fans

Two FD fans (2 x 60%) of the axial, variable pitch type shall be provided with necessary ancillary equipment and VIS foundation.

Each fan shall be provided with bearing lubrication and hydraulic blade pitch control unit each consisting of 2 x 100% oil pumps, oil coolers and filters On-line bearing temperature and vibration monitoring shall be provided.

Blade material for FD fans shall be high strength aluminium alloy having minimum hardness of 75 BHN. The material of construction of fans, the blade thickness, liner thickness etc. for fans as per manufacturer's recommendation is also acceptable.

For FD fans, for limiting the noise level, silencers shall be provided at the suction of the fans to limit the noise level On-line bearing temperature and vibration monitoring shall be provided.

b) Induced Draft (ID) Fans

Two ID fans (2 x 60%) shall be provided and they shall be of the radial backward curved type with renewable liners and variable frequency drive with VIS foundation or constant speed axial type with blade pitch control with VIS foundation . The blade material of ID fan shall be minimum of 25 mm thick and provided with renewable liners of wear resistant material having a minimum thickness of 10 mm. These shall be designed to withstand high bending and axial load and a temperature upto 200°C. However, the material of construction of fans, the blade thickness, liner thickness etc. for fans as per manufacturer's recommendation is also acceptable.

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Each ID fan shall be provided with bearing lubrication and inlet vane control each consisting of 2 x 100% redundancy for oil pumps, oil coolers, filters. On-line bearing temperature and vibration monitoring shall be provided

1.4.3 Regenerative Air Pre-Heater (RAPH)

1. Ljungstrom regenerative type air heater with vertical axis of rotation for secondary air heating. Each boiler shall be provided with 2 x 60% regenerative air heater to reduce the diluted flue gas temperature to not less than the acid dew point when firing the specified fuels, under all boiler operating conditions. There shall be adequate margin between the sulphuric acid dew point and the temperatures of the flue gases to the electrostatic precipitators and the flue gas desulphurization equipment (if applicable) under all operating conditions. These operating conditions shall include start ups and shutdowns.
2. Each regenerative air preheater shall have 2 x 100% AC drive (1 W + 1S) and lube oil pump.
3. Each air heater shall be performance tested in accordance with ASME PTC 4.3. The air heater design and construction shall ensure that the leakage from the air space to the gas space shall not be greater than 10% of the inlet gas flow after 8760 hours of operation.
4. Air heaters shall be provided with forced lubrication system for bearing, 2 x 100% oil coolers, pressure & temperature indicators, complete piping valves, pressure switch and all the bearings shall be provided with temperature sensing elements for local as well as remote measurement.
5. The air heater shall be equipped with an approved means of internal fire detection and fire fighting water supplied from the station fire hydrant system. The equipment shall be complete with all the necessary probes, scanners and controllers etc., to operate in conjunction with the station alarm system.
6. Steam soot blowers, complete with the necessary pipe work, valves and fittings, shall be provided to enable effective on load cleaning and cleaning during the start-up period of the air heater.
7. Air heater housing shall be provided with suitable access doors for inspection, cleaning and maintenance. It shall be possible to replace the cold end elements without dismantling the RAPH. Inspection ports in the air inlet duct for rotor inspection shall be provided with glass windows and vapor proof lights. Suitable water washing arrangement shall be provided which includes necessary pumps, pipes, valves, fittings & drains. The drains shall be connected to the slag flush channel.
8. The handling arrangement for RAPH shall include hoist for
 - Basket removal operating floor to ground level (1 no common for two RAPH)
 - From Air heater top to operating floor (one number for one RAPH)

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1.4.4 Steam Coil Air Pre-Heaters (SCAPH)

Steam coil air preheaters shall be provided in FD fan outlets with necessary dampers, condensate collection flash tank, along with drain pipe up to flash tank and from flash tank up to condenser, auxiliary steam piping to supply heating steam to each SCAPH from the auxiliary steam system during start up along with individual temperature control valves.

SCAPH of modular construction shall be provided by the Bidder for start up, for low load operation of the boiler or at any abnormal condition when an increased air inlet temperature is considered desirable. SCAPHs shall be adequate to maintain cold end metal temperature 10 deg.C. above acid dew point throughout the load range i.e. 60%TMCR to 100% BMCR with a minimum ambient temperature specified. These shall not be used under normal operating conditions for the whole range of fuel specified.

Each SCAPH and connected air ducts to handle flows shall be designed for 30% BMCR load.

Air temperature at SCAPH outlet (with best Coal firing) shall be as below:

- At 30% BMCR - 100°C (minimum)

SCAPHs shall be provided on the outlet of each FD fan in a bypass duct with necessary shut off and control dampers so that the SCAPH can be completely isolated from the service line, whenever it is not required. Steam supply arrangement for SCAPH shall be complete with necessary valves, power operated control valves, motor operated isolating valves, steam piping, steam traps etc. Steam for SCAPH shall be taken from auxiliary steam header of the boiler. Each SCAPH shall be provided with its own drain and the drain condensate from SCAPH shall be directed to IBD tank.

1.4.5 Coal Mills

The coal Mills shall be vertical spindle type (like pressurised type bowl mills, ball and race mills, roller mills or the approved equivalent. The number of coal pulverisers to be provided shall conform to sizing /standby requirement. Each Mill shall be complete with all wear parts/ grinding elements and shall be provided with platforms around the Mill, lubrication systems (comprising of [2x100% pumps, 2x100% cooler and 2x100% filters] for each pulveriser) drive motors, auxiliary gear, instrument tapping points and any other equipment necessary for safe and efficient operation of Mill. The Mill shall also include static classifier and all the automatic auxiliary equipment necessary to make the Mill self contained. Adequate number of temperature sensors, temperature transmitters, local indicators and signaling contacts for bearings and lube oil systems shall be provided as per standard practice of Bidder. Independent purge meters, air filter cum regulator sets, local pressure indicators, instruments and sensing device for milling system including the instrument requirements shall be provided. Primary airflow measuring devices shall be provided at air inlet of each coal pulveriser.

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Adequate number of thermocouple type fire detection system with temperature transmitters as a composite & complete unit with all required accessories with adequate redundancy shall be provided.

Proven fire detection and fire extinguishing systems in line with the standard practice of the manufacturer shall be provided. In case of CO₂/N₂ based system, the scope of supply shall also include the required cylinder/piping and valves network etc. In case, the proposed type of mill requires inerting during start-up/ shut-down of the mill to ensure safety of operation, suitable system along with all piping, valves, instrumentation, interlock system etc. shall also be provided.

The bidder shall provide the necessary interlocking features for the coal mills for safe operation of the Boiler.

Bidder to ensure the sufficient access is provided for removal of mill components as well as from maintenance consideration. Dismantling of any duct, platforms, structural steel, coal pipes shall not be required to remove beater mill internals.

Bidder shall take care of over load imbalance in the mill and shall not be transferred to the boiler main structure.

1.4.6 Seal Air Fans

2x100% centrifugal seal air fans common for all the mills of one Boiler unit shall be provided. Seal air catered through FD Fans' discharge is also acceptable provided adequate size and capacity of FD fan /Ducts is taken care of by the bidder. The sealing system shall prevent ingress of any dust into the bearings and cold air leakage in to the Mill from atmosphere.

Following margins shall be provided for each fan over and above the calculated values under maximum duty conditions are:

Margin on flow : 25%

Margin on pressure : 30%

The above margins shall be based on an ambient temperature of 27 deg C, relative humidity of 60 % and system leakages with mill operation at maximum duty.

1.4.7 Coal Burners

- i. Number and arrangement of the coal burners shall be such that there is stable firing and efficient total combustion in the furnace while firing the specified fuel and operating with any combination of pulverisers. The basic criteria for selection of firing system shall be:
- ii. Stable flame over entire operating range of the furnace.
- iii. Complete burn out at furnace exit.
- iv. Avoiding contact between flame and furnace wall.

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- v. More number of burner with less heat release rate in order to ensure better turn down than few larger rates.
- vi. Selection of heat release rate for furnace & burners that will prevent inadmissible fouling in particular within the burner area.
- vii. Burner design shall be such as to minimize NO_x generation. Bidder to furnish the detail of the design to keep the NO_x level within permissible values

Pulverised coal coming out of mill goes to the vertical coal burners through pulverised piping. Each coal burner has an inclination of 10 Deg downstream. Secondary hot air is fed through proper air duct to the coal burners. Pulveriser coal velocity shall be in the range of 15-28m/sec.

The air / fuel ratio around the burner shall be optimized to ensure low emission of NO_x which shall not exceed [260] grams / gigajoule of heat input of the boiler.

1.4.8 Oil Burners

Oil Burner design basis shall be as follows:

Table 1.10

S.No	Particulars	HFO Firing System	LDO Firing System
1	Type of burner	Steam atomised (steam to tap off from the auxiliary steam header)	Air atomised(to draw from the compressed air system)
2	Burner cooling medium	Steam or air	Air
3	Burner tip material	Resistant to corrosion	Resistant to corrosion
4	Minimum life of burner tip before needed any maintenance	16000 hours	16000 hours
5	Hardness of atomizer (hardness retained even at 400°C)	Minimum vickers hardness 400	
6	Type of oil igniters	High Energy Arc Igniters	High Energy Arc Igniters
7	Oil burner turndown	4:1	4:1

1.4.9 Dampers

- Isolation dampers with electric drives on all cold air, hot air, seal air, and flue gas ducting before and after equipment.
- Electrically operated guillotine type gas tight isolators at inlet and outlet of each ID fan and electrically operated dampers at inlet and outlet of each RAPH where ever required for local/remote operation

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- Regulating dampers with pneumatic drives, supporting structure for all damper drives.
- Air registers with drives at various elevations

1.4.10 ESP

- For designing ESP ash % of the coal shall be considered as [.....%] as per worst coal analysis.
- The Electrostatic Precipitators shall be of outdoor type and installed on the cold end side of regenerative air pre heaters. The flue gas shall be drawn from air pre heater outlets of the balanced draft, pulverized coal fired Boiler and guided through adequately sized duct work into the specified number of independent gas streams of the Electrostatic precipitators. Similarly, the flue gas after the Electrostatic Precipitators shall be led to the suction of the induced draft fans. The flue gas temperature may approach the economiser outlet temperature of about 300 deg C in case the regenerative air pre heaters fail to operate. The Bidder shall take these aspects into account while designing the precipitator.
- [4 Nos.]. ESPs per boiler (i.e. [four Nos. gas paths per boiler housed in four independent casings]) have been envisaged. The capacity of each ESP shall be designed for a gas flow of [30% BMCR].
- The Boilers are designed to burn HFO (Heavy furnace oil) and LDO in conjunction with pulverized coal during startup and at low loads for warm up and flame stabilization. Further, the frequency and duration for startup and low loads operation may be quite long during the first year of unit commissioning and operation after R&M. The Bidder shall take into account the entire characteristics of expected combination of fuels to be fired and shall clearly bring out in his proposal the recommendations on preventive measures or equipment to be provided by him to minimize the possibility of fires in the Electrostatic Precipitators and the features/materials provided to avoid the corrosion of ESP components/surfaces.
- The Bidder shall offer the best design to accommodate the Electrostatic precipitator and accessories within the confines of the space available. The design shall permit satisfactory duct layout before and after the ESP terminal flanges.
- ESP control room (Individual for each unit) located at grade elevation adjacent to ESP shall house the control cubicles. Man Machine Interface (MMI) to be provided to enable UCB operator to access the ESP controls for control, monitoring and data acquisition functions. The MMI may be suitably located in UCB .Necessary provision shall be provided for integration of ESP with plant DCS for effective monitoring.

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- vii. Bidder to furnish the ESP control room AC, ventilation system and passenger lift (if control room building is having more than 2 floors) arrangement details in the offer.
- viii. The design of the precipitators shall allow adequate space above and between the adjacent fields to carryout necessary inspection and maintenance. A permanent walkway shall be provided at each rapper level both for the discharge and collecting electrodes. Minimum 3.0m wide platforms shall be provided between the two casings of the ESP's to facilitate maintenance work. The protection for the platform and the rapping motors from exposure to rain shall also be provided.
- ix. Staircases as per the requirements shall be provided from ground to the roof of the ESPs with landings connected to all platforms. Further, the platforms between all the ESP casings shall be interconnected at least at three intermediate elevation. Stair cases and handrails shall be of 40mm GI pipes etc.
- x. A monorail system with movable trolley and an electrically operated hoist mounted on the precipitators roof shall be provided for handling and maintenance of HVRT, rapper motors, fans (if applicable) etc.
- xi. Collecting electrodes shall be designed for dimensional stability and to maintain the collection efficiency at the specified level. Minimum Specific Collection Area (sca) with one series electric field out of operation shall not be less than $[180 \text{ m}^2/\text{m}^3/\text{sec}]$ for a maximum collecting plate spacing of $[400 \text{ mm}]$ and shall not be less than $[240 \text{ m}^2/\text{m}^3/\text{sec}]$ for a maximum collecting plate spacing of $[300 \text{ mm}]$.
- xii. The plate spacing shall be either 300mm or 400 mm, and the specific collecting area and the plate spacing shall be so chosen to achieve the required dust concentration of less than $50\text{mg}/\text{Nm}^3$.
- xiii. The high tension discharge electrodes shall be of rigid frame type design, located mid-way between the collecting electrodes. The electrodes shall be self tensioned, or restrained in pipe frames. They shall be constructed from durable, corrosion and erosion resistant material, helical wires, spiral of SS material to ensure uniform current distribution. In case spiral type discharge electrodes are being offered, the material for the same shall be high tension discharge electrode of durable, corrosion and erosion resistant material like stainless steel. Vertical and horizontal members shall be rigid enough to maintain the alignment of the system without warping or distortion even at elevated temperatures. Provisions made to maintain alignment of electrodes during normal operation, including rapping and thermal transients, shall be clearly brought out in the offer. However, no anti-sway insulators shall be used at the bottom of the discharge electrodes frame to accomplish the above

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- xiv. Independent rapping system shall be provided for discharge and collecting electrodes with control systems as per the requirement specified in Electrical Sub-Section (Part-B, Section-II, Volume-II). The rapping mechanism shall be of either electric impact type or tumbling hammer type. This shall be adjustable in frequency, intensity (for electric impact type only) and duration (for tumbling hammer type) to provide an efficient cleaning rate. Separate rapping equipment, shall be provided for the discharge and collecting electrodes served by one HVRT so that each mechanism can be suitably adjusted when required. It shall be so arranged that the rapping frequency can be independently set from the control room in accordance with the operating requirements. The rapping frequency range shall be adjustable in wide range from 0 to a minimum of 24 hours, and this facility shall be such that it does not require any stoppage of rapper operation. Sufficient number of rappers and rapper drives shall be provided so that minimum collection area and discharge electrode lengths are rapped at a time, which shall not be more than 4.33% of the total collection area for at least the last two fields/discharge electrode length of each field served by one HVRT. The Bidder shall provide necessary calculations in support of fulfilling the above requirements along with the offer. The rapping system shall be designed for continuous sequential rapping to prevent puffing under any conditions of precipitator operation.
- xv. All internal parts of the rapping mechanism shall be accessible for inspection and they shall be placed on wide access passages and shall be easily accessible for operational and maintenance purposes. Major part of the rapping mechanism shall be located external to the precipitator. Necessary lubrication system shall be provided for the rapping mechanism.
- xvi. The perforated plates and/or guide vanes furnished for gas distribution system shall also be provided with rapping systems.
- xvii. Dust hoppers shall be of pyramidal type, each having a storage capacity of minimum of eight (8) hours corresponding to the maximum ash collection rate of the field under which the hopper is being provided when two preceding fields are de-energized. The ash carry-over to ESP shall be taken as 90% of total ash produced while burning worst coal having maximum ash content. The hopper capacity shall be based on the inlet dust burden, gas flow rate and gas temperature indicated in ESP sizing criteria for the design point condition while firing the maximum ash coal. Storage shall be up to a level which will not reduce the overall efficiency of the precipitator due to re-entrainment. Ash storage capacity shall be at least 10% higher than the ash storage capacity theoretically required for each dust hopper. Specific weight of ash shall be assumed as 600 kg/m³ for calculating storage capacity and 1600 kg/m³ for structural design. Further for hopper strength and ESP structural calculations the level of

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ash in ESP shall be considered at least up to the top of hopper partition plane or the bottom of electrodes (whichever is more) plus the angle of repose from the 3rd field backward i.e. towards ESP inlet. In case a bidder desires to adopt any level higher than that calculated as above, this higher level may be adopted. Necessary calculations supporting the same shall be furnished along with the bid. The number and arrangement of dust hoppers shall be such that there is at least one dust hopper per HVRT. Further, an arrangement with one hopper being shared by more than one HVRT set is not acceptable. The hoppers for all fields shall be identical in shape and size.

- xviii. Hoppers shall be in welded steel plate construction. The lower 1.5 meters of each hopper shall be lined with 16 gauge or heavier, type 304 stainless steel. All hopper internal sloping corners shall have 100 mm radius. Hopper valley angle to the horizontal shall not be less than sixty-five (65) degrees. Hopper outlet flanges shall be terminated at 3.5 m height above the ground level to facilitate installation of fly ash removal system.
- xix. The dust hoppers shall be electrically heated up to a minimum of lower one third (1/3) of the dust hopper height but not less than 1.5 meter in height by thermostatically controlled panel type heating elements to prevent ash bridge formation. All heaters on each level shall have same wattage and be capable of maintaining internal hoppers temperature in excess of 150°C and capacity selection of these heaters shall be as per Owner approval. The heater arrangement shall be such not to produce any localized hot spot causing self burning of heaters. This temperature must be maintained even when there is no flow of flue gases through the precipitator. Maximum excursion of flue gas temperature up to 350 deg C, while the air heaters are out also shall be considered for heater mechanical design. They shall be arranged in at least three groups i.e. for the lower, middle and upper half of the heated height. The heating system shall be of low watt density, panel type to avoid hot spots and to have more uniform distribution of heat having the heating capacity not less than 10 kW per hopper, or approved equivalent and shall be complete with local junction box, indicating lamps and test lamps. The Minimum heat input shall in no case be less than 500 Watts/m² of hopper surface area. Each hopper shall be provided with separate thermostats. External surface of the hoppers shall be properly insulated.
- xx. Each hopper shall be provided with two (2) nos. of hundred (100) mm dia poke hole in mutually perpendicular directions, with threaded caps. The caps shall have flat iron bars suitable for striking with a hammer, to assist in breaking free any seized threads. The hoppers shall also be provided with suitably designed and located rapping anvils for loosening the fly ash by striking with sledgehammer.

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- xxi. Hopper baffles shall be designed to be capable of withstanding the unbalance of pressure created when one side of the hopper is filled with fly ash and the other side is empty. All bracing and stiffening shall be on the external side of the hoppers. Internal bracing, stiffening etc., shall not be accepted.
- xxii. Each dust hopper shall be provided with a high level, high-high level and a low level monitor operating on proven Radiofrequency measurement principle. The level monitoring system shall incorporate all the necessary accessories including three nos. level switches per hopper (one each for high, high high and other for low level), each with 2 NO + 2 NC contacts, local and remote signaling lamps and high and low level alarms. The high level ash switch shall provide contact closure and activate the alarm when the ash level reaches a level high enough to cause deterioration of ESP performance and possibility of damage to ESP structure if not corrected. After a preset time elapses with the ash under high alarm activated, the logic shall have provisions to de-energies the HVRT of the particular field of the affected ash hopper. The level control device shall be unaffected by ash build up, due to moisture or charged ash on either the hopper walls or on the probe itself. The high level switches shall be used for operation of ash evacuation systems.
- xxiii. The structural rigidity & strength of the ESP should be able to withstand the load of all hoppers fully filled with ash.
- xxiv. Each hopper shall be provided with a quick opening access door of not less than 600 mm dia, if round or not less than 450 mm x 600 mm, if rectangular. Access doors shall be hinged vertically and provided with a safety chain and grounding strap. Suitable access ladders shall be provided from the walkway beneath the hoppers to facilitate approach to the access doors.
- xxv. Thermal Insulation along with G. I. / Aluminium cladding shall be provided for ESP surfaces and hoppers having skin temperature more than 60 degree Celsius. Weather proof enclosure for insulator compartment complete with heaters, air blowers, filters, controls etc.
- xxvi. ESP shall be provided with pent house on roof top. ESP pent house shall be covered continuously with corrugated coloured metapoly sheet of min 0.6 mm thickness
- xxvii. Lower portion of each fly ash hopper shall have SS 304 liner plates. The outlet flanges shall be standard size and shall be located at a height of minimum 3.5m above the ground floor level. Suitable opening shall be provided on both sides in the lower portion of the hopper for providing fluidizing pads by others. The sizes and location of the opening shall be finalized during detailed engineering.
- xxviii. Transformer Rectifier Unit

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- a) Adequate number of roof mounted transformer-rectifier (TR) sets, mounted on ESP roof top, for supplying HVDC to the ESPs shall be provided by the Bidder. Minimum one no. of TR set per stream per series electrical field shall be provided. Each leg of the TR set shall not be connected to more than one bus section. Protection against surge, excess temperature rise and under voltage, etc. shall be provided for the TR units. Ambient temperature for design of TR units shall be taken as 50°C. Transformers shall be mineral insulated oil filled type class ONAN cooling type. The transformers and its associated equipment shall conform to IS or other approved international standards (like BS / DIN/JIS etc.) Each field of each section shall be provided with one TR set.
 - b) Relays and local instruments, such as, Buchholz relay, local oil level gauge, dial type thermometer with alarm & trip contact, pressure relief valve etc. and two nos. marshalling box, one for power and other for protection & control cable entry shall be provided by the Bidder.
 - c) Clear indication for 'ON' & 'OFF' for the transformers shall be provided. Dedicated key shall be provided in each rectifier panel and corresponding transformer for maintenance purpose so that in no case running transformer can be taken for maintenance. Provision for switching off each TR set from control room shall be provided.
 - d) Silicon diode type rectifiers with proven service record and conforming to relevant IS or other approved international standards shall be provided by the Bidder. The rectifier units shall be suitably arranged to give satisfactory operation at all loads with arrangement to take any one unit off the system without affecting operation of the precipitator. Each TR set shall be placed on a metal tray to collect leakage/spillage oil. All such trays shall be connected to common drain pipe which shall be extended up to ground level with necessary valves. The TR set shall be of approved make having adequate proven experience of use and subject to approval of the Purchaser. The HV Rectifier set shall preferably be located in a separate chamber, other than the transformer tank, in order to facilitate replacement / maintenance of the diodes. However, designs having HV rectifier integral to transformer tanks are also acceptable. Over current protection shall be provided in case of failure of diodes. Each TR panel shall have a provision of interfacing with ESP control room PC for ON – OFF, data logging, alarm and display, etc. During normal operation, if power fails, the system can be restarted from PC after revival of power.
 - e) HV side of the TR set shall be provided with isolator and earthing switch that can be operated from outside the HV enclosure.
- xxix. Control Panel, auxiliary control panel, rectifier control cubicle, annunciation
- a) Control Panel

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Microprocessor based semi pulse control system shall be provided. Bidder shall make a separate ESP cum VFD control building, which shall house LT transformers, Power Control Centers (PCC), MCC, auxiliary control panels and rectifier control cubicles. One no. Each unit ESP PLC shall be suitably interfaced with Plant DCS through suitable protocol located in unit control room. With this various parameters of the ESP shall be monitored and controlled from unit control room. The incomer and bus coupler status of LT main switch board, transformer troubles, indication, metering annunciation etc. of breakers, etc. shall also be monitored at DCS through hard wiring.

b) Auxiliary Control Panel

For control / regulation of operation of auxiliaries (rapping system, heating elements, etc.) auxiliary control panels for each horizontal pass of the ESP shall be provided. Each aux. control panel shall consist of necessary relays, Electronic master-controllers, timers, switches, indicating lamps etc. for the efficient operation and control of individual / group tapping mechanism and heating elements. Master controller and timer shall be designed to control the sequence and frequency of the operation of rapping mechanism of the collecting and discharge system of the different fields of the precipitators. Signal lamps shall indicate overload tripping of the rapping motors.

c) Rectifier Control Cubicle

Control cubicles for the TR unit shall incorporate protections for abnormal condition such as under-voltage protection and protection for excessive temperature rise and internal short circuit of the transformer winding. It shall also include devices like arc suppression unit. The panel shall be complete in all respects with DC and AC ammeters, voltmeters, circuit breaking devices, pulse rate controller, L.T. bus bar, control/ switches, indicators, visual and audio alarm overload and earth fault protection, current limiting relays, polarity switch (if applicable) and all necessary relays. The panel shall also provide all necessary interlocks, automatic regulator and other protective devices for safe and efficient operation of the precipitator and safety for operating personnel. DC voltage and current measurement must be directly from DC side.

d) Annunciation

Annunciation in the unit control room shall include.

- ESP rectifier faulty
- Electric supply to ESP failed
- Rapping mechanism trip
- Outlet dust emission level high
- Under voltage

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The annunciations shall be suitably made available in the HMI of ESP PLC.

xxx. 415V Power cum motor control center / PCC/PMCC

- a) 415 V power control center shall have two incomers and one bus coupler (all electrically operated ACB controlled). This PCC / PMCC shall have sufficient active / spare feeders for feeding the ESP MCCs, ESP control panels, etc. ESP MCCs shall have required no. of active and spare feeders for feeding all loads of ESP. Required number of active and spare outgoing feeders for control of various ESP drives and loads (including ESP, control building lighting, air conditioning & ventilation system and hoist loads) shall be provided for each unit. Electrical panels (PCC, MCC, etc.) shall be housed in a pressure ventilated room and ESP control panels shall be housed in air conditioned room.
- b) Each ESP PMCC / PCC shall be fed from 11 KV unit switchgears located in Power House building via a pair of dry type L.T. transformers to be installed adjacent to ESP PMCC / PCC within ESP cum VFD control building. LT transformers located near the ESP switchgear shall be connected to ESP PMCC / PCC by non-segregated phase, L.T. bus duct.

xxxi. Cables and cabling

- a) All power and control cables including special cables as required for inter connection of L.T. PCC & MCC, control cubicles, auxiliary control panel, TR units, heaters and rapping mechanism motors, remote signaling devices etc. of ESP system and AC & Ventilation equipment shall also be provided by the Bidder.
- b) Supply and installation of power and control cables including termination at both ends is included in the scope. Cable trays, supporting structures, cable trestle / tunnel / trench, etc. all accessories like cable lugs, glands, clamps, etc. are also included. Cabling shall be complete with cable numbering tags, core ferrules, indicating termination and destination at both ends, cable glands, supports and accessories. Connection between the TR units and the discharge system shall be provided by bus bar in ducting by the Bidder.

xxxii. Earthing and Shielding

- a) All electrical equipment shall be properly protected and two terminals shall be provided for earthing of each equipment. Earthing of electrical equipment shall be done as detailed elsewhere. Special electronic type earthing shall be envisaged for PLC/microprocessor based control system.

xxxiii. Safety Interlocks

- a) Safety sequential interlocks with mechanical key exchange boxes shall be provided to prevent access to interior of precipitator or hoppers unless all transformer rectifier sets are de-energised and grounded. This should be

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achieved by key interlock between the rectifier feeder circuit breakers and the door lock of the precipitator hoppers and roof doors.

xxxiv. Power Supply

- a) 11 kV power shall be fed to ESP L.T. transformer by cables and 415V, 3 phase, 4 wire 50 Hz power from secondary of the L.T. transformer shall be received at 415 V ESP PMCC / PCC through LT bus duct. Other power supply requirement if any shall be derived from this supply by Bidder

xxxv. Routine, Acceptance and Type Tests

Routine and Acceptance Tests

All acceptance and routine tests as per the specification and relevant standards shall be carried out in the presence of the Purchaser.

Type Test

The Bidder shall submit type test certificates of similar type of the equipment for the tests indicated below.

a) TR Set

- 1). Temperature rise test at rated DC current at 1:1 charge ratio
- 2). Lightning Impulse voltage test
- 3). Jacking test on Transformer load bearing member
- 4). Measurement of harmonic current in no load current
- 5). PRD operation test
- 6). Short Circuit Test (To be conducted as described below)

This short circuit test shall be performed on TR set along with the TR panel and controller with a spark gap connected across the output. The gap is adjusted to get the spark at kVp as applicable which is the short circuit condition and the controller shall control the voltage to quench the spark.

- 7). Oil leakage test for 24 hours
- 8). Vacuum test on tank
- 9). Pressure test on tank
- 10). Induced over voltage test
- 11). Measurement of no load losses and current
- 12). Measurement of impedance voltage/ short circuit Impedance and losses
- 13). Measurement of IR

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- 14). Measurement of acoustic sound level
- 15). Degree of protection test
- 16). Measurement of capacitance and tan delta

b). Insulators

- 1). Compression test on support insulator
- 2). Torsion test on shaft insulator
- 3). Lightning impulse test and one minute dry power frequency test on each type of insulators.

c). Disconnecting Switch

- 1). Lightning impulse test and one minute dry power frequency test

In case the bidder is not able to submit report of the type test(s) conducted or in the case of type test report(s) are not found to be meeting the specification requirements, the bidder shall conduct all such tests without cost implication in the presence of the Purchaser and submit the reports for approval.

However, in spite of availability of valid type test certificate following minimum tests shall have to be performed in presence of Owner / Owner's representative as per IS/IEC Standards:

- Impulse test on any one transformer of each type selected by the Owner.
- Heat run (Temperature rise) Test on any one transformer of each type selected by the Owner.

xxxvi. Model Study

- a. The Bidder shall conduct computer based model study using CFD technique to achieve optimum size and layout of the ducting, uniform flue gas distribution, maximum particulate collection, minimum draft loss, minimum dust drop out and build up and minimum re-entrainment from within the precipitator.
- b. The model study shall include the design of all connecting duct work from the air preheater gas outlets to the induced draft fans inlets, induced draft fan outlet to chimney flue inlet including the inlet duct transition piece, including all dampers, turning vanes and distribution devices. Based on the model test studies, the Bidder shall finalize the design of the duct work, guide vanes, flow splitters etc. The model study shall also include a gas distribution study for the duct system around ESP to find out the effect of isolation of one stream of the ESP.
- c. The report of CFD model study shall be furnished to the Owner. CFD model study for the ESP may not be needed in case the bidder has earlier carried out the CFD modeling for similar size and type of the ESP.

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The report of CFD model study earlier carried out by bidder for similar size and type of the ESP shall be furnished to the Owner.

1.4.11 Fuel Oil System

Fuel Oil System under Boiler & Auxiliaries package is envisaged from the terminal points onwards, as mentioned in Clause No. 5.1 of Section-I of Volume-II.

i. HFO Transfer System

HFO will be sent to the steam generator by means of positive displacement screw type supply pumps located in Fuel Oil Pump House. The HFO pumps shall deliver filtered heavy fuel oil in a common header kept at the correct pressure by means of a pressure control station on a recirculation line to the storage tanks; the pressure holders / accumulators if applicable, shall be installed to assure the minimum pressure required by the burners during trip of one pump and start up of the stand-by pump. Steam tracing is envisaged for all the heavy fuel oil lines to maintain required flow ability. Fuel oil burners shall be provided complete with diffusers, tips extension pipes, atomizers, burner shut off valves, flexible hoses and all other ancillaries. Oil connections to each burner from ring main shall be provided complete with fine filters as near as possible to each burner and means for determination of oil flow to each burner. Complete Piping along with auxiliary steam piping, oil drain piping, vent piping, tracing steam piping and recirculation piping shall be provided complete with all protection & instrumentation controls, suitable hangers, support, pipe trestles, etc.

ii. LDO Transfer System

LDO will be sent to the steam generator from by means of horizontal screw type LDO supply pumps complete located in Fuel Oil Pump House. A common re-circulating line with a pneumatic control valve is foreseen to re-circulate the light fuel oil to the LDO storage tanks. One pressure holder is envisaged to assure the minimum pressure required by the burners in case of trip of one pump. The light fuel oil system will have the following design features:

Relief valves will be provided on larger section of fuel oil pipes, which can be isolated. Isolation valves will be provided both on upstream and downstream sides for all in-line items like pumps, heaters, flow meters, filters, control valves etc., which are required to be taken out for maintenance. For LDO handling system, steam flushing system will be provided for cleaning during commissioning. Adequately sized pressure accumulators will be provided on fuel oil lines to individual Steam Generator for maintaining constant oil pressure. Each accumulator will be complete with a pressure gauge, stop cock and isolation valves to ensure maintainability of nitrogen pressure.

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iii. Pippings, Valves, Fittings, Pipe Support, etc.

The layout of oil piping, valves, flanges, steam traps, fittings and supports etc. shall be such as to facilitate maximum flexibility of interconnection of pumps, heaters, strainers. All HFO lines shall be steam traced and properly lagged. All lines carrying steam and oil shall be provided with adequate drain and vent connection. All fuel oil lines and filters shall be provided with steam flushing points at suitable locations. All steam and condensate piping handling fluid of pressure below 20kg/Sq.cm.g shall conform to the latest edition of IS: 1239 (Heavy grade) or ASTM-A-106 Gr. B or other approved equivalent standards. Oil pipelines from discharge of pressurising pump to boilers shall conform to IS: 1978 or other approved equivalent standard with latest amendments. Double isolation valves shall be provided from the discharge of the pressurizing pumps, for inline items that are to be removed for maintenance. This applies to flow meters, filters, isolation valves and the pressure maintaining valves etc. Larger lengths of piping that can be isolated shall be provided with thermal relief valves.

Between the pressure oil line and the return oil line, an interconnecting line shall be provided with automatic pressure control system to maintain the pressure of oil to the Boiler at a predetermined value. The interconnecting line shall also serve to divert the fuel oil to the return line under conditions when oil supply to the burners is to be cut off or reduced. Suitable non-return valves shall be provided on the return oil lines from the Boilers to prevent pressurized fuel oil from going back into the burners in the reverse direction when the quick acting valve closes. The fuel oil lines to individual boilers shall be provided with pressure accumulators of adequate size (if warranted by design) to maintain the oil pressure at a constant value.

All flanges shall conform to IS: 6392 or equivalent. The nominal pressure and temperature ratings of flanges shall be such as to withstand the design condition of the respective pipe/equipment to which they are attached. Matching counter flanges with nuts, bolts and gaskets shall be provided for all the system terminal points on oil, steam/condensate and air lines.

All high pressure pipe fitting shall be of butt welded construction, wherever possible and shall conform to ASTM-A-234 (carbon steel) or other approved equivalent.

All valves on oil, steam and condensate lines shall have cast steel body. Valves for oil service shall be fire safe ball valves type, easy to operate, less maintenance prone, leak proof, and self-lubricating type. The valve internals shall be chrome-steel for oil, steam / condensate lines. The drain valves shall be located at the lowest points in the system to ensure complete draining of the system.

Suitable supports / hangers shall be provided for all the piping covered under fuel oil facilities. Piping in the boiler area shall be designed with laying up on trestle supports as far as possible. The pipes crossing roads/rails shall also be trestle-supported. Dead zones in pipes shall be avoided as much as possible.

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The high temperature piping / heat traced piping shall be provided with expansion loops to take care of thermal expansion.

The steam traps shall be of proven design and provided with integral/separate strainers. The trap body shall be of carbon steel and the internals including strainer screen shall be of stainless steel conforming to AISI-316.

iv. **Steam Heat Tracing and Insulation**

The entire HFO pipeline shall be steam heat traced and insulated with slag wool to maintain heavy oil temperature in the system at 85 deg C \pm 5 deg C. The insulation shall be fixed with wire netting & external protection given by 22SWG thick aluminium sheets. Insulation shall be carried out as per IS: 7413.

v. **Condensate Flash Tank**

- Bidder shall provide all necessary arrangement to bring all the steam condensate drains of the fuel oil system to a common condensate flash tank.
- Condensate flash tank of adequate capacity one per boiler shall be provided in the Boiler area. The drains from these tanks shall also be led to the guard pond in effluent treatment plant

1.4.12

HP Chemical Dosing System

Phosphate Dosing System (Drum type Boiler)

High pressure chemical dosing system to be supplied shall be complete with solution preparation tanks, metering tanks, dosing pumps with motors, actuators and all accessories for pump stroke control including instrumentation, connected piping as required and all necessary relief, isolation and non-return valves, strainers and fittings, DM and condensate water supply piping as required for dosing system. The tank shall be provided as per IS:4682 and the tank shall be provided with 4.5mm thick rubber lining.

- (i). 2 x 100% capacity HP dosing pump shall be furnished for each boiler.
- (ii). Dosing pump shall be of positive displacement type, all stainless steel construction, adjustable stroke, complete with built-in recirculation type safety valve, drive motor, base plate etc. the discharge pressure of the pump shall be as per the requirement of the HP dosing system.
- (iii). On line self cleaning type filter shall be provided after the tank for removing the suspended particles.
- (iv). All piping, valves & fittings shall be as per ASTM SA 210 Gr.A1 or equivalent.

All Volatile Treatment (AVT) – For Once through Boiler

Bidder to consider an appropriate dosing system for the once through boilers as per the requirement.

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1.4.13 Auxiliary Steam System

The auxiliary steam system (Aux. PRDS) shall include the high capacity and low capacity pressure reducing stations to meet the continuous and start-up auxiliary steam requirements of the boiler turbine units. The steam source for high capacity PRDS shall be the main steam pipes and that for the low capacity PRDS shall be the cold reheat (CRH) pipes.

A high temperature unit auxiliary steam header operating at [16 kg/cm² (a) and 310 deg C] taking steam from the above PRDS stations and also a low temperature unit auxiliary steam header operating at [16 kg/cm² (a) and 210 deg C] shall be provided.

The auxiliary steam systems of the units shall be interconnected through the station auxiliary steam headers.

Bidder shall provide auxiliary steam system for meeting internal auxiliary steam requirement for the following services:

- i) Steam coil air pre-heater
 - ii) Burner atomizing steam
 - iii) Fuel oil heaters
 - iv) Steam tracing of fuel oil system
 - v) RAPH soot blower
 - vi) Systems of TG sets & auxiliaries, vapor absorption air conditioning machine.
 - vii) Besides above, spare tapplings with isolating valves shall also be provided. System provided shall be complete with pressure reducing desuperheating stations, valves, piping, headers, spray water system, supports and necessary instrumentation and controls.
- Each Boiler shall be provided with a suitable capacity High Capacity PRDS (HCPRDS), one no. Low Capacity PRDS (LCPRDS). For the HCPRDS, steam shall be tapped off from Main Steam Line and for the LCPRDS, steam shall be tapped off from Cold Reheat Line.
 - Suitable interconnection between the headers shall be provided generally and shall be subject to approval of the Owner / consultant. All interconnections shall be through motorized isolation valves. Besides normal tapplings shown in the tender drawing. 2 nos. spare tapplings with isolation valves shall also be provided on each of the headers indicated above. All stub connections on the unit / station aux. PRDS headers shall be provided with isolation valves.
 - Isolation valves with blank flanges shall be provided on both low temperature as well as high temperature station headers for future interconnection.
 - Auxiliary steam tapping from the boiler shall be provided with a root valve and a non return valve. Main PRDS station shall be complete with pneumatic control

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valve, facilities for automatic control with remote manual operation feature from fireman's panel.

- High temperature unit aux. headers shall receive steam from the above mentioned PRDS units. Low temperature unit aux. steam header shall receive steam by connecting it to high temperature header through a desuperheater. Station headers shall receive steam from respective unit auxiliary headers of both the units.
- The PRDS station shall be located at a suitable location in the boiler area. Tentative location of these low temperature header(s) & high temperature header(s) shall be in main turbine building (under the scope of TG package) *[at 32 m level in BC bay along C – row columns]*. Exact location shall be intimated to the successful Bidder after award of contract.
- The LCPRDS shall meet normal auxiliary steam requirements, whereas the HCPRDS shall meet the increased intermittent requirements of the unit and station. *[During cold start up auxiliary steam shall be supplied by the auxiliary boiler]*. Subsequently, when the MS pressure is more than 60kg/cm² and the CRH steam pressure is inadequate, the LCPRDS shall be inoperative and the auxiliary steam requirements shall be catered only by the HCPRDS. The same operation philosophy shall be adopted during hot start up also when there is adequate main steam available in the boiler and the CRH steam pressure is not adequate. Once the CRH steam pressure become adequate, LCPRDS shall become operative while the HCPRDS shall close down. Further, when the auxiliary steam requirement increases beyond the capacity of the LCPRDS, the HCPRDS shall open to meet the steam demand. However, in this case the LCPRDS shall be kept fully open and the auxiliary steam flow shall be controlled by the HCPRDS only. Thus the staggered opening of the HCPRDS shall allow parallel operation of both high and low capacity PRDS so as to meet the increased auxiliary steam demand. When the aux. Steam demand decreases within the capacity of the LCPRDS, the control shall be transferred back to the LCPRDS and the HCPRDS shall close fully. Changeover of control from HCPRDS to LCPRDS and vice versa shall be automatic with facility of manual override by the operator. Design shall ensure that changeover is bump less and smooth. Throughout the range of operation of the auxiliary PRDS, the steam flow shall be controlled either by LCPRDS or HCPRDS depending on the unit condition and steam demand. Load sharing between the two stations is not envisaged
- High Capacity PRDS shall supply steam for the following
 - i) Auxiliary steam requirement for air heater soot blowing,
 - ii) Pulveriser fire fighting etc.
 - iii) Intermittent requirements of Unit and Station
 - iv) Turbine driven Boiler Feed Pump

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- v) Start up requirement of other units
- vi) As stand by to Low Capacity PRDS station
- vii) Capable of delivering at least 20 T/Hr steam to Low Temperature Auxiliary steam station header.
- The exact quantity of minimum and maximum aux. steam required under different startup and operating condition shall be furnished by the Bidder along with the sizing and arrangement of PRDS units proposed by him.
- Low Capacity PRDS shall supply steam for normal requirements of it's own unit
- Adequate capacity safety relief valves and escape pipes shall be provided at auxiliary steam headers at suitable locations as per applicable codes to protect the equipment situated downstream of the pressure reducing stations.
- If steam for the Boiler unit auxiliaries is required at pressure/temperature other than that of the auxiliary steam header, suitable arrangements shall be made by the Bidder in the design of the Boiler to meet such requirements.
- All control valves used in the system shall be pneumatically operated.
- The HCPRDS system shall comprise of steam pressure reducing cum desuperheating valve, motorized isolation valve with integral bypass valve (motorised), separate steam temperature and pressure control valves, etc. as follows:
 - i) One number angular type electro pneumatically operated combined pressure reducing cum desuperheating valve rated for full duty.
 - ii) One number motorized isolation valve with motor operated integral bypass at the up- stream of the pressure reducing and desuperheating valve.
 - iii) 2 nos. desuperheating spray water lines (one main and one 100% bypass line) each having one number pressure control valve and one no. temperature control valves (electrohydraulically / electropneumatically operated). These two lines shall be interconnected and a common line shall be led up to the combined HCPRDS.
 - iv) One number motorized isolation valve at the inlet of pressure and temperature control valves on each desuperheating spray water line.
 - v) One no. non return valve (NRV) and one number manual isolation valve at the downstream of combined HCPRDS station.
 - vi) One no. manual isolation valve on each spray water line downstream of pressure and temperature control valves. One no. NRV on common spray water line going to HCPRDS.
- The LCPRDS system shall include steam pressure control valve, motorized isolation valves, motorized bypass control valves, separate pressure and temperature control valves, etc as follows:

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- i) One number electro pneumatically operated pressure reducing valve rated for full duty.
 - ii) One number of motor operated pressure reducing valve rated for full duty on the bypass line to the main pressure reducing valve.
 - iii) One number motorized isolation valve at the inlet of main pressure reducing valve.
 - iv) One number motorized isolation valve at the inlet of the motor operated pressure reducing valve on the bypass line.
 - v) One number desuperheater downstream of the pressure reducing valve.
 - vi) 2 nos. desuperheating spray water lines (one main and one 100% bypass line) each having one number pressure control valve and one no. temperature control valves (electrohydraulically / electropneumatically operated). These two lines shall be interconnected and a common line shall be led up to the desuperheater.
 - vii) One number motorized isolation valve at the inlet of pressure and temperature control valves on each desuperheating spray water line.
 - viii) One no. manual isolation valve on each spray water line down stream of pressure and temperature control valves. One no. NRV on common spray water line going to desuperheater.
 - ix) One number motorized isolation valve on the steam line, upstream of the desuperheater.
 - x) One number NRV and one number manual isolation valve on the downstream of the desuperheater.
- The control system for Auxiliary PRDS system shall be microprocessor based with facility of TFT/KBD operation as well as through the back up push button station etc.
 - For pneumatic actuation system envisaged for the control valves, positioners with complete set of feedback cams, position transmitters , smart positioners, air filter regulator sets, with inlet and outlet pressure gauges, solenoid valves, air lock(if required), limit switches and other accessories to make the system complete shall be provided.
 - All local sensors and gauges for pressure /temperature and process suitable devices as per the process requirements.
 - Complete control system inclusive of control system components, control cabinets, console inserts, transmitters, sensors, interlocks, prefabricated cables, interconnecting special cables, etc. and all required accessories shall be provided.
 - For meeting auxiliary steam requirement of the facilities falling under the battery limit of this package, entire auxiliary steam piping from the headers up to the

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consumer points along with all valves, supports, fittings and specialty shall be provided by the Bidder.

1.4.14 Blow Down Tanks

Blowdown vessel shall receive blow down from the drum, water walls drain header & attemperator headers. Blowdown vessel shall be designed as per IS-2825 or approved equivalents. All the inlet connection to the tanks shall be tangential and wear plate shall be provided to take of the erosion.

Two number blowdowns tanks shall be provided for each Boiler, one intermittent blow down (IBD) tank and other continuous blow down (CBD) tank. The IBD shall be sized to receive the following:

- (i). All blow down and drains from Boiler.
- (ii). Drain from water wall headers, attemperators headers and CBD tank.
- (iii). Alternate drains from main steam lines, CRH lines, HRH lines and SCAPH drains.
- (iv). Other drains from power cycle piping.

The CBD tank shall receive the continuous blow down from the Boiler drum. CBD system shall be designed for maximum blow down of 5% BMCR load. Facility for complete bypass of CBD tank shall also be provided. The flashed vapour from CBD vessel shall be led to the deaerator.

The IBD tank shall be located at ground level near Boiler and CBD tank shall be located at deaerator floor.

Tank design shall not allow discharge of any free water from vent. The steam velocity through the vent pipe shall not exceed 90 m/s. Vent pipe size shall be so selected that no pressurisation takes place in the blow down tank.

Drain valve & drain piping shall be provided with a suitable loop pipe arrangement so as to maintain a minimum water level inside the tanks. The drain shall be cooled and the cold discharge shall be connected to guard pond in the effluent treatment plant.

Blowdown tank shall include level gauges, local pneumatic level controllers, redundant level transmitters for remote level control through Boiler C&I system, control valves, safety valves, vents, drains. All other local instruments like gauge glass, level switch, high/low level alarms and pressure/temperature instrumentation shall also be provided.

1.4.17.1 Tank Constructional Features

1. Tanks shall be designed and fabricated as per requirements of IS 2825/ BS 806.
2. All drain connection to the tanks shall be tangential, and wear plates shall be provide to prevent erosion due to high pressure and high velocity drains.
3. Matching flanges shall be provided for level switches and other instruments.

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4. Drain valves and drain piping shall be provided at the bottom of the BDT. All drains from BDT shall be cooled to a temperature not exceeding 60°C.
5. Manholes on BDT shall be provided with hung on hinged type bolted doors.
6. IBD Tank drain shall be connected to guard pond provided by purchaser and the vent shall be routed to above boiler roof.

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2 DESIGN AND SIZING OF POWER CYCLE PIPING

2.1 Codes & Standards

The Design, manufacture, shop testing, erection, testing and commissioning of piping and valves shall conform to the latest revisions of the following codes and Indian Standards or equivalent international codes, in addition to other standards mentioned in the tender documents subject to any modification and requirement as specified hereinafter.

IS: 778	: Gunmetal gate, globe and check valves for general purpose.
IS: 780	: Sluice valves for water purpose (50 to 300 mm).
IS: 1239	: Mild steel tubes and fittings - Part I & II, ERW pipe upto 8" diameter.
IS: 1536	: Centrifugally cast (spun) iron pipes for water, gas and sewage.
IS: 8329	: Centrifugally cast (Spun) Ductile Iron Pressure Pipe for water, gas and sewage
IS: 1537	: Vertically cast iron pressure pipe for water, gas and sewage.
IS: 1538	: Cast iron fittings for pressure pipes for water, gas and sewage.
IS: 1703	: Ball valves (horizontal) plunger type including floats for water supply purposes.
IS: 2379	: Colour for the identification of pipe line.
IS: 2685	: Code of practice for erection, installation, and maintenance of sluice valves.
IS: 2906	: Sluice valve for water works purposes (350 to 1200 mm).
IS: 3042	: Single faced sluice gates (200 to 1200 mm).
IS: 3589	: Electrically welded steel pipes for Water gas & sewage (200 to 2000 mm).
IS: 4038	: Foot valve for water works purposes.
IS: 4984	: High Density polyethylene pipes.
IS: 4985	: Unplasticised PVC Pipes.
IS: 5312	: Swing check type reflux (non-return) valve Part-I.
IS: 458	: Concrete pipes (with and without reinforcement).
IS: 3952	: Cast Iron butterfly valves for general purposes.
ASTM-A 106	: Gr.C Seamless carbon steel pipe.
ASTM 53	: Seamless carbon steel.
AWWA-C-504	: Standard for butterfly valve.
BS: 5156	: Standard for Diaphragm valve.
IS: 554	: Pipe thread for pressure tight joints.

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IS : 1363	: Black hexagon bolts, nuts and lock nuts.
IS: 1364	: Precision and semi-precision hexagon bolts, screws, nuts and lock nuts.
IS: 2062	: Structural steel fusion welding quality.
IS: 4736	: Hot dip zinc coating on steel tubes.
IS: 2825	: Code of unfired pressure vessels.
IS: 2712	: Gaskets.
IS: 4192	: Part-I Rubber lining.
IS: 9523	: Specification for Ductile Iron fittings for pressure pipes for water, gas and sewage
IS: 3006	: Acid resistant SWG Pipe.
IS: 783	: Code of practice for laying RCC pipes.
IS: 3114	: Code of practice for CI Pipes.
BS: 5142	: CI globe valve.
ANSI:B 16.5	: Steel pipe flanges and flanged fittings.
ANSI:B 31.1	: Power Piping code.
ANSI B 16.34	: Valves-Flanged, threaded and welding ends
ASME Sec –VIII, Div 1	: Boiler and pressure vessels code
ASME B 16.21	: Non metallic gaskets for flange
ASME B 16.20	: Metallic gaskets for flange
ASME B 16.11	: Screwed joints
ASME B 16.25	: Welded joints
ASTM A 106, Gr. C	: Schedule 80 - Seamless carbon steel pipe
ASTM A 312 Grade TP-316	: Schedule 40s - Stainless Steel pipes
IS:4984- Class-5	: High density polyethylene pipes
IS:4985- Class-4	: PVC Pipes.
ASTM D 3517 / 4024	: GRP pipes
ASTM A 105	: Standard specification for carbon steel forgings for piping application.
ASTM A 182	: Standard specification for forged or rolled alloy and stainless steel, pipe flanges, forged fittings and valves and parts for high temperature service.

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ASTM A 216	: Standard specification steel casting suitable for fusion welding for high temperature service.
ASTM A 217	: Standard specification for steel castings martensitic stainless and alloy for pressure containing parts suitable for high temperature service.
ASTM A 234	: Standard specification for pipe fittings of wrought carbon steel and alloy steel for moderate and high temperature service.
ASTM A 312	: Standard specification for seamless welded and heavily cold worked austenitic stainless steel pipe.
ASTM A 335	: Standard specification for seamless ferritic alloy steel pipe for high temperature service.
ASTM A 403	: Standard specification for wrought austenitic stainless steel pipe fittings.
MSS SP-58	: Pipe hangers and supports- Materials, designs and manufacture
MSS SP-69	: Pipe hangers and support – Selection and application
API-6D	: Specification for pipe line valves
API-607	: Fire test for soft seated ball valves
API-598	: Valve inspection test
API-594	: Standard for dual check valve
ASTM A-193-194	: Specification of alloy steel and stainless steel bolting material;/ nuts for high temperature services

2.2 Design Basis

1. Design, fabrication, testing & erection of Power Cycle Piping, valves & specialties for critical piping system under purview of IBR, shall satisfy IBR, and ANSI/ASME B31.1 latest code.
2. Design, fabrication, testing & erection of Power Cycle Piping, valves & specialties for non-critical piping system which are not purview of IBR, shall satisfy ANSI/ ASME B31.1 latest code.
3. Sizing, design and installation of safety valves shall conform to IBR and the non-mandatory rules for the design of safety valve installation of ANSI/ ASME B31.1.
4. Piping Flexibility analysis shall be carried-out for all piping having sizes equal to or above 50 mm NB & design temperature 100°C and more, according to ANSI/ASME B-31.1 latest & also satisfying IBR latest.
5. Design pressure and temperature shall be as per IBR. Wherever not clearly stipulated in IBR, criteria stipulated in ASME/ ANSI B31.1 for selecting design pressure & temperature shall be followed.
6. Material of construction of piping, valves & specialties shall conform to relevant ASME / ASTM / BS / IS or equivalent codes/standards. In case materials not approved by IBR are used, it is the Bidder's responsibility to obtain IBR approval, without affecting the Construction schedule.

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7. Type of Hangers, supports etc. shall be selected as per the following criteria:
- a) Variable spring hangers
 - (i). Where the variation in supporting effort between hot and cold condition does not exceed 20% of the higher of the operating load and cold setting load.
 - (ii). The resulting effect of load take-up/ release by a group of hangers in a span does not overstress the piping span or cause overloading at equipment terminals.
 - (iii). Thermal deflection between hot & cold conditions does not exceed 40 mm.
 - b) Constant load hangers

When thermal deflection between hot and cold conditions exceeding 40mm, these are used.
 - c) Spring hangers

These should not be loaded more than 80% of the spring travel range.
 - d) Rigid hangers & restraints

To be judiciously selected, without exceeding the stipulated limits of terminal forces & moments and stress level. Struts shall be considered where compressive load is expected.
8. Design Requirement of Hangers & Supports:-
- In order to minimize any horizontal force components of the dead weight or any binding of the pin or rocker joints used on the hangers, the hanger rods should be as long as possible. In critical piping systems, the length of the hanger assembly capable of swinging shall not be less than 20 times the maximum expected pipe movement in the horizontal plane at the hanger location. It is recommended in case of main steam piping to provide for a hanger rod length of at least 5-6 meters wherever feasible.
- Constant support type of hangers shall be adopted at all locations on critical piping excepting where the smaller of vertical movements of pipe justifies the use of variable spring hangers.
- As far as practicable, connections of hangers to supporting structure shall be achieved without welding to structural members. If welding is inevitable, adequate factor of safety shall be considered in the design and specification of the weld.
- The attachment of support brackets to brick walls shall be avoided as far as possible and where this is not possible, details of the attachment shall be furnished to the consultant for his approval. Under unavoidable circumstances, when medium or heavy brackets are bolted to walls, back plates of adequate size and thickness shall be furnished to distribute the load against the wall. Where the use of a back plate is not practical, the brackets shall, be fastened to the wall in an approved manner.
- Diameter of hanger rods for piping NB 50 mm and smaller shall not be less than 10 mm and for piping with size NB 65 mm and larger shall not be less than 13 mm.
- All components for hangers such as turn buckles, clamps, etc. shall be of forged steel.
9. Snubbers, dampers etc.

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To take seismic / dynamic loads, thrust due to safety valve discharge. Effort shall be made to limit its use by judicious placement of rigid hangers. Bottom support spring hangers are to be avoided as far as possible.

10. Design, materials, fabrication, testing and erection of hangers, supports, anchors, guides etc. shall be as per ANSI/ASME B31.1 latest code. Material of support packing used for alloy steel piping shall be same or better than the parent pipe material.
11. Hanger suspension rods, tie-rods/ struts should have proper arrangement & adequate length, so that thermal movements in direction which are free are not constrained and should not make an angle more than 4 degree with vertical due to horizontal pipe movement.
12. Pipe Thickness calculations shall be made on the basis of procedure and formula given in ANSI B31.1. Stress values of piping material for calculation shall be selected from tables given in ANSI B31.1. Thickness, thus calculated shall be checked as per the formula of IBR and the more stringent of the two shall then be selected. If it is seen that sizes arrived at for main steam and hot reheat pipes are not in the standard range of the manufacturers, ID controlled piping, shall then be selected for these piping systems.
13. Pipe sizing and piping system design shall conform to the requirements of power piping code ANSI B31.1. Statutory requirements as laid down in Indian Boiler Regulations (latest edition) shall also be taken care in pipe system designs. Pipe wall thickness as calculated by ANSI Code formula shall also be checked for IBR requirements for piping systems falling under IBR purview.
14. Inside diameters of piping shall first be calculated for the flow requirement of various systems. The velocity limits for calculating the inside diameters are listed below used to determine line size if dictated by considerations of pressure drop, NPSH, surges, water hammer, etc.
 - a) Steam
 - i) Main Steam hot and cold reheat pipes : 75 m/sec.
 - ii) Saturation steam : 40 m/sec
 - iii) Auxiliary steam : 30 m/sec.
 (Aux. steam to take care of various design flows)
 - b) Feed Water :
 - i) Suction : 2.0 m/sec.
 - ii) Discharge : 5.0m/sec.
 - c) HP bypass
 - i) Upstream : 75 m/sec.
 - ii) Downstream : 100 m/sec.
 - d) LP bypass
 - i) Upstream : 75 m/sec.
 - ii) Downstream : 100 m/sec.
 - e) Extraction steam

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- i) Superheated steam : 60 m/sec.
 - ii) Saturated steam : 30 m/sec.
- f) Condensate
 - i) Discharge : 3.4 m/sec.
 - ii) Suction : 1.5 m/sec.
- g) Heater vents : 25m/sec.
- h) Heater drains : 1.5m/sec.
- 15. Other piping - As per good engineering practice.
- 16. Drains shall be provided, at all low points and vents at all high points as per actual layout regardless of whether the same have been shown in the flow diagrams or not. Pipelines shall be sloped towards the drain points. For operating temperatures of greater than 400 deg C, drip leg with drains, operated by a motor operated valve shall be provided. At all other drain locations (operating temperatures less than 400 deg C) traps shall be provided. All traps shall be provided with strainers, isolating, bypass and free blow valves. Traps shall be thermodynamic type

2.3 Piping Design

Complete design, engineering, etc. for the power cycle piping systems and other piping systems shall be the responsibility of the Bidder. Owner's/Consultant responsibility/ function in this connection shall be limited to review and approval of Bidder's design/ calculation, engineering, drawings, documents. Bidder's scope of services for complete engineering of the piping systems shall include but not be limited to the following:

1. Preparation of engineering piping diagram indicating flow schematic, flow parameter, pipe sizes, line designations and tag nos. of various components etc.
2. Design parameter selection, pipe sizing calculation, pipe schedule, valve schedule, insulation schedule, specialties schedule and hanger schedule for the systems.
3. Preparation of preliminary as well as final composite piping layout drawings of pipe size 65mm NB & above.
4. Design in detail all piping supports including restraints, guides, stops etc., after deciding the final location of hangers and supports and based on final stress analysis and hanger/ support load data.
5. Prepare separate sketches for each hanger/ support, restraint, anchor, etc. These sketches shall include the location with reference to column co-ordinates, identification number, bills of material, design loads, operating load, spring stiffness, amount of spring pre-compression etc., the method of attachment to the pipe and steel structure. Additionally the sketches shall show a key plan referenced to plant north and centre line elevation of the pipe at the point of attachment for cold and hot conditions.
6. Preparation of fabrication and erection isometric (with material take off) drawings for shop fabricated piping which are of size 65 mm NB and above.

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7. High pressure piping shall be manufactured from hot or cold finished, seamless steel tubes. Bosses shall be provided for the purpose of creep checking. Zero measurements shall be taken and recorded before the plant goes into service.

2.4 Stress Analysis

The Bidder shall carryout stress analysis of piping system using proven and validated software and shall submit for Owner's/Consultant approval.

- (a) Following loading conditions shall be considered for stress analysis:
- i) Internal pressure
 - ii) Thermal loads due to – (i) Piping thermal expansion and (ii) Anchor displacement due to thermal movements of piping anchors.
 - iii) Piping weight consisting of weight of piping, valves, bends, fittings, insulation etc. as well as weight of support components like clamps, shoes, suspension rods, trapeze etc. & weight of contained fluid.
 - iv) Test or cleaning fluid load
 - v) Equivalent static loads due to discharge of safety valve (SV), Electromatic relief valve (ERV), simultaneous discharge of SV & ERV where applicable.
 - vi) Dynamic load due to steam hammer (if applicable)
 - vii) Seismic loads due to
 - Equivalent static load due to seismic inertia effect and
 - Equivalent static load due to seismic anchor displacement
 - viii) Wind load where applicable
- (b) Loading combination Design load for supports, restraints, anchors & supporting structures shall be obtained by proper selection of one or combination of two or more of the loads as above based on the possibility of independent or simultaneous occurrence. Loads imposed due to hydrostatic tests shall also be taken into consideration for the design of supports.
- (c) Bidder shall clearly indicate the basis of his judicious selection or loading combination for support, restraints and anchor design. Component of thermal expansion reaction range expected to appear at cold condition, as per equation 9 & 10 of ANSI/ASME B31.1 shall be considered in loading combinations. As overload factor of 1.30 shall be considered over the computed loads except occasional loads before combining them. Bidder shall justify with reasoning in case any one of the specified loads is not considered in analysis.
- (d) Combination of Stresses the computed stress under different loading conditions shall be combined as per equation 11, 12 & 13 of ANSI/ASME B31.1 & the stress shall be within allowable limits.

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- (e) Allowable stress values for piping materials other than ASME/ASTM materials, values shall be derived as per the criteria defined in Appendix-P of ASME Boiler & Pressure Vessel Code, Section-VIII, and Division 1 while computing pipe wall thickness and flexibility analysis shall be conducted as per ANSI/ASME B31.1. However, higher of pipe wall thicknesses derived between IBR regulation & ANSI/ ASME B31.1 code shall be considered.
- (f) Factor to be considered in flexibility analysis.
 - i) Cyclic load operation of the Unit. Bidder shall consider value of stress range reduction factor 'f' for cyclic conditions due to temperature reversals equal to ONE.
 - ii) Stress intensification factor at all transitions, fittings & all branches as per ANSI/ASME B31.1.
 - iii) Variation in supporting effort by variable spring due to pipe movements
- (g) Piping Flexibility analysis is to be conducted as per the piping layout in case any modification of piping layout is felt essential to maintain stresses & terminal reactions within allowable ranges, same are to be carried out by the Bidder after discussion with Owner/Consultant.

The following piping systems shall be analyzed:

- i) Pipelines with a maximum operating temperature equal to or greater than 100 deg C having size 50NB or above.
- ii) A write up on the stress analysis including codes used and design conditions considered.
- iii) A copy of the computer print out for input data for the various design conditions considered for stress analysis along with the stress diagram (piping isometric marked with node points marked.)
- iv) A copy of flexibility analysis software soft copy shall also be submitted for Owner/Consultant approval.
- v) Analysis results in tabular form giving calculated and allowable reactions / forces / moments on equipment nozzles/terminals for the various design conditions considered for analysis.
- vi) Allowable and calculated code stresses at various node points in the piping for the design conditions considered based on code requirements for analysis.
- vii) Analysis results giving calculated forces and moments and movements at various hanger / support / restraint / anchor points from the static analysis corresponding to various thermal / operating conditions, sustained load case, hydro load case (other than water lines) and occasional loads, as applicable, for each piping system analyzed.

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2.5 Statutory Approvals

- (a) It is the sole responsibility of the Bidder to identify and obtain all necessary approvals from various Government agencies / statutory authorities including IBR, CCoE, etc., as applicable for the design, manufacture and testing of pipes, valves, fittings, specialties etc.
- (b) The Bidder shall also identify and obtain all necessary approvals from the IBR authority in the state where the plant is being installed, for the erection / testing / commissioning and any other requirement as required by IBR.
- (c) It is also the responsibility of the Bidder to get approval(s) from any other statutory authority in other countries from where the supplies are made, as applicable and acceptable to IBR for the design/manufacture/testing etc. for the piping / fittings / valves / specialties etc.
- (d) In order to obtain the above approvals, all necessary documentation etc. required shall be arranged and furnished by the Bidder to the statutory authorities.

2.6 Installation

- (a) Cleaning including chemical cleaning of all systems as specified herein and installation of temporary pipe work for the same. All hot bent, forged formed, fabricated and straight pipes shall be chemically cleaned, pickled or wire brushed and purged with air blast or shot/grit blast to remove all sand and scale from the inner surface as applicable.
- (b) Making temporary closures/ stubs on piping system as required for hydrostatic testing and performing hydrostatic test on all piping. All pipes shall be hydro tested at shops for pressures as per standards and all erected piping shall be tested 1.5 times the design pressure.

The Bidder shall carryout the following cleaning after hydro test.

- i) All piping shall be mass flushed, in addition to the specific cleaning operations as described below, as required.
- ii) Main steam, cold and hot reheat piping and HP & LP bypass piping shall be steam blown.
- iii) Auxiliary steam piping and associated steam lines, heavy fuel oil/ LDO piping shall be steam blown.
- (c) Making interface piping connections at TP with equipment/piping etc. as applicable.
- (d) Apart from carrying out chemical cleaning, the work shall include neutralization disposal of water, clean up, reinstatement of the cleaned piping system, dismantling and removal all temporary piping, equipment and materials from site.
- (e) Painting of piping system shall be in accordance with the stipulations laid down elsewhere in this specification.
- (f) Weather hood for pipes crossing ceilings and walls.

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2.7.1 Checks after Installation

In order to ensure that all supporting elements, anchor and restraints have been installed and adjusted in accordance with design documentation, the Bidder shall inspect and log the hanger readings for the hangers associated with the power cycle piping system as follows:

- (a) After hydrostatic test with the piping in the cold position, with all travel stops removed, with the pipe completely insulated and in all respect ready for start-up.
- (b) Piping in hot position (rated parameter condition) after six (6) months of operation.
- (c) Piping in cold position during the first complete shutdown after at least six (6) months of operation.
- (d) After steam blowing, in case steam blowing is applicable for the line.
- (e) At the time of each inspection, the Bidder shall determine the necessity for revision, adjustment or replacement of pipe supporting elements, restraints and anchors. Any changes proposed shall be subject to the concurrence of the Owner/Consultant. The changes shall be incorporated by the Bidder after Owner's/Consultant concurrence.

2.7 Inspection and Testing

All shop tests as required by the applicable codes, ANSI Standards, IBR and other standards specified.

- (a) Obtaining approval from Chief Inspector of Boiler as per latest Indian Boiler Regulations (IBR) is the responsibility of the Bidder. This shall include furnishing all necessary certificates for design, manufacture and testing for pipe, valves, fittings, specialties, tanks, vessels certificate of manufacture and test for each erected entity in the relevant formats to the Chief Inspector of Boilers, obtaining his approval and furnishing the same to the Owner/Consultant.
- (b) The Bidder shall also identify and satisfy all other statutory code requirements as may be required for the piping systems covered in this specification.
- (c) Certified copies of test reports for all tests and examinations specified in the specification and for the mandatory test and analysis required by ASME/ ASTM material specification, for the materials used for piping, shall be furnished to Owner/Consultant.
- (d) Provide complete interface engineering with the suppliers of other equipment and piping with which the piping systems in the Bidder's scope are connected.
- (e) Performing all tests and implementing all quality control procedures as specified herein including provision of testing equipment, stress relieving equipment, radiography equipment and any other equipment necessary to meet the requirements of the specification.

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2.8 Low Pressure Piping, Valves and Fittings

This section of specification covers all low pressure piping within the battery limits handling fluids HFO, LDO, etc.

Low Pressure (LP) piping shall, basically, cover piping systems for the following services:

- i) Boiler fill system.
- ii) Fuel oil (LDO / HFO) Systems.
- iii) Chemical feed lines
- iv) Auxiliary cooling water system
- v) Drain piping system for the piping\equipment etc.
- vi) Re-circulation pipes along with valves, break-down orifices etc., wherever required.
- vii) DM, Potable and service water distribution
- viii) Compressed air piping
- ix) Laying of AC/Ventilation ducting within the battery limits.
- x) Any other piping system required to make the Low Pressure (LP) piping systems complete.

All the piping systems be designed to operate without replacement and with normal maintenance for a plant service life of [20-25] years, and shall withstand the operating parameter fluctuations and cycling which can be normally expected during this period.

2.9 Piping Materials and Sizes

All piping system shall be capable of withstanding the maximum pressure and temperature in the corresponding line. The pressure rating of individual piping system component such as valves, flanges etc shall however be not less than that specified. Nominal pipes sizes and pipe outside diameters shall generally be as per ANSI B36.10. In case of deviation Bidder shall bring it to the specific attention of Owner/Consultant for prior approval stating reasons for the deviation.

The Steel pipes (Welded type) for the services of water/clarified water/Filtered water shall conform to the following standards or codes.

- i) Pipes upto 150 NB
 - a) IS:1239 Part-I (Heavy grade-Black)
 - b) ASTM-A-53 Grade B (Welded) Sch 80 up to 2 inch nominal size(Minimum)
Sch 40 above 2 inch nominal size (Minimum).
- ii) Pipes 200 NB and above

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- a) IS:3589 – Grade 410
- b) ASTM – A53 Grade B (Welded) Sch. 40 (Minimum)

2.10 Wall Thickness

The calculation of wall thickness required for pipelines subject to internal and/or external pressure shall be based on the formulae and recommendations as given in the applicable codes. Adequate allowances shall be made towards thinning due to bending, weakening at branch connections, threading, commercial tolerances on pipe wall thickness, corrosion and erosion, etc. and the same shall be subject to approval by consultant. In any case a minimum corrosion allowance of 1.0 mm shall be considered while selecting the thickness.

In case of carbon steel materials, the nominal wall thickness of pipeline shall be not less than the minimum acceptable values given below:

NB mm	15	20	25	32	40	50	65	80	100	125
(inch)	(1/2)	(3/4)	(1)	(1 1/4)	(1.5)	(2)	(2.5)	(3)	(4)	(5)
Min. thickness, mm	3.2	3.2	3.6	3.6	3.6	3.6	3.6	4.0	4.5	5.4

NB mm	150	200	250	300	350	400	450	500	600
(inch)	(6)	(8)	(10)	(12)	(14)	(16)	(18)	(20)	(24)
Min. thickness, mm	5.4	6.35	6.35	6.35	7.1	7.1	7.1	8.0	8.0

> NB 600 mm to NB 950 mm - 10.00 mm

> NB 950 mm to NB 1200 mm - 12.00 mm

2.11 Fittings

Fittings to be used with carbon steel pipes shall conform to IS: 1239 Part-II (Heavy grade) or ASTM A 234 Gr. WPB. for sizes upto 150 NB.

For sizes 200 NB & above steel fittings shall conform to ASTM A 234 Gr. WPB. However for sizes above 300 NB fabricated fittings (mitre bends etc) may be used.

Wherever regular pipe bends are employed for change of direction the same shall be to a radius of 5 times the pipe diameter. Mitre bends shall be 1.5D radius.

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Inside surface of all the fittings used for the rubber lined application shall be de beaded and made suitable for rubber lining.

Galvanized pipe application all the fittings shall be galvanized as per IS: 4736. Fittings to be used in other type of piping shall conform to relevant IS/BS ANSI Standards and in conformity with the parent pipe standard.

Branch connections in piping shall be made by the use of wrought or forged seamless fittings such as tees, laterals and crosses. Small stubs as may be required for instrument, drain and vent connection may be provided in the form of weld outlet fittings or forged couplings. Intersection welds are acceptable only in the event of non-availability of fittings.

2.12.1 Design and Construction

(a) Pipes, valves and Fittings

Following items shall be included for piping:

- i) Pipes, bends, elbows, tees, branches laterals, crosses, reducing unions, couplings, cap, expansion joints, flanges, blank flanges, saddles, shoes, sampling connections etc. necessary for making a reliable piping system.
- ii) Valve, gates, dampers, etc.
- iii) Strainers and filters.
- iv) Instrument tapping connection, stubs and thermo-wells, root valves.
- v) Matching flanges, pipe spools and matching pipes to connect to equipment, instruments, etc. as necessary.
- vi) Gaskets, ring joint, bracing rings, jointing material etc. as required.
- vii) Bolts, nuts, fasteners as required for interconnecting piping, valves and fitting as well as for terminal points.
- viii) Pipe supports like pedestals, Anchor blocks (for buried / over ground piping), brackets, hangers, clamps, trestles, etc.
- ix) Secondary steel for pipe supports and embedded steel. Also pipe supports and necessary embedment required to be embedded in concrete for underground/above ground pipes.
- x) Painting, anti-corrosive coatings, wrapping and coating, thermal insulation, etc. inside and outside of pipes as necessary.

(b) End connections

Unless otherwise specified, following types of end connections shall be used:

Pipes 50 NB and smaller shall have socket welded joints for chlorine line. For water, air and other services where steel pipes are used, joints of this size range shall be Socket welded/screwed/flanged type (For rubber lined pipes).

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All unlined steel pipes 65 NB and above (other than CI pipes and air service pipes) shall be jointed by butt welding. All rubber lined pipes shall have flanged joints.

Butt welding edge preparation shall be done as per ANSI B 16.25. The Bidder shall furnish details/specifications for all welding electrodes and welding rods including special ones, if any for approval.

Steel pipe flanges shall be generally slipped on flat face type. Weld neck flanges shall be used when flange follows immediately after a butt welding or where it is required with respect to service conditions. Slip-on type of flanges may be only up to a maximum pressure rating of ANSI 300 lbs. In case of higher pressure ratings, weld-neck type of flanges shall be employed. When weld neck or socket weld flanges are used, their bore must be made the same as that of the pipe being welded to. Socket welded or threaded flanges may be used, with the appropriate piping system for connection of pipe to the flanged equipment.

All the piping flanges and counter flanges shall conform to ANSI B 16.5 Cl. 150 (minimum). However wherever the interferences is involved with the Owner's pipe, the flange/interconnection details shall be designed to match the piping and the details of which will be intimated later.

For easy handling & removal of equipments, valves etc. and for maintenance purpose, break up flanges for 65 NB and above sizes and suitable type of compression flexible coupling for flanged joints of 50 NB and below size shall be provided. The over ground piping wherever routed inside building, shall have a clear head room of minimum 2.1 metre from operating floor/walk ways.

2.12 Piping Layout

- (a) Pipes shall be generally routed above ground but where specifically indicated/specified the pipe may be laid in trenches or buried. Buried piping shall be generally installed so that the top of pipe is 1.0 meter below the ground level unless otherwise specifically mentioned. Full length of buried piping shall be provided with 100 mm thick sand bed.
- (b) Complete supporting system for the pipe line shall be designed, fabricated and supplied by the Bidder. Inside the building, the overhead portion of the pipe line may be supported from the building structures. No support shall be taken from the brick wall. Outdoor, pipes other than buried pipes shall run on steel trestles. Crossing of the road shall be on a pipe bridge with a clear height of at least 8.0 meters (minimum) over the road surface. All the steel structure for the pipe bridge and the supporting posts/trestles along with all necessary hangers clamps, connecting steel, fixing bolts, nuts etc. shall be supplied and erected by the Bidder. All pipe rack shall be provided with 750 mm (Minimum) clear width walkways.
- (c) Hangers and supports shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipe line movements as necessary. All guides, anchors, braces, dampener, expansion joint and structural steel to be attached to the building/structure, trenches etc. shall be provided.

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- (d) Mitre bends shall not be accepted for steel pipes of 250 NB and below. For sizes above 250 NB, the mitre bends shall conform to BS: 534.
- (e) For rubber lined pipe of acid service, lining should be applied in two (2) layers, giving a total thickness not less than 3 mm.
- (f) Pipe coming under purview of IBR should meet its requirements and getting the IBR approval shall be under Bidder's scope.
- (g) A commercial grade of 'E' type glass fibre should be used conforming to IS: 11320-1985 IS: 11273-1985 IS: 11551-1986 for Glass Fibre Reinforced Plastic Pipes (GRP pipe). The resin shall be either isophthalic or bisphenol. No glass fibre reinforcement shall penetrate the interior surface of pipe line. Each pipe length shall have sufficient strength to withstand class AA type vehicular loading in addition to the overburden of backfill load. The pipeline shall be designed for 2500 N/M stiffness class (min.).
- (h) Anti corrosive protection shall be provided for all buried piping including galvanised steel piping. In case of buried pipes of size 1000 mm NB and above, the Bidder shall stiffen them and/or increase the thickness of pipe adequately against ovality formation in use.
- (i) Flexibility analysis for piping systems wherever required. Whenever, straight run of the above ground yard pipes are more than 50 metres, flexibility analysis shall be conducted by the Bidder to identify the requirement of loops, type of supports etc.
- (j) The Bidder shall prepare the flow diagrams, detailed dimensional piping layout/ Isometric/ fabrication/ as built drawings of all the systems along with Cross sectional drawings, showing all supports and equipment as required.
- (k) All pipelines with size greater than NB 50 mm are considered as shop fabricated piping and detailed piping layout drawings shall be prepared for all such pipelines. The drawings shall be to scale and shall be prepared as plan & sections and shall carry the following minimum details:
 - i) Fully dimensioned layout with locating dimensions referred to plant axes and coordinates
 - ii) Details of all stub connections and other welded attachments as required for anchors, restraints, hangers supports, etc.
 - iii) Slope, drains and vents
 - iv) Edge preparation details of weld ends
 - v) Mounting and orientation of valves and specialties and maintenance space requirements
 - vi) Location and tag numbers of hangers, supports, restraints, anchors, etc.
 - vii) Location and magnitude of cold cuts, if any
 - viii) Pipe sizes, materials, design parameters, shop and field test requirements
 - ix) Insulation details

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- x) Tolerances, if any
- xi) Any specific requirements on shop fabrication and/or field erection
- xii) Any other detail considered necessary by the Owner/Consultant.
- (l) Bidder shall carry-out Transient/surge analysis for long (1 kilometer or more) pipe lines, and/or large diameter (i.e. large volume) pipe lines. Bidder shall also furnish calculation to establish adequacy of size and provision of Air Release Valves in a piping system etc. These calculations are subject to Owner's/Consultant approval.
- (m) The piping shall be arranged to provide clearance for the removal of equipment requiring maintenance and for easy access to valves and other piping accessories required for operation and maintenance. Layout drawings shall indicate valve orientations and availability of access to valves and specialties. Layout of all piping shall ensure that all valves including motor operated valves are located as to be accessible conveniently for operation. Valves for operation and maintenance shall have 1.0 m clear approach space. If any of the valves are not accessible, suitable access platform shall be provided by the Bidder.
- (n) All drains & vents lies in piping system (both water and steam) with design pressure 40 KSC & above shall be provided with two valves.
- (o) The piping routing shall be such that a clear head room of not less than 2.1 m above the walkways/working areas is available.
- (p) Provision shall be made while preparing piping layout to accept control valves, flow measurement element and any other on-line specialty or equipment. Sufficient upstream and downstream lengths shall be provided for flow measuring devices, control valves, desuperheaters and other specialties as required by the respective equipment manufacturer.

2.13 Valves

- (a) All valves shall be suitable for service conditions i.e. flow, temperature and pressure under which they are required. The valves shall be of standard pressure rating as per the relevant code/ standard.
- (b) Either Butterfly type or sluice/gate valves shall be used for isolation purposes in raw water, Clarified & Filtered water application. Butterfly valves shall be of double flanged or lugged wafer type of low leakage rate conforming to AWWA-C-504 class 150 or EN-593 Class 150.
- (c) Manually operated valves shall be provided with reduction gear unit for valves of size 200 NB and above. Valve provided with motorized or pneumatic actuator shall be provided with a hand wheel for manual operation.
- (d) All the valves shall be equipped with adjustable mechanical stop-limiting devices to prevent over travel of the valve disc in the open and closed positions. The valve operators (Hand wheel or Gear reduction unit or Motor actuator etc.) shall be designed as per relevant International Standard.

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- (e) Ball valves or Globe Valves may also be provided for the application of Raw/ Clarified / Filtered water services for sizes 50 NB and below.
- (f) Butterfly valves or proven patented diaphragm valves shall be used for the services of demineralised water application for isolation purposes.
- (g) Sluice valve/knife edge type slide valves shall be used in the sludge and drain pipe line.
- (h) For Air services, globe valves or Ball valves may be used for sizes 50 NB and below. For sizes higher than 50 NB, either Butterfly valve or Ball valves shall be used.
- (i) Check valves for Raw / Clarified / Filtered water may be offered in Gun metal construction and with threaded ends for sizes 50 NB and below conforming to IS: 778 or Equivalent.
- (j) The safety valves / relief valves at the downstream of positive displacement type metering pumps shall be of the standard type manufactured by the pump manufacturer and the material of construction shall suit to the fluid handled.
- (k) Safety valve
 - i) Number, size, location and setting of safety valves on Superheater, reheater and drum (if applicable) shall conform to the requirement of IBR. Relieving capacity of all the safety valves on the Drum and the superheater taken together (excluding power operated impulse safety valve) shall be at least 105% of the BMCR.
 - ii) The escape pipes of safety valves shall lead to the nearest convenient point above the boiler house roof.
 - iii) Noise level during lifting of the safety valves shall not exceed 115 dBA. Silencers for the lowest set pressure safety valve on Drum, superheater and reheater separately shall be provided by the Bidder.
 - iv) Power operated impulse safety valves with isolating valves and silencer at superheater outlet shall be provided. Associated solenoid valve assembly, pressure sensing devices, controller relays, indicating lamps, impulse piping, accessories, control station, etc. shall also be provided. Relieving capacity of this valve shall be 30% of BMCR.
 - v) Power operated impulse safety valves with capacity equal to minimum 30% of reheater flow at BMCR shall also be provided at reheater outlet. This shall also be provided with all accessories as shall be provided for SH outlet impulse safety valve.
- (l) The butterfly valves for DM water application shall conform to the following requirements:
 - i) Body shall be lined (minimum 3 mm) with natural rubber, ebonite, polypropylene or PVDF.
 - ii) Disc shall be lined with PVDF, polypropylene, or natural rubber.
 - iii) Seat rings shall be of Nitrile rubber or Hypalon

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- (m) Valves for Acid & Alkali Services (if applicable) shall be proven patented diaphragm type. Diaphragm shall be of reinforced teflon, EPDM/Black Butile/appd. eqv. For acid services and reinforced Neoprene/Hypalon/app eqv for alkali services.
- (n) For air application, Body material of Ball valves shall be leaded Tin Bronze (IS: 318 Gr.2) or stainless steel (AISI: 304/316). Body & Disc of Butterfly valves shall be either cast iron lined with elastomer such as PVDF or PTFE or stainless steel construction (AISI 304/316).
- (o) For the application of alum, lime, coagulant aid solution, DM water and air, the body, cover & Disc of Non return valves shall be lined with natural Rubber, PTFE or Viton.
- (p) Motor operated valves:

Motor operated valves shall be fitted with both hand and motor operating gear and where a bypass valve is provided this also shall be provided with both hand and motor operating gear and interlocked to ensure that the bypass valve is opened before the main valve. Each valve gate has reached the 'full open' or 'full closed' position (with a minimum increase in the torque). The motor shall be placed in such a position relative to the valve that there is no possibility of leakage of liquid, steam or corrosive gas from valve joints on to the motor or control equipment.

The hand operating and motor operating mechanism shall be so interlocked that the hand operating mechanism is disconnected before the motor is started. Valves shall be provided with seating control and except where specifically approved by the Owner/Consultant for small valves, a slipping clutch or other torque-limiting device shall be incorporated in the motor drive. The operation of opening or closing the valve shall be controlled by means of push buttons labeled respectively 'Open' & 'Stop'. The control shall be so arranged that the motor can be stopped with the valve in any position by means of 'stop' push button and after having been stopped can be restarted either direction by the 'open' or 'close' push buttons.

Necessary positioning indicators for valves closely connected with the operation of main units and need continuous and repeated monitoring shall be provided in plant control room/control pulpits

2.14.1 Design and Construction Features

The following design and construction features of valves shall be complied with.

All gate and globe valves shall be of rising stem, outside screw and yoke type. The design of valves shall ensure a streamlined passage and gate valves shall have low pressure drop. The seats and discs shall be easily renewable and/or shall be suitable for easy refacing and grinding. Valve discs shall be of such design as to keep the seats tight when the valve body is subjected to pressure, temperature variations and piping stresses. Gate valves shall close in both flow directions.

All globe valves shall be capable of being closed against pressure.

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In the case of all end-welded valves, the stub ends of the valves shall project from the valve body a sufficient amount to ensure that the welding process shall not distort the valve body and internal parts.

Valves for regulating duties shall be of the globe type with tapered plug type disc.

Hardness of seating surfaces shall be a minimum of 350 BHN and a minimum differential hardness of 50 BHN shall be provided between seats to prevent galling. This is not applicable for stellite seats.

Check valves of sizes 400 mm NB and larger shall have dash pot arrangement.

All gate and globe valves shall have back-seating arrangement to facilitate easy replacement of packing with the valve in service.

All valves shall be so designed that the hand-wheel moves in a clockwise direction to close the valve. The face of the hand-wheel shall be clearly marked with the words 'OPEN' and 'CLOSE' and an arrow to indicate the direction for opening. All hand-wheels shall be fitted with name plate. All globe valves shall be provided with position indicator.

Piston lift check valves shall have accurately guided pistons so that the pistons are cushioned in their cylinders as they move up.

All gate, globe, Y-type and angle valves intended for manual operation and falling under the following categories shall be equipped with a gear operator for ease of operation and to ensure fast and tight closure:

ANSI Pressure Rating

Valve Sizes

Class 300 and below

350 mm and larger

Class 600 and above

200 mm and larger

All gate valves falling in the following categories shall be provided with integral bypass valve. Bypass size shall conform to MSS-SP-45 as a minimum standard. The bypass valve shall be hand operated unless otherwise. Pipe for bypass shall be at least schedule 80 seamless and of a material of the same nominal chemical composition and physical properties as that used for the main line. Orientation of bypass arrangement shall be subject to the approval of Owner/Consultant.

ANSI Pressure Rating

Valve Sizes for which Bypass is required

Class 600 and over

200 mm and larger

Class 300 & 150

350 mm and larger

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All gate valves of ANSI pressure rating class 150 and 300 shall have solid or flexible wedge and ANSI pressure rating class 600 and above shall have flexible or parallel slide type of wedge.

Valves with flexible wedge shall have provision for relieving the pressure in the neck of the valve when the valve is in the closed position.

All valves of ANSI pressure rating up to class 600 shall have bolted bonnet construction and class 900 and above shall have bonnet construction of the pressure seal type. Pressure seal valves shall have stainless steel inlay in the gasket area and silver-plated gaskets or other acceptable proven features.

All carbon steel valves of ANSI pressure rating up to class 150 and 300 shall have stainless steel trim (13% Cr) and ANSI pressure rating class 600 and above shall have stellited trim.

All alloy steel valves shall have stellited seats.

All valves of ANSI pressure rating up to class 900 and higher shall have yoke with anti-friction bearing arrangement.

Valves that are to be kept in full 'OPEN'/'CLOSE' position shall be provided with a non-detachable locking arrangement. The locking arrangement provided shall be subject to approval by the Owner/Consultant.

Valves operating under vacuum conditions shall have glands with water sealing. The inlet and outlet connections shall be NB 15mm. The Bidder shall indicate the maximum and minimum sealing water pressure and the required flow rate.

Motor actuators for motor operated valves shall meet requirements mentioned in the specification.

2.14 Cleaning

Prior to factory inspection, all manufacturing waste, such as metal chips and filings, welding rods and stubs, rags, debris and all other foreign matter shall be removed from the interior of each valve. All mill scale, rust, oil, grease, chalk, crayon, paint marks and other deleterious material shall be removed from the interior and exterior surfaces. At the time of shipment, valves shall be clean inside and outside.

2.15 Inspection and Tests

Inspection and tests for piping systems which are under the purview of IBR shall be tested at manufacturers work and site as per the requirement of IBR as a minimum.

Defects in excess of acceptance standards shall be removed by suitable means. If removal of surface defects does not result in reduction in wall thickness below 5% of intended thickness of metal at that location, the area shall be blended smoothly into the surrounding surface. Where defect removal results in a wall thickness less than the above resultant cavity may be repaired by welding. The procedure and operator shall be qualified as per applicable standards. Major weld repairs shall be stress relieved or heat treated in accordance with ASME Section VIII Division I-UCS 56.

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The required area shall be re-examined and the acceptance standards shall be as in the original examination.

Weld repairs made as a result of radiographic examination shall be radiographed after welding. Repairing a particular area more than 2 times is not permitted and the component shall be rejected. The acceptance standards for welds shall be as per ASME Boiler and Pressure Vessel Code, Section VIII, Division I, UW - 51.

Prior approval shall be obtained from the Owner/Consultant before taking up major weld repairs (major weld repair - when depth of repair exceeds 20% of thickness or 1 inch whichever is smaller). Mapping of major weld repairs is also required.

All valves shall be tested hydrostatically for strength, tightness of seats and tightness of back seating at the pressures, in accordance with MSS-SP 61, "Hydrostatic Testing of Steel Valves". Water used for hydrostatic testing of valves with stainless steel components shall not have chloride content exceeding 20 ppm. Clean potable water may be used for testing of all other valves.

All valves except check valves shall be tested for seat tightness by air at a pressure of 6 bar (g) on both sides of seat.

All check valves shall also be hydro tested at 125% of the seat hydro test pressure.

All valves shall be checked for correctness in respect of specified end details as per applicable standards.

2.16 Painting and Corrosion Protection

Two coats of primer of thickness 35 microns for each coat shall be applied to all steel and cast iron exposed surfaces as required to prevent corrosion, after release has been given for painting and before dispatch. The use of grease or oil, other than light grade mineral oil, for corrosion protection is prohibited. Bores of all valves shall be covered immediately after testing, draining and drying with suitable plastic end covers to avoid ingress of foreign materials. Also refer section-XI for painting.

2.17 Material Specification for Piping and Fittings

2.18.1 Materials for Boiler Components

The material used for Boiler components like piping, valves & fittings etc. and other components shall be equal to or better than the following unless specified otherwise:

The temperature range indicated below is design metal temperature.

- i) Up to & including 400 deg C Carbon steel to ASME SA-106Gr. B/C, SA 210 C or SA 210 Gr A1 or approved equivalent.
- ii) Up to & including 550 deg C: Alloy steel to ASME SA-335: P-11/P-12/P-22/; ASME SA213: T-11/T-22 or approved equivalent.
- iii) Up to & including 600 deg C: Alloy steel ASME SA-335/213: P 91 /T-91, or approved equivalent.

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Service	Pipes	Fittings	Flanges
Main steam			
65 NB & above	A 335 P91/ A335P22	A234 WP91/ A234 WP22	A182 F91/ A182 F22
50 NB & below	A 335 P91	A182 F91 or Gr F22/ASTM 105A	A182 F91
Cold reheat			
65 NB & above	A106 Gr. C	A 234 WPC	A 105
50 NB & below	A106 Gr .C	A 105	A 105
Hot reheat			
65 NB & above	A 335 P91	A234 WP91	A182 F91
50 NB & below	A 335 P91/ A 335 P22	A182 F91/ A182 F22	A182 F91/ A182 F22
Aux. Steam/boiler feed /condensate/fuel oil			
65 NB & above	A106 Gr. B/ Gr. C	A 234 WPB	A 105
50 NB & below	A106 Gr. B/ Gr. C	A 105	A 105

2.18.2 Specific Requirement for Valves

Service	Size	Body/ bonnet	Disc	Stem	Hand wheel	Valve ends
Steam lines (temp > 400°C) except for main steam and hot-reheat	≥ 65NB	ASTM A217 WC-6/WC-9	ASTM A217 WC-6/WC-9	ASTM A182 Gr. F6a	ASTM A47 G Gr. 32510	Butt welded.
	≤ 50 NB	ASTM A182 Gr.F-11/Gr.F-22	ASTM A182 Gr.F-11/Gr.F-22	ASTM A182 Gr.F6a	ASTM A97 Gr.32510	Socket Weld
Steam lines (temp < 400 °C), feed water, Condensate blow down, steam tracing	≥ 65NB	ASTM A216 Gr WCB	ASTM A216 Gr WCB	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Butt welded
	≤ 50 NB	ASTMA105	ASTM A182 Gr F6a	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Socket welded

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Service	Size	Body/ bonnet	Disc	Stem	Hand wheel	Valve ends
HFO, LDO, lube oil, oily water drain	≥65NB	ASTM A216 Gr WCB ASTMA105	ASTM A216 Gr WCB	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Butt welded
	≤ 50 NB		ASTM A182 Gr F6a	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Socket welded
Boiler feed system	65NB	ASTM A216 Gr. WCB/WCC	ASTM A 216 Gr. WCB/WCC	ASTM A 182 Gr. F6a	ASTM 417 Gr. 32510	BW
	≤50NB	A105	ASTM A 182 Gr.F6a	ASTM A 182 Gr.F6a	ASTM 417 Gr. 32510	SW
Cooling water system	BFV	AWWA C-504; flanged or long body wafer type; Body A 216 WCB;SHAFT A 182 304; seal & O ring: EPT/ BUNA – N / Neoprene				FL

Service	Size	Body/ bonnet	Disc	Stem	Hand Wheel	Valve ends
Instrument air system, potable water system (ball valves)	≥65NB	ASTM A216 Gr WCB	ASTM A216 Gr WCB	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Flanged
	≤ 50 NB	ASTMB62 / IS318 Gr.2	ASTM B62 / IS:318 Gr.2	ASTM B312 Gr A / IS320 HT2	ASTM A47 Gr 32510	Screw type
Service air system, (ball valves)	≥65NB	ASTM A216 Gr WCB ASTM A105	ASTM A216 Gr WCB ASTM A182 Gr F6a	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Butt welded
	≤ 50 NB			ASTM A182 Gr F6a	ASTM A47 Gr 32510	Socket welded

Note:

1. Testing of body, seat and back seat shall be as per ANSI B16.34
2. For water system with sizes greater than NB200 butterfly valves shall be used and shall conform to AWWA C-504.
3. Butterfly valves for main cooling water lines shall be hydraulically operated with oil pack.

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2.18 Gates (if applicable)

Design standard for gates shall be IS: 3042 or equivalent. The gates shall be rectangular or square sluice, rising spindle type conforming to class-1 of IS: 3042. The Material of Construction shall be as follows:

- i) Frame and Door : Cast Iron IS:210 Gr. 260
- ii) Spindles, bolts & nuts : ASTM A 182 Gr. F6A
- iii) Face & seat rings : Gun metal (as per IS: 3042).

All the parts of gates shall be applied with the coats of heavy duty bitumastic paint.

2.19 Strainers

(a) Basket Type Strainers

Basket strainers of simplex design shall have the following materials of construction for raw/clarified/filtered water application.

- i) Body : Fabricated mild steel : IS:2062 (Tested quality)
- ii) Strainers : Wire shall be stainless steel (AISI: 316 30 mesh suitably reinforced. Reinforcement material shall also be of stainless steel construction)
- iii) Drain Plug/Nuts : Gun metal

Screen (strainer) flow area shall be at least four times pipe sectional area. Flow area in any portion of Basket strainer assembly shall not be less than the pipe cross sectional area. Pressure drop in clean condition shall not be more than 1.0 MWC.

Basket Strainer shall be provided with lifting lugs and suitable mounting arrangement. Suitable Vent and drain valves shall be provided for the strainers.

For DM water service, body shall be rubber lined to minimum 4.5 mm thickness (soft rubber of shore Hardness 65 ± 5 Deg A).

(b) Y-Type Strainers

Y-Type strainer for water application shall be constructed of following materials

- i) Body : Cast Iron IS: 210 Gr. FG 260
- ii) Strainers: Wires of stainless steel AISI-316, 30 mesh suitably reinforced. Reinforcement material shall also be of stainless steel construction.
- iii) Drain Plugs: Gun metal (threaded construction)

Body of the Y-type strainers of alkali, and demineralised water shall be of Cast Iron (IS: 210, Gr.FG 260) and lined with soft or hard rubber to a thickness of 4.5 mm.

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For acid services, apart from the rubber lined body material, the screen material shall be Polypropylene or HDPE wire cloth of suitable mesh and thickness.

2.20 Steam Traps

- (a) The steam traps shall be inverted bucket or thermodynamic type complete with integral or separate strainers.
- (b) The internal components of traps shall be of AISI- 316 stainless steel construction. Material of construction of the body shall be selected by the Bidder based on the service conditions stipulated.
- (c) All Y-type strainers, wherever provided with steam traps or otherwise, shall have AISI-316 stainless steel screen of not more than 20 mesh size. Screen open area shall be at least three (4) times the pipe internal cross-sectional area. The strainer shall have a screwed blow-off connection with a removable plug. Material of construction of the body shall be selected by the Bidder based on the duty conditions specified.
- (d) All traps and strainers shall have socket weld ends as per ANSI B16.11 for size NB 50 mm and smaller and butt weld ends as per B 16.25 for size NB 65 mm and above.

Steam drain traps shall be provided with strainers, inlet and discharge valves and by-passes and test cocks as schematically indicated in the enclosed drawing. Materials and other details of these valves shall meet the specified requirement.

General

Note: The specification furnished above shall be considered as broad requirement. The Bidder shall consider compatible material and specification for all piping components as well as specialties for the corresponding service applications.

2.21 Instrument Connections

Unless otherwise called for by Owner, all thermo well stubs shall have an internal threading to M33 x 2.

All stubs for pressure or flow measurement for pipelines with a maximum working pressure equal to or above 42 bar(g) or with a maximum working temperature equal to or above 350 deg C shall be NPS 25 mm and double root valves shall be used.

Stubs for pressure or flow measurement on pipelines with a maximum working pressure less than 42 bar(g) and a maximum working temperature less than 350°C shall be of NPS 15 mm size and single root valves can be used.

Measurement stubs on fuel oil lines shall be of NPS 25 mm size and provided with two root valves.

2.22 Welding and Heat Treatment

All heat treatment, welding, post and pre weld temperatures shall be as per the code ASME B31.1.

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2.23 Painting and Corrosion Protection

All uninsulated piping systems, hangers and supports shall have two coats of red oxide Zinc Chromate primer (conforming to IS 2074) with minimum dry film thickness (DFT) of 25 microns per coat and two coats of finish paints using enamel paint to give a minimum total DFT of 100 microns (after two coats of primer and two coats of finish paint). Shades shall be as per IS 5 or as indicated by Owner. Service of the pipe/line designations shall be painted on all pipes at visible locations.

Before application of paint, Bidder shall clean the pipes of all mill scale, dirt dust, soot, grease, rust etc.

All pipe lines, piping components shall be adequately protected against corrosion during manufacture, fabrication, shipment and storage by appropriate protective paint.

2.24 Underground Protection

Where pipelines are buried, underground protection shall be provided for the piping system as indicated any one of the methods given below:

- (a) Coal tar primer, coal tar enamel, inner wrap of fiber glass, final outer wrap of enamel impregnated fiber glass. Total thickness of coating shall not be less than 4.0 mm.
- (b) With anti-corrosive tape of 4 mm thick conforming to IS-10221 and AWWA C 203-93.

Pipe surfaces shall be cleaned by shot or sand blasting before application. Slag blasting may also be considered.

Tests to be carried out after application

- (c) Bond/Adhesion test
- (d) Holiday test

2.25 Non destructive examination

- (a) Mandatory as per ASME B31.1 & Regulation 360(d) of IBR.
- (b) Special requirements
 - i) 100% UT/RT & MPI and 3% hardness testing on butt welds of P22, P12, and P11 materials.
 - ii) 100% UT/RT & MPI and 100% hardness testing on butt welds of P91, and X20 materials.
 - iii) 100% MPI on butt welds of carbon steel materials.
 - iv) 100% UT/RT for fittings of 200NB & above for X20 & P91, material.
 - v) 100% UT/RT for fittings of all other piping of size OD 508mm & above.

2.26 Hydrostatic Test Pressure

- (a) Piping system under IBR purview:

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- i) At Shop All piping including fabricated piping shall be hydro tested at 1.5 times the design pressure subject to regulation 374 of IBR. However, non-destructive testing in lieu of hydro test is also acceptable subject to regulation 343 (3) of IBR
- ii) After Erection all piping systems shall be hydro tested at 1.5 times the design pressure subject to regulation of 374 IBR. However, for such systems where it is practically not possible to do hydro tests, the tests as called for in ANSI B31.1& IBR in lieu of hydro test shall also be acceptable.
- (b) Non-IBR Piping Systems:-
 - i) At Shop All piping including fabricated piping shall be hydro tested at 1.5 times the design pressure.
 - ii) After Erection All piping systems shall be hydro tested at 1.5 times the design pressure subject.

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3 THERMAL INSULATION

3.1 Genaral

All equipment / pipes / ducts whose surface temperature is higher than 60 deg C, shall be provided thermal insulation along with aluminum cladding for personnel protection and heat conservation. The insulation material shall be chemically inert, non-combustible and shall be harmless. Outer surface of the insulation shall be covered with aluminium cladding.

3.2 Design Criteria

Thermal insulation to be provided for:

- i) Piping & equipment having rated operating temperature exceeding 60 deg C.
- ii) For insulation thickness calculation ambient temperature shall be [45 deg C] or as per ASTM C 650 or equivalent.
- iii) Wind velocity = 0.25 m/sec for outside the plant building and 0.5 m/sec for inside the plant building.
- iv) Thermal conductivity = Not less than values given in IS-8183
- v) Emissivity = 0.2

3.3 General Requirements

3.3.1 Insulation Material

- a) Material and application of insulation material, protective cladding, wire mesh etc. shall be conforming to latest edition of following Codes:
 - i) IS:8183 - Bonded mineral wool
 - ii) IS:3677 - Unbonded Rockwool/Mineral Wool
 - iii) IS:3144 - Methods of test for mineral wool thermal insulation materials
 - iv) IS: 14164 – Thermal insulation of cold services
 - v) IS:280 - Mild Steel Wire for General Engineering Purposes
 - vi) ASTM-B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - vii) IS 4412 – Copper wires for general engineering purposes
 - viii) IS 7413 – Code of practice for thermal industrial application and finishing of thermal insulating materials
 - ix) IS 9843 – Code Of Practice For Use Of Adhesives For Packaging
 - x) IS 737 – Wrought aluminium and aluminium alloy sheet and strip for general engineering purposes

Other equipment or better international codes/ standard shall also be acceptable.
- b) Insulation material for all equipments, piping, ducting, etc. shall conform to following requirements:

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- i) Material Lightly resin bonded mineral wool of best grade conforming to IS: 8183. (Hand made mattresses are not acceptable). Material shall be rock wool only. Slag wool or slag wool inclusion shall not be accepted. Lightly resin bonded glass wool mattress, having density 64 kg/m³ (min.), self stitched in shop can also be accepted for temperature less than 400 deg C.
- ii) Bulk density of lightly resin bonded mineral wool mattresses shall be 100 kg/m³ for use up to 400 deg C and 150 kg/m³ for use above 400 deg C.
- c) The Insulation mattress shall be rated incombustible when tested by the method prescribed in clause 15 of IS:3144 and shall meet the requirement of the Mercantile Marine department, Lloyd's Register of shipping, underwriter, fire hazards codes and other International standards.
- d) Insulation material (and protective covering) shall:
 - i) Be fresh, incombustible, rust proof, non hygroscopic,
 - ii) Be capable of withstanding continuously and without deterioration the maximum temperature to which they shall be subjected.
 - iii) Not react chemically, either to itself or with other components.
 - iv) Not sustain any fungi or vermin and must not pose health hazards.
- e) The use of insulation of finishing materials containing asbestos in any form is not permitted.
- f) Insulation mattress/section shall be supplied in thickness of 25, 40, 50 and 75 mm. Insulation of higher thickness shall be made up in multiple layers using mattress/slabs of thickness specified above. However, if the required thickness is such that by using above mattress/slabs the calculated thickness is not achieved, the mattress/slabs in increment of 5 mm shall be acceptable for outer layers. The min. thickness however, shall not be less than 25 mm and number of layers shall be minimum and innermost layer shall be thickest.

3.3.2 Sheathing Material

Sheathing material for all insulated surfaces, equipments, piping etc. confirming to ASTM B-209-1060 temper H-14 or IS: 737 Gr. 19000/H2 shall be provided as per following:

- a) For dia of insulated surfaces of 450 mm & above - 16 SWG and for flat surfaces
 - b) For dia of insulated surfaces less than 450 mm - 20 SWG
- For Boiler outer casing ribbed Aluminium - 16 SWG

3.3.3 Binding and Lacing Wires

Binding and lacing wires shall be provided in line with following:

- a) Up to 400 deg C - Galvanised Steel of 20 SWG dia.
- b) Above 400 deg C - Stainless Steel of 20 SWG dia.

3.3.4 Straps and Bands

Straps and bands shall conform to materials as under:

- a) Up to 400 deg C - Galvanised Steel

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- b) Above 400 deg C - Stainless Steel
Bands shall be 20 mm wide and 0.6 mm thick
For securing Aluminium sheathing material, stainless steel or anodised aluminium bands shall be used.
Screws shall be of galvanised steel, check headed, self tapping type. Above 400 deg C temperature, screws shall be stainless steel.
Non metallic components like 3 mm thick mill board, aluminium pigment sealant, white glass cloth, insulating cement, neoprene washer shall be provided.

3.3.5 Application of Insulation

- a) All surfaces to be insulated shall be cleaned of all foreign materials such as dirt, grease, rust etc. and shall be dry before the application of insulation.
- b) Before applying the insulation the Bidder shall check that all instrument tapping, clamps, lugs and other connections on the surface to be insulated have been properly installed as per the relevant erection drawing.
- c) All flanged joints shall be insulated only after the final tightening and testing.
- d) The insulation shall be applied to all surfaces when they are at ambient temp. Ample provision shall be made for the maximum possible thermal movement and the insulation shall be applied so as to avoid breaking/telescoping due to alternate periods of expansion and contraction.
- e) All cracks voids and depressions shall be filled with finishing cement, suitable for the equipment operating temperature so as to form a smooth base for the application of cladding.
- f) All vertical pipes shall be provided with the suitable insulation supports to prevent collapsing/crushing of insulation due to its self weight. Support rings shall be provided on all vertical piping with a difference in elevation of 4 m or above, and there shall not be more than 3 m straight length between support rings.
- g) joints of insulation mattress sections of horizontal piping shall be on the bottom or at the sides of the pipe.
- h) When more than one layer of insulation mattress/section is required on piping the circumferential joints on adjacent layers shall be staggered by at least 150 mm and longitudinal joints shall be staggered by at least 50 mm.
- i) The mattress type insulation shall be formed to fit the pipe and applied with the mattress edges drawn together at the longitudinal joints and secured by lacing wire. Pipe section insulation shall be fitted on pipe using binding wires.
- j) Where insulation is applied in two or more layers each layer of mattress shall be backed with hexagonal wire mesh. For the first layer of insulation and in case of single layer insulation, hexagonal wire mesh shall be provided on both the surface of the mattress. For pipe sections, the sections shall be held in place by binding wires without any wire mesh.
- k) The ends of all wire loops shall be firmly twisted together with pliers, bent over and carefully pressed into the surface of the insulation. Any gap in the insulation shall be filled with loose mineral wool or finishing cement.
- l) Insulation mattress/section ends shall be terminated at a sufficient distance from the flanges to facilitate removal of bolts.

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- m) The insulation shall be held in place by fastening over with binding wire for insulation surface with diameter up to and including 550 mm and with metal bends for insulation surfaces with diameter over 550 mm. The fastening shall be done at intervals of 250 mm except where specified otherwise. The ends of the binding wires shall be hooked and embedded in the insulation. The straps shall be mechanically stretched and fastened with metallic clamping seals of the same materials as the strap.
- n) Insulation for application on bends and elbows shall be cut into mitred segments, sufficiently short to form a reasonably smooth internal surface. After the application of insulation material place, insulating cement shall be applied as required to obtain a smooth surface.
- o) Weather hoods shall be provided for insulated piping passing through floors/walls.
- p) All pipe attachments coming on horizontal pipes, inclined pipes and bends shall be insulated along with pipe such that there shall be no insulation applied to hanger rod and the component connecting hanger rod to pipe attachment. All pipe attachments exposed to weather shall be provided with weather proof covering.
- q) Upstream of all drain lines and the lines connected to steam traps, shall be insulated up to and including first isolating valve for heat conservation. Rest of such lines such as downstream of the drain valves, traps etc. and other lines such as safety valve discharges, vents, etc. shall be insulated for personnel protection.
- r) All valves fittings and specialties shall be insulated with the same type and thickness of insulation as specified for the connected piping with the special provisions and or exceptions as given below.
- s) All valves fittings and specialties shall be insulated with the same type and thickness of insulation as specified for the connected piping with the special provisions and or exceptions as given below.
- t) All valves and flanges shall be provided with removable box type of insulation covered with box fabricated from aluminium sheets of thickness same as the connected pipe cladding. Adjoining pipe insulation shall be bevelled back to permit removal bolts and nuts or bands. The portion of the valve which can not be covered by box type insulation shall be filled by loose insulating material of packing density at least equal to that of the insulating material of adjoining pipe. The insulation for valves/flanges shall be applied after the finishing has been applied over the connected piping. The cladding shall be applied in such a manner that the bonnet flange can be exposed easily without disturbing the complete insulation and cladding.
- u) Union shall not be insulated. Expansion joints, metallic or rubber, shall not be insulated unless otherwise specifically indicated.
- v) Safety valves shall be insulated.
- w) Sampling of steam, feed water lines at high temperatures shall be insulated.

3.4 Testing of Insulation

- a) All tests, as per the applicable material standards and as specified shall be carried out in accordance with the methods prescribed. Owner/Consultant shall have the

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right to witness any or all of the tests conducted by the Bidder at the shop or laboratory.

- b) The Bidder shall guarantee that if on actual measurement the specified maximum insulation surface temperatures are exceeded, if the Bidder shall either replace the insulation with a superior material or provide additional insulation thickness at no extra cost.

3.5 Refractories

The refractory material shall comply with relevant Indian Standards. The refractory selected shall ensure perfect sealing, and shall have good thermal cycling properties allowing quick startup/shut down of Boilers.

3.5.1 Materials

The refractory material shall

- a) Have high bulk density and minimum moisture content,
- b) Be capable of withstanding service temperature of 1700 degree Celsius.
- c) Be resistant to slagging products due to coal, and to impurities of oil like V_2O_5 , Fe_2O_3 , K_2O_2 , Na_2O etc. and to erosion due to fly ash.
- d) Be chemically inactive towards alkalis, iron, silica etc. shall pose no health hazard to working personnel, and shall not have any explosive properties.
- e) Have sufficient strength to withstand forces generated in boiler, without any rupture or damage.

3.5.2 Application

Application of refractory shall be such that:

- a) To ensure perfect sealing, easy maintenance, minimum time for application.
- b) To ensure minimum number of joints. All the joints to be filled and tightly packed with loose powder of same material.
- c) Selection of Refractory shall consider the applied stress, stress distribution and expansion allowance.
- d) Refractory shall have good thermal cycling properties to ensure quick start up and shut down of Boilers.

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4 QUALITY ASSURANCE

4.1 Introduction

All materials, components and equipment covered under the scope of supply shall be procured, manufactured, erected and tested at all stages as per the comprehensive Quality Assurance (QA) programme. The QA document indicating the specific inspection and testing requirements to be followed shall be subject to the approval of the Owner/Consultant. The Bidder shall submit his quality assurance programme for review by Owner/Consultant and shall generally cover the following:

- a) Organizational structure for management and implementation of the proposed quality assurance programme.
- b) Quality system manual.
- c) Documentation control system.
- d) Qualification and experience data of Bidder's key personnel.
- e) The procedure for procurement of materials, parts, components and equipment.
- f) Procedure for inspection at source, inspection of incoming raw-materials/ parts/ components & verification of materials purchased.
- g) System for shop manufacturing including process controls, fabrication and assembly controls, and procedure for product identification & traceability.
- h) System for inspection and testing during manufacture, processing, fabrication, welding, assembly and other activities.
- i) The reference documents, plant standards, acceptance norms, test and inspection procedure etc.
- j) Control of calibration and testing of measuring and testing equipments.
- k) System for quality audits, documentation to indicate conformance or nonconformance of the product to the specification and testing and inspection requirements; review and control of non- conforming items and system for corrective actions.
- l) System for indication and appraisal of inspection status.
- m) System for authorizing release of manufactured product to the Owner.
- n) System for packaging, handling, transportation, storage and delivery.
- o) System for generation and maintenance of inspection and test records.

4.2 Boiler and Auxiliaries

Testing and inspection requirements of major equipment over and above the respective codes / standards requirement are given hereunder:

4.2.1 Pressure Parts

Only those materials shall be used in the manufacture of pressure parts which can be identified against mill sheet or manufacturer test certificates. Material shall meet all the mandatory requirements (and supplementary checks, if asked

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for) of specified specification, Indian Boiler Regulations (IBR), and relevant code/standard. All non destructive testing as detailed against relevant equipment shall meet the requirement of ASTM section 3 Vol. 3.03 or equivalent BIS standard.

A. Drum

- i) Each plate shall be subjected to a 100 % normal and shear ultrasonic at the mill to meet the minimum requirements of BS: 5996 grade LC3/ ASTM or equivalent standards. Elevated temperature tensile tests shall also be carried out on plate material for each heat.
- ii) After cutting to size and removal of cut outs, the plates shall be subjected to magnetic particle examination (MPE) along the edges of the plate and on areas adjacent to the cutouts.
- iii) All forged connections shall be examined by 100% ultrasonic testing (UT) before machining.
- iv) Fully machined connecting pieces of internal diameter 100mm and above, except for forgings, shall be subjected to MPE.
- v) Mechanical tests shall be carried out on specimens prepared from the production control test plates of the longitudinal welds.
- vi) Mechanical tests shall be conducted on the specimens from manhole cutouts of dished ends.
- vii) All butt welds shall be subjected to 100% radiographic test (RT) before stress relieving.
- viii) On completion of welding, the entire drum shall be subjected to stress relieving in the furnace.
- ix) All butt welds shall be subjected to 100% ultrasonic test and magnetic particle examination after stress relieving.
- x) All full penetration welds shall be subjected to ultrasonic examination after stress relief.
- xi) After stress relieving, all welds shall be examined by magnetic particle examination (MPE) methods depending on size and accessibility.
- xii) Complete drum shall be subjected to hydraulic pressure test and all compensating pads shall be pneumatically tested.

B. Headers

- i) Raw material for headers shall be subjected to UT prior to fabrication.
- ii) All butt welds shall be subjected to MPE and radiographic examination before stress relieving.
- iii) All full penetration nozzle and attachment welds shall be subjected to UT prior to stress relieving.

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- iv) All nozzles, branches, stubs and load bearing attachment shall be examined by MPE techniques after the toes of the weld have been ground smooth and stress relieved.
- v) Non-load bearing welds shall be examined by MPE techniques after the toes of the welds have been ground smooth and stress relieved.
- vi) Completed closed end headers shall be subjected to hydraulic pressure tests and all compensating pads shall be pneumatically tested.

C. Tubes and tube elements

- i) Raw material for tubes for water wall, superheater, reheater, economiser, riser, supply and connecting tubes including nozzle/stubs, connections for drum, headers, pipe work etc., shall be subjected to 100% UT prior to fabrication as per IBR or ASME E 213 or equivalent with the longitudinal calibration notch of depth 5% of wall thickness (0.3mm minimum and 1.5mm maximum).
- ii) All bent tubes, stubs shall be checked for ovality and thinning by ultrasonic method on first off lot and random checks on subsequent pieces.
- iii) All tubes, stubs, panels, coils shall be checked for clearance by steel ball test and for cleanliness by sponge passage.
- iv) Finished butt welds shall be subjected to RT and UT. Wherever the code/standard/process specifies random sampling, the same shall be minimum 20%. All fillet welds shall be subjected to MPE or dye penetration test (DPT).
- v) Tubes and fabricated panels, coils shall be subjected to hydraulic pressure test excluding water wall panels and loose tubes but including burner panels, reheaters, superheaters and economizers.

D. Integral piping and fittings

- i) All pipe lengths shall be subjected to 100 % ultrasonic examination as per ASME E213 or equivalent, with longitudinal calibration notch of depth 5% of wall thickness (0.3mm minimum and 1.5mm maximum) or hydraulic tests and UT or RT on longitudinal welds at the tube mill.
- ii) All mother pipes shall be subjected to 100% UT prior to fabrication as per ASME E 213 or equivalent with longitudinal calibration notch of depth 5% of wall thickness (0.3mm minimum and 1.5mm maximum).
- iii) All forged fittings shall be checked by UT and formed fittings shall be checked by MPE.
- iv) All pressure parts shall be 100 % UT tested. All welded, cast alloy steel and carbon steel fittings for use above 71 bar design conditions shall be 100 % RT tested. However, wherever the code/standard/process specifies random sampling, the same shall be minimum 20%.
- v) 10% of each lot of bent pipes shall be checked for quality and thinning by UT on first off lot and on random samples for subsequent pieces. Outer surface of bends shall be subjected to MPE or DPT.

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- vi) The edge preparation for shop and site welds in stainless steel and alloy steel shall be subjected to dye penetration check. Non-destructive examination of welds shall be carried out after post weld heat treatment, if any.
- vii) All butt welds shall be subjected to UT or RT and MPE. For weld on alloy steel piping, UT or RT shall be done after stress relieving. Wherever the code/ standard/ process specifies random sampling, the same shall be minimum 20 %.
- viii) All butt welds in alloy steel piping of P91, X20 and X 22 shall be checked for RT or UT and MPE after stress relieving (SR). UT shall be of digital recordable type.
- ix) All weld joints in alloy steel piping of P 91, X20 and X22 shall be checked for hardness. For preheating and post weld heat treatment (PWHT) induction heating shall be deployed. However, PWHT can be done in furnace also. 3% hardness check shall be carried out on welds of other alloy steel piping.
- x) All load-bearing attachment welds shall be subjected to MPE after stress relieving.
- xi) For HP piping, non-destructive examination of welds shall be carried out in accordance with the relevant design/manufacturing codes. However, apart from above, the following requirements shall be met. Further statutory requirement, wherever applicable shall also be complied with the following:
 - a. Temperature > 400 deg C and/ or pressure exceeding 71 bar
 - 100% RT or UT on butt welds and full penetration branch welds.
 - 100% MPE.
 - b. Temperature > 175 deg C up to 400 deg C and/or pressure exceeding 17 bar and up to 71 bar
 - 100% RT or UT on butt welds and full penetration branch welds for pipe diameter more than 100NB.
 - 10% RT or UT on butt welds and full penetration branch welds for pipe diameter up to 100NB.
 - 100% MPE.
 - c. All other pipes not covered above shall be subjected to 100% MPE or DPT in case of underground pipes and 10% MPE or DPT in case of piping above the ground. Further, 10% of butt welds of underground piping shall be subjected to RT.

E. Valves

- i) Pressure retaining parts of valves shall be subjected to NDT as per Table 4.1.
- ii) Hardened and stellited valve disc and seat shall be subjected to DPT and hardness check.
- iii) Color matching of valve disc/plug and seat shall be carried out to ensure minimum 80% contact and no through passage.
- iv) Hydraulic pressure test and seat leak test shall be carried out as per ANSI 16.34 or IBR.
- v) Air seat leak test shall be carried out as per applicable standards or codes.

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- vi) Functional tests shall be carried out on each valve to check the following as per the approved valve data sheet
- vii) Smooth operation.
- viii) Valve travel, closing and opening time.
- ix) Current drawn by actuators.
- x) Springs for safety valves shall be tested with suitable NDT and for spring stiffness rate.
- xi) Safety relief valves shall be tested for performance.

Table 4.1

NDT requirements for pressure retaining components of valves

S.No.	Valve size NB (mm)	ANSI Class upto 300	ANSI Class above 300 upto 600	ANSI Class above 600 below 900	ANSI Class 900 and above but below 4500
1	Less than 50	Visual	Visual	Visual	MPE (for special class valves)
2	50 & above but below 100	Visual	Visual	MPE (for special class valves)	MPE and RT on 10% of valves on 100% area
3	100 & above but less than 300	Visual	MPE	MPE and RT on 10% of valves on change of section and weld ends	MPE and RT on 100% area
4	300 and above	MPE	MPE	MPE and RT on change of sections and weld ends	MPE and RT on 100% area

Note:

- a. For body and bonnet forgings, UT with MPE may be adopted in place of RT.
- b. For austenitic steel, MPE may be replaced by DPT.

F. Non pressure bearing attachments

Load bearing welds shall be subjected to UT and MPE after stress relieving. Non load bearing welds shall be subjected to MPE after stress relief. The toes of the welds adjoining the drum shall be ground smooth prior to stress relieving before carrying out this examination.

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G. Hydraulic test

- i) The drum and all components which are to be subjected to fluid pressure shall be tested to minimum of 150% of the design pressure. The duration of the pressure tests shall be sufficient, as approved by the Owner/Consultant, to show any leakage paths and to permit a thorough examination of the component whilst under pressure.
- ii) The temperature of the fluid used for the pressure test shall be such as to avoid any possibility of brittle fracture at a low temperature and the same shall be modified and submitted to the Owner/Consultant for approval, before commencing the test.
- iii) The fluid used shall be of a sufficient purity and where relevant, suitable inhibitors shall be used to avoid excessive corrosion and /or damage to temporary parts either during the test or prior to drying and cleaning.

H. Pneumatic test of compensating pads

All compensating pads shall be provided with two-threaded weep holes to test welds at 0.5 kg/cm² (g) with soap solution and no leakage shall be ensured.

4.2.2 Air Preheaters, Steam Coil Air Pre-Heater and Fuel Oil Heaters

A. Air Preheaters

- i) Forged shafts for air preheater like stub shaft, main rotor forging, housing hub shall be subjected to 100% UT at mill and magnetic particle examination after machining.
- ii) For non-modular design, trial assembly shall be carried out at shop prior to dispatch to site.
- iii) Critical welds of rotor post shall be subjected to radiographic examination.

B. Steam coil air pre-heater and fuel oil heaters

Hydraulic pressure test shall be carried out on the heating coils. All pipes, valves, steam traps and mountings shall be subjected to hydraulic test as called for under IBR, BS or other approved codes.

4.2.3 Soot Blowers

- i) Butt weld between nozzle and lance tube shall be subjected to 100 % radiography tests.
- ii) Soot blower shall be subjected to operational checks as below:
 - a) Smooth operation
 - b) Long tube travel, closing and opening time.
 - c) Current drawn.

4.2.4 ID and FD fans

- i) Rotor components shall be subjected to ultrasonic test at mill and magnetic particle examination/dye penetration examination after rough machining.
- ii) Butt welds in rotor components shall be subjected to 100% UT and all welds shall be subjected to MPE or DPT after stress relieving.

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- iii) All rotating components of fans shall be dynamically balanced to quality grade 2.5 of ISO 1940.
- iv) Test for natural frequency of all fan components, including fan blades shall be carried out for the fans.
- v) Full range performance test shall be carried out on one fan of each type and size as per BS 848, Part-1.
- vi) ID fan shall be checked for string test i.e., operational check of one fan assembly to check temperature rise, smooth operation, vibration and noise level. Dry run test shall preferably be carried out during string test.

4.2.5 Coal Mills, Pulverised Coal Piping and Burners

- i) Raw material for shaft, coupling, gears and pinions, top and bottom races and other rotating components shall be subjected to UT. MPE or DPT shall be carried out to check surface soundness.
- ii) Wear-resistant parts shall be subjected to UT or RT to check soundness after suitable heat treatment. Check for chemical composition and hardness shall be carried out. For ceramic materials check for various properties including hardness, density, wear rate and composition shall be carried out.
- iii) Butt welds in the body casing and separator of the mill shall be tested by RT and MPE. All other welds shall be tested by MPE or DPT for acceptance.
- iv) All gearboxes shall be run tested for adequate duration to check rise in oil temperature, noise level and vibration. Check for leak tightness of gear case also shall be performed.
- v) Fabricated pipe welds shall be examined by MPE.
- vi) Ceramic/basalt lined piping and bends etc. shall be checked for proper layout.
- vii) Weldments on burner components shall be checked with suitable NDT. The burner assemblies shall be tested for operation at shop.
- viii) All rotating components shall be dynamically balanced.

4.2.6 Coal Feeders

- i) Type tests including degree of protection and routine tests shall be done as per relevant Indian Standards or equivalent International Standards.
- ii) All major items like plates for casings, head pulley, tail pulley, pulley shaft and major castings shall be procured with respective material test certificates.
- iii) Explosion proof test at 50 psi as per NFPA code shall be done as type test. Leak tightness test shall be done on apron feeder casing. Endurance test for load cell shall be carried out.
- iv) Test for weighing accuracy, calibration and repeatability shall be carried out at various speeds by coal flow on one feeder.
- v) Calibration check shall be carried out on all feeder cabinet and assemblies prior to dispatch.

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4.2.7 Boiler structure, ducts, hoppers, dampers etc.

- i) Only those materials which have been identified against mill sheet or test certificates shall be used for construction. Structural steel and built up plate girders for main boiler shall be as per approved Indian / international standards. All plates of tension and compression flanges and connection material and plates above 40mm thickness shall be 100% ultrasonically tested.
- ii) Visual inspection of all welds shall be performed in accordance with AWS D.1.1. Also the butt and fillet welds for built up plate girders shall be inspected 100% by magnetic particle examination.
- iii) RT or UT shall be performed on all butt welds of thickness 32mm and above. For thickness below 32mm and upto 25mm, 100% MPE shall be carried out and for thickness below 25mm 10% MPE or DPT shall be performed. Edge preparations for field welding shall be examined by MPE for plate thickness 32mm and above. Field welds ends in ceiling girder shall be subjected to Ultrasonic examination for 100mm depth from the edges.
- iv) Ceiling girders, columns, ducts hoppers and tunnels shall be trial assembled and match marked prior to dispatch/erection. At least two consecutive girders along with cross member shall be assembled at a time.
- v) Drum sling rods
 - a) Sling rods forging shall be subjected to ultrasonic examination.
 - b) Welds shall be examined by UT and MPE after stress relief.
 - c) Trial fitment of the rods with the drum shell shall be carried out to ensure proper contact.
 - d) Screw thread of the rods shall be suitably protected to avoid damage during handling and transport.
- vi) Dampers
 - a) All the dampers shall be subjected to operational test/checks.
 - b) Gas tight dampers shall be subjected to shop leakage test to demonstrate the guaranteed tightness (minimum one damper of each type and size offered). In case such type test is already done, the reports of the same shall be submitted for review.
 - a) All dampers shall be checked for sealing dimensions to establish guaranteed tightness.

4.2.8 Electro- Static Precipitators (ESPs)

A. Discharge and collecting electrodes

- i) Work tests for discharge electrodes shall include the following (for the wire type electrodes):
 - a) Chemical and tensile tests.
 - b) Metallographic examination-longitudinal and transverse (250X)
 - c) Surface finish and surface purity from chloride ions.

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- d) Spring back and surface finish after coiling (applicable to helical discharge electrodes
- ii) Work tests for collecting electrodes and rigid discharges electrode shall include the following:
 - a) Chemical and mechanical properties.
 - b) Check for profile and straightness.
 - c) Check for surface finish and dimensional accuracy.
 - d) Cupping test for deep drawn sheets.

B. ESP structure

- i) Visual inspection of all welds shall be performed in accordance with AWS D1.1.
- ii) Also the butt and fillet welds for built up plates and columns shall be inspected by 100% MPI.
- iii) Radiographic examination shall be performed on butt welds as per AWS D1.1. 100% radiography on tension flange (bottom flange) welds and spot radiography on all joints in compression flange (top flange) of all beams and columns shall be carried out. The minimum length of welds for spot radiography and acceptance criterion shall be as per AWS D 1.1.
- iv) Edge preparation for field welding shall be examined by MPI.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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1. Invitation For Bid
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4. General Condition of Contract (GCC)
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* * * * *

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

BOILER & AUXILIARIES (PACKAGE NUMBER: R&M-SP-01)

VOLUME-II, SECTION-II, PART-B DETAILED TECHNICAL SPECIFICATION- ELECTRICAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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1. GENERAL

This specification is intended to cover the *[design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of Boiler complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

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2. LIST OF ATTACHMENTS

The following List of attachments is enclosed along with this specification.

[Note: List of attachments is depends on specific project scope of work. R & M consultant may attach the attachments as per project specific scope of work. For reference all attachments are considered in this package as per scope of work considered]

Legend: O: USE, X: NOT USE

Table: 1.1

Sl.No	Attachment Number	Description	Rev No	Application
1	E1	Motor	R1	O
2	E2	Motorized Actuators	R1	O
3	E3	LV Transformers(Dry type/Oil type)	R1	O
4	E4	415V Switchgear, MCC and DBs	R1	O
5	E5	415V Non Segregated Bus Duct	R1	O
6	E6	220V DC system	R1	X
7	E7	HV Cables	R1	O
8	E8	LV Cables	R1	O
9	E9	Illumination system	R1	O
10	E10	Cable Carrier System	R1	O
11	E11	Earthing and Lightning Protection system	R1	O
12	E12	6.6kV Switchgear	R1	X
13	E13	Variable Frequency Drives	R1	O
14	E14	6.6kV Segregated Phase Bus Duct	R1	X

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E1
TECHNICAL SPECIFICATION FOR MOTORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E1

1.0 MOTOR

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Electric Motor complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS : 325	:	Specification for three phase induction motor.
IS : 900	:	Code of Practice for installation and maintenance of induction motors
IS : 996	:	Single phase AC motors
IS : 1231	:	Dimensions of three-phase foot-mounted induction motors
IS : 1271	:	Thermal evaluation and classification of electrical insulation.
IS : 2223	:	Dimensions of flange mounted ac induction motors.
IS : 2254	:	Dimensions of vertical shaft motors for pumps
IS : 3177	:	Crane duty motors
IS : 4029	:	Guide for testing three phase induction motors.
IS : 4691	:	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	:	Specification for rotating electrical machinery.

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IS : 4728	:	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	:	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	:	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	:	Designation of Method of Cooling of Rotating electrical machines.
IS : 8223	:	Dimensions and output ratings for foot mounted rotating electrical machines with frame numbers 355 to 1000.
IS : 8789	:	Values of performance characteristics for three phase induction motors.
IS : 12065	:	Noise level of motors.
IS : 12075	:	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	:	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	:	Temperature rise measurement of rotating electrical machines
IS : 12824	:	Type of duty and classes of rating assigned.
IS : 14222	:	Requirements and method of Impulse withstand test
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IEC: 60034	:	Rotating electrical machines.
NEMA, MG-1	:	Motors and Generators
ISO : 1940-1	:	Mechanical vibration – Determination of permissible residual unbalance

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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All motors shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment.
- b. AC Motors shall be of [constant speed, squirrel cage, three/ single phase, induction type.] Motors shall be rated for [continuous duty/intermittent duty]. They shall also be suitable for long period of inactivity. They shall also be suitable for direct online starting (DOL starting).
- c. DC motors provided for emergency service shall be shunt / compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.
- d. Power supply for AC motors shall be as follows:

Table: 2.0

1.	[Below 0.22 kW]	:	240V, 1 Phase, 50Hz
2.	[From 0.22 kW up to & including 160 kW]	:	415V, 3 Phase, 50Hz
3.	[Above 160 kW]	:	6.6kV, 3 Phase, 50Hz

- e. All AC motors shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- f. DC motors shall be rated for 220V DC supply with voltage variation of -15% to +10%.
- g. The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, break down and full load torques are available for the intended service.

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- h. Moreover, motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
- i. Motors shall be capable of developing the rated full load torque even if the supply drops to 70% of the rated voltage.
- j. For 6.6kV motors, locked rotor current not to exceed [600%] of full load current, including positive tolerance, except for BFP. For BFP the starting current shall be [450%] of FLC. For 415 V motors Locked rotor current not to exceed [600%] of full load current with IS tolerance.]
- k. For DC motors, the starters shall be provided to limit the starting current to [2] times of the full load current.
- l. Maximum continuous motor ratings shall be at least [10%] above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.
- m. Accelerating torque at any speed with the lowest permissible starting voltage shall be at least [10%] motor full load torque. Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.
- n. The motors shall be suitable for bus transfer schemes provided on the 6.6kV and 415V systems without any injurious effect on its life. If motors are connected to an automatic bus transfer system, they may be subjected to 150% of the nominal voltage during changeover of buses due to the phase difference between the incoming voltage and motor residual voltage. In such cases, motors shall be capable of restarting under full load after momentary loss of voltage.
- o. Motors shall be of [energy efficient of type Eff-2] as per IS: 12615/equivalent IEC/ International Standards.
- p. Motor shall be designed to keep torsional and rotational natural frequencies of vibration of the motor and driven equipment at least 25% above the motor operating speed range.

1.3.1 System Grounding

Table: 3.0

(a)	6.6 kV	:	Low Resistance Grounded to limit the earth fault current to [300 Amps]
(b)	415 V	:	Solidly Grounded
(c)	220V DC	:	Ungrounded

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1.3.2 Fault Level

Table: 4.0

(a)	6.6 kV	:	[40 kA for 1 second]
(b)	415 V	:	[50 kA for 1 second]
(c)	220V DC	:	[25 kA for 1 second]

1.3.3 Degree of Protection

Table: 5.0

(a)	Indoor Motors	:	[IP 54]
(b)	Outdoor Motors	:	[IPW 55]
(c)	Cable Box located in Indoor Area	:	[IP 54]
(d)	Cable Box located in Outdoor Area	:	[IPW 55]

1.3.4 Winding Insulation

Table: 6.0

(a)	For 6.6 kV AC Motors	:	[Class – F]
(b)	For 415V AC Motors	:	[Class – B]
(c)	For 220V DC Motors	:	[Class – B]

1.3.5 Winding Conductor Material

Table: 7.0

(a)	For 6.6 kV AC Motors	:	Copper
(b)	For 415V AC Motors	:	Copper
(c)	For 220V DC Motors	:	Copper

1.3.6 Bearing

Table: 8.0

(a)	For Drive End	:	[Roller]
(b)	For Non Drive End	:	[Roller / Ball]

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1.3.7 Temperature Rise

Table: 9.0

(a)	For Air Cooled Motors	:	[70 °C] over ambient temperature [Class B]
(b)	For Water Cooled Motors	:	[80 °C] over inlet cooling water temperature [Class B]

1.3.8 Motor Earthing

Table: 10.0

(a)	Motors above 90 kW	:	[50 x 6 mm GI Flat]
(b)	Motors above 30 kW and up to 90 kW	:	[25 x 6 mm GI Flat]
(c)	Motors above 5 kW and up to 30 kW	:	[25 x 3 mm GI Flat]
(d)	Motors up to 5 kW	:	[8 SWG GI Wire]
(e)	Terminal Box	:	[8 SWG GI Wire]

1.3.9 Space Heater

Table: 11

(a)	For Motors 30 kW rating and above	:	Space heater suitable for 1Phase, 240V AC, 50 Hz supply
(b)	For Motors below 30 kW rating	:	No Space heater provided.

1.3.10 Painting

Table: 12

a)	Paint Type	:	Epoxy based with approved class
b)	Paint Thickness	:	[Within 100 to 150 micron.]
c)	Paint Shade	:	[RAL5012 BLUE]

1.4 Specific Requirements

1.4.1 Locked Rotor Withstand Time

- The starting time of the motor shall be at the minimum permissible voltage.
- For motors with starting time up to 20 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot

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condition at highest voltage limit shall be at least 2.5 second more than starting time.

- c) For motors with starting time more than 20 second and up to 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 second more than starting time.
- d) For motors with starting time more than 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- e) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.

1.4.2 Starting Voltage Requirement

I.	All motors (except mill motors):
a)	[85% of rated voltage for motors up to 4000 kW]
b)	[75% of voltage for motors above 4000 kW]

II.	For mill motors:
a)	[85% of rated voltage for motors above 1000 kW]
b)	[90% of rated voltage for motors below 1000 kW]

The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at [125%] rated speed in reverse direction.

The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

1.4.3 Winding and Insulation

a)	6.6 kV AC motors	:	Winding material shall be of copper. Insulation shall be of [Class F with winding temperature rise limited to Class B]. They shall withstand 1.2/50 microsecond switching surges of "4U + 5 KV" (U= Line voltage in KV). The coil inter-turn insulation shall be suitable for 0.3/3 micro second surge of 32 / 12 KV followed by 1 min
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			power frequency high voltage test of appropriate voltage on inter turn insulation.
b)	415V AC & 220V DC motors	:	Winding material shall be of copper. Insulation shall be of [Class B with temperature rise limited to Class B.]
c)	Conveyor motors		Short circuit rings of conveyor motors shall be either joint less or welded type. Brazed joint is not acceptable.

1.4.4 Motor Control

a) For HV Motors

- i. Motors of rating above [160 kW] shall be suitable for 6.6 KV voltage
- ii. Frequent starting motors of rating above [160 kW] shall be suitable to be controlled by vacuum contactors

(b) For LV Motors

- i. Motors of rating less than [132 kW] shall be operated by Contactor from respective MCCs. Motors of rating up to [18.5 kW] shall be provided with MPCBs and Electronic overload relays. Motors of rating above [18.5 kW] and below [45 kW] shall be provided with MCCBs and Electronic overload relays. Motors of rating [45 kW] and above but less than [132 kW] shall be provided with MCCBs and CT operated Electronic over load relays.
- ii. Motors of rating [132 kW] and up to [160 kW] shall be suitable to be controlled by Air circuit breakers from switchgear, PMCCs and shall be provided with comprehensive numerical motor protection relays.
- iii. Only for firefighting system, motor rated [upto 200kW] shall be fed from 415V switch board.

1.4.5 Starting duty

Motors shall be suitable for [3 nos. consecutive Cold starts ups and 2 nos. consecutive Hot starts ups.] Motors shall be suitable for three equally spread starts per hour when the motor is under normal service condition.

1.4.6 Bearings

- a) Anti-friction type radial and thrust bearings (ball, roller) and sleeve bearing shall be rated for minimum standard life of 40,000 hours taking bearing and driven equipment loads (in case the drive is not having

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separate thrust bearing) into account. If bearings are lubricated, loss of grease shall be scarce and it shall not creep along shaft into motor housing. Facility of removal of excess grease shall also be provided for grease lubricated bearings.

- b) Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if Anti-friction bearings can take vertical thrust, thrust & guide bearings are not required.
- c) Bearing shall be effectively sealed against dust ingress and shall be pressure grease gun lubricated. The bearing and housing shall be so designed that greasing shall be possible while the motor is running, without removal of covers.
- d) Where bearing supports are attached to the motor casing, adequate bracing shall be provided on these supports to reduce vibrations and ensure life of bearings.
- e) If the bearings are oil lubricated, a drain plug shall be provided for draining residual oil and oil level gauge shall be provided to show precisely oil level required under standstill and running conditions.
- f) Unless otherwise approved, bearing lubricating system shall be such that no external forced oil or water is necessary to maintain required oil supply to keep bearing temperature within design limits.
- g) Lubricants shall be selected for prolonged storage and normal use of motors in tropical climate and shall contain corrosion and oxidation inhibitors. Greases shall have suitable bleeding characteristics to minimize setting. The selected lubricants shall be indigenously available.
- h) Motors rated above 1000 kW shall have insulated bearings to prevent flow of shaft currents.

1.4.7 Temperature Rise

- a) For Air Cooled Motors, temperature rise of insulation should be limited to [70 °C] over ambient temperature by resistance method.
- b) For Water Cooled Motors, temperature rise of insulation should be limited to [80 °C] over inlet cooling water temperature mentioned elsewhere, by resistance method.

1.4.8 Cooling

[All motors shall be either Totally Enclosed Fan Cooled (TEFC) or Totally Enclosed Tube Ventilated (TETV) or Closed Air Circuit Air Cooled (CACA) type. However, motors rated 3000 kW or above can be Closed Air Circuit Water Cooled (CACW)]

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1.4.9 Enclosure

- a) All motor enclosures shall conform to the degree of protection of [IP54] for indoor and IPW-55 for outdoor installation unless otherwise specified. Motor for outdoor or semi outdoor service shall be of weather proof construction. Motors of large output rating located indoor could have screen protected drip proof (SPDP) enclosure conforming to [IP-23.]
- b) For motors located in outdoor & corrosive locations, FRP canopy shall be provided. In case steel canopy is provided, the same shall be epoxy painted to meet the surrounding atmosphere. Motors located in hazardous areas such as Hydrogen plant shall have flame proof enclosures of Group – IIB conforming to IS: 2148.
- c) For hazardous locations such as fuel oil facilities area, the enclosure of motor shall have flame proof construction conforming to IS 2148.

1.4.10 Noise Level and Vibration

Noise level shall be limited to 85 dB (A) at 1.5 meters from the motor. However the same shall be as per IS: 12065 unless otherwise specified. The peak amplitude of vibration shall be within the specified limits laid down in IS: 12075. Motors shall withstand vibrations produced by driven equipment. HV motor bearing housings shall have flats in both X and Y directions suitable for mounting 80mmX80mm vibration pads. Vibration pads with screwed holes for mounting vibration probes shall be provided at both DE and NDE.

1.4.11 Temperature Monitoring

[In HV motors, at least four numbers simplex/ two numbers duplex platinum resistance type temperature detectors shall be provided for each phase of stator winding]. Each bearing shall be provided with dial type thermometer with adjustable alarm contact and two numbers duplex Platinum resistance type temperature detector (3 wire, 100 ohm at zero °C). In case of CACA and CACW motors dial type temperature indicator shall be provided (one each for hot and cold air temperature monitoring for CACA and CACW and one each for inlet and outlet water temperature monitoring for CACW). If alarm and trip are required for cooling air temperature, temperature switch shall be provided. The contact rating shall be minimum 0.5A at 220V DC and 5A at 240V AC. Flow switches shall be provided for monitoring cooling water flow of CACW motor and oil flow of forced lubrication bearing. Low voltage motors rated 100 kW and above shall be provided with two PT100 RTDs per phase of winding.

1.4.12 Earthing

Motor body shall have two earthing points on opposite sides. Motor terminal boxes shall also have separate grounding terminals.

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1.4.13 Termination

- a) HV motors can be offered with either Elastimold termination or dust tight phase segregated double walled (metallic as well as with insulated barrier) cable boxes. In case Elastimold terminations are offered, then protective cover and trifurcating sleeves shall also be provided. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided in case of cable boxes. The main cable box / terminal box shall withstand *[a fault current up to 40 kA for 0.25 seconds for HV motors and 50 kA for 0.25 seconds for LV motors]*. Separate terminal boxes shall be provided for space heaters and RTDs and NCT (if applicable).
- b) *[All terminal boxes shall be capable of being turned through 360 degrees in steps of 90 degrees unless otherwise specified.]*
- c) For HV motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

1.4.14 Differential Protection

For motors rated 6.6kV, *[2000 KW & above,]* neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box for differential protection.

1.4.15 Tropical Protection

- (a) All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- (b) All fittings and hardware shall be corrosion resistant.
- (c) Space Heater
- (d) Suitable single phase space heaters operated at 240V, 50Hz, 1Phase AC supply shall be provided on motors rated for 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided.
- (e) The space heater shall be sized to maintain the motor internal temperature above dew point when the motor is in idle condition.

1.4.16 Rating Plate

Motor shall have Stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / NEMA-MG-1 and following additional information:

- (a) Type of bearing and recommended lubricants along with location of insulated bearing.
- (b) Temperature rise under normal/abnormal conditions.

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(c) In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.

(d) Year of Manufacture

1.4.17 Drain Plug

Motor shall have drain plugs so located that they shall drain the water, resulting from the condensation or other causes from all pockets of the motor casing.

1.4.18 Dowel Pins

Motor shall be designed to permit easy access for drilling holes through motor feet or mounting flange for installation of dowel pins after assembling the motor and driven equipment.

1.4.19 Painting

The complete motor assembly including fan shall be painted with corrosion proof paints of approved class.

1.4.20 Lifting provision

Motor weighing 25 Kg or more shall be provided with eyebolt or other adequate provision of lifting.

1.4.21 Local Push Button Station (LPBS)

- a) Each motor shall be provided with push button station as per process requirement i.e. Start/Stop or Emergency Stop.
- b) The degree of protection of LPBs shall be IPW 55 for outdoor and IP 54 for indoor applications.
- c) All Push Buttons shall be push to actuate type and stop Push Button shall be lockable in off position as per the scheme requirement.
- d) The Emergency local stop push button of Stay put type shall be provided with Press to lock & turn to release keyless mechanism.
- e) All PBs shall be provided with 2 numbers NO and 2 numbers NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to switchgear module for direct tripping and another contact to control system.
- f) Terminals to be suitable for 2 cores of 2.5 Sq.mm. cable with 20% spare terminals.
- g) All LPBS shall be of Poly Carbonate /FRP / Die Cast Aluminium material.

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I) TestsType Test

For each type & rating of HV and LV motors of rating above [50 kW], the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last[five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- (a) Visual and dimensional check
- (b) Winding resistance measurement
- (c) No load test
- (d) Mechanical vibration
- (e) Direction of rotation versus phase sequence
- (f) Insulation resistance measurement
- (g) High potential test
- (h) Locked rotor test
- (i) Speed/torque test
- (j) Over speed test
- (k) Temperature rise test
- (l) Determination of characteristic
- (m) Degree of protection test for the enclosure.
- (n) Noise level
- (o) Shaft current and bearing insulation test (Applicable for HV motors)

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

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IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.5 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

Dimensional General Arrangement drawing

- a) [Motor sizing calculation
- b) Foundation Plan & Loading
- c) Cable end box details
- d) Space requirement for rotor removal
- e) Thermal withstand curves hot & cold
- f) Starting and speed torque characteristics at 80% & 100% voltage
- g) Complete motor data
- h) Erection & Maintenance Manual
- i) Test reports
- j) QAP]

1.6 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	Technical Particulars	Unit	Parameters	Remarks
1	Motor application		[As per requirement]	
2	Rated Output, kW	kW	[As per requirement]	
3	Maximum continuous kW obtainable without exceeding specified temperature rise	kW	[By Bidder]	
4	Motor type		Squirrel cage induction motor	
5	Duty Cycle (IEC 60034-1)		[S1]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
6	Rated voltage	kV	6.6 kV for HV motors 415 V for LV motors 220V DC for DC motors	
7	Phase/frequency	Hz	50	
8	Allowable variation in supply conditions			
a)	Voltage		6.6 kV	
b)	Frequency		50	
c)	Combined			
9	Method of starting		DOL	
10	CT details for differential protection	Yes/No	For motors of rating > 2000kW	
11	Full load amperes	A	[By Bidder]	
12	Locked rotor current amperes	A	HV(Except BFP): 6 times without tolerance BFP: 4.5 times without tolerance LV: 6 times with IS specified tolerance DC : 2 times with no positive tolerance at rated terminal voltage.	
13	Method of Cooling (IC code)		[As per requirement]	
14	Enclosure (IP Code)		Indoor : IP54 Outdoor : IPW55	
15	Construction (horizontal or vertical)		[As per requirement]	
16	Max. temperature, by resistance method	Deg C	120 deg (Class B)	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
17	Insulation class		HV: Class F LV: Class B	
18	Motor insulation system (describe material used)		[By Bidder]	
19	Bearings		[By Bidder]	
a)	Type			
b)	Quantity			
c)	Lubrication system pressure and flow			
20	Temperature detector (type & quantity)			
a)	Winding		[As per requirement]	
b)	Bearing		[As per requirement]	
21	Space heaters		30 kW and above	
a	Watts (Rating/Operating)	W	[By Bidder]	
b	Volts (Rating/Operating)	V	[By Bidder]	
22	GD ² of motor		[By Bidder]	
23	Power factor		[By Bidder]	
a)	Full load	p.u		
b)	3/4 load	p.u		
c)	1/2 load	p.u		
d)	No load	p.u		
24	Efficiency		[By Bidder]	
a)	Full load	%		
b)	3/4 load	%		
c)	1/2 load	%		
25	Impedance data		[By Bidder]	
a)	locked rotor reactance per phase	Ohm		
b)	Rotor resistance per phase	Ohm		

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S. No.	Technical Particulars	Unit	Parameters	Remarks
c)	stator resistance per phase	Ohm		
26	Net motor weight	Kg	[By Bidder]	
27	Terminal box dimensions H/W/D	Mm	[By Bidder]	
28	Rotor removal clearance	mm	[By Bidder]	
29	Winding connection (star or delta)		HV: Star LV: Delta	
30	Noise Level	dB(A)	[As per requirement]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E2
TECHNICAL SPECIFICATION FOR MOTORIZED
ACTUATORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E2

1.0 MOTORIZED ACTUATORS

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Motor Operated Actuator complete with all accessories for efficient and trouble-free operation of valves, dampers and gates for R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS : 325	Specification for three phase induction motor.
IS : 900	Code of Practice for installation and maintenance of induction motors
IS : 996	Single phase AC motors
IS : 1271	Thermal evaluation and classification of electrical insulation.
IS : 2223	Dimensions of flange mounted ac induction motors.
IS : 4029	Guide for testing three phase induction motors.
IS : 4691	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	Specification for rotating electrical machinery.
IS : 4728	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	Designation of Method of Cooling of Rotating electrical machines.

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IS : 8789	Values of performance characteristics for three phase induction motors.
IS : 9334	Electrical Motor Operated Actuators.
IS : 12065	Noise level of motors.
IS : 12075	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	Temperature rise measurement of rotating electrical machines
IS : 12824	Type of duty and classes of rating assigned.
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package
IEC: 60034-1	Rotating electrical machines.
NEMA, MG-1	Motors and Generators

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All motor operated actuators shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.
- Depending on the required type of services, the rating of motor operated actuators shall be selected. For isolating service, the actuator shall be [rated for three successive open-close operations of the valve/ damper or 15 minutes continuous operation whichever is higher.] Whereas for regulating service, the actuator shall be suitably [time rated for required number of duty cycle or 150 start per hour whichever is higher].
- The actuator shall be accompanied with constant speed, squirrel cage, three/ single phase, induction motor. The motor shall be designed for high

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torque and reversing service. They shall also be suitable for direct online starting (DOL starting).

- d. Motors of actuators shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- e. The motor operated actuator shall be sized for performing open / close operation at rated speed against designed differential pressure at [90%] of rated voltage. The motor shall have [10%] design margin on the shaft design power.

The actuator shall meet the following performance requirements:

- i. Open & Close the valve completely and make leak tight valve closure without jamming.
- ii. Attain full speed of operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- iii. The motor reduction gearing shall be sufficient to lock the shaft when the motor gets de energized and prevent drift from torque switch spring pressure.
- iv. The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.
- v. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

1.4 Specific Requirements

1.4.1 Construction

- a) The actuator shall essentially comprise of drive motor, limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, space heater and internal wiring.
- b) The actuator enclosure shall be totally enclosed, dust tight, weather proof with [IPW 55] degree of protection.
- c) All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

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- d) Gear train shall be made of metal (fiber gears are not acceptable). Self locking feature shall be provided to prevent drift under torque switch (wherever applicable) spring pressure when motor is de energized.
- e) Manual wheel shall disengage automatically during motor operation.

1.4.2 Type

- a) The actuators shall have integral starters along with overload relays with built-in single phase preventer.
- b) A 415 V, 3 phase, 3 wire, 50 Hz power supply will be provided from power plant 415 V switchgear through MCCB. Control voltage of the starter circuit shall be 110 V AC or depending on manufacturer's practice. But the same shall be derived from incoming 415 V, 3 phase, 3 wire supply.

1.4.3 Motors

- a) Type: The drive motor shall be three phase, squirrel cage induction motor suitable for direct on line starting with starting current limited to six times the rated current
- b) Enclosure: The motor shall be totally enclosed, self ventilated with [IPW 65] degree of protection.
- c) Insulation: The motor winding shall be insulated with [Class – B] insulation having temperature rise limited to [Class – B].
- d) Bearing: The motor bearing shall be [double shielded, grease lubricated and antifriction type].
- e) Earthing: At least two earthing terminals shall be provided for the motor body. Separate earthing terminal should be provided for terminal box.
- f) Protection: The following electrical protections should be provided for the motor:
 - i. Single Phasing Protection
 - ii. Overload Protection
 - iii. Overheating Protection through thermostat
 - iv. Wrong Phase Sequence Protection
- g) Limit Switches: Each actuator shall be accompanied with following switches:
 - i. Four nos. positional limit switches (2 for open & 2 for close), each adjustable at any position from fully open to fully closed positions of the valve / damper.
 - ii. Two torque limit switches, one for each direction of travel, self blocking & adjustable torque type.

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- iii. Four nos. end travel limit switches, two for each direction of travel.
 - iv. A single shaft shall actuate all contacts of limit switches at each position.
- h) Interface: Open/close command termination logic with position and torque limit switches, positioned circuit shall be suitably built in the PCB inside the actuator.
- i. For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided. Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the DCS shall be energized to initiate opening and closing, by 24V DC signal from the external control system. Potential free contact provided by the IPR shall be utilized in the control circuit of the contactor of motorized actuators.
 - ii. For modulating drive, the command to actuator shall be in form of 4- 20mA signal. The necessary positioning circuit and motor protection shall be provided.
 - iii. Open/close command termination logic shall be suitably built inside actuator.
- i) Hand Wheel: Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall disengage automatically when the motor is energized.
- j) Position Indicator / Transmitter: The actuator shall have
- i. One built in local position indicator for 0 – 100% travel.
 - ii. One position transmitter of modulating / inching type for remote indication suitable to stabilize 4-20mA signal and operated with [24V DC].
- k) Space Heater: Space heater of suitable rating shall be provided. The power supply shall be derived from main power supply available in the actuator.

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- l) Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be done with [2.5 sqmm] copper wires. All wiring shall be well identified at both ends with ferrules.
- m) Terminal Box:
- i. The terminal box shall be weather proof with removable front cover and cable glands suitable for cable connection. The terminals shall be suitable for connection of [2.5 sq.mm copper] conductor.
 - ii. Necessary double compression cable glands with nickel coating and tinned copper lugs for cables shall be provided.
 - iii. The terminal block shall be suitable for 650V grade power cable.
- .
- n) Rating Plate : Motor and actuator shall have Stainless steel nameplate(s) showing all particulars as per relevant IS/ IEC and following additional information:
- i. Type of bearing and recommended lubricants.
 - ii. Temperature rise under normal/abnormal conditions.
 - iii. Degree of Protection
 - iv. In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.
 - v. Year of Manufacture

1.5 Tests

The actuator and all components thereof shall be subject to routine factory tests as per relevant IS standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

1.5.1 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum [7] days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc.]

1.5.2 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished with requisite no. of copies for approval of the Owner.

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- b) The equipment shall be dispatched from works only after receipt of owner's written approval of shop test reports.

1.6 Drawings Data and Manuals

The drawings, data & manuals for the motorized actuators shall be submitted as indicated below:

1. [Actuator Data Sheet
2. General arrangement drawing
3. Internal wiring Diagram and Control Schematic.
4. Torque switch and Limit switch contacts development.
5. QAP for Test Reports
6. Manufacturer's Catalogue.
7. Instruction manuals on Installation methods.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		Integral
2.	Application		[As per project specific]
3.	Motor type		Squirrel Cage
4.	Supply voltage	V	415 V, 3 ph, 3 wire.
5.	Phase, frequency	Hz	3ph, 50 Hz
6.	Motor rated voltage	V	415V/230 V
7.	Control Voltage	V	[110 V AC]
8.	Voltage and its variation	V	± 10%
9.	Frequency and its variation	Hz	+ 3 to -5%
10.	Combined V & f variation	%	10%

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S. NO.	DESCRIPTION	UNIT	DATA
11.	Degree of Protection		IPW 65
12.	Winding Insulation		Class B
13.	Temperature Rise (over ambient temperature)	°C	Class B
14.	Painting		[RAL 5012]
15.	Motor Starting		
a)	Method		DOL
b)	Starting Current		6 times

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E3

TECHNICAL SPECIFICATION FOR LV TRANSFORMERS

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E3

1.0 LV TRANSFORMER (DRY TYPE/OIL TYPE)

1.1 General

This specification is intended to cover [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV Transformers (Dry type/Oil type) complete with all accessories for efficient and trouble free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

CODE	NAME OF STANDARD
IS:334	Dimensions for porcelain Transformer bushing
IS:335	New insulating oil for transformers and switchgears
IS:1271	Classification of insulating materials for Electrical Machinery and apparatus in relation to their stability in service.
IS 2026	Specification for power Transformer (all parts)
IS:2071	Method of high voltage testing
IS:2099	High voltage porcelain bushings
IS:2147	Degree of protection.
IS:2705	Current transformers
IS:3202	Code of practice for Climate proofing of electrical equipment
IS:3637	Gas operated relays
IS:3639	Fittings and accessories for power Transformers
IS:5561	Electric Power connectors
IS:6600	Guide for loading of oil immersed transformers

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CODE	NAME OF STANDARD
IS: 11171	Dry type transformers
IS:10028	Code of practice for selection, Installation and maintenance of transformers Part I, II and III
CBIP	Manual on transformers
IEC60076	Power Transformer
IEC 60214	Tappings
IEC 60726	Dry-type power transformers
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
ANSI C57.12.51	Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160 Volts
ANSI C57.12.55	Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard
ANSI/IEEE C57.98	Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
ANSI/NFPA 70	National Electrical Code
IEEE C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.94	Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers

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CODE	NAME OF STANDARD
NEMA ST 20	Dry Type Transformers for General Applications
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The transformers shall be dry type (AN) for indoor location and shall be oil type (ONAN) for outdoor location.
- b) The oil type transformer shall be installed in hot, humid and tropical atmosphere with ambient temperature equal to 50°C. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- c) The transformer shall be capable of continuous operation at specified rating under the following condition:
 - i) Voltage variation - $\pm 10\%$
 - ii) Frequency variation - $[+3\%, -5\%]$
 - iii) Combined voltage and frequency variation (absolute sum) - $[10\%]$
- d) The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.
- e) The noise level shall be limited to the value specified by NEMA Standard Publication No. TR-1-1993 when measured in accordance with conditions outlines in ANSI/IEEE C57.12.90-1999/IS13964/CBIP publication.
- f) The design shall be such as not to cause any undesirable interference with radio or communication circuits.
- g) Transformers shall accept without injurious heating, combined voltage and frequency variation which produce an over fluxing condition of 120% for one (1) minute.

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- h) Each transformer shall be sized based on actual load with 10% margin and considering voltage regulation factor. It shall be sized by considering 100% load connected on the bus considering other transformer outage. An appropriate load factor of 0.9 for continuous and 0.2 for intermittent shall be considered.
- i) The impedance of the transformers shall be chosen such that the fault level on the LV switchgear does not exceed 50kA including the motor contributions and also voltage dip while starting the motor does not exceed 15% at motor terminal.

1.4 Specific Requirements of Transformers

1.4.1 Enclosure (for dry type)

- a) The encapsulated cast resin transformer shall be housed in naturally ventilated floor mounted cold rolled sheet steel cubicle with louvers backed by fine brass wire mesh. The enclosure shall be of bolted type fabrication and degree of protection shall be at least IP32. The minimum sheet steel thickness shall be 2 mm.
- b) Enclosure shall be provided with lifting lugs and grounding terminals at both ends. Further the enclosure door shall have pad locking provision.
- c) The enclosure door shall be interlocked with service transformer incoming breaker such that.
 - The door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position.
 - [6.6] kV side circuit breaker can be closed only when the doors are closed.
- d) Necessary illumination with controls shall be provided in the enclosure.
- e) Thermostatically controlled space heater inside the enclosure of suitable rating shall be provided if necessary.

1.4.2 Tank (for oil type)

- a) For LV transformers, the tank shall be of conventional type.
- b) Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.
- c) Tank shall be designed to permit lifting, by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.
- d) Tank together with radiators, coolers, conservator, bushings vessel and other fittings, shall be designed to withstand full vacuum without permanent distortion.
- e) The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

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- f) The material used for gaskets shall be cork-neoprene or approved equivalent. Gasketed joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather. Spare gaskets shall be provided for all openings as shipping gaskets will not be reused.
- g) Tank shall be provided with all necessary valves.
- h) Tank shall be provided with a pressure release device which shall operate at a pressure below the test pressure for the tank and radiators. This device shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall be rain proof after blowing and shall be provided with a device visible from ground to indicate operation. An equaliser pipe connecting the pressure relief device to the conservator shall be supplied. This device shall be provided for all transformers. Pressure relief device shall be equipped with remote monitoring/alarm contacts

1.4.3 Core

- a) The transformers shall be three phase core type. The core shall be built up with high grade, non-ageing, low loss, high permeability grain oriented cold rolled silicon steel laminations especially suitable for core material. Laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.
- b) CRGO sheets shall be coated with insulation varnish. Insulation shall be able to withstand the curing temperature and shall reduce eddy current to minimum. The core shall be protected from corrosion with a rust-resistant coating.
- c) The core clamping brackets shall be designed to provide an even distribution of clamping forces to the core, yokes and legs and shall be rigidly braced to reduce sound levels and losses.

1.4.4 Winding

- a) The coils shall be manufactured from electrolytic copper conductor with sufficient number of radial supports and fully insulated for rated voltage.
- b) The insulating material shall conform to Class F. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and shall withstand even the severest of temperature fluctuations.
- c) Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. The windings shall be arranged to ensure a free circulation of the air and to reduce the hot spots in the winding.

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- d) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.
- e) The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer, under short circuit stresses, switching or other transients.
- f) All coils rated 1200V or higher shall be subjected to partial discharge tests to ensure a properly cured and void free casting.

1.4.5 Encapsulation (for dry type)

- a) HV and LV coils shall be separately cast under vacuum in fibre glass reinforced epoxy resin compound. The insulation shall be fire resistant, non-inflammable, non-hygroscopic and resistant to temperature fluctuations.
- b) The epoxy shall contain filler material providing characteristics superior to unfilled epoxy including higher temperature rating, better heat conductivity, better arc resistance and adhesion to the conductor, plus a coefficient of expansion closer to that of the conductor material. The epoxy resin shall be self extinguishing.
- c) Encapsulated winding shall be free of internal voids, surface irregularities, etc. No surface finishing of encapsulated winding shall be undertaken after the process of encapsulation.

1.4.6 Insulating Oil (for oil type)

- a) The transformer shall be filled with mineral insulating oil suitably inhibited to prevent sludging.
- b) The quality of oil to be supplied for the transformer shall conform to the parameter specified in IS: 335 with latest amendments. No inhibitors shall be used in oil. Prior to filling oil shall be tested as per IS: 335 for tan delta, specific resistivity, breakdown voltage, moisture content etc.
- c) Transformer shall be dispatched oil filled. 10% excess oil for topping up shall be supplied in non-returnable container suitable for outdoor storage.
- d) Oil preservation shall be by means of conservator tank complete with silica gel breather and oil seal.
- e) Oil preservation shall be by means of bellows/ diaphragm sealed conservator tank with silica gel breather to avoid direct connection between atmosphere and transformer oil. It shall be complete with level gauges, pipes , drain valve etc. The level gauges shall be so placed that same can be readable standing from ground.
- f) Necessary device shall be kept to provide annunciation in the event of rupturing of bellow.

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1.4.7 Tappings (OCTC)

- a) Off-circuit taps as specified shall be provided on the high voltage winding.
- b) The transformer shall be capable of operation at its rated KVA on any tap provided the voltage does not vary by more than $\pm 10\%$ of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be provided.
- e) Off circuit tap changer switch where provided shall be 3 phase, hand operated, by an external handle with position markings and pad locking facility and mechanical stops to prevent over cranking beyond extreme positions.
- f) Arrangement shall be such that switch can be operated at standing height from ground level.
- g) The operating handle can be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator with pad locking facility.

1.4.8 Fittings and Accessories:

The following fittings and accessories shall be provided :

- a) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the purchaser's earthing conductors. Suitable earthing terminals on cable boxes shall also be provided.
- b) Terminal marking and rating plates shall be as per the specified standard.
- c) In case of oil type, the conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of -5°C up to an oil temperature of 100°C , with oil level varying within the minimum and maximum visible levels with necessary accessories.
- d) In case of oil filled type, Valves shall be supplied on the transformer tank and radiators.
- e) Pressure relief device: Pressure relief device shall be provided for transformers rated 2 MVA and above which shall be of sufficient size for rapid release of any pressure that may be generated within the tank and which may result in damage of the equipment
- f) Gas and Oil Actuated Relay (Magnetic Reed Type Gas & Oil Relay):

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A double float type magnetic reed type gas and oil relay as per applicable standard shall be provided for all oil filled transformers. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. These contacts shall be wired up to the transformer marshalling box. The relay shall be provided with shut off valves on the conservator side as well as the tank side.

g) Temperature Indicators

i Oil temperature indicator (OTI)

All oil type transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device. The contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC.

ii Winding Temperature Indicator (WTI):

A device for measuring the hot spot temperature of the winding shall be provided. The accuracy class of winding temperature indicator shall be $\pm 20^{\circ}\text{C}$ or better.

iii Oil Level Indicator:

A magnetic type oil level indicator shall be provided to indicate oil level in the tank.

iv RTD/transducers for remote annunciation:

In addition to the above mentioned indicators, the Oil and winding temperature measurement, RTDs / transducers shall be provided for remote indication in the DCS. RTDs shall be duplex platinum type with nominal resistance of 100 ohms at zero degree centigrade.

h) Bushing Current Transformers for stand by earth fault protection shall be provided in the neutral bushing and lead shall be brought to Marshalling box.

i) Radiator (oil filled type): Tank mounted radiators banks shall have bolted flanged connections and pipe extensions to permit withdrawal of

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transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes (unless otherwise approved) to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. The interconnecting pipes shall be provided with drain plug and air release vents.

- j) Conservator (For oil filled type): The transformers rated below 7.5MVA shall be provided with conventional single compartment conservator with dry air filling the space above the oil.

1.4.9 Bushings

- a) The bushing shall conform to the requirements of IS:2099 and IS:3347.
b) All transformer bushings shall be of porcelain (for oil filled)/ epoxy (for dry type).
c) The neutral terminal of 433V winding shall be brought out on a bushing along with the 433V phase terminal to form a 4 wire system for the 433V. Neutral CTs shall be located in the lead coming out of the winding and location of these CTs shall not be inside the tank.
d) The neutral terminal of secondary shall be brought out through an outdoor. Further this neutral terminal shall be connected by a copper flat of size [50 mm x 6] mm, which shall be brought down upto 100 mm above ground. The copper flat shall be insulated and supported from the tank body.

1.4.10 Terminal arrangement

- a) Cable boxes
i. Wherever cable connections are specified, suitable cable boxes shall be provided and shall be air insulated.
ii. Cable boxes shall have drilled gland plate of adequate size to receive cables and to allow easy termination.
iii. Removable drilled gland planes shall be provided in the cable boxes.
iv. The additional supports for the cable boxes shall be galvanised iron.
v. The contractor shall provide earthing terminals on the cable box, to suit [50mmx6] mm GI flat.
b) Bus duct
i. Wherever Bus duct termination is specified a flanged throat or equivalent connection shall be provided for termination of bus duct enclosure. The winding termination shall be outdoor type bushing. The material of the bus duct termination arrangement of the transformer shall be nonmagnetic. The bus duct may be either phase-segregated or non-segregated.

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- ii. Tolerance permissible for the height of terminals and bus duct flange location specified for bus duct termination over ground level is $\pm 5\text{mm}$. Contractor has to ensure that radiator, conservator and explosion vent do not obstruct the path of the bus-ducts.

1.4.11 Marshalling box

- a) A sheet steel weather, vermin and dust proof marshalling box shall be furnished. The sheet steel used shall be at least 2.0 mm (CRCA) thick. The box shall be free standing floor mounted/tank mounted type and have a sloping roof. The degree of protection shall be IP-55 in accordance with IS:2147.
- b) The marshalling box shall have a glazed door of suitable size for convenience of temperature indicators reading.
- c) All incoming cables shall enter the marshalling box from the bottom.

1.4.12 Wiring

- a) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- b) Wiring shall be done with 650V PVC wires in conduit or PVC armored cable. *[Minimum wire size shall be 1.5 sq.mm stranded copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.]*
- c) Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. *[Terminals shall be stud type, suitable for terminating 2 nos. 2.5 mm2 stranded copper conductor and provided with acrylic insulating cover.]*
- d) All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- e) Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

1.4.13 Painting

- a) All steel surfaces shall be thoroughly cleaned by sand blasting and / or by chemical agents, as required to produce a smooth surface free of scales, grease and rust.
- b) The external surfaces, after cleaning, shall be given a coat of high quality red oxide or yellow chromate primer followed by filler coats.
- c) The transformer finished with two coats of epoxy based powder coated paint. The paints shall be carefully selected to withstand tropical heat,

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rain etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

- d) Painting shade shall be subject to owner's approval.
- e) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.14 Name Plate

Nameplates of approved design shall be furnished at each cubicle (one no. each at front as well as at backside of cubicle) and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black background. Self-tapping screws shall hold the nameplate. *[Nameplate size shall be minimum 20 x 75mm for instrument/device and 40 x 150mm for panels. Caution notice on suitable metal plate shall be affixed at the back of terminal Box.]*

1.5 Tests

1.5.1 Type Tests

For each type & rating of LV Transformers, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within *[last five]* years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within *[last five]* years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- a) Temperature rise test
- b) Dielectric test

1.5.2 Routine Tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The following tests shall be performed on each transformer as a minimum:

- a) After assembly, each core shall be pressure tested for one minute at 2KV (r.m.s.) A.C. between all bolts, side plates, structural steel works and the core.

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- b) The wiring for auxiliary power and control circuitry shall be subjected to withstand one minute power frequency test with 2.0KV (r.m.s.) to earth
- c) Measurement of winding resistance
- d) Measurement of voltage ratio and check of phase displacement
- e) Measurement of short circuit impedance and load loss
- f) Measurement of no load loss and current
- g) Dielectric routine tests
- h) Excitation loss and current measurements shall be made at 90%, 100% and 110% of the rated voltage as routine test.
- i) Partial discharge test
- j) Tan delta test

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings/ Data and Manuals

Drawings, data, and manuals for the transformers shall be submitted as indicated below:

- a) *[General Arrangement Drawing]*
- b) *Dimensioned general arrangement drawing showing enclosure, core coil assembly, terminal arrangement, marshalling box and various fittings.*
- c) *Transport/shipping dimensions with weights, wheel base detail etc.*
- d) *Foundation plan & loading.*
- e) *Bus duct/cable termination arrangement.*
- f) *Control schematics and wiring diagrams.*
- g) *Test reports and QAP*
- h) *Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.*
- i) *Instruction manuals on Transformer and its various fittings The manual shall clearly indicate method of installation, checkups and tests to be carried out before commissioning of the equipment.]*

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Note: The drawings, data and manuals listed are minimum requirement only. The Bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted.

1.7 Ratings and Requirements

Table 2.0

6.6/0.420 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Application	[As per project requirement]	[As per project requirement]
2.	Location	Indoor	Outdoor
3.	Type	[Dry Type: epoxy cast resin transformer]	[Oil type transformer]
4.	Reference standard	IS 11171	IS 2026
5.	Rated power (indicative)	[As per project requirement]	[As per project requirement]
6.	Rated winding voltage ratio (line to line)	6.6/0.433 kV	6.6/0.433 kV
7.	Number of phases	3	3
8.	Winding	2	2
9.	Rated frequency	50 Hz	50 Hz
10.	Type of cooling	AN	ONAN
11.	Insulation Class	Class F or Better	Class F or Better
12.	Temperature rise Over ambient temperature of 50°C		
a.	For Winding by	90°C or lower as permissible for class	55°C

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	resistance method	of insulation offered	
b.	For Oil by Thermometer method	Not Applicable	50 °C
13.	Insulation level (LI/AC)		
a.	HV- (LI/AC)	60 KVp/20 kVrms	60 KVp/20 kVrms
b.	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
14.	Vector group	[Dyn11]	[Dyn11]
15.	Short-circuit impedance on principal tap	[As per project requirement]	[As per project requirement]
16.	Parallel operation of transformer	Momentarily	Momentarily
17.	Type of taps provided	OCTC, full capacity	OCTC, full capacity
18.	Taps provided on	H.V. winding	H.V. winding
19.	Range of taps	[+/- 5 % in steps of 2.5%]	[+/- 5 % in steps of 2.5%]
20.	Method of Tap charge control-		
a.	Manual local	Yes	Yes
b.	Electrical local	No	No
c.	Electrical remote	No	No
d.	Automatic	No	No
21.	System earthing		

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a.	H.V.	Non-effectively earthed			Non-effectively earthed
b.	L.V.	Effectively earthed			Effectively earthed
22.	Terminal arrangement				
a.	H.V.	6.6kV(UE) Cable/ busduct			6.6kV(UE) Cable/ busduct
b.	L.V.	Non-segregated phase bus duct			Non-segregated phase bus duct
23.	Neutral for earthing	GS flat connector			GS flat connector
24.	Transformer bushing	HV	LV	LV - N	Same as Dry type transformer
25.	Voltage class KV(r.m.s.)	7.2	1.1	1.1	
26.	Creepage distance mm	[As 25mm/kV]			[As 25mm/kV]
27.	Min. Ph-Ph/ Ph-E clearance mm	As per Standard			As per standard
28.	System fault Level				
a.	HV Side	40 KA (r.m.s.)			40 KA (r.m.s.)
b.	LV Side	50KA (r.m.s.)			50KA (r.m.s.)
29.	Max. Noise level	As per NEMA std. TR-1			As per NEMA std. TR-1
30.	Auxiliary supply	415 V, 3 ph, 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)			415 V, 3 ph 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)
31.	LV neutral side	[As per project]			[As per project]

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	current transformer for standby earth fault protection	requirement]	requirement]
32.	Guaranteed no load loss (kW)	[By Bidder]	[By Bidder]
33.	Guaranteed load loss (kW)	[By Bidder]	[By Bidder]
34.	Efficiency		
a	At full load	[By Bidder]	[By Bidder]
b	At 75% load	[By Bidder]	[By Bidder]
c	At 50% load	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E4

**TECHNICAL SPECIFICATION FOR 415V SWITCHGEAR,
MCC & DBs**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
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ANNEXURES-E4

1.0 415V SWITCHGEAR, MCC AND DB

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Switchgear MCC and DBs, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2551	Danger notice plates
IS :2705	Current transformers-specification
IS :3156	Voltage transformer specification
IS :3231	Specification for electrical relays for power system protection
IS: 8084	Specification for interconnection busbars for AC voltages above 1kV up to and including 36kV.
IS :8623	Specification for low-voltage switchgear and control gear assemblies
IS :8686	Specification for static protective relays
IS :10118	Code-of practice for selection installation and maintenance of switchgear and control gear
IS :12021	Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 v ac
IS : 13947 (Part 1)	Specification for low-voltage switchgear and control gear
IS : 13947 (Part 2)	Specification for low-voltage switchgear and control gear –part 2: circuit breakers
IS : 13947 (Part 4)	Specification for low-voltage switchgear and control gear -part 4 : contactors and motor feeders

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Codes	Name of Standard
IS : 13947 (Part 5)	Low-voltage switchgear and control gear specification Part 5 : control circuit devices and switching elements
IEC 61439	Low voltage switchgear and control gear assemblies.
CEA	CEA regulations for installation and operation of meters 2006.
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All 415V Switchgear, MCC and DB shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- All 415V Switchgear, MCC and DB shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-) 5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC system	:	-15% to +10%

- 415 V switchgear & MCCs shall be of indoor /outdoor, double front/single front [Preferably single front] and fully draw out type. ACB feeder may be of single tier/two tier configuration depending upon rating. DBs (ACDB / DCDB) shall be of single / double front [Preferably single front] and fixed type. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration shall be provided.
- All AC motor starters shall be suitable for Direct on Line (DOL) starting. Motors rated below [132]kW shall be provided with combination starters consists of MCCB/MPCB, contactors and electronic over load relay and

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the motor starter shall comply with Type – 2 coordination conforming to relevant code and standards. Motors rated [132] kW and above shall be breaker controlled and shall be provided with comprehensive motor protection relay. Motors rated above [160]kW shall be fed from MV Switchgear [Only for firefighting system Motor rated up to 200kW shall be fed from 415V switch board].

- e) For 415 V switchgear & MCCs Feeders rated [630A] and above shall be equipped with Air Circuit Breaker (ACB). Outgoing/Incoming feeders rating below [630] A shall be MCCBs.
- f) For DBs Incomer rated 630A and above shall be ACB. Incomer below 630A shall be MCCB. Outgoing feeder may be MCCB/MCB depending upon the bus fault level.
- g) All ACB shall be draw out type & should have Service, test and disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- h) Local/remote selection shall be provided for all incoming/Outgoing ACB module. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local(Switchgear).
- i) Two out of three breaker logic shall be considered for switchgear/MCC. However mechanical interlock shall be considered for income of MCCB operated DBs.
- j) Also, Local/remote selection switch shall be provided for all motor modules for control from Remote(DCS). Also for breaker operated motor, breaker shall be closed in Test position from local(Switchgear).
- k) All motors shall be provided with Emergency stop push button.
- l) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary MCCB/MCB shall be provided for each MCC, 2 x 100% per section. However breaker shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from bus bars. This control supplies shall be monitored.
- m) All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 415V switchgear, MCC and DBs shall have following minimum features.

- a) All 415V switchgear, MCC and DBs shall be metal enclosed, indoor, floor mounted and free standing type. The panels shall be suitable for cable entry at bottom and busduct connection at top.

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- b) Between 415V Switchgear and dry type transformers, non segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with busduct manufacturer in this regards is covered in this specification.
- c) All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d) Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels
- e) Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f) The switchgear enclosure shall confirm to the degree of protection IP-54 (for outdoor). For indoor, enclosure shall confirm to IP52, however for Busbar chamber of switchboards rated above 1600A, degree of protection shall be IP-42.
- g) Paint shade for complete panels excluding end covers shall be [RAL 9002] and [RAL 5012] for extreme end covers for all board.
- h) The switchgear assembly shall comprise a continuous, line-up of single / multi tier cubicles. The installations of circuit breakers however shall be limited to the bottom two tiers only. Working height shall be limited to [250 mm to 1800 mm] from the floor level.
- i) Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc
- j) A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgears having more than one bus section.
- k) Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable

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terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.

- l) For MCC/DB a full height vertical cable chamber with cable supports shall be provided in each section to facilitate unit wiring.
- m) 2x100%, 415V/110V AC control transformer shall be provided for control, Indication and annunciation supply for contactor operated motor feeder. All the necessary auxiliary and main contactor shall be provided suitable for this control supply.
- n) Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module.
- o) Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- p) Supplier shall provide total 20% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- q) Motors of rating 30 kW and above shall be provided with anti-condensation heaters. Necessary provision for supply of motor space heating shall be considered in the switchgear.
- r) The incoming connection to transformer of more than 1000kVA and inter-connecting sections between switchboards shall preferably be of bus ducts.
- s) It should be possible to carryout maintenance on a feeder with adjacent feeders alive.

1.4.2

Bus and Bus taps

- a) The main buses and connections shall be of high [conductivity Aluminum / Copper] alloy sized for specified current ratings with temperature rise limited [to 40°C over ambient temperature of 50°C].
- b) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminum contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance. Adequate contact pressure shall be ensured by means of two bolts connection with plain & spring washers and locknuts. Temperature rise shall not exceed 105 degree for silver plated joints over an ambient temperature of 50 degree.
- c) Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- d) Bus insulators shall be flame-retardant, track resistant type with high creepage surface. All buses and connections shall be supported and braced to withstand the stresses due to maximum short-circuit current and also to take care of thermal expansion.

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- e) Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f) Power shall be distributed to each module or compartment by a set of vertical bus bars. The vertical bus bars shall run behind the modules. Necessary tee off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.
- g) The clearance between the individual bare phase power bus bars and between the phase and earth bus bars in air shall be not less than [25.4] mm.
- h) Three phase, neutral (with at least [50] % rating of main Bus bar and continuous earth bus shall be provided. Bus bar and tapping shall be provided with color coded PVC sleeves.

1.4.3

Air Circuit Breaker

- a) All Circuit Breakers for incoming feeders and Bus couplers shall be [four] poles; single throw, motor operated and air break type. Circuit breaker for outgoing feeders shall be triple pole, single throw and air break type. However for supply feeders it shall be [four] pole.
- b) Circuit Breakers shall be [draw out type] having Service, Test & Disconnected positions with positive indication for each position.
- c) Circuit breakers of identical rating shall be physically and electrically interchangeable.
- d) Bolted disconnected links shall be provided for all outgoing feeders for isolation of neutral, if necessary.
- e) For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open – close – open operation of the circuit breaker shall be possible after failure of power supply to the motor when the spring is charged after a closing operation.
- f) Mechanical safety interlock shall be provided to prevent the circuit breaker from being racked in or out of the service position when the breaker is closed.
- g) Automatic safety shutters shall be provided to fully cover the female primary disconnects when the breaker is withdrawn.
- h) Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indicator, an operational counter and mechanism to indicate spring charge / discharge condition.
- i) In addition to the auxiliary contacts required for normal breaker operation and indication, each breaker shall be provided with followings for interlocking purpose:-
 - i. Position / cell switch with 4 No + 4 NC contacts.

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- ii. Limit / auxiliary switches shall be convertible type that is facility for changing N.O. contact to N.C. and vice-versa.
- iii. Mechanical stopper to prevent accidental falling while withdrawing.
- j) Breaker cannot be racked in from 'isolated' to 'test' position with the door open together with provision for defeat of this interlocking, however, the door can be closed only when the breaker is brought back to 'isolated' position. Insertion of breaker into 'Service' position not possible if the shutters are not free.
- k) Door can be opened only when breaker is OFF and is in 'Isolated' position. Remote closing of breaker not permitted with door open.
- l) Anti pumping relay / device to ensure that there can be only one closing operation for each closing command.
- m) Suitable trolley arrangement shall be provided for breaker/starter modules. Two trolleys per switchgear room shall be provided so that top most breaker module of all types, sizes and rating can be withdrawn on trolley and lowered for maintenance purpose.
- n) Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage.

1.4.4 Contactors, MCCB and MPCB

- a) Incomers for MCCs and DBs rated below 630A shall be MCCB.
- b) Incomer and bus coupler rated below 630A shall be mechanically Interlocked.
- c) Motor starter contactors shall be of air break, electromagnetic type. Suitable for DOL starting of motor, and shall be of utilization category AC-3 for ordinary and AC-4 for reversing starters. DC contactor shall be of DC-3 utilization category.
- d) The contactors shall be three pole, air break type designed for [duty class III category A.C. –3 with non-bouncing silver / silver alloy.]
- e) Each contactor shall be provided with two (2) normally open and two (2) normally closed auxiliary contacts unless otherwise specifically stated. Rating shall be decided by the bidder.
- f) Reversing contacts shall be electrically and mechanically interlocked.
- g) Contactors with delayed dropout feature shall be provided for some essential auxiliaries. These contactors shall not dropout on power failure if the voltage is restored within 3 seconds.

1.4.5 Electronic over load relays

- a) Electronic overload relays shall conform to IEC:292-1 and shall be triple pole, ambient temperature compensated with adjustable setting, inverse time lag, built in single phase preventer and hand/auto reset type

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provided as per requirement along with necessary command, feedback cable, coupling relays etc.

- b) Provided with 1 NO and 1NC contact of rating same as the auxiliary contact of the contactors.
- c) The relay shall be able to withstand prospective short circuit current without damage or injurious heating till the motor protection MCCB/MPCB clears the fault.
- d) Relays may be direct acting or CT operated, depending on current rating. CTs shall be included in the scope of supply.

1.4.6 Bus Transfer scheme:

Each switchgear of two incomer and bus coupler shall be provided with the following provisions.

- i) Dead bus closing.
- ii) Manual live change over (Momentary paralleling)
- iii) Automatic bus transfer scheme.

1.4.7 Current Transformer

- a) Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made.
- b) CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c) CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d) All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e) CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Voltage Transformer

- a) Voltage transformers(VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b) VTs shall be of the single-phase type. VTs shall be protected on their primary side by MCCBs with interrupting ratings corresponding to breaker rating and by MCB (with auxiliary contacts) on the secondary sides.

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- c) VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d) It shall be possible to replace VTs without having to de-energise the main busbars.
- e) VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.9 Transducer

For all the incoming and the outgoing of 415V Switchgear / MCC/ DB Feeders requiring remote metering and/or current monitoring shall be provided with multi-functional transducers. The output shall be 4-20 mA DC which shall correspond to the normal range.

1.4.10 Secondary Wiring

- a) The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b) Fuse /MCB and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c) Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d) Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with [stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring.]
- e) Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.11 Terminal Blocks

- a) Terminal blocks shall be 660V grade box-clamp type with marking strips, similar to 10 mm² or equal. Terminals for C.T. secondary leads shall have provision for shorting.
- b) Not more than two wires shall be connected to any terminal. If more than two wires at one terminal are required, separate terminals with function wise shorting links shall be provided. [Spare terminal equal in number to 20% of active terminals shall be furnished.]
- c) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged so that individual wires of an external cable can be connected to consecutive terminals.

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1.4.12 Ground bus

- a) A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b) Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c) C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.13 Space Heater

- a) Each vertical section shall be provided with thermostat controlled space heater 5A, 3 pin socket plug.
- b) In addition, motor feeders rated [30 KW and above] shall be wired up for feeding the motor space heater through suitably rated breaker auxiliary NC contact and/or contactor.
- c) Cubicle heater, Motor heater, and Plug socket circuit shall have individual switch fuse units/MCB.

1.4.14 AC Distribution Boards (ACDBs)

- a) AC Distribution Boards shall have MCCB/MCB at incomer depending upon the short circuit rating. Distribution Boards may be fed from switchgear and shall have two incomers. AC distribution Boards shall be of two types - one with 415V, 4-wire, triple pole and neutral (TPN) outgoing feeders and the other with 240V, 2-wire, single pole and neutral (SPN) outgoing feeders.
- b) For small loads, MCB boards with TPN MCB as incomer and TPN/SP MCBs for outgoing may be considered. The feeder rating and quantity shall be as per requirement.
- c) Board shall be single/double front [preferably single front], metal clad, front matched, dust and vermin proof, fixed type, compartmentalized and extensible on both sides.
- d) Bus bars shall have same cross section throughout the length. Rating of the neutral bus bar shall be 50% of the main bus bar. Earth bus bar shall run in bottom chamber throughout the length of the Board.

1.4.15 DC Distribution Boards

DCDBs shall have two incomers and a bus coupler. Incomers and outgoing feeders of DCDBs shall be MCB/MCCB modules. They shall be fixed type and floor mounted. Other constructional features shall be similar to ACDB.

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The feeder rating and quantity shall be as per requirement.

1.4.16 Control & Indication

The circuit breaker shall be wired up for local & remote operation. Each breaker cubicle shall be equipped with following:

- a) Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In switchgear position, the breaker shall be operated from switchgear only in test position with only protection (no interlock).
- b) Two (2) heavy duty, oil-tight, push buttons for Trip & Close.
- c) Circuit breaker shall be indicated electrically. The following indication colour shall be used.

Breaker open - GREEN

Breaker closed - RED

Spring Charged - WHITE

Breaker Auto Trip- AMBER

- d) However, any other indication shall be provided as per owner's requirement.
- e) Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.
- f) For all MCCB feeders, trip indication lamp shall be provided on front of the compartment.
- g) For all starters, ON, OFF and trip indication lamps shall be provided on front of the compartment.

1.4.17 Relays, Protection & Metering

- a) The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- b) All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner.
- c) All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.

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- d) All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- e) Energy meters shall be provided for incomer of 415V Switchgear and MCC and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than 1.0S.
- f) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- g) All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- h) The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- i) All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- j) Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- k) D.C supply shall be supervised by DC supervision relays.
- l) Trip circuit shall be supervised by Trip circuit supervision.
- m) Tripping shall be done through high speed lock out relays.
- n) All meters/ instrument shall be flush mounted on front panel, at least 96mm² size with 90° linear scales and accuracy class of 2.0.
- o) Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- p) For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- q) Metering and protection shall be as per below table

a)	Incomers	
	Protections	Metering
i	Time graded short circuit protection	Local Current (single phase) indication and remote indication through transducer.

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ii	Over current protection	Voltage Measurement for all three phases and remote indication through transducer.
iii	Earth fault protection	KW, Kwhr
b)	Bus coupler	
	Protections	Metering
i	Over current protection(51)	Local Current (single phase) indication.
ii	IDMT Earth fault protection(51N)	
c)	Contactor controlled motor feeders [90kW and above motor only]	
	Protections	Metering
i	Time graded short circuit protection	Local Current indication and remote indication through transducer.
ii	Over current protection	
c)	[Motor Feeders [of 132KW and above only]]	
	Protections	Metering
	Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload etc.	Local Current indication and remote indication through transducer.
[Other feeders]		
a)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection	[Voltage – phase to phase,]
	Fuse failure protection	
b)	Motor feeders (MPCB/MCCB with Contractors)	
	Protections	Metering
	Electronic Overload relay (with single phase preventor), short circuit protection (through fuse/MCCB/MPCB as specified)	
c)	Incoming feeders for ACDB/DCDB	
	Protections	Metering

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	Short circuit protection (if MCCB)	[Voltage (single phase and, Phase Current (1 Phase))] Local indication only.
d)	Outgoing feeders of ACDB/DCDB	
	Protections	Metering
	Short circuit protection (through fuse/MCCB)	

1.5

Tests

I) Type Test

For each type & rating of 415V Switchgear, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted are as follows:

- Measurement of insulation resistance of Circuit Breaker in closed and open positions.
- Measurement of milli-volt drop across Circuit Breaker main contacts and other joints.
- Measurement of Circuit Breaker/Contactor operating time for close & open at nominal voltage and 80% of rated voltage.
- Measurement of resistance, IR value and drop-off/pick-up voltage of close and trip coils.
- Healthiness of limit switch contacts.
- Spring charging motor functional checks.
- Verification of phase sequence and checking of clearances of busbars between phase to phase and phase to earth.
- Measurement of milli-volt drop across busbar joints

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- i) Torque tightness test.
- j) High voltage test on busbar.
- k) Measurement of CT/PT polarity, ratio and knee point voltage.
- l) Electrical and mechanical interlock checks.
- m) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- n) Secondary injection of all metering circuits.
- o) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below

- a) [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening.
- b) Bill of Materials.
- c) Technical Data sheet and Catalogue.
- d) Foundation drawing details with bottom view of switchgear.
- e) Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f) Control Schematics & Wiring diagram.
- g) Inspection and Test Plan (ITP).
- h) Suggestive list of protective relays.
- i) Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

415V switchgears, MCC and DB shall comply with the particulars indicated in the following tables.

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Table- 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		415 Volts, 3 Phase, 4 wire 50 Hz.
2.2	System neutral earthing		Solidly earthed
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		a) 2.5kV b) 1.5kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		90°C for busbars having non-silver plated joints 105°C for busbars having silver plated joints
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	50
b	Dynamic Rating	kA (peak)	105
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		Cu/Al
2.14	Fully draw out (FD)/ Fixed (F)		FD for Switchgear/MCC; F for DBs.
2.15	Entry –Top (T)/Bottom (B)		Top for busduct, bottom for cables
2.16	Degree of protection		IP 52
2.17	Colour finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	GS
2.19	Minimum clearances in air of live parts	mm	As per standard
3.0	Starters		
3.1	Type	DOL	DOL
3.2	Contactor rated duty		AC3 for DOL
3.3	Single phasing preventer required.	Yes / no	Yes
3.4	Thermal overload relay reset	Manual / Auto	Settable for either to Manual or Auto
4.0	Circuit breakers		
4.1	Maker's name		[By bidder]
4.2	Voltage, frequency & no.of phases , poles		415 V, 50 Hz, 3 Ph, 4 Pole
4.3	Rated operating duty		O-3min-CO- 3min -CO
4.4	Circuit breakers type		ACB
4.5	Short circuit withstand current for 1 sec. Duration	kA	50
4.6	Rated making current	kAp	105
4.7	Rated current at site reference ambient temp	A °C	[By bidder]

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S. No.	DESCRIPTION	UNIT	DATA
4.8	Type of operating mechanism		Spring charged motor and manual
4.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
4.10	Control voltage		
a	Spring charging motor	V AC/DC	[220V DC/240V AC]
b	For closing/tripping	V AC/DC	220V DC
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	As per IS
b	Closing at normal voltage	%	As per IS
c	Trip coil	%	As per IS
4.12	Power required for closing at normal voltage	W	[By bidder]
4.13	Power required for tripping at normal voltage	W	[By bidder]
4.14	Spring charging motor details:		
a	Rating	kW	[By bidder]
b	Rated voltage	V, AC/DC	[By bidder]
c	Spring charging	Sec.	[By bidder]
	Electrical and mechanical anti-pumping features been provided	Yes/No	Required
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		415 V, 50 Hz & 3 P for outgoing, 4P for incoming and supply feeders
5.2	Rated operating duty		As per IS
5.3	Rated breaking capacity	kA (rms)	50

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S. No.	DESCRIPTION	UNIT	DATA
5.4	Rated making current	kA (Peak)	105
5.5	On/off operation		
5.6	Manual	Yes/No	Yes
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	Yes
5.8	Auxiliary contacts required	Yes/No	[As per project specific]
6.0	Contactors		
6.1	Make		[By Bidder]
6.2	Rated duty	AC3/A C4	AC3 for DOL AC4 for RDOL
6.3	No of poles		3
6.4	Utilization category		[By Bidder]
6.5	Rated voltage of auxiliary contacts	V	[By Bidder]
6.6	Rated voltage of coil	V	[By Bidder]
6.7	Rated breaking capacity	Factor of rated current	[By Bidder]
6.8	Rated making capacity	Factor of rated current	[By Bidder]
6.9	Limits of operation		As per IS/IEC
a	Supply voltage variation		[By Bidder]
b	Supply frequency variation for closing		[By Bidder]
c	Drop out voltage		[By Bidder]
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		

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S. No.	DESCRIPTION	UNIT	DATA
7.1	Voltage Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
7.2	CT Ratio		Primary current/1A or 5A
7.3	Measuring CTs		CI - 1.0 instrument safety factor 5.0
7.4	Protection CTs		CI 5P20
7.5	Measuring VTs		(min)/phase CI1.0
7.6	Protection VTs		CI 3P
8.0	Control transformers		
8.1	Make		[By Bidder]
8.2	Type		Dry Type
8.3	Applicable standards		As specified in the specification
8.4	Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
8.5	Class of insulation		Class-B or Better
8.6	Rated output	VA	[As per project specific]
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		[By Bidder]
10.2	Make		[By Bidder]
10.3	Type designation		[By Bidder]
10.4	Setting range		[By Bidder]
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		[By Bidder]
11.2	Make		[By Bidder]
11.3	Type		[By Bidder]
11.4	Current setting range		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	[By Bidder]
12.0	Under voltage relay		
12.1	Make		[By Bidder]
12.2	Type		[By Bidder]
12.3	Voltage rating	V	[By Bidder]
12.4	Setting range	V	[By Bidder]
13.0	Auxiliary relays and timers		
13.1	Make		[By Bidder]
13.2	Type		[By Bidder]
13.3	Coil voltage	V	[By Bidder]
14.0	Control/selector switch		
14.1	Make		[By Bidder]
14.2	Type designation		[By Bidder]
15.0	Meters		
15.1	Applicable Standards		As specified in the specification.
15.3	Accuracy Class		Class 1.0 or Better
15.4	Make		[By Bidder]
15.5	Type		Multi function with RS 485 connectivity
16.0	Voltmeter		
16.1	Make		*[By Bidder]
16.2	Type		Moving coil
16.3	Applicable standards		As specified in the specification.
16.4	Accuracy class		Class 1.0
17.0	Ammeter		

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S. No.	DESCRIPTION	UNIT	DATA
17.1	Make		As specified in the specification.
17.2	Type		Moving coil
17.3	Applicable standards		As specified in the specification.
17.4	Accuracy class		Class 1.0
18.0	Indicating lamps		
18.1	Make		As specified in the specification.
18.2	Type		Clustered Led
18.3	Voltage	V	As specified in the specification.
18.4	Wattage of lamp	W	As specified in the specification.
19.0	Push buttons		
19.1	Make		As specified in the specification.
19.2	Type designation		As specified in the specification.
19.3	Contact rating	A	As specified in the specification.
20.0	Space heater		
20.1	Make		As specified in the specification.
20.2	Type		As specified in the specification.
20.3	Rated voltage	V	As specified in the specification.
21.0	Wiring and terminal blocks		
21.1	Voltage grade		1.1 kV
21.2	Insulation		[By Bidder]
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	2.5 for CT & PT 1.5 for Others
b	Control wiring	Sq.mm	1.5 for Others

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S. No.	DESCRIPTION	UNIT	DATA
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		Sliding type
	II) For Fixed Type		Stud & nut type
21.5	Minimum current rating of terminal blocks	A	10

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E5
TECHNICAL SPECIFICATION FOR 415V NON
SEGREGATED PHASE BUS DUCTS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E5

1.0 415V NON SEGREGATED PHASE BUS DUCT

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Non Segregated Phase Busduct, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS 8084	Interconnecting Bus bar for AC Voltage above 1KV up to and Including 36kV
IEC 60947	Low Voltage Switchgear and Control gear
ANSI/IEEE C37.20	Metal-Clad and Station-Type Cubicle Switchgear
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear
IEC 60439	Low-voltage switchgear and control gear assemblies.
BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) The 415V Non-segregated phase bus duct shall serve as an interconnection between the 415V Switchgear and 11/0.433kV LV Transformer. The Non-segregated phase bus duct shall be installed

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indoor/Outdoor in a hot, humid and tropical atmosphere. All panels associated with Non-segregated phase bus duct shall be located indoors/Outdoors.

- b) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- c) For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be as specified in Clause 1.7 Rating and requirements.
- d) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the required short-circuit currents.
- e) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- f) The bus ducts shall be self cooled and shall not be equipped with blower or any other type of forced ventilation.
- g) The equipment rating shall be based on an ambient temperature. Same phase disposition shall be maintained throughout the run of the bus duct. Phase crossover units, if required, shall also be provided inside the Busduct itself.
- h) Bus ducts shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current.

1.4 Specific Requirements

1.4.1 General

- a) 415V Non Segregated Phase Busduct is provided for connection between low voltage side of 11/0.433kV cast resin dry type /oil type transformers and associated 415V Switchgears shall be of TPN (3 phase and neutral) along with necessary bends, flexible at both transformer & switchgear ends, flanges, phase crossover chambers (if required), support structures & accessories including terminations at the equipment ends.
- b) The 415V bus duct shall be metal enclosed, non-phase segregated enclosure type, self cooled and insulated for 1.1kV voltage. The cooling medium inside the duct shall be air.

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- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) The 415V non-segregated phase bus duct will be installed indoor or partially indoor & outdoor depending upon the location of equipment being interconnected in a hot, humid and tropical atmosphere. All panels associated with LV non-segregated phase bus duct will be located indoors.
- e) The continuous current rating and momentary peak withstand current rating of the Busduct between transformers & their associated switchgears shall be same as that of the associated switchgears and as indicated in the specification.
- f) All supporting steel structures shall be hot dip galvanized.
- g) The bus ducts shall be provided with space heaters to control moisture. Slicagel breather if required same shall be provided.

1.4.2 Enclosures

- a) The enclosure shall be rectangular and shall be made of [aluminium alloy/Mild steel] of grade [19000H2] as per IS-5082. The entire bus duct shall be designed with dust, weather and vermin-proof construction. The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- b) *[Phases shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminum alloy) of 3mm for bus rating including and above 3000A whereas enclosures for normal bus current rating (<3000 A) shall be sheet steel fabricated type of 2.5mm thick].*
- c) Enclosures shall be provided with flange ends with drilled dimensions to suit the flanges at the switchgear and transformer ends.
- d) Circumferential neoprene rubber gaskets shall be provided for dust tight joints with adjacent enclosure section.
- h) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion / contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.

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- i) All outdoor bus-enclosures shall be so designed & constructed as to prevent accumulation of rain water on top sheet. Similarly all Gasketed flanged joints shall be suitably protected against direct splashing of rain water in case of outdoor runs. The connection flanges shall be sufficiently stiffened so as not to bend while tightening the bolts.
- j) Outdoor portions of the bus duct, if any, shall have continuous rain hood of non magnetic material or with suitable arrangement for rainwater prevention.
- k) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, switch gear terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets.
- l) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between indoor and outdoor portions of the bus duct.
- m) In case, the bus duct penetrates the firewall, the wall frame assembly and the seal shall be designed for the same fire rating as the firewall.
- n) Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct. Space Heaters shall be provided in the bus duct.
- o) Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- p) Shipping length of the Busduct shall be not more than three (3) meters in length.
- q) Minimum Degree of protection of Busduct enclosure shall be IP-52 for indoor and IPW-55 for outdoor section of the Busduct.

1.4.3

Bus Conductor

- a) The bus conductor shall be of high conductivity, [Aluminium alloy / Aluminium].
- b) The bus conductors shall be given a coat of matt black paint to facilitate heat dissipation. However the sizing of the bus conductor shall consider the conductor as bare.
- c) The bus conductor shall be designed for bolted connections throughout the run.
- d) Flexible connection shall ensure an efficient and trouble-free connection.

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- e) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminium contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- f) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.
- g) The bus bar shall be sleeved with FRLS heat shrinkable, colour coded PVC sleeves at intermittent points for phase identification.
- h) The material of the conductor shall be aluminium alloy of grade [63401WP] as per IS: 5082. The temperature rise of conductor shall be 40 degree over design ambient temperature of 50 degree. Also, the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.

1.4.4 Disconnect Link

- a) Removable bolted disconnected link shall be provided in the bus for the purpose of isolation.
- b) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- c) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- d) A minimum clearance of [300 mm. (12")] shall be provided between the disconnected bus sections with the link removed.

1.4.5 Insulators

- a) The bus conductor supporting insulators shall be flame retardant, non-hygroscopic, high impact and high dielectric strength material with an anti tracking contour.
- b) Material of insulator shall be [Epoxy SMC moulded /FRP].
- c) Spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the short circuit current assigned to the bus duct.
- d) Bus support insulators shall be interchangeable, high creepage, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.

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- e) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- f) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator.
- g) Space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus duct.

1.4.6 Connections & Terminations

- a) All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the switchgear, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the switchgear and auxiliary transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.

1.4.7 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- c) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- d) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.
- e) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.

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- f) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

1.4.8 Ground bus

- a) The ground bus of two numbers of separately run [50x10 mm] minimum GS flat shall be provided along the run of the bus duct. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.
- b) Ground bus shall be finally to connected to power plant earth grid at one end.

1.4.9 Wiring

All wiring for space heaters shall be done with insulated stranded copper conductor of not less than [2.5 mm² cross-section]. Each wire shall be identified at both ends with wire designation as per bidder's wiring diagram and shall be brought out to a terminal box outside the bus duct.

Terminal blocks shall be box-clamp type minimum 10 mm² with marking strips.

At [least 20% spare terminals] shall be furnished in the terminal block.

1.4.10 Name Plate

Suitable name plate shall be furnished with each piece of equipment.

[Materials for name plate shall be plastic / lamicoid, 3 mm thick, using white letters on black background.]

1.4.11 Space Heater

Thermostatically controlled Space heaters shall be provided in the bus ducts, wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation. At least one number space heater with thermostat shall be provided at each transformer and switchgear end.

The space heaters shall be suitable for continuous operation on single phase supply, and shall be automatically controlled by thermostats. Necessary wiring up to junction boxes mounted on bus duct and from junction boxes to switchboards shall be provided.

1.4.12 Painting and Finish

- a) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as

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possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint

- b) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- c) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- d) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].
- e) The interior surface finish shall be as per manufacturer's standard.
- f) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- g) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.
- h) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- i) The paint shade shall be subject to owner's approval.

1.5

Tests

l) Type Test

For each type & rating of 415V Non segregated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test

1.6 Drawings and Documents

Drawings, data & manuals for the 415V Non segregated phase bus duct shall be submitted as indicated below:

- a) [Dimensional GA drawing
- b) Data sheets
- c) Typical calculation for arriving at the size of conductor and the insulator spacing.
- d) Type test report (short circuit, temperature rise test) for similar bus duct manufactured by the proposed manufacturer.
- e) Foundation layout and requirements
- f) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

1.7 Ratings and Requirements

Major technical parameters of 415V non segregated Bus Duct are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table: 2.0

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.	Type of bus duct		Non segregated phase bus duct	
2.	Rated voltage and No. of phase	V	415V, Triple Pole , Neutral(3Phase & 4 Wire)	
3.	Applicable standard		IS 8084	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
4.	System Frequency	Hz	50	
5.	Design ambient temperature	Degree	50	
6.	Rated Current	A	[As per project Requirement]	
7.	Designation (from & to)		[As per project Requirement]	
8.	Type of cooling (NSPBD)		Natural air	
9.	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
10.	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
11.	One minute power frequency voltage withstand	KV (RMS)	2.5	
12.	Continuous current rating at 50°C design ambient air temperature	A	[As per project Requirement]	
13.	Material a) Bus bar b) Enclosure		a) [Aluminum] b) [Aluminum alloy/MS]	
14.	One second short circuit withstand rating	KA (RMS)	50	
15.	Momentary short circuit withstand current	KA (Peak)	105	
16.	Bus bar Support		[FRP/ SMC]	
17.	Degree of protection		IP 52 for indoor IP W55 for outdoor	
18.	Earthing Conductor Material		GS	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
19.	Heating		Thermostat controlled space heater	
20.	Fittings of silica gel breather and drain plug		Required	
21.	Finish of Bus Enclosure		a) Inside: Matt Black b) Outside [RAL 5012]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E7
TECHNICAL SPECIFICATION FOR HV CABLES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E7

1.0 HV CABLEs

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of HV cables complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part II)	:	XLPE insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques
IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the

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		cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All HV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The HV power cables shall be 6600V unearthed grade, single/multi core stranded Aluminum conductor, extruded XLPE insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-2). These cables shall conform to IS 7098 (Part II).
- d) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- e) HV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- f) HV cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)
 - v. Installation conditions.
 - vi. Voltage drop under normal running and starting condition
 - vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
 - viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
 - ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.

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1.4 Specific Requirements

1.4.1 Type of Cable

- a) HV cables shall be 6600V unearthed grade, heavy duty, stranded aluminium conductor, XLPE insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-2) cables conforming to IS: 7098 part II.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum to form compact conductor having a resistance within the limits specified.

1.4.3 Conductor Shield

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be provided over the conductor by applying non metallic semi conducting tape or by extrusion of semi conducting tape or by extrusion of semi-conducting compound or a combination of the two. The semi conducting polymer shall be cross linked for XLPE cables.

1.4.4 Insulation

The insulation of the HV cables shall be XLPE type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

1.4.5 Insulation Shield

A non magnetic semi conducting shield shall be put over the insulation to confine electrical field to the insulation. The XLPE cable insulation shield shall be strippable.

The metallic layer of the insulation shield shall be grounded at least at one location in the cable's run. In the case of single conductor cable, care should be taken with regard to ampacity when grounding at more than one point.

For all the cables having insulation shield, it shall have some form of stress relief measure at every splice at termination. This can be stress cones, moulded devices, heat shrink or cold shrink kits. All kits must be suitable for the voltage class and cable size.

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1.4.6 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.7 Armour

HV cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.8 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.9 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than 500m or as per required length.

1.4.10 Identification of cores:

HV power cables shall be identified by color code.

1.4.11 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers

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shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.

b) Workmanship shall be neat, clean and of the highest grade.

c) Special Properties:

All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:

- i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
- ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
- iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
- iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
- v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
- vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
- vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.12 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.13 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]
- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.

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- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.4.14 Fire Proof sealing system

- i) General
 - a) Fire proof sealing system shall consist of Fire-stops/fire-seals for sealing of cable/cable tray and conduit/pipe penetrations, both horizontal and vertical, through brick or RCC walls/floors, to prevent the spread of fire from one area, which is separated from others by fire-resistant barriers.
 - b) 'Fire-breaks' provided on long runs of cable racks/trays to prevent the propagation of fire along the cable rack, within a single fire-area or fire- zone.
 - c) The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop/fire-break.
 - d) The FPS system shall comply in all respects with the requirements of the codes and standards listed below

IEEE-634 ASTM-E-814

ANSI-IEEE-383 IEC-331 IEC-332

ii) Fire stop/ seal

The FPS system adopted for cables or cable trays penetrating through walls and floor constitute a openings, or cables passing through embedded conduits / pipes / pipe- sleeves, fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

iii) Fire Break

The fire proofing system, other than fire-stops, adopted to retard flame propagation long runs of horizontal or vertical cable trays in the same fire zone or area, in an event of a fire, shall constitute a 'fire-break' and shall be provided by applying a suitable fire –resistance coating on cables and cable trays for the required length, with or without a fire resistant panel, at the point of the fire break to obtain the fire-rating specified.

iv) Application of fire proof sealing system

Fire stops shall be provided for cable penetration openings listed below

The passage of cables/cable trays pipe sleeves/embedded conduits through walls / floors.

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Vertical raceways, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

Cable entry through openings in floor slabs below HT/LT switchgear, MCCs, various Control and relay panels and other bottom entry panels, shall be effectively sealed by fire stop

Location of fire breaks

Firebreaks shall be provided on both cable rack and trenches at all cable tray Intersections and tee-offs.

On linear runs of cable trays between fire stops or fire breaks, fire breaks shall be provided at intervals of 15 metres on horizontal cable runs and 5 m on vertical cable runs.

Fire breaks in linear runs of cable trenches between intersections and tee-offs shall be provided at intervals of 30 metres.

Bidder shall furnish the test certificates for the fire stops and fire breaks after award of contract for Owner/Owner's Representative review. If the certificates are not satisfactory all the tests shall be conducted free of cost. The offered system i.e. fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Owner / Owner's Representative.

v) Test on fire stops

The fire stops shall be subjected to the following type tests:

- a. Fire Rating Test
- b. Hose Stream Test

Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

Preconditioning of fire stop test specimens before conducting the fire rating and hose stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the fire rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable

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penetration fire stop, with a maximum temperature limit on the unexposed surface of 200°C.

Tests on fire breaks

Firebreaks shall undergo the following tests as per ANSI-IEEE-383:

- Ampacity test
- Flame test

1.5 Tests

1.5.1 Type Test

For each type & rating of HV cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 H.V. Power cable, 6600V unearthed grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		6.6 V	
2.	Voltage Grade		6.6/6.6kV Unearthed	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE cables		90°C	
5.	Maximum conductor temperature for		250°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE cables			
6.	Conductor		Aluminum	
7.	Insulation		XLPE	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		Armoured	
11.	System Grounding		Resistance Grounded	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		40 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E8
TECHNICAL SPECIFICATION FOR LV CABLES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E8

1.0 LV CABLES

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV cables for power & control applications complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS:1554(Part I)	:	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100V
IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part I)	:	XLPE insulated PVC sheathed cables for working voltage up to 1.1kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques

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IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All LV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The LV power cables shall be 1100V grade, single/multi core stranded Aluminum conductor, extruded XLPE/PVC insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1). These cables shall conform to IS 7098 (Part I) for XLPE and 1554(part 1) for PVC insulation.
- d) The control cables shall be 1100 V grade, multi core, stranded annealed high conductivity copper with extruded PVC insulated inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1).
- e) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- f) The continuous and short time current carrying capacity of PVC insulated cables shall be based on maximum operating temperature of 70°C and 160°C respectively.
- g) LV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- h) Power cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)

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- v. Installation conditions.
- vi. Voltage drop under normal running and starting condition
- vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
- viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
- ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.
- x. The minimum size of cables to be used shall be as follow :
 - Aluminium conductor : 6 Sq. mm.
 - Copper conductor : 2.5 Sq. mm

1.4 Specific Requirements

1.4.1 Type of Cable

- a) LV power cables shall be 1100V grade, heavy duty, stranded aluminium conductor, XLPE/ PVC insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS: 1554(Part 1) for PVC insulation and IS 7098(Part 1) for XLPE insulation.
- b) Control Cables shall be 1100 V grade, heavy duty with annealed high conductivity stranded copper conductor, PVC insulated, FRLS PVC inner sheathed, armoured and FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS : 1554.
- c) LV power cables of size above 35 sq. mm may be provided with XLPE insulation. Bidder shall clearly indicate the type of insulation provided in the technical bid.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum for LV Power cables and Copper for control cables to form compact conductor having a resistance within the limits specified. All the cables of size 25mm² and above shall have sector shaped conductors.

1.4.3 Insulation

The insulation of the LV power and control cables shall be [XLPE/PVC] type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

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1.4.4 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.5 Armour

LV power and control cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.6 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.7 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than the following:

- a) Power cables: 500m
- b) Control cables: 1000m

1.4.8 Identification of cores and spares:

LV power cables shall be identified by color code. However LV control cables shall be identified by the number of its cores.

[Multi-core control cables shall have 20% spare core, minimum one spare.]

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1.4.9 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.
- b) Workmanship shall be neat, clean and of the highest grade.
- c) Special Properties:
All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:
 - i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
 - ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
 - iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
 - iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
 - v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
 - vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
 - vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.10 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.11 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]

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- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.
- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.5 Tests

1.5.1 Type Test

For each type & rating of LV power and control cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 L.V. Power and control cables, 1100 V grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		415 V	
2.	Voltage Grade		1.1 kV	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE/PVC cables		For XLPE: 90°C For PVC: 70°C	
5.	Maximum conductor temperature for		For XLPE: 250°C For PVC: 160°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE/PVC cables			
6.	Conductor		For power cable: Aluminum	
			For Control Cable: Copper	
7.	Insulation		For power cable: XLPE/PVC	
			For Control Cable: PVC	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		For power cable: Armoured	
			For Control Cable: Armoured	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
11.	System Grounding		415 V system is solidly grounded.	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		50 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E9

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E9

1.0 ILLUMINATION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Illumination System complete with luminaries and all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS 1913	:	Electrical lighting fittings- General and safety requirements
IS 2418 - Part I	:	Tubular fluorescent Lamp
IS 3480	:	Flexible steel conduits for electrical wiring
IS 3646 (Part I to III)	:	Code of Practice For Interior Illumination
IS 4012	:	Dust proof electric lighting fittings
IS4013	:	Flame proof enclosure
IS 6665	:	Code of practice for industrial lighting
IS 5077	:	Decorative light fittings
IS 9537 - Part II	:	Rigid steel conduits for electrical installations

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IS 9583	:	Emergency lighting units
IS 9900	:	High pressure mercury vapor lamp
IS 9974	:	High pressure sodium vapor lamp
IS 10322	:	Luminaries for street lighting
CBIP Manual	:	Substation Equipment, Illumination and Layouts
IES (Illuminating Engineering Society of North America)	:	Application and Reference Volume
IEC 60598	:	Luminaries
CEA	:	CEA regulations and standard technical specification.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All illumination systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The illumination systems shall be suitable for operation in a highly polluted environment.
- b. Lighting fixtures shall be suited for the following range of frequency and voltage variations:
 - i. Voltage Variation : $\pm 10\%$
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

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- c. All emergency DC lighting systems shall be suited for voltage variation from -15% to + 10% of rated voltage.
- d. The design of the lighting systems shall be such that it shall ensure average lux levels specified for different areas.
- e. The illumination system shall comprise of the following:
 - i. Normal AC lighting
 - ii. Normal cum emergency lighting system
 - iii. 220V DC Emergency lighting system
 - iv. Maintenance 24V AC lighting system
 - v. Portable emergency lights with self contained battery packs.

1.4 Specific Requirements

1.4.1 Scope of work

The scope of work shall include design, preparation of Lighting design and manufacture, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with Lighting system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Switchgear room and cable gallery.
- iv) All roads within battery limit.
- v) Perimeter and boundary illumination of the above premises.
- vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room and cable gallery.
- v) FOPH area.
- vi) Transfer towers & Conveyor galleries.
- vii) All roads within battery limit.
- viii) Perimeter and boundary illumination of the above premises.

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- ix) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- c) Balance of plant Area:
 - i) Lighting system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- e) AHP Area:
 - i) Switchgear rooms.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard control room
 - ii) GIS building (if applicable)
 - iii) Transformer area
 - iv) All roads within battery limit.
 - v) Perimeter and boundary illumination of the above premises.
 - vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

1.4.2 Illumination System Description

The plant illumination system shall comprise of the following categories:

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a. Normal AC lighting

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply from the normal lighting distribution boards (LDB). All the lighting fixtures connected to this system shall be available as long as the 415V station / unit auxiliary service supply is available.

b. Normal cum emergency lighting system

Certain lighting fixtures considered essential shall be connected to this system. In this system the lighting circuits shall be fed from lighting distribution board connected to 415V Normal cum Emergency Switchgear. The lighting fixtures connected to this system shall be available whenever normal supply is available in the plant and also whenever DG set supplies the power to 415V Normal emergency switchgear.

These lighting fixtures will go off for a few seconds when normal supply fails but will be automatically restored when the emergency AC bus is re-energized by automatic transfer to standby DG supply.

[20% of the total fittings shall be fed from Emergency lighting for areas such as Switchgear room and control rooms etc.]

c. Emergency 220 V D.C. Lighting

The Emergency DC Lighting System shall be located strategically in critical operating areas and at emergency exits. Emergency DC lighting shall also be provided in the Control rooms, Switchgear/ MCC rooms and other strategically important areas. These fixtures shall be fed from respective Emergency DC Lighting Panels. The Emergency DC Lighting Panels (DC ELLP) shall be fed from 220V DC Distribution Boards (DCDB).

These lights shall remain normally OFF but on failure of AC supply these lights shall be automatically ON. Tube lights with Electronic choke suitable for 230 V, AC / DC operation or other Energy Efficient Lamps may be used for DC emergency lighting.

d. Maintenance 24 V AC Lighting System

For lighting facilities comprising portable hand lamps and/or connection of portable hand tools etc., required during the routine maintenance work, 24V single phase 3 pin sockets with switches shall be provided at selected points in the areas listed below. Such sockets for routine maintenance shall be clearly identified by colour coding in order to distinguish them from the normal 240V power outlets. Necessary outlets shall be made on the inside walls of the building near equipments.

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- i. Boiler area: Near inspection manholes on the boiler platforms and near boiler drum at different levels on all four sides.
- ii. TG building: Near HP & LP heaters, turbine flash tank, blow down tank, near condenser water box and near bus duct termination of generator end.
- iii. ESP columns: Near inspection manholes
- iv. Near de-aerator.
- v. Cable galleries.

Any other areas considered necessary identified during detailed engineering.

e. Portable Emergency Lights

This system shall be provided by portable self-contained battery / automatic charger / inverter fed compact fluorescent lamps in isolated buildings / areas where station D.C. supply is not available. These portable emergency light units shall be switched on automatically on loss of normal AC supply. *[Battery packs for portable emergency lights shall be rated for minimum 3 hours duty and the battery shall be of Ni-Cd.]*

f. Exit lights

Emergency escape signs shall be provided at the exit doors, escape routes, intersection corridors, at different floor levels/directions, windowless rooms, toilets, firefighting equipment, lifts, control rooms, switchgear rooms and the areas considered necessary by bidder. *[9W CFL]* lamp shall be used for exit lamps.

The contractor shall design emergency exit lighting system based on plant layouts and install escape lights at suitable locations considering the various escape routes. Emergency exit lights will be fed from normal-cum-emergency lighting panel, wherever available, *[and will be with in-built battery (Ni-Cd) back up of 3 hours operation.]*

1.4.3

Illumination Calculation

- a. Standard Lumen method shall be adopted for interior and exterior lighting in order to determine the number of lighting fixtures for obtaining the desired average level of illumination.
- b. The coefficient of utilization shall be considered to take care of Lumen loss due to:

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- i. Effect of room dimensions.
 - ii. Absorption of light in luminaries.
 - iii. Absorption of light at various room surfaces i.e. ceiling wall etc.
 - iv. Floor cavity, ceiling cavity.
 - v. Mounting height.
- c. Moreover a maintenance factor shall also be considered to account for the fall of illumination due to aging, pollution like dust deposits etc.
- d. Voltage drop at the fixture terminals from the MLDB shall [not exceed 3%]. Circuit loading of each lighting Panel shall be done in such a way that almost balanced loading in all the phases i.e. R, Y and B is achieved. At least two sub circuits shall be used for illumination of a particular area. Sub circuit loading of each lighting panel shall be restricted to 2000 Watts.
- e. Design of lighting system shall be such that the average lux level as specified is achieved. The Bidder shall submit illumination calculation/layout for the purchaser's review.

1.4.4 Lighting Distribution System

- a. Separate lighting transformers shall be provided inside the lighting distribution boards located at required location. Lighting distribution system shall be distinct and separate from the LV main distribution. Lighting transformers shall be encapsulated cast resin dry type.
- b. AC lighting panels shall have 240V single-phase, 2 wire incomer controlled by earth leakage circuit breaker and number of single phase outgoing circuits controlled by MCBs. The lights connected to a circuit or few circuits shall be 'ON' automatically through photocell for outdoor lighting. Provision shall be made for switching 'ON' the rest of the lights. Lighting fixtures in indoor areas shall be controlled from the respective lighting panels
- c. Normal 240 V AC Lighting System
For this system, lighting points shall be supplied at 240 V AC through 415 V, 3-phase, 4-wire, 50 Hz, LDB. The supply shall be derived from 415 V, 3-phase, 4-wire, 50 Hz switchgear through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant. Different circuits shall be used from different source. The whole lighting network shall be balanced as far as possible.
- d. Normal/Emergency 240V AC System
For these systems, the distribution shall be by 415V, 3-phase, 4-wire, 50 Hz supply. This supply shall be derived from 415 V, 3-phase, 4-wire, 50

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Hz normal emergency switchgear for NE & lighting through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant.

e. Emergency 220 V DC Lighting System

The power supply shall be obtained from the nearest 220 V DC switchboard. DC lighting panel will have one (1) incomer controlled by double pole MCB, Outgoing circuits will be controlled by DP MCB. Upon failure of the normal-cum-emergency AC supply, emergency DC lighting fixtures will be made automatically ON. The change over in the reverse direction shall also be automatic.

f. Maintenance 24V AC Lighting System

24 V AC supply for maintenance purposes (for hand lamps and/or hand operated tools) shall be supplied from 24 V AC distribution panel, which receives 240 V power supply from 415 V/240V transformer modules of N/E switchgear. 24 V AC distribution panel consists of one incomer controlled by MCB, one 240/26.5 V dry type transformer of adequate rating and number of outgoing circuits controlled by MCB.

1.4.5 Illumination levels and choice of lighting fixtures

The area-wise distribution of average illumination levels and type of luminaries shall be as indicated below:

[Note: These are indicative only. However as per specific Existing project, Bidder may refer section I of this specification for exact details of type of fixtures.]

Table 2.0

Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
A - TURBINE GENERATOR BUILDING				
1.1	General (auxiliary equipment areas)	200	Industrial well glass fixture, dust & jet proof, die cast aluminium body, stove enamel finish, vitreous enamel reflector integral mounted control gear/industrial bulk head with integral mounted control gear.	1x70 W/ 1x150 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.2	Cable vault	100	Industrial type FTL with vitreous enamel reflector	Energy Efficient FTL
1.3	All switchgear room area (including off-site building control room)	250	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.4	TG Building operating floor	250	Industrial high bay with anodized aluminium reflector with all accessories including control gear	1x400 W Metal Halide lamp
1.5	Unit control room and Switchyard control room	400	Decorative recessed with wide angle mirror optic antiglare type	Energy Efficient FTL
1.6	Battery rooms	150	Corrosion-proof	Energy Efficient FTL
1.7	TG building ground, mezzanine floor and misc. floors	200	Industrial well glass with integral control gear	1x150 W/ 1x250W Metal Halide lamp
1.8	Air washer room and A/C plant room	200	Totally enclosed vapor proof with clear acrylic cover	Energy Efficient FTL
1.9	Unloading and maintenance bay	300	Industrial high bay with anodised aluminium reflector	250 W HPSV lamp (for mounting height > 9m)

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.10	Electrical laboratory, chemical laboratory etc. (air-conditioned)	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
B -	BOILER AREA			
1.1	Boiler area and platforms, ESP area and platforms	100	Dust proof / dust tight well glass fixture	70 W Metal Halide lamp
1.2	Feeder floor areas	150	Dust proof / dust tight increased safety well glass	70 W Metal Halide lamp
1.3	ESP control room	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
C -	VARIOUS OFF-SITE BUILDING			
1.1	Equipment room (pump house)	200	Industrial type with vitreous enamel reflector upto mounting height of 8 M	150 / 250 W HPSV lamp
1.2	Switchgear room	250	Industrial high bay for mounting heights above 8M	Energy Efficient FTL
1.3	Outside working areas	70	Flood light medium beam	250 W HPSV lamp
1.4	Stores	100	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.5	Fuel Oil Tank Farm	50	General Purpose flood light with weatherproof fixture	250 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.6	Fuel oil decanting pump house, Hydrogen storage area, Coal conveyor areas	150	Flame-proof well glass	1 x 70 W HPMV lamp
D -	GENERAL			
1.1	Corridors, walkways, staircase, etc.	100	Industrial type with vitreous enamel reflectors/channel mounted box type	Energy Efficient FTL/1 x 70 W HPMV lamp
1.2	Lockers, toilets, wash rooms, etc.	100	Channel mounted box type	Energy Efficient FTL
1.3	Elevator well	50	Industrial bulk head	1 x 100 W incandescent lamp
1.4	Building periphery lighting	50	Industrial well glass with integral mounted control gear/industrial bulk head with integral mounted control gear/flood light fittings with timer control	70 W HPSV lamp / 400 W HPSV lamp
1.5	Office Rooms	300	Decorative recessed type FTL	Energy Efficient FTL
1.6	Transformer yard and Switchyard	50 on equipment, 20 general	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
1.7	Street lighting	20	Street weatherproof fixture with timer control	150 / 250 W HPSV lamp
1.8	Parking area	70	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
E	DC LIGHT FITTINGS			

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.1	Control room	400	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp
1.2	Other areas	250	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp

1.4.6 Area wise distribution of Lighting system in plant

Area wise lighting distribution shall be as below:

Table: 3.0

Area/building	Percentage Distribution of Lighting		
	Normal	Normal & Emergency	220V DC
Turbine Generator Building (all the bays)	80%	20%	10%
Control rooms	80%	20%	10%
Boiler Area (Grade level & Platforms)	80%	20%	5%
Service building	90%	10%	5%
Various pump houses and electrical switchgear rooms such as AHP, CHP, FOPH switchgear room, etc.	90%	10%	5%
Electro static precipitator	90%	10%	5%
Switchyard and Transformer yard	80%	20%	5%

1.4.7 Lighting System Design

The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of

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lighting specified in following paragraph. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

a. Indoor Lighting

The recommended values of illumination level for various areas in the plant are indicated in the table above. Lighting layouts shall be designed such that the ratio of minimum to average illumination shall not be less than [0.6]. Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/buildings in the plant.

i. Maintenance Factor:

- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Industrial areas with normal interiors such as workshops, stores : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors such a crusher house and junction towers : 0.5

ii. Reflection factor for wall/ceiling

- White and very light colors : 0.7
- Light colors : 0.5
- Middle tints : 0.3
- Dark colors : 0.1

iii. The working plane shall be considered at 0.85 m from the floor level.

iv. The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1 meter.

b. Outdoor Lighting

- i) The recommended illumination levels for outdoor areas are indicated in the above table.
- ii) Mounting height, spacing of flood lights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.05.

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- iii) Maintenance factor shall be generally 0.6 under average conditions.
- iv) Flood lights for area lighting shall be mounted on building structures. For outdoor lighting i.e. around the power plant building and transformer yard provision to be made with 400W outdoor type lamps mounted on wall/structures.
- v) Automatic switching ON/OFF shall be shall be provided through timers/photo cells.
- vi) For road illumination inside the boundary limit lighting poles shall be provided and the distance between the poles shall not exceed 30m.
- vii) Aviation obstruction lights shall be provided on tall installations (Chimney, Cooling Towers etc) as per Airports Authority and international standards. Aviation warning lights shall be high intensity type-A flashing LED type with varying intensity for day and night.
- viii) In an area, the lighting fixtures shall be arranged in different phase / LPs such that even in case one lighting panel is faulty complete lighting is not affected. In any location the lighting shall be arranged from two phases.
- c. The circuit loading on each circuit shall be restricted to 80% of the MCB rating.
- d. The voltage drop from LDB and any fixture shall not exceed 3%.
- e. All lighting design calculations, layouts, conduit wiring diagrams, LDBs and LPs drawings and technical data sheets etc shall be furnished for Owner/ Owner's consultant's approval.

1.4.8 Lighting system equipment

- a. Lighting Distribution Boards (LDB) & Lighting Panels (LP)
 - i. The Lighting Distribution board shall be fed through 415V/433V lighting transformers with off circuit taps $\pm 5\%$ in steps of 2.5%. The lighting transformer shall be cast resin dry type , vector group of [Dy1], class F insulation with temperature rise limited to class F and shall be housed in a suitable enclosure. In general, the transformers shall conform to the specification covered under 'Service transformers. The lighting distribution boards shall consist of MCCB incomer and required number of double pole MCB controlled out going feeders to LPs. The LDB shall be designed for the required short circuit level of [20] kA. All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-52. Outdoor panels shall be weather proof type with IPW-55 protection. The

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thickness of sheet steel enclosures shall be CRCA, 2 mm minimum for load bearing and 1.6 mm for other members.

- ii. Number of outgoing feeders in each LDB shall be provided as per requirement including the minimum 3 nos spare feeders for "Purchaser use". Each outgoing MCB in LDB's shall be of 15 A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB
- iii. Individual control in office buildings shall be through single pole flush type switches/MCBs. In those areas where group controls are required, rotary switches shall be provided
- iv. External area lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers/photo cell.
- v. In high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder / platform / approach shall be provided for maintaining / replacement of light fittings.
- vi. Each of the LDBs shall be provided with voltmeter and ammeter along with selector switches, "SUPPLY ON" indicating lamps, etc. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.
- vii. Two ground pads with bolts and nuts shall be provided on each board for connection to 50x6/25x3 mm GS flat.

b. Lighting Fixtures and Lamps

- i) Fluorescent fixtures with electronic ballast shall be generally provided for a room height upto 5m. Type of fixture shall be industrial type with gasket, clear acrylic cover and enamelled reflector or decorative type to suit the aesthetics. For areas with false ceiling, recessed mounted decorative fixtures with mirror optic louvres shall be used. In control room / computer rooms, decorative mirror optic fluorescent light fittings with antiglare features shall be provided. The surface finish shall be smooth, unobtrusive and scratch resistant.
- ii) Reflector shall be of sheet steel or aluminium, minimum 20 SWG thick and securely fixed by fastening device of captive type.
- iii) Fixture shall be suitable for 19 mm conduit entry and 16 SWG GI earth wire connection.
- iv) Fixture shall be furnished complete with lamps and integrally mounted accessories. These shall include holders, ballast, capacitor, starter, ignitors (separate type) etc.

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- v) For corrosive areas, corrosion proof lighting fixture shall be provided. For hazardous areas, light fittings, conduits, junction boxes etc. shall have to meet the corresponding area classification requirement.
- vi) Medium bay or high bay type of lighting fixtures with HPMV/HPSV lamps shall be used depending on the mounting heights for indoor areas having room height more than 5m. Medium/ High bay fixtures shall be provided with vibration damper wherever required.
- vii) For areas like boiler and outdoor areas such as roads, street, transformer areas and open yards, weatherproof HPSV flood/ street lighting fixtures shall be used. For areas like boiler platforms, weatherproof well glass type HPSV fixtures with wire guards shall be used.
- viii) All type of fluorescent lamps including Compact Fluorescent Lamp (CFL) shall be bi-pin rotary type and either cool daylight or white.
- ix) Mercury / Sodium vapour lamp shall be colour corrected type with screwed cap.
- x) Lamps shall be suitable for use in position and capable of withstanding small vibrations.
- xi) Ballasts shall be of heavy duty, low loss and polyester-filled type with copper winding.
- xii) Ballasts for Mercury / Sodium vapour lamps shall be provided with suitable tappings to set the voltage within range specified.
- xiii) Ballasts shall be free from hum. Ballasts which produce humming sound shall be replaced, free of cost.
- xiv) In multi-lamp fixture, each lamp shall be provided with individual ballast.

c. Switches, Receptacles

- i. In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms, etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided
- ii. 240V, 50 Hz, 3 pin Power Receptacles (5A, 15A) shall be provided in all building/areas of the plant. Inside a building, receptacles shall be provided at interval of 30m or part thereof for hand tools, water coolers, exhaust fans etc. Inside each cabins at

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least two receptacles shall be provided and the same shall be indoor/outdoor/flameproof as per the location. Minimum 2 nos of 5A and 1 no 15A receptacles shall be provided in each room. Receptacles shall be heavy duty, complete with individual plug and switch as described below:

Table: 4.0

S.No.	Type	Description
1	RA	5A, 240V, 2 Pole, 3 Pin with third pin earthed - Suitable for flush mounting in office areas and control room. The switch shall also be flush mounting piano type.
2	RB	15A, 240V, 2 Pole, 3 Pin with third pin earthed - Wall/column mounted, metal clad gasketed construction, suitable for 19 mm conduit entry, screwed metal cover tied with metal chain, weatherproof construction suitable for indoor/outdoor installation. This shall be provided at an interval of 30m, or minimum one in each room.
3	RC	63A, 415V, 3 Phase, 5 pin interlocked plug and switch with fifth pin earthed. Wall/column mounted, metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 4 Core 35 sq.mm AYWY cable. These receptacles shall be provided at an interval of 50m throughout the Plant Area.
4	RD	100A, 415V, 3 phase, 5 Pin interlocked plug and switch with fifth pin earthed Wall/column mounted metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 3.5 Core, 95 sq.mm AYWY cable.

d. Cables and Wiring

- i. Wiring from lighting DBs/panels to individual fixtures, plug points, fans, etc. shall be of single core, 2.5sq.mm, 1100 V grade PVC stranded copper conductors through surface mounted or concealed medium duty GI conduits confirming to IS 1239 with earth wire. The wires in the conduits shall not exceed 60% of the conduit area.
- ii. 1100V grade stranded copper conductor, PVC insulated, colour coded, wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, outdoor areas like transformer yard and road lighting, cabling shall be adopted. The

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specification of cable shall conform to the details indicated in "Cabling System" section.

- iii. Minimum size of wires in case of conduit wiring shall be 2.5sq.mm copper in case of lighting and 4sq.mm copper in case of receptacle wiring
- iv. Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits. Wires of AC and DC lighting system shall be carried out in separate conduits
- v. For outdoor lighting, the cable shall be buried at a minimum depth of 750 mm from ground level or run in cable trays. The buried cables shall have suitable bedding, protective covers and markers
- vi. Material used for saddles, clamps, JBs, etc. shall be galvanized
- vii. Office buildings, laboratory buildings shall have concealed wiring with 2.5sq.mm wires using PVC conduits. In heat zones, i.e. in the areas where ambient temperature is 600 C and above, heat resistant control cables shall be used in hot dip galvanised rigid steel surface mounted conduits

e. Fans and Regulators

- i. The fans shall have three well balanced blades, double ball bearings and shall be reasonably free from noise. Fan motor shall be totally enclosed type with copper winding and class-E insulation. Sweep shall be given as 1200 /1400 mm.
- ii. Regulators shall have minimum five steps. Electronic Regulators with smooth control shall be provided.

f. Flame-Proof Equipment

- i. The enclosure of all flameproof equipment for use in hazardous areas where gases/vapors of Group I, IIA, IIB are present, shall be of cast iron/cast aluminum, stove enamel finished. Chemical corrosion resistant epoxy finish shall be provided in corrosive areas. The construction shall comply with relevant applicable standards
- ii. If the enclosures are additionally required to be weather proof, neoprene gaskets shall be provided to make the enclosure dust and weather proof providing a degree of protection of IPW 55.
- iii. All ferrous parts, exposed to atmosphere shall be suitably plated/galvanized

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- iv. All internal wiring shall be connected to terminal blocks provided in terminal enclosure on incoming side.
- v. Flameproof cable gland entries shall be provided suitable for the cable sizes. The number of required cable entries for junction/terminal boxes as required for branching, terminating of cables for lighting distribution shall be provided. All unused cable entries shall be closed by flameproof plugs.
- vi. Flameproof receptacle unit (socket with associated switch/MCB and plug) shall have interlocking feature such that plug cannot be inserted or taken out with switch/MCB in "ON" position.
- vii. Adequate mounting lugs with necessary hardware shall be provided for mounting the equipment on wall/structure.
- viii. These enclosures shall have inscription warning against opening the enclosure unless the circuit is isolated. Equipment rating and ON/OFF positions of switches/MCBs shall also be designated.
- ix. The BIDDER shall indicate that the enclosures have been tested and certified by relevant statutory authorities for use in hazardous areas.

g. Lighting poles and towers

- i. Lighting poles for street lights and flood lights shall be of swaged and welded steel, pole of height 9M/11M and shall conform to relevant standard. Poles shall be hot dip galvanized internally and externally after fabrication as per IS 2629 / IS 2633 / IS 4759 standards. The Poles shall be designed to withstand the maximum wind speed as per IS 875. The steel sheet used to manufacture steel poles shall be of minimum thickness of 3 mm and shall conform to relevant standard . Junction boxes shall be provided with weather proof flush doors and locking facility. Bidder shall design and furnish the foundation drawings for the poles to withstand basic wind speed of minimum [50]meter/sec.
- ii. The supply of poles/Towers shall be complete with base plate, foundation bolts, hot dip galvanized brackets / necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
- iii. Towers for mounting flood lights shall be e of continuously tapered poly gonol cross section and shall be supplied with all acesssories. Steel structure for towers shall be made of hot dip galvanized steel. A steel ladder and platform at the top shall be provided. The length of each step of the ladder shall be at least

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300 mm and spacing between two adjacent steps not more than 300 mm. The structure shall be suitable for mounting the required number of flood lights, weights of maintenance crew and specified wind pressure. The factor of safety shall be [2] for each part and section. The Contractor's structural design drawings shall be approved by the Purchaser before fabrication.

1.4.9 Name Plate

Name plates shall be furnished for identification of devices and circuits. All switches, controls and indications shall be permanently and legibly marked in English regarding the functions.

1.4.10 Painting

All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.

After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoved after each coat.

The equipment shall be finished in approved color shade by owner with two coats of epoxy based powder coated paint. The coating shall be done electro statically followed by stoving.

Sufficient quantity of touch-up paint shall be furnished for application at site.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

Tests on Lighting Distribution Boards / Panels shall include:

a. Wiring continuity tests.

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- b. High voltage and insulation tests.
- c. Operational tests.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *Lighting panels & distribution boards.*
- b) *Receptacles & Junction boxes.*
- c) *Street light poles & towers.*
- d) *Lighting fixture complete with lamps and accessories.*
- e) *Non-integral/separate type control gear box for lighting fixtures, as applicable.*
- f) *Lux level calculations for each area.*
- g) *Data sheets for lighting fixture, lamps, accessories with light distribution curves, co-efficient of utilization charts etc. Type and routine test certificates of transformer and cables.*
- h) *Control schematic and wiring diagram of 415V AC/220V DC lighting panel with automatic changeover from AC to DC and vice-versa, 415V normal AC Street/area lighting panel with automatic ON/OFF feature.*
- i) *Technical leaflets and data sheet on each piece of equipment/ device such as MCB, switch, fuse, receptacle etc. Type and routine test certificates of transformer and cables.*
- j) *QAP and relevant test certificates*

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- k) Lighting layouts showing the disposition of fixtures, lighting panels/boards, circuit distributions, conduit & wire routing.
- l) Key Single Line Diagram for lighting distribution, board wise single line diagram with feeder loading, cable schedule and interconnection chart, design calculation for lighting.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC DC	240V, 1Ph, 50Hz 220V DC
1.2	Variation in Supply		
	a) Voltage	%	±10
	b) Frequency	%	±5
	c) Combined voltage & frequency	%	10
1.3	Design Ambient Air Temperature	°C	50
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	50KA for 1 sec
	b) At 220V DC (For DC LP)	kA(DC)	[10] kA for 1 sec
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		G.I
b	Conductor size	SWG	12
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		[By bidder]
2.2	Rated Voltage, phase and Frequency	AC	415V, 3phase, 4 wire, 50Hz
2.3	One Minute Withstand Voltage	V	2500
2.4	Mounting Type		

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S. No.	DESCRIPTION	UNIT	DATA
	a) LDBs		Floor Mounted
	b) Single Phase LP		Wall/Structure mounted
2.5	Type and no of circuits & feeder rating		[As per project requirement]
2.6	Colour shade		[RAL 5012]
2.7	Lighting Transformer		
	a) Type		Epoxy cast resin dry type
	b) Voltage Ratio	V	415/415V
	c) Taps	%	+/-5%
	d) Vector Group		[Dyn1]
	e) Impedance	%	[5%]
	f) Rating	KVA	[As per project requirement]
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		[By Bidder]
3.2	Luminaries		[By Bidder]
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		[By bidder]
	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		[By bidder]
	a) Luminaires		
	b) Accessories		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Schedule of fitting and Accessories		[As per project requirement]
5.0	Technical details of luminaries		[By bidder]
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumen s	
	ii) After 1000 burning hours	Lumen s	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		[By bidder]
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		[By bidder]
a	Power factor		
5.4	Luminaries		[By bidder]
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		G.I
	ii) Suitable upto conductor size	SWG	12
c	Internal wiring size	Sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		[By bidder]
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		[By bidder]
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		CTs VTs
8.1	Make		[By bidder]
8.2	Type		[By bidder]
8.3	Output	VA	[By bidder]
8.4	Accuracy Class		[By bidder]
8.5	Literature enclosed	Yes/No	[By bidder]
9.0	Meters		VOLTMETER AMMETER WATTMETER
9.1	Make		[By bidder]
9.2	Type		[By bidder]
9.3	Accuracy Class		[By bidder]
9.4	Literature enclosed	Yes/No	[By bidder]
10.0	Relays (if any provided)		[By bidder]
10.1	Make		

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S. No.	DESCRIPTION	UNIT	DATA
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a)Normally open		
	b)Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		[By bidder]
11.2	Suitable for use in hazardous area		
	a)Area classification		[Fuel oil pump house, Main oil tank area]
	b)Gases/Vapor group		[By bidder]
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	[By bidder]
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	[By bidder]
12.0	Lighting Control Switches		[By Bidder]
12.1	Make		
12.2	Decorative		
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		[By Bidder]
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	

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S. No.	DESCRIPTION	UNIT	DATA
14.0	Lighting wires		[By Bidder]
14.1	Make		[Point wiring with respect to different length shall be furnished]
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	Conduits		[By bidder]
15.1	Make		
15.2	Rigid Steel		Galvanized
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		[By bidder]
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		Yes
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		[By bidder]
17.1	Make		
17.2	Type of Poles/Towers		

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S. No.	DESCRIPTION	UNIT	DATA
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		[By bidder]
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E10
TECHNICAL SPECIFICATION FOR CABLE CARRIER
SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E10

1.0 CABLE CARRIER SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Cable Carrier system complete with all accessories for efficient and trouble free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS 800	Code of Practice for structural Steel
IS 1646	Code of Practice for Fire Safety of buildings
IS2667	Fittings for Rigid steel Conduits
IS 3419	Fittings for Rigid Non – Metallic Conduits
IS 3837	Accessories for Rigid Steel Conduits
IS 4649	Adaptors for Flexible Steel Conduits
IS 5216	Guide for Safety Procedures and Practices in electrical Work

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Cable and cable trays shall be installed in an ambient temperature of 50 °C and relative humidity of 95%.
- b) The cable carrier system shall be designed considering the following:
 1. Facility for easy laying of cables.
 2. Access to maintenance.
 3. Neat and aesthetic appearance.
 4. Safety of equipment & personnel.
 5. Ground water seepage.
- c) Cables shall be laid in prefabricated ladder/perforated type trays and in conduits. Direct burial of cable shall be mostly avoided.
- d) Upper cable trays and all vertical cable trays shall be provided with tray covers.
- e) Cable filling in the trays or racks shall not exceed 80%. Conduits if used, the wires in the conduits shall not exceed 40% of the conduit area.
- f) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V cables shall be laid in top trays and cables of subsequent voltage grade in lower tier of trays. Instrumentation cables shall be laid at bottom most tray.
- g) At least 300mm clearance shall be provided between HV and LV cables & LV and control/Instrumentation cables.
- h) Support system for cables shall be prefabricated type.
- i) Single core cables shall be laid in trefoil touching formation. Trefoil clamp shall be provided in a staggered manner.
- j) 1100V grade power cables of [120] mm² size and above shall normally be laid in single layer in trays/on racks.
- k) 1100V grade power cables below [120] mm² may be run in double layers in case of space restrictions.
- l) Control and instrumentation cables can be laid up to a maximum of three layers in each tray/rack.

1.4 Specific Requirements

1.4.1 Scope of work:

The scope of work shall include Design, Preparation of Cable Tray, Trench/Duct bank/Conduit Layout, supply of Cable tray and its Accessories, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the Cable Carrier System

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for following package. The below list indicates area where cable carrier system to be provided but not limited to:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- iv) Laying and Termination of power & control cables for all the equipments of TG package.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room.
- v) FOPH area.
- vi) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- vii) Laying and Termination of power & control cables for all the equipments of Boiler package.

c) Balance of Plant Area:

- i) Cable Carrier System for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
- ii) Laying and Termination of power & control cables for all the equipments of BOP package.

d) CHP Area:

- i) CHP Switchgear room
- ii) Conveyor.
- iii) Crusher House
- iv) Stacker and Reclaimer
- v) Any other area covered in this package.
- vi) Laying and Termination of power & control cables for all the equipments of CHP package.

e) AHP Area:

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- i) AHP Switchgear room.
- ii) Silo Area.
- iii) Any other area covered in this package.
- iv) Laying and Termination of power & control cables for all the equipments of AHP package.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard
 - ii) Transformer yard
 - iii) Inter plant cabling.
 - iv) Any other area covered in this package.
 - v) Laying and Termination of power & control cables for all the equipments of eBOP package.
- g) All civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification. Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Bidder.
- h) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work.
- i) For Terminal Points and Exclusions of Cable Carrier system and Specific scope of work Bidder may refer section I of this specification.

1.4.2 General Installation Requirements:

- a) Cable trays shall be fabricated from 14 gauge mild steel sheets. Cable trays shall be of hot dip galvanized Steel of ladder/perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings to be submitted by Bidder. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanized.
- b) Constructional details, supporting arrangement and installation details for cable trays shall be furnished by Bidder.
- c) Each 2.5 meter section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.
- d) Cable tray covers shall be fabricated from 16 gauge MS sheets. Cable tray covers shall be hot dip galvanized and same shall be provided for all outdoor cable trays and vertical raceways/trays. Covers for vertical raceways shall be in individual, easily removable sections to facilitate cable maintenance.

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- e) Cable Tray of Standard width of 600mm shall be followed. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.
- f) Cable trays shall be ladder type with maximum rung spacing 250 mm depth 100 mm and rung width not less than 50 mm.
- g) Cable trays in areas subjected to excessive coal dust, or mechanical damage shall have hot-dip galvanized sheet metal tray cover installed on front tray in vertical run and inverted 'V' type on upper tray in horizontal run. Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.
- h) Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal / vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.
- i) Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/termination kits, lugs, glands, ferrules, tapes etc. and other accessories, grounding of cable armor. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.
- j) Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.

1.4.3 Cable Routing/Laying

- a) Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some

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cases cables may have to be laid underground and for short runs in conduits for protection while crossing roads and other facilities.

- b) For interplant connections, the cables may be routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.
- c) For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.
- d) In boiler area, trench shall be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.
- e) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.
- f) Cables for redundant equipment/system shall be run in separate trays in separate route.
- g) Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.
- h) Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).
- i) The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall and fire proof doors.
- j) The floor of the cable spreader rooms shall have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably planned to avoid water entry through this place.
- k) Cables shall generally be laid on cable trays either in concrete trenches or overhead supported from building steel/structures. Cables shall be run in concrete trenches in those electrical rooms at ground level, which are without any spreader room below. In mechanical equipment areas (Indoor), overhead cable trays shall generally be used.

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- l) For inter plant connections, the cables shall be routed through an overhead cable bridge pipe cum Cable Bridge. For isolated but long outdoor cable route with very few cables of 3/4 nos., the cables may be directly buried with prior permission from the purchaser.

1.4.4 Installation of Cables

- a) The Bidder shall install, terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.
- b) The HV power cables of 6.6kV shall be laid in trays or racks as follows:
- In single layer only.
 - 3 core cables to be laid in touching formation.
 - Cables in trefoil groups of the same circuit shall be laid as indicated below so as to ensure balanced current distribution:

Y Y Y Y

R B B R R B B R and so on.

- c) 1100V grade power cables shall be laid in single layer in trays depends on size of cables. Cable of up to 120 sqmm shall be laid in two layers. Beyond this size single layer will be followed.
- d) Control and Instrumentation cables can be laid up to a maximum of three layers in each tray.
- e) The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.
- f) Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there shall not be more than 2 nos. 90 Deg. Bends between pull points.
- g) Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension, minimum bending radius and no. of bends.

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- h) All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :
- Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.
 - Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.
 - For all HV, LV, Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.
- i) All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.
- j) The portion of galvanized steel, which, if required, undergoes any welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.

1.4.5 Cable Termination and Joints (if applicable and not covered in cable specification)

- a) The Bidder shall supply cable termination and jointing kits in requisite quantity for HV. Power Cables, LV. Power, Control Cables, etc. along with all accessories & consumables required for making termination and joints complete . All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/joints are intended.
- b) The straight through joints of HV. cables shall be heat shrinkable and pre moulded push on type. The end termination kits for HV. cables shall be of {Raychem/3M/Elastimold} type. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.
- c) Glands and lugs required for termination of HV, LV. shall be supplied by the Bidder in required quantity.
- d) Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer etc. Cable glands shall match with the sizes of different HV/LV/Control cables.

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- e) Cable lugs shall be suitable for termination of different cross-sections of L.V./Control cables and shall be of following types:
 - i. Aluminium tubular terminal end for solderless crimping to aluminium conductors.
 - ii. Copper tubular terminal end for solderless crimping to copper conductors.
 - iii. Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.
 - iv. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.
 - v. The terminations shall with tinned copper only.
 - vi. For mill area, the cable shall be routed through GI pipes embedded in Ground.
 - vii. In heat zone areas as far as possible the cables shall be taken away from the area to avoid heat. If cabling in the heat zones can not be avoided, the cables shall be terminated in junction box of IP 67 protection class away from the heat zones and small length of cables may be laid from junction box to the respective equipment to facilitate easier replacement in case of fire. Bunching of cables in the heat zones and boiler areas shall be avoided and laid in separate groups.

1.4.6 Identification

- a) The complete cabling system shall be properly identified. Methods for identification of cabling system will be furnished to the Bidder and the Bidder shall strictly adhere to the said methods.
- b) Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- c) Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate, projected above ground level.
- d) Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) meters in cable tray/trench runs. Cable tags shall also be provided

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inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant / purchaser or his representative.

- a) Checking of continuity / phasing and IR values for all the cables before and after HV test
- b) Checking of continuity / phasing and IR values for all the cables before and after HV test.
- c) HV test and measurement of leakage current after termination of cable kits (for HT cables).
- d) Checking of earth continuity for armour.
- e) Check for mechanical protection of cables.
- f) Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
- g) Check earthing of cable structures.
- h) Check safe head room in gallery area
- i) Check clearance from ventilation duct and light fittings for cable structures.
- j) Check proper fixing of cable structures.
- k) Check for proper drainage and removal of water (if any).

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall

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obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[General arrangement drawing Cable Tray]*
- b) *[Cable Tray Accessories like Tee, Cross, Bends, Coupler, Reducer etc]*
- c) *[Cable Tray support materials]*
- d) *[Technical Data sheets for cable carrier system].*

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		[By bidder]
2.	Size of Tray	mm	[600/450/300/150]
3.	Material		Galvanised Steel
4.	Application		[As per project requirement]
5.	Type of Tray		[Ladder/Prerforated]
6.	Thickness of Tray	mm	2mm
7.	Thickness of Galvanization		[100 microns]
8.	Tray Cover Size	mm	[As per project requirement]
9.	Cable Tray Accessories		[By bidder]

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SL NO.	DESCRIPTION	UNIT	DATA
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	a) [100] b) [50x 50 x 6]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E11

**TECHNICAL SPECIFICATION FOR EARTHING AND
LIGHTNING SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E11

1.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Earthing and Lightning Protection System complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanizing of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:9537	Conduits for electrical installation.
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
CEA	CEA Regulations and standard technical specification for main plant package.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Earthing system design shall consist of earth grids and electrodes buried in soil in the whole plant area, embedded in concrete inside all the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.
- b) The main objectives of earthing system is to:
 1. Provide safety to personnel from contact of dangerous potential caused by ground fault.
 2. Ensure sufficient grounding current for effective relaying.
 3. Stabilize circuit potential with respect to ground.
- c) The earthing conductor shall be designed for fault current of [50 kA] for duration of 1 second.
- d) It is the responsibility of the Bidder to undertake the soil resistivity measurements at site and select suitable size of conductor based on the soil resistivity.
- e) Ground conductor shall be of galvanized steel for above ground and mild steel for embedded and below ground earthing.
- f) Main earth grid conductor shall be mild steel (MS) of [40] mm dia.
- g) Suitable corrosion allowance shall be considered over ground conductor size depends upon soil resistivity.
- h) The main purposes of lightning protection system are to :
 1. Provide protection to structures from lightning strokes.
 2. Provide a low resistance-conducting path to lightning discharge.
 3. Lightning protection shall be provided as per IS: 2309 for Boiler area and other tall structures within the battery limit.

1.4 Specific requirements

1.4.1 Scope of Work

The scope of work shall include Design, Preparation of Earthing and Lightning Layout, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the safety earthing and Lightning Protection system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

- a) TG Area:
 - i) TG Platforms.

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- ii) TG area Grade Levels Maintenance area.
- iii) All equipments, structures etc of TG package.
- iv) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- b) Boiler Area:
 - i) Boiler Platforms
 - ii) Boiler Grade Levels covering coal mill and Maintenance area.
 - iii) ESP Platforms
 - iv) ESP/FOPH switchgear room.
 - v) FOPH area.
 - vi) All equipments, structures etc of Boiler package.
 - vii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- c) Balance of plant Area:
 - i) Earthing and lightning protection system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- e) AHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- f) Electrical Balance of Plant (Switchyard) Area:
 - i) Switchyard, Transformer yard and BTG area are provided with earth mat of [40] mm dia MS Rod conductor buried below 600mm from ground level. Areas like AHP, CHP, Boiler and TG, and all other

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BOP area below grounding system are covered in this eBOP package and above ground earthing for AHP, CHP, Boiler, TG and Mechanical BOP are covered in respective package itself. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system for above ground are covered in respective packages and below ground is covered in this eBOP package in same way as earthing system.

1.4.2 Earthing system

- a) Earthing system shall be designed in accordance with IS 3043 and Indian Electricity Rules and Acts.
- b) Fault current for the earthing system shall be designed for [50] KA for duration of 1 sec.
- c) All electrical equipment, non-current carrying metal parts, structures, building steel, lightning protection system, transformer neutrals shall be connected to station ground grid.
- d) Treated earth pits including riser shall be provided for transformer neutral earthing.
- e) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- f) Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.
- g) All off site area of AHP , CHP etc shall be provide with peripheral earthing with at least two connection to main station earth grid through treated earth pit.

1.4.3 Ground Grid Conductor

- a) Ground grid conductor of mild steel rod shall be used.
- b) *[The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.12 mm (on diameter of conductor) per year over the design life of 40 years.]*
- c) However bidder shall consider as per CBIP norms “ Manual on Earth mat design” the corrosion allowance as below:
 - For soil resistivity greater than 100 ohm-meter: No allowance.

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- For soil resistivity greater than 25- 100 ohm-meter: 15% allowance.
- For soil resistivity less than 25 ohm-meter: 30% allowance.

1.4.4 Underground Grid

- The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80.
- [The ground grid conductors shall be buried in earth at a depth of 600 mm]. The length of ground conductors below earth shall be sufficient to ensure a ground resistance less than one (1) ohm.
- The ground grid conductor shall be so laid as to provide short and direct connection to building steel and major electrical equipment.
- Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.
- All ground grid conductor connections shall be welded type.
- Ground grid shall be interconnected with the ground grid of neighboring areas at least at two (2) points for further reducing the ground grid resistance.
- Suitable pigtails shall be provided and shown in the [layout drawing] for connection with ground grid of neighboring areas.
- A minimum earth coverage of [300] mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.
- In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.
- Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.
- Grounding conductor around the building shall be buried in earth at a minimum distance of [1200] mm from the outer boundary of the building.
- The Bidder shall carryout the grounding of all electrical equipments and connection to main earth grid.

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1.4.5 Ground Electrode

Ground electrodes shall be [40] mm dia. and [3] metre long M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductors. All connections to the conductors shall be done by arc welding process.

1.4.6 Above Ground Connections

- Galvanized steel flats shall be used for all connections above earth.
- Inside building, ground conductors shall be run for each floor supported on building steel and/or cable trays. These ground conductors in turn shall be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.
- Two separate and distinct ground connections shall be provided for each electrical equipment in compliance with I.E. Rules.
- All steel columns and structures shall be connected to the earth mat through earth leads.

All connections above ground shall be welded type except connection to equipment/structures which shall be bolted type.

1.4.7 Risers

Risers are required for connecting the equipment and structures with the ground mat. Risers are to be provided from underground mat to above ground levels where the ends shall be left free for connecting to the equipment. Each riser shall be 1 No. [40] mm dia. M.S. rod and shall project above grade level/concrete floor level by minimum 300 mm. They are to be clamped or supported along the outer edge of the concrete foundation. Connection to the ground mat shall be done by arc welding.

1.4.8 Equipment Ground Lead

- Equipment ground connections shall be sized to carry the ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.
- The minimum ground conductor sizes for various equipment and structures are given in below.

Table 2.0

DESCRIPTION	SIZE	MATERIAL
a) Main Grounding Grid Conductor	[40] mm dia Rod	Mild Steel
b) Riser/Pigtail From Grounding Grid/Mat	[40] 40 mm dia Rod	- Do -

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DESCRIPTION	SIZE	MATERIAL
c) Electrode	[40] mm dia, [3000] mm long Rod	- Do -
d) Conductor used for connection of various equipment/structures as listed below		
HV motors, Earthing ring, Earthing lead to earth pits etc.	[50 x 10] mm	Galvanised steel
Structures, Control Panels, Cable Trays etc.	[50 x 10] mm Flat	- Do -
415V Power Control Centres, Motor Control Centres, Distribution Boards etc.	[50 x 10] mm Flat	- Do -
Local Panels, Lighting Panels	[25 x 6] mm Flat	- Do -
Motors :		
Above 90 kW	[50 x 10] mm Flat	Galvanised steel
Above 30 kW Upto 90 kW	[25 x 6] mm Flat	- Do -
Above 5 kW Upto 30 kW	[25 x 3] mm Flat	- Do -
Upto 5 kW	[8] SWG	- Do -
Miscellaneous Items, viz. Push Button Station, Junction Boxes etc	[8] SWG	- Do -

{ The Above size of Earth flat is indicative only. Bidder shall refer Volume II Section I for size of earth flat used for existing plant or as per design. }

1.4.9

Jointing and Connection

- All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.
- The bending of the large diameter ground conductor where necessary shall be done by gas heating.
- The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- The connections between the riser/pigtail and earthing conductors

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(galvanized steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.
- g) Equipment/structures ground connections shall be coated with weather resistant paints/cold galvanizing paints after proper checking / testing.
- h) Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

1.4.10 Earthing system installation

- a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
- b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750 mm.
- c) The earthing conductor crossing the road / track shall be laid in hume pipe or laid at a greater depth to avoid damage.
- d) When earth conductor passes through floors, walls, etc suitable pipe sleeves shall be provided and the same shall be sealed after installation.
- e) The connection between earthing pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
- f) Metallic conduits and pipes shall not be used as earth continuity conductor.
- g) Street lighting poles, flood light poles & towers, their junction boxes shall be connected to the earthing conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.
- h) The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.
- i) Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten [10] metres. Fence gate shall be separately grounded with flexible connection to permit movement.

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- j) [50 x 10] mm galvanized steel flats(minimum size) shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing. These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground. Earthing conductors can be embedded in concrete floor of the building wherever necessary without having direct contact with the reinforcement rods. At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- k) All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.
- l) Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.
- m) Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.
- n) A continuous [50 x 10] mm (minimum size) G.S. flat earthing conductor shall run along the cable trays and supporting structure of all cable routes. This earthing conductor shall be attached to each section of cable tray/trays through [50 x 10] mm G.S. flats. The earthing conductor shall be securely connected to the earth mat at both ends.
- o) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
- p) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.
- q) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- r) The cable sheaths, screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.
- s) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- t) Main plant earth grid and switchyard earth grid shall be interconnected each other by minimum two numbers of leads.

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1.4.11 Lightning Protection System Design

- a) Lightning protection design and installation work shall be provided on the basis of IS 2309 Code of Practice.
- b) Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down conductors and pipe electrodes.
- c) The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than value specified in IS shall be provided with lightning protection. However, Boiler areas, station building, switchyard building shall be provided with lightning protection irrespective of the arrived risk index.
- d) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.
- e) Down conductors shall run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.
- f) A Lightning electrode shall be provided at the connection point of the down conductor with the station ground.
- g) Galvanized steel rods and flats shall be generally used for air termination and connections. All connections shall be welded type.

1.4.12 Air Terminations

- a) The vertical air terminal rods shall be installed at the roof of Turbo generator building, Boiler and chimney etc to protect these objects from lightning strokes.
- b) The projected length of the Air termination rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.
- c) The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building, the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.
- d) All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size [50 x 6] mm galvanized steel flats.
- e) For chimney air termination, rods interconnected by circumferential conductors will be provided at the apex of flue and also upon outer shell of the chimney. The air termination system will be formed by lead coated copper conductors to prevent melting and corrosion of conductors due to flue gas.
- f) For cooling towers, air termination system will comprise of horizontal

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circumferential conductors at the top

1.4.13 Down Conductors

- a) Galvanized steel down conductors of suitable size [25 x 6] shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.
- b) Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.
- c) The connection between each down conductor and rod electrode (by means of 40 mm mild steel rod riser) shall be made by others. However Bringing down comer with test link at a level of 1500mm approximately from above ground level shall be boiler contractor scope of work.
- d) The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleared on outside of the building wall and column/structure at about 750 mm intervals unless stated otherwise in the drawing.
- e) At all supports for down conductor along the column/wall of the buildings etc. the portion embedded inside the building concrete should not touch the reinforcement bars.
- f) All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.
- g) The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

1.4.14 Switchyard Lightning protection

- a) For switchyard lightning protection shall be provided by lightning masts and/or shield wires.
- b) In case of lightning protection by shield wire, the shield wires provided shall be of GS wire strung across the pinnacles of the gantry tower structures. The size of shield wire shall be based on the lightning impulse current expected and the time duration for which it is likely to flow. Allowance shall be given in the final size to account for corrosion of the shield wire during service at rate of [0.03] mm per annum. However, minimum size of the shield wire shall not be less than [70]sq.mm. The zone of coverage for the shield wire shall be considered as 60 deg between the two shield wires and 45 deg for end shield wires. The down conductors from shield wires shall be run along the towers and

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connected to rod/pipe electrodes.

- c) In case of lightning protection by lightning protection masts, the down conductors from the masts/peaks/shield wires shall be run along the tower and connected to the test links mounted on the towers at 1500m from the ground level. Conductors from the test links shall be connected to the rod/pipe electrodes which in turn are connected to the main earth grid in the switchyard. Calculations for sizing and determining topography and number of lightning masts shall be furnished for approval.

1.4.15 Electrodes (for Lightning Protection)

The electrodes shall be [40 mm] diameter [3000 mm] long mild steel rod. These shall be driven into the ground.

All the electrodes shall be interconnected by means of one (1) [40 mm] dia mild steel rod which shall be laid under ground at a minimum depth of [600 mm] below finished grade level unless stated otherwise. This ground mats/electrode in turn shall be connected to main grounding grid.

1.4.16 Riser (for Lightning Protection)

All risers connected to grounding mat shall be [40 mm] mild steel rods and shall be projected 300 mm above grade level unless stated otherwise.

1.4.17 Jointing & Connection

- a) All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.
- b) The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- c) The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.
- d) All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.
- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- g) The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- h) The steel to copper connection shall be brazed type.

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- i) The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.
- j) The sizes and materials of earthing conductors to be used in lightning protection system are listed below :
- k) Note: The above sizes are indicative only. Actual size shall be as per Bidder design or as per existing plant details as provided in Section I in case of replacement work as called for.

Table 3.0

DESCRIPTION	SIZE	MATERIAL
a) Vertical Air Termination	[20] mm dia Rod	Galvanised steel
b) Horizontal Conductor	[50 x 6] mm flat [25 x 6] mm Flat	-----do-----
c) Down Conductors	[25 x 6] mm Flat	-----do-----
d) Ground electrode / riser	[40] mm dia Rod	Mild Steel
e) Interconnection with earth mat	[40] mm dia Rod	Mild Steel

1.5

Tests

l) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the

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Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

The following test shall be conducted:

- a) Measurement of earth resistance for each electrode.
- b) Measurement of total earth resistance.
- c) Measurement of earth loop resistance for E/F path of biggest LV drive.
- d) Check tightness of all earth connections
- e) Check earthing of all metallic equipments, cable trays, bus bar supporting structures, building column (if steel all elect equipments, pipe lines etc. as per the drawing / specification)

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[Earthing Material like conductor , flat , welding description etc]*
- b) *[Air termination rod and its accessories etc]*
- c) *[Technical Data sheets for Earthing and Lightning system].*

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1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E13

**TECHNICAL SPECIFICATION FOR VARIABLE FREQUENCY
DRIVES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E13

1.0 VARIABLE FREQUENCY DRIVE

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Variable Frequency Drives complete with all accessories for efficient and trouble-free operation of of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS-3700	:	Essential ratings and characteristic of semi-conductor devices
IS-3715	:	Letter symbols for semi-conducting devices
IS-4411	:	Code of designation of semi-conducting devices
IS-5001	:	Guide for preparation of drawings for semi-conductor devices
IS-5469	:	Code of practice for the use of semi-conductor junction devices
IS-5621	:	Hollow Insulators for use in electrical equipment
IS-6209	:	Methods for partial discharge measurement.
IS-6297	:	Transformers and indicators for electronic equipment
IS-8789	:	Performance parameters for motors
IS-12729	:	Switchgear and control gear for voltages exceeding

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		1000V- General requirements
IS-13408	:	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IEC 146	:	Semi Conductor converters
IEC 168	:	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V
IEC 270	:	Partial discharge measurement
IEC 297	:	Dimension of panels and racks
IEC 326	:	General requirements and measuring methods for printed wiring boards
IEC 352	:	Solder less wrapped connection
IEC-61800-3,4&5	:	EMC requirements and specific test methods
IEC-60664-1	:	Insulation coordination for equipment within low-voltage systems
IEC/EN-60204-1	:	Safety of machinery-electrical equipment of machines
IEC/EN-60529	:	Degrees of Protection Provided by Enclosures (IP Code)
IEC/EN-61000-3-12	:	Electromagnetic compatibility
IEEE 444	:	Protection standards for converters
IEEE 519	:	Harmonic control & reactive compensation of static power converters

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DIN 41488	:	Electrical engineering dimensions
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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) All VFDs shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The VFDs shall be suitable for operation in a highly polluted environment.
- b) All VFDs shall be suited for uninterrupted operation under the following variations in bus voltage and frequency:
 - i. Voltage Variation : +/-10%
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency
- c) The VFD shall be of modern design for similar applications in power plants. The system shall be commutated inverter type with minimum [six] pulse design, [IGBT based] and PWM controlled or better control system.
- d) VFD shall consist of Input section (rectifier and filter), control section and output section (PWM module, base drive circuits).
- e) VFD shall include an input filter for limitation of the harmonic current. General requirements of VFD shall conform to IEC 61800-2 and IEEE-519.
- f) VFD shall follow EMC directives as specified in IEC-61000.
- g) VFD model shall be suitably selected based on actual cable length from VFD to motor terminals. Shielded cables suitable for VFD applications shall be provided by the bidder.
- h) For [12 pulse] VFD, required 3 winding transformer and necessary cabling shall be provided by the bidder.
- i) Bidder shall provide inverter duty motor to withstand voltage stresses produced by PWM action

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1.3.1 Performance requirements:

- a) The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise.
- b) The system shall be suitable for the load characteristics and the operational duty of the driven equipment.
- c) The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment:
 - i. Variable torque changing as a function of speed i.e. speed squared.
 - ii. Constant torque over a specific speed range.
 - iii. Constant power over a specific speed range where the torque decreases when speed increases.
- d) The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The system shall be designed for linear continuous speed control from [10% to 100%] of driven equipment's rated speed and shall be of a modern proven design.
- e) The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800-4 and it shall be considered in the design of the motor.
- f) Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 115% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than one minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- g) During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit up to 60 seconds.
- h) The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- i) The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95 % of the minimum operational speed for more than 10 seconds.
- j) Maximum noise level of motor shall be measured as per relevant IS standard.

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- k) Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and troubleshooting/ maintenance.
- l) Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

The drive system shall ensure following:

- i. VFD induced torque pulsation are limited to maximum 1% (even at low speed) so there is minimal stress to the equipment
- ii. Motor is protected from dv/dt stresses.
- iii. No appreciable increase in motor audible noise.

1.3.2 Control requirement:

- a) The VFD and motor characteristics shall be suitable for load specific torque-speed characteristics.
- b) Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.
- c) The system shall also be equipped with a facility which shall restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart the converter shall be capable of synchronizing on to a rotating motor and develop full acceleration torque within 10 seconds.
- d) The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.
- e) The drive motor shall be speed controlled corresponding to 4-20 mA reference input signal unless otherwise specified upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed at the last speed reference available prior to the loss of signal.
- f) It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/manual selection shall be from VFD panel unless otherwise specified.
 - i. With the selector switch in "manual" mode, the operator shall be able to set the speed through keypad, mounted on front of the drive panel or from speed increase/decrease push buttons from the field. Motor operated potentiometer shall be provided as a speed set point device.
 - ii. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's DCS (Process Control) system. Necessary equipment required for interfacing with DCS shall also be provided in the drive panel.

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- g) The required provision for the interface with remote I/O (*as per requirement*) shall be through hardwired connection (with potential free contacts and transducers)
- h) Drive system shall have provision for interface with upper level automation such as electrical control system.
- i) The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.
- j) Bypass Feature
 - i. Bypass breaker / contactor-HRC fuse complete with protection, annunciation and metering shall be provided.
 - ii. All Variable frequency drives (VFD) having bypass feature shall have motor protection relay along with necessary control and metering etc. Switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended by opening its isolation devices.
 - iii. Safety interlock between inverter and bypass breaker/contactors shall be provided such that closing of healthy device is inhibited in case of external fault.

1.4 Specific Requirements

1.4.1 Constructional Requirements

- a) Panel Construction
 - i. The panel shall include suitable semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors (if required), filters (if required), control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of integrated standards.
 - ii. Upstream breaker include suitable semi conducting power devices (Diodes / IGBT) modules will be provided on the front door.
 - iii. Safety Interlock shall be provided so that power cabinet cannot be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.
 - iv. The drive shall be suitably housed in sheet steel panels fabricated with 2 mm thick cold rolled sheet steel. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. The maximum and minimum operating height shall be 1800 mm and 400 mm respectively.

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- v. Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600 mm clear from bottom of the cable gland plate.
- vi. Bus bars shall be of electrolytic copper, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.
- vii. All the switches component and accessories which are essential for normal and emergency operation shall be mounted on the door and shall be operable externally. Digital meters shall be preferred. Analogue instruments, where provided, shall be switchboard type, back connected, 72x72mm. Scale shall have red mark indicating maximum permissible operating rating.
- viii. All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- ix. All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with PVC insulated, fire retardant, copper conductor wire. 1.5 mm² size wire shall be used for control circuits, 2.5 sq.mm for CT/PT circuits and 0.75 mm² for electronic circuits. The control fuse rating is 10 Amps or less and 2.5mm² size for control fuse rating above 16A for electrical circuits and 0.7 mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered. Minimum 20% spare terminals shall be provided.
- x. All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipment and power electronic equipments shall be used.
- xi. All low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.
- xii. DC link capacitor and pre charging and discharging circuit shall be preferably mounted in the rear of the panel. Suitable removable type hooks shall be provided for lifting the panel.
- xiii. Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- xiv. All equipment shall be complete with double compression glands, lugs etc.

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b) Cooling

- i. The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Bidder shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N + 1) shall be provided.
- ii. Necessary starters shall be provided within the VFD panels for the ventilation fans, any other auxiliary motor etc.
- iii. The system provided shall be interfaced with drive starting and shut down such that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., shall be incorporated in the overall sequence logic.
- iv. MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easily accessible location.

1.4.2 Motor

The motor shall be designed, constructed and tested in accordance with the Specification for high Voltage Induction / Synchronous Motor, in addition to the following requirements:

- a) The motor shall be suitable for VFD control.
- b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- c) The motor shall be designed to operate continuously at any speed in the operating range for the driven equipment (ie; ID fan / Coal feeder).
- d) The permitted voltage variation shall take into account the voltage drop across the AC drive and all other system components upstream the motor.
- e) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications.
- f) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- g) The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4.

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- h) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

1.4.3 Static Power Converter

- a) The static power converter shall consist of a line side converter for operation as a rectifier and a load side power converter for operation as a fully controller inverter. Power converter shall be fast switching, most efficient and low loss type.
- b) The converter shall be co-ordinated with the transformers. The converter shall be able to withstand a three phase short circuit current until interrupted by normal breaker operation.
- c) Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- d) All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- e) The current rating of the converters semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range. If the parallel connection of semi conductor is applied, the above current rating shall not be less than 140% of the above values.
- f) All power diodes shall be of silicon type with minimum V_{BO} rating at 2.5 times the rated operating voltage.
- g) The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise nor reducing its service factor due to harmonic currents generated by the inverter operation.
- h) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions / tools.
- i) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

1.4.4 Converter Transformer

- a) The converter transformer, if provided, shall be copper wound dry type. Insulation class of dry type transformer shall be H with temperature rise of body limited to 75°C. Dry type transformer shall preferably be mounted inside the drive system panel. The impedances of converter input transformers with more than one secondary winding for minimum 18 pulse systems shall be selected to ensure equal load / current sharing

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between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

- b) The transformation ratio, impedances, taps and secondary voltage shall be chosen by the drive vendor to optimize system performance.

1.4.5 DC link reactor

- a) Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- b) Unless otherwise specified, the reactor shall be dry type, air cored, air-cooled or fan cooled type located within the panel.
- c) Reactor shall be suitable for withstanding earth fault continuously and for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.
- d) Noise level shall not exceed value specified in NEMA TR-1

1.4.6 Output filter

- a) VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance free and self-healing type.
- b) The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

1.4.7 Protection, Control, Metering, Indication and Annunciation

- a) The Bidder shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

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- b) Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.
- c) Protective Relays:
For details on protective relays used, refer to Technical Specifications on MV Switchgear
- d) Operator Control Panel
- i. Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to start/Stop, Local/Remote, auto/manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
 - ii. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
 - iii. Operator console shall have facility /port to connect external hardware such as Lap-Top etc. Console shall have facility for upload and download of all parameter settings from one drive to another identical drive for start up and operation.
 - iv. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing up stream breaker after all required process parameters are achieved.

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- v. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.
 - vi. Suitable interface with DCS to be provided for control and status signals of VFD.
- e) Local Motor Control Station
- i. The local motor control station shall be installed near the motor. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
 - ii. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current.
 - iii. Requirement of controls and indications required in the Local Control Station shall be as specified in the data sheet.
- f) Protective Features:
- The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:
- i. Incoming line surge protection
 - ii. Under / Over voltage protection
 - iii. Phase loss, phase reversal protection.
 - iv. Programmable Over current protection and under load protection.
 - v. Motor differential protection for motor rated above 1000 kW
 - vi. Inverter Fault.
 - vii. Over frequency operation.
 - viii. Ventilation loss,
 - ix. Over temperature of equipment.
 - x. Over speed of motor.

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- xi. Specific motor protection, including motor winding, bearing temperatures, over-current, overload, negative phase sequence, locked rotor and earth fault protections etc.
- xii. System Earth fault protection.
- xiii. Excitation system protection for synchronous motor
- xiv. Over and under frequency, rotor earth fault, field failure protection for synchronous motor
- xv. Additional protection for drive system

g) Control features

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

- i. Start/Stop
- ii. Speed control (Raise/lower)
- iii. Forward/Reverse(if Specified)
- iv. Auto/Manual /test mode
- v. Local/remote
- vi. Emergency stop
- vii. Start/stop for by pass starter (where specified)
- viii. Trip-Remote Breaker
- ix. Excitation control system for synchronous motors
- x. Sequential switching of filters

h) Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- i. Input AC Current
- ii. Input AC voltage
- iii. Input AC frequency
- iv. Output voltage
- v. Output current VFD / Bypass
- vi. Output frequency
- vii. Motor thermal state

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- viii. Drive thermal state
- ix. Motor speed
- x. Motor energy meter
- xi. DC Link voltage
- xii. Hour Run
- xiii. Voltage and current meter for excitation system for synchronous motor.
- xiv. KVAR, power factor meter for synchronous motors
- xv. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

i) Indications

Bidder shall provide indications as required for normal operation and for easy maintenance, which shall not be limited to the following indications both at local and at plant DCS.

- i. Motor running
- ii. Motor stopped
- iii. VFD System Fault
- iv. System ready to start
- v. AC mains ON
- vi. Motor over speed
- vii. Rectifier output 'ON'
- viii. Motor zero speed
- ix. Remote breaker trip
- x. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e., door mounted keypad or through hardwired indicating lamps/LEDS.

Potential free contacts of items i- iv shall be wired separately for remote indications in DCS.

j) Audio-visual annunciations

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- i. The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter, output transformer etc.
- ii. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.
- iii. Audio-visual window annunciations shall be provided on the front of the panel All annunciations as required for normal and satisfactorily operation of the drive system shall be included as per Bidder standards. These annunciations can be part of operator console panel or separately mounted type.
- iv. Bidder shall include audio-visual alarm as required for normal operation and maintenance of the system but not be limited to the following,
 - Rectifier fuse failure
 - Main AC failure
 - Inverter fuse failure
 - Inverter overload
 - Inverter high temperature
 - Cooling system failure
 - Motor failed to start
 - Transformer failure
 - Excitation system failure for synchronous motor
 - Battery monitoring healthiness
 - Communication and measurement system un healthy
 - Motor temperature high
 - Harmonic filters monitoring
- i. Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminals of DCS I/O panels for remote alarm and monitoring.

k) Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available for a period of minimum 4 days (96 hours) after a shut down even though no supply

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would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

1.4.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle lamps (CFL) etc. shall operate on 240 volts single phase AC.

All control circuit shall operate at voltage of 110V AC or 220V DC.

Bidder shall include supply of all control transformers, protective devices, required accessories etc. and any other control supply voltage as required for the system.

1.4.9 Maintenance features

The controller design shall incorporate the following maintenance features:

- a) Modular construction
- b) All components shall be easily accessible.
- c) Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

1.4.10 Painting

- a) All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.
- b) After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be as per manufacturer's standard, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

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- c) All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

Final paint shade shall be light gray and dove gray 631 and 632 as per IS-5 for indoor and outdoor equipment respectively unless otherwise specified

1.5 Tests

The Routine and Type Tests to be performed on the drive system in the presence of the purchaser of consultant shall be as follows:

1.5.1 Type Tests

For each rating and type of VFD, the Bidder shall submit for Owner's approval, the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

All type tests shall be conducted as per relevant standards and test certificates of similar panels conducted within last 5 years shall be furnished.

1.5.2 Routine tests

- a) Visual Inspection
- b) It involves checking of the various equipments/components fault diagnostic unit, Wiring, Terminals, earthing ratings etc.in line with the approved drawings and visual inspection shall not be limited to the following:
- c) Insulation Test
- d) Light Load and Functional Test
- e) Load characteristics test
- f) Load duty test
- g) Checking of Auxiliary Devices
- h) Checking the properties of the control equipment

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- i) Checking the Protective Devices
- j) Checking of control and functional requirements
- k) High voltage test
- l) Leakage and pressure test for cooling water system where provided
- m) Shaft current/bearing insulation
- n) Automatic restart/re-acceleration

Additional tests on switchgears and dry type transformers shall be carried out based on the requirement defined in the technical specification.

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data and Manuals

The engineering services scope and the documentation to be issued with the bid are described hereafter. The list shows the minimum requirements for the documentation, so that any additional documentation considered as necessary will be added to this.

- a) Engineering, manufacturing, delivering and test schedule
- b) Sub-Supplier lists.
- c) General arrangement drawings(plan, elevation, section view) with dimensions
- d) Foundation drawing including loading data.

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- e) Technical Data sheets.
- f) Electrical and control wiring diagram.
- g) Terminal arrangement drawing, interconnection wiring diagram.
- h) Cross sectional drawing.
- i) Inspection and test plan.
- j) Manufacturing Quality Plan.

1.7 Ratings and requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table 2.0

Sl. No	Technical Parameters		
		6.6 kV	415 V
1	Manufacturer Name	[By Bidder]	[By Bidder]
2	Model No.	[By Bidder]	[By Bidder]
3	Application		
4	Quantity		
5	Enclosure Protection Rating	IP-31	IP-31
6	Output Current Rating at ambient temperature	[as per requirement]	[as per requirement]
7	% derating considered for specific ambient	As per IEC	As per IEC
8	Rated Voltage (volts) Input	6.6 kV AC ± 10%, 3-phase	415 V ± 10%, 3-phase

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Sl. No	Technical Parameters		
		6.6 kV	415 V
9	Output Frequency Range (Hz)	[By Bidder]	[By Bidder]
10	Number of Phases and Frequency (Hz)	3 Phase, 50 Hz (+ 3% to -5%)	3 Phase, 50 Hz (+ 3% to -5%)
11	Rectifier type & Design	[6/12/18 Pulse Diode Bridge]	[6/12/18 Pulse Diode Bridge]
12	Inverter type & Design	[as per requirement]	[as per requirement]
13	Min/Recommended / Max switching frequencies (kHz)	[as per requirement]	[as per requirement]
14	Filters	[as per requirement]	[as per requirement]
	Line Side	[as per requirement]	[as per requirement]
	Load Side	[as per requirement]	[as per requirement]
15	Output Modulation Method	PWM	PWM
16	Speed Accuracy (+/- %)	[as per requirement]	[as per requirement]
17	Response time (speed)	< 5ms with nominal Torque	< 5ms with nominal Torque
18	Response time (Torque)	[By Bidder]	[By Bidder]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
19	Type of cooling	[Natural/forced/water] cooled	[Natural/forced/water] cooled
20	Whether VFD is suitable for outdoor installation	No	No
21	Drive Control Capabilities		
	Start/Stop Push button	ON/Speed Increase/Speed decrease From DCS	ON/Speed Increase/Speed decrease From DCS
	Modbus control	Yes	Yes
22	Load parameters at rated voltage & frequency		
	Output Frequency (Hz)	[0 to ± 120Hz]	[0 to ± 120Hz]
	Full Load current (Amp)	[By Bidder]	[By Bidder]
	VFD Heat dissipation (w)	[By Bidder]	[By Bidder]
23	VFD Efficiency		
	At Full rated Torque	[Approx 98% (Only drive)]	[Approx 98% (Only drive)]
	At 75% of full load torque	[By Bidder]	[By Bidder]
	At 50% of full load torque	[By Bidder]	[By Bidder]
24	Drive Power factor range		
	At rated speed, Torque	[≥ 0.98 (Fundamental)]	[≥ 0.98 (Fundamental)]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
25	DC Voltage	[1.35 times of supply voltage]	[1.35 times of supply voltage]
26	Fundamental power factor	≥ 0.98(At nominal Load)	≥ 0.98(At nominal Load)
27	Switching Frequency	[By Bidder]	[By Bidder]
	Drive Dimensions	[By Bidder]	[By Bidder]
	Length	[By Bidder]	[By Bidder]
	Height	[By Bidder]	[By Bidder]
	Depth	[By Bidder]	[By Bidder]
	Weight	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-C
DETAILED TECHNICAL SPECIFICATION-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Contract Document For R&M of Unit No.[..] of [Name of the Power Plant]	[Logo of Utility]
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1 CONTROL & INSTRUMENTATION

1.1 General

This specification is intended to provide the technical guidelines for the fully coordinated Control & Instrumentation (C & I) system for the Steam Generators and its Auxiliaries of *[210/215/220/250]* MW, Coal fired Subcritical Thermal Power Plant. DCS & other common systems/items procured under TG package shall be deleted from SG package.

The Control and Instrumentation system for the plant shall be designed to ensure safe, efficient and reliable operation of the plant under all regimes of operation namely start up, shutdown, normal operation, part load operation and under emergency conditions resulting in cost effective power generation with optimum fuel consumption and reduced emission levels.

The technical specification shall serve as the guide specification for the proprietary controls like Boiler & its integral control, Burner Management System, Furnace Protection System including Master Fuel Trip (MFT), Safety Shutdown System, etc equipment packages, as also various stand alone system controls included as part of sub-packages, as in case of plant auxiliaries. It is not the intent or purpose of this specification to give details of every single item that might be required for completeness and/or proper integration of the overall system.

It is to be noted that where equipment or system for the Steam Generating Units are described, it shall be understood that the quantities described are per unit basis, i.e., identical sets to be furnished for each of the units. Where equipment or systems for common facilities are described, it shall be understood that the quantities described are the total quantities required.

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2**SYSTEM DESCRIPTION**

The plant C&I system is envisaged to be configured by interfacing main plant control system for Station C&I namely Plant DCS interfaced with SG Integral control system (Separate Control system or implemented in DCS) and provided with different special plant monitoring and analysis systems to provide supervisory and reporting facilities to plant personnel and management.

The plant C&I system is envisaged to permit centralized operation and monitoring of the power plant from the central control room (CCR). The system shall consist of a functionally distributed microprocessor based system (DCS) with facility for VDU (Video Display Unit) / Keyboard & Large Video Screen based operation, control and monitoring.

SG Integral control system shall include Burner Management System (BMS) & Boiler protection system and could be an independent microprocessor based control system. BMS & Boiler Protection system shall be a fail-safe type system conforming to SIL 3 with certification from authorized agency.

SG Integral Control system (For BMS & Boiler protection system) shall be interfaced with Plant DCS through redundant bi-directional OPC link with Ethernet based TCP-I/P protocol or by only Ethernet based TCP-I/P protocol.

The plant C&I system is envisaged to be configured by interfacing main plant control system namely Plant DCS interfaced with other different plant control systems namely, TG Integral control system and other utility and auxiliary plant control systems (unit specific and plant common systems) and provided with different special plant monitoring and analysis systems to provide supervisory and reporting facilities to plant personnel and management.

The control requirements of the main power plant comprising SG with associated auxiliaries (except for SG Integral control systems) to be implemented in microprocessor based Distributed Control system.

Following PLC based systems shall be interfaced with plant DCS through redundant unidirectional OPC link with Ethernet based TCP-I/P protocol.

- ESP Control System
- Auxiliary Boiler Control System (if applicable)

CCR operation / monitoring of equipment/systems under SG Integral control systems shall be through plant DCS system OS /LCD.

A common time synchronization system is envisaged for time synchronizing of all programmable control systems like SG Integral control system, TG Integral Control System plant DCS, PLC control systems etc. for the whole station.

Operation and Monitoring of Plant Electrical 11 kV, 6.6 kV and Downstream System shall be performed through Plant DCS. Additionally, DCS shall have a redundant Software link with Substation Automation System (SAS) for monitoring of 400 KV & 220 KV switchyard systems. Switch yard system equipments shall be primarily operated from CCR (Operator stations shall be

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provided in CCR by extending the SAS bus) and control/monitored from SAS in Switchyard. For SOE inputs hardwired signals shall be connected to Plant DCS.

3 DESIGN PHILOSOPHY

This section covers the design philosophy which shall be used for all control & instrumentation system for steam generator & its auxiliaries.

1. Pressure indicators shall be used wherever indicating type Pressure transmitters are not envisaged. The applications include:
 - a) Suction and discharge lines of pumps & fans, including header section, if two or more pumps are employed for the same service.
 - b) All input and output lines of process equipments.
 - c) Inlets and outlets of heat exchangers (both the fluid media) and de-super heaters.
2. Pressure Switches shall be avoided as far as possible and in place, smart pressure transmitters with soft limit value monitoring in Plant DCS shall be used. The applications shall include the following:
 - a) On all process lines / Equipments where parameter abnormality / status including pre trips alarms to be communicated to the operator in control room.
 - b) For all permissive and protection conditions governed by safety operation of the equipments. e.g. pressure adequate, pressure very high / very low conditions.
 - c) For all interlock conditions, governing starting of standby equipment or subsequent equipments for safety operation of the system.
 - d) Inlet and outlet of filters / strainers.
3. Differential Pressure Switches (indicating type) shall be used across filters/strainers for remote monitoring.
4. Smart Pressure Transmitter shall be used for all control applications and as demand by the process. Pressure stubs with isolating valves shall be used.
5. Differential Pressure Transmitter shall be used for all the requirements of differential pressure, flow, level measurement. Pressure stubs with isolating valves shall be used.
6. Temperature indicators (Thermometers) shall be used for following applications
 - a) On all process lines where local indication is warranted by the system either for monitoring or testing.
 - b) On the inlet/outlet of equipments such as desuper-heaters, Heat Exchangers & Coolers for both the fluid media.
 - c) Differential temperature indicator shall be used across BFP suction and discharge service.

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7. Temperature Elements: Thermocouples / RTDs shall be used for casing metal temperature monitoring and bearing temperature monitoring of HT drives/motors.
- The elements shall be duplex type with integral thermowell (except for metal thermocouples). K Type Thermocouples shall be used for all temperature measurements wherever possible. However, for high temperature flue gas services R or S type thermocouple shall be used. For metal thermocouples suitable MS pads, clamps, flexible extension lengths etc. shall be used. Temperature elements in boiler and air ducts shall be used with protective tubes. Both the elements of duplex temperature sensors shall be brought to junction boxes.
 - Compensating cable shall be used with all thermocouples for terminating to the control system eg. Plant DCS.
 - Six nos. (2 nos. per phase) Resistance temperature detectors (RTD's) shall be used for all HT motors, for winding temperature monitoring. Each element shall be 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Plant DCS system.
 - 1 no. duplex PRT-100 type RTD shall be used for each bearing of HT equipment and its driving equipment (motor).
 - All RTDs shall be PRT-100 type with each element being 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Plant DCS system.
 - For process temperature up to 200 degree C, RTD shall be used. Beyond 200 °C temperature thermocouple to be used.
 - Temperature measurement shall have upscale / down scale protection features not to cause major process upset in case of sensor failure.
8. Level gauges shall be used on all tanks and the maximum length of one gauge glass shall not exceed 1 meter. The gauge glasses shall be stacked to cover the complete height of the tanks including over flow level. There shall be an overlap of minimum 100mm, when more than one level gauge is required.
9. Level switches: The instrument shall be used for the following applications:
- On all equipments (storage vessel) where parameter abnormality/status has to be communicated to the operator in the control room.
 - All permissive, interlock and protection conditions governed by the safe operation of the equipment.
 - The instrument shall be external cage type with SW connection with isolation facility for surface mounted tanks and top mounted with still pipe for all sumps. Still pipes shall be used with adequate supports.
 - Conductivity type level switches shall be used for all heaters and drain pots.
 - Radar type level switches shall be used for bulk material bunkers.

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10. Level Transmitters Stubs with impulse pipes, root valves for mounting Level transmitters shall be used on process equipments where continuous remote monitoring and/or control of level is envisaged. Wherever necessary standpipes or float chambers and also makeup line shall be used for filling up the constant level vessel.
- a) The instrument shall be differential pressure type for boiler drum etc.
 - b) Radar type level transmitter shall be used for fuel oil storage tanks.
 - c) Admittance or Radar type shall be for sludge and slurry applications.
11. Flow Glasses shall be used at the outlet of the pipe lines and shall be employed under the following conditions:
- a) Coolers
 - b) The instrument shall be rotary type with glass mounted for indication
 - c) Up to 6 inch on-line flow glasses shall be supplied and above 6 inch bypass type flow glasses shall be used. Sight flow and variable flow indicators shall be used for low pressure and low temperature applications.
12. Speed Measurement shall be used, where variable speed drives are controlled from remote (e.g. feeders, ID fans etc). All speed sensors shall be non-contact type. All speed transmitters shall be microprocessor based. Microprocessor based speed switches shall be used for zero speed detection, chain cut detection, locked rotor protection etc. Microprocessor based reverse rotation switch shall be used for pump protections.
13. Pneumatically Operated Control Valves shall be used for all control application. If the process demands any other control, then control valves shall be used for those applications also. Where a single control valve cannot meet the turn down ratio as dictated by the process, control valves with split range application shall be used.
- a) All bypass valves of control valves shall be motor operated valves suitable for inching operation provided with position transmitters.
 - b) All integrated bypass valves shall be motor operated. Electro-pneumatic positioners shall be used for all pneumatic control valves.
 - c) Pressure test points & drains shall be used across each control valve
14. The pneumatically operated control valves shall be used with Smart Positioners, diagnostics and HART compatibility. Control Valve diagnostics shall be transmitted through this HART Protocol to Plant DCS.
15. Solenoid Valves shall be used for all pneumatic control valves hooked up with process interlock requirements and where direct tripping is involved. All solenoid valves shall be uniformly rated for 24V DC or 220V DC. The number of ways for solenoid valve shall be used as indicated below :

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- a) On line two (2) way solenoid valves shall be used, where process line of less than 2 inch with low pressure & temperature application is involved.
 - b) Three (3) way solenoid valves shall be used commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder. E.g.: Pneumatic operated spray water block valve.
 - c) Four (4) way solenoid valve shall be used for operating double acting cylinders (If applicable). E.g.: Pneumatically operated on-off type dampers.
 - d) Dual coil, latch, unlatch type Solenoid valves shall be supplied for equipment trips/critical applications.
 - e) Five port solenoid valves shall be used for pneumatic retract/insert mechanism power cylinders for Oil gun, ignition gun etc.
- 16.Position Transmitters shall be used for all motorized inching valves. Position transmitters shall be 24 V DC, 2 wire, non-contact type.
- 17.Electro-Pneumatic positioners shall be used for all pneumatically operated control valves, power cylinders etc., for converting controller output of 4-20 mA to appropriate pneumatic signal.
- 18.Air Filter Regulators along with gauges shall be used in each of the:
- a) Air supply line to valve positioners /power cylinders
 - b) Air supply line to pneumatic interlocked block valves
- 19.Interposing relay (To be mounted in Control room cabinet) for interface to the following:
- a) Solenoid valve (if output module cannot directly drive SOV) - Relays with contact rating of minimum 2 Amps.
 - b) DC Starter ((if output module cannot directly drive) - Relays with contact rating of minimum 0.2 Amps.
 - c) Hardwired signal exchange – as required.
- 20.For all HT rotating equipment bearings provision for mounting vibration probes shall be used.
- 21.Junction Boxes/Field termination cabinet: All JBs /FTCs shall be SS. Junction Boxes shall be used for:
- a) Termination of all sensors located equipment wise.
 - b) Termination of Duplex Thermocouples / RTDS
 - c) Termination of limit switch, torque switch, position transmitter and control demand, independently for each valve.
 - d) Area wise or Elevation wise bunching of cables.
- 22.Instrumentation & control cables and Prefabricated Cables with Anti-Rodent treatment shall be used to:

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- a) Connect field instruments to field junction boxes/Local Panels. For switches, both the SPDT contacts of switches shall be wired up to the J.B.
 - b) Connect limit switches, torque switches and position transmitters to their respective field junction boxes.
 - c) Compensating cable shall be supplied for connection between the element and the respective junction boxes / system cabinets as per guidelines.
 - d) Prefabricated cable for connecting between system cabinets, marshalling cabinet to system cabinet, system cabinet to Relay Rack, system cabinets to engineering work stations etc.
 - e) Entire I&C cable within the battery limits.
23. All field instruments including electronics located outside control room areas shall be tropicalized and shall be designed to work in site specific atmosphere/climatic conditions and enclosed in dust tight, waterproof and weatherproof enclosures. In general, transmitters and switches installed at outdoor location shall be mounted in closed type transmitter enclosure. For other areas (indoor), open type racks may be used for installation of transmitters and process switches.
24. Conventional hardwired alarm annunciation system has not been envisaged. All alarm shall be displayed in the Plant DCS HMI/LVS. However where local panels are used for local operation/monitoring, PLC/ DCS driven alarm annunciation system with LED type lamps for local panel shall be used.
25. Pressure, temperature and flow test points shall be used in line with latest performance test code requirements.
- In general, pressure and temperature test points shall be used for the following services:
- a) At the discharge of all pumps and fans
 - b) At the inlet and outlet of the heat exchangers for the fluid media involved
 - c) Adequate number at the Combustor at different zones
 - d) At the inlet and outlet of each control valve
26. The ranges of the instruments shall be selected based on the following philosophy:
- a) For pressure and draft measurements, the maximum operating pressure shall be within 70 to 80% of the maximum scale range.
 - b) For temperature measurement, the maximum operating temperature shall be within 80 to 90% of the maximum scale range.
 - c) For pressure switches and temperature switches, the set points shall fall within 40% to 70% of the scale range selected.
 - d) For level measurement, the maximum of the range shall cover the overflow point or six inches from the top of the vessel and the minimum of the range

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shall be six inches above the bottom of the vessel. Also, the gauge glasses shall be stacked with overlap to cover permissive, alarm and trip levels.

- e) For flow measurement, the maximum range shall be fixed at about 10 to 15% above the maximum operating flow
 - f) For electro-chemical measurements (conductivity, pH, dissolved O₂, Silica etc.), the maximum range shall be around 10 to 15% higher than the recommended alarm settings.
 - g) For gas analyzers, the maximum range shall be around 10 to 15% higher than the recommended alarm settings.
27. Individual (one for each transmitter) purging line connected to the impulse line before the root valve with required accessories shall be used for all Air and Flue gas transmitters impulse lines.
28. Spring-loaded/ Cage clamp type terminals shall be used for termination of instrumentation cables at field JBs, FTCs and local panels.
29. Signal Exchange Between Boiler Equipments / System and Plant DCS System
- a) All the signals required for interlock / alarm / SER purpose (to be Implemented in the Plant DCS) shall be hardwired.
 - b) All binary outputs provided to local panels/sensors for connection from Plant DCS shall be potential free contacts with a rating of 0.2 amps at 220 V DC or 2 amps at 24 V DC or 5 amps at 240 V AC. All check backs to Plant DCS shall only be potential free contacts.
 - c) All analog outputs provided to local panels/sensors for connection from Plant DCS shall be isolated 4-20 mA DC.
 - d) Command outputs from Plant DCS to motorized valve actuator shall be logic level signal (24 V DC) and necessary interposing relays suitable to accept 24 V DC logic level command signal shall be used in MCC module for MOV actuator.
 - e) Push buttons station/panel for safe emergency shutdown of the plant shall be provided.
30. Flow elements for measurements of secondary airflow to the furnace & Primary air flow to Pulverizer shall be used along with 3 (three) tapping's for measurement & Control and one tapping for test purpose.
31. Airflow shall be measured by aerofoil or venturi or by any special online measurement technique with high accuracy (typically better than + /- 2%).
32. All indication lamps shall be LED type.
33. All interposing relays shall be Plug in type with screw type base & LED for status indication. Relay modules/boards etc. are not acceptable.
34. All Limit Switch shall be Non-Contact type. If there is constraints because of process conditions/space, mechanical lever actuated Limit switch may be used.

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4 DESIGN CRITERIA

This section covers the general design criteria to be adopted in designing the Control & Instrumentation system for the SG Package.

4.1 General Requirements

Ambient Conditions

Instruments, devices and equipment for location in outdoor / indoor / air-conditioned areas shall be designed to suit the environmental conditions indicated below and shall be suitable for continuous operation in the operating environment of a coal fired Power plant and also during periods of air conditioning failure without any loss of function, or departure from the specification requirements covered under this specification.

Table 4.1
Protection Class Requirement

Ambient Temperature (outside temperature)	Pressure	Relative Humidity	Atmosphere	Required Protection class of panels / cabinets / desks
Outdoor Location				
55 °C max	Atmosphere	100%Max	Air (dirty)	IP 65
4 °C min	Atmosphere	5% Min	Air (dirty)	IP 65
Indoor Location				
55 °C max	Atmosphere	95% Max	Air	IP 54
4 °C min.	Atmosphere	5% Min	Air	IP 54
Air-conditioned Area				
24 +/- 2 °C normal	Atmosphere	95% Max	Air	IP 44
50 °C Max.	Atmosphere	5 % Min	Air	IP 44
a) For Ventilated enclosures, protection class shall be IP 42. b) For hazardous areas the protection class shall be in accordance with the requirements of the relevant NEC code for the location. c) For PCs, OWS, EWS, Servers, Printers and other peripherals, maximum temperature limit shall be 35 °C, For LVS the same shall be 25 °C & for UPS the same shall be 40 °C				

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4.2 Codes & Standards

All equipment, system and service covered under this specification shall comply with the requirements of the latest statutes regulations and safety codes as applicable in the locality where the equipment/systems shall be installed.

The equipment, systems and services furnished as per this specification shall conform to the latest edition of codes and standards mentioned in this section. However in the event of any conflict between the requirements of two standards or between the requirements of any standard and this specification, the more stringent requirements shall apply unless confirmed otherwise by the owner/owner's engineer in writing. The decision of the owner shall be final & binding in all such cases.

All equipments supplied under this specification shall be given tropical treatment for the climatic conditions prevailing at site as described under project data. Tropical protection shall conform to IS-3202 (Climate proofing of electrical equipments) or any other applicable international standard for protection of Electrical power equipments against climatic conditions.

Reference Codes and Standards

The design, manufacture, inspection, testing, site calibration and installation of all equipment and systems covered under this specification shall conform to the latest editions of codes and standards mentioned below and all other applicable ANSI, ASME, IEEE, NEC, NEMA, ISA, DIN, VDE and Indian Standards and their equivalents.

Temperature Measurement

- Instrument and apparatus for temperature measurement ASME PTC 19.3
- Temperature measurement - Thermocouples ANSI-MC 96.1
- Temperature measurement by electrical resistance thermometers – IS: 2806.
- Thermometer-element-platinum resistance-IS-2848 / DIN 43760/ IEC 751

Pressure Measurement

- Instrument and apparatus for pressure measurement - ASME PTC 19.2
- Bourdon tube pressure and vacuum gauges - IS 3624

Flow Measurement

- Instrument and apparatus for Flow measurement – ASME PTC 19.5 Interim supplement, Part-II
- Measurements of Fluid flow in closed conduit – BS 1042 / ISO 5167.

Electronic measuring Instruments & Control hardware

- Automatic null balancing electrical measuring instruments - ANSI C 39.4 (Rev.)
- Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5.

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- Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1.
- Dynamic response testing of process control instrumentation - ANSI MC 4.1: ISA-S26.
- Surge withstand capability (SWC) tests - ANSI C 37.90a IEEE Std. 472. IEC - 254.1.
- Printed circuit boards - IPC TM-650, IEC 326 C
- General requirements and tests for printed wiring boards - IS 7405 (Part-I)
- Edge socket connectors - IEC 130-11.
- Requirements and methods of testing of wire wrap terminations DIN 41611 Part-2.
- Dimensions of attachment plugs & receptacles ANSI C73.
- Direct acting Electrical Indicating Instruments: IS-1248.

Electronic Cards, Subassemblies & Components

1. Unpackaged
 - Vibration IEC 68.2.26
 - Shock IEC 68.2.27
 - Drop & Topple IEC 68.2.31
2. Packaged
 - Vibration, Drop & Static Compression – NSTA
3. Electromagnetic Compatibility
 - Electrical Fast Transient – IEC 801.4
 - Surge Withstand – IEC 255.4
 - Radiated Electromagnetic Field – IEC 801.3
 - Electrostatic Discharge – IEC 801.2
 - Electromagnetic Emissions – VDE 0871, Class B

Instrument Switches and Contacts

- Contact rating - AC services NEMA ICS Part-2 125, A600
- Contact rating - DC services NEMA ICS Part-2-125, N600.

Enclosures

- Types of enclosures - NEMA Std. ICS-6-110.15 through 110.22 (Type 4 to 13).
- Racks, panels, and associated equipment - EIA: RS-310-B (ANSI C83.9)

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- Protection Class for Enclosure, Cabinets, Control Panels and Desks - IS-13947, & IEC 529.

Apparatus, enclosures and installation practices in hazardous areas

- Classification of hazardous area - NFPA Art. 500, Vol.70.
- Electrical Instruments in hazardous dust locations - ISA-RP 12.11
- Intrinsically safe apparatus - NFPA Art.493 Vol.4.
- Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Art. 496.

Sampling System

- Stainless steel material of tubing and valves for sampling system - ASTM A269-82 Gr. TP316.
- Submerged helical coil heat exchangers for sample coolers ASTM D 11-92.
- Water and Steam in power cycle - ASME PTC 19.11.
- Standard methods of sampling system - ASTM D 1066-69.
- The system shall be based on established Standard & Codes of Practice, such as GDCD 234 / 164 / 163, CEGB, UK.

Annunciator

- Specifications and guides for the use of general purpose annunciator - ISA RP 19.1.
- Surge withstand capability tests - ANSI C.37.90a and IEEE std. 472

Interlocks, Protections

- Relays and relay system associated with electric power apparatus - IEEE std.3.13.
- Surges withstand capability tests - ANSI C.37.90a and IEEE Std. 472.
- General requirements & tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I).
- Boiler safety interlocks - NFPA Section 85B, 85D, 85E, 85F, 85G.

Control Valves

- Flow Equation for Sizing Control Valves – ISA S39.2
- Control Valve Seat Leakage – ANSI / FCI 70.2
- Face to face Dimensions of Control Valves – ANSI B16.10, ISA – S75.03 & ISA – S75.16
- Steel Pipe, Flanges & Flanged Fittings – ANSI B16.34
- Control Valve Capacity Test Procedure – ISA – S75.02

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- Industrial Process Control Valves - IEC 534

Process Connection and Piping

- Codes for pressure piping power piping ANSI B31.1
- Seamless carbon steel pipe ASTM A-106.
- Forged and Rolled Alloy steel pipe flanges, forged fittings, valves and parts - ASTM A-182.
- Material for socket welded fittings - ASTM A-105.
- Seamless Ferritic alloy steel pipe - ASTM A-335.
- Pipe fittings of wrought carbon steel and alloy steel - ASTM A-234.
- Composition bronze or metal castings - ASTM B-62.
- Seamless copper tube, bright annealed ASTM B-168.
- Seamless copper tube - ASTM B-75.
- Dimensions of fittings - ANSI B-16.11
- Valves flanged and butt welding ends - ANSI B16.34.
- Nomenclature for Instrument tube fittings ISA-RP-42.1.

Instrument Tubing

- Seamless carbon steel pipe - ASTM - A106.
- Material for socket welds fittings - ASTM - A105.
- Dimensions of fittings - ANSI B16.11
- Code for pressure piping, welding, hydrostatic testing - ANSI B31.1.
- Nomenclature for Instrument Tube Fittings – ISA RP 42.1
- Seamless Stainless Steel Tubes ASTM A 312 TP 304

Cables

- Thermocouple extension wires/cables - ANSI C 96.1.
- Colour coding of single or multi-pair cables - ICEA S-61- 402. (Third edition) NEMA WCS.
- Guide for design and installation of cable systems in power generating stations (insulation, jacket materials) - IEEE Std. 422.
- Requirements of vertical tray flame test - IEEE 383.
- Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B-33 - 81.
- Oxygen index and temperature index test - ASTM D-2863.
- Smoke generation test - ASTM D-2843 and ASTM E-662.

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- Acid gas generation test - IEC-754-1.
- Swedish chimney test - SEN - 4241475 (F3)
- Instrumentation cables and internal wiring IS-1554 (Part-I) and IS: 5831.
- Mono-mode Fibre – ITU-T G.652 for Optical Fibre Cable
- IEEE 1138 / IEC 1089 / EIA-455 B for Optical Fibre Cable

Cable Trays, Conduits

- Guide for the design and installation of cable systems in power generating station (cable trays, support systems, conduits) - IEEE Std. 422, NFPA-70.
- Guide for the design and installation of cable systems in power generating station (Cable trays, support systems, conduits) Test Standards, NEMA VE-1.
- Galvanizing of Carbon steel cable trays - ASTM A-386-78.

4.3 Power Supply

All instruments and control devices shall be designed to operate on power supplies as follows:

1. Electric:
 - a) 230 volts AC, 50 hertz, single-phase for low torque drives with guaranteed satisfactory operation when equipment is continuously energized at any voltage from 216VAC to 264VAC.
 - b) 24V DC for PLC & DCS.
 - c) 24 VDC, 110VAC or 230 VAC for Field Instruments.
2. Pneumatic:

Clean, dry, and oil free instrument air at 4.2 to 8.6 bars gauge. All necessary pressure reducing controls, where required, shall be furnished by the equipment supplier as specified at some other place under air compressors section.

4.4 Standard Ranges of Analog Signals

The ranges of analog signals shall normally be as follows:

- a) Electric -- 4 to 20 mA DC.
- b) Pneumatic -- 0.2 to 1.0 kg/cm².

The use of any signal range other than the above shall not be acceptable.

4.5 Contact Ratings

The ratings of all instrument contacts used for alarms and interlocks shall be as follows:

Table 4.2
Contact Ratings

Voltage Rating (volts)		Continuous Rating	Switching Rating (break)	
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a)	240 AC	480 volt-amperes	1200 volt-amperes
b)	220 DC	60 watts	200 watts
c)	24 DC	12 watts	25 watts

The ratings of all microprocessor-based controller or programmable controller output contacts shall be as required by the controlled devices. Where necessary for higher current ratings or isolation, interposing relays shall be used.

4.6

Reliability and Availability

1. Each component and system shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
2. Detailed reliability calculations shall be used for each system/ equipment (with the help of a schematic of various sub-system connected in series or in parallel as the case may be and MTBF & MTTR values for the various equipments). Availability calculation shall be as per IEEE Standard-P1046 or equivalent.
3. When more than one device uses the same measurement or control signal, the transmitter and other components/ module shall be fully equipped to provide all signal requirements. The system shall be arranged so that the failure of any monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.
4. To ensure availability, adequate redundancy in system design shall be used at hardware, software and sensor level to satisfy the availability criteria. For the protection system, independent sensing device shall be used to ensure adequate safety of plant equipment.

4.7

Standardization & Uniformity of Hardware

To ensure smooth and optimal maintenance, easy interchange ability efficient spare parts management of various C&I instruments, ensure that all instruments/devices (Processor modules, input/output modules, power supply modules etc.) are of the same family of hardware. For example, all 4-20 mA electronic transducers, control hardware, control valves, actuators instruments/ local devices etc. being furnished shall be boiler manufacturer specific. Take special care towards selection of SG Integral Control system.

4.8

Redundancy

1. Reliability of the Control System shall be established by judicious incorporation of redundancy. In general all critical parts shall have hot standby feature to render the system immune to any single failure.
2. Measurement system (MS), Closed Loop Control System (CLCS) and Open Loop Control System (OLCS) shall all be configured with redundancy at processor modules, communication modules, data bus and power supply modules.

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3. Both CLCS & OLCS shall be configured with I/O channels redundancy for each sensor/signals. Where redundant sensors are provided redundant I/O channels shall be used for each sensors/signals.
4. Two out of three measurements philosophy shall be adopted for the control of all closed and critical open loop variables for reliability of operation. The control system shall select the median value for the normal control purpose.

4.9 Operability & Maintainability

1. The design of the control systems and related equipments shall adhere to the principle of 'Fail Safe' operation wherever safety of personnel / plant equipment is involved. 'Fail Safe' operation signifies that the loss of signal or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips are avoided / minimized.
2. The types of failure which shall be taken into account for ensuring operability of the plant shall include but not be limited to:
 - a) Failure of sensor or transmitter,
 - b) Failure of main and/or redundant controller/other modules,
 - c) Loss of motive power to final control element,
 - d) Loss of control power.
 - e) Loss of instrument air
3. The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:
 - a) Standardization of parts.
 - b) Grouping of functions.
 - c) Interchangeability.
 - d) Malfunction identification facility/self surveillance facility.
 - e) Easy modular replacement.
 - f) Fool proof design providing proper identification and other features to preclude improper mounting and installation.
 - g) Appropriate derating of electronic components and parts.

4.10 Metering Bases of Units

The following system of units shall be followed throughout the specification unless otherwise mentioned.

Table 4.3
Metering Bases of Units

S.N	Parameter	Unit
1	Pressure	Kg/sq. cm
2	Differential pressure	mm of H2O column or Kg/sq. cm

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S.N	Parameter	Unit
3	Draught	mm of H ₂ O column
4	Vacuum	mm of Hg
5	Temperature	Degree Celsius
6	Flow (Steam / Feedwater)	Tonnes / hr or Kg/hr
7	Flow (Air / Gas)	Tonnes / hr or N. Cu. M /hr
8	Flow (Oil)	Tonnes / hr or Kg/hr
9	Density	gm / cu.cm
10	Level	mm or M
11	Conductivity	Micro-mho/cm

4.11

Grounding System

All panels, desks, cabinets shall be used with a continuous bare copper ground bus. The ground bus shall be bolted to the panel structure on bottom on both sides. The bolts shall face inside of panels.

The system ground shall be isolated from the panel ground with suitable isolators. All internal component grounds or common shall be connected to the system ground, which shall be fabricated of copper flat (size 25 mm x 6 mm min, length as applicable).

Shield on instrumentation cables shall be grounded on panel side. When shielding termination is required in cabinets furnished under this specification, suitable terminals shall be furnished on copper flat forming system ground. System and shield ground shall be connected to earthing strip at 0.0 meter level using suitable size of cable.

4.12

Flow Element Selection

Table 4.4
Flow Element Selection

Sl. No.	Type of Flow meter	Fluid medium	Process Parameter	Pipe sizes suitable for FE	Application	Type of connection
1	Orifice Plate	Water (DM Water)	As per process requirement	For all sizes Except very large diameter pipe	DM Water Flow To CST	Flange
2	Orifice Plate	Steam	For any condition	< 3"	Soot blowing steam flow	BW
3	Flow nozzle(Al Si Type316 L)	Water	As per process requirement	For all pipe sizes except very large diameter Pipe	(i) FW Flow to boiler drum (ii) SH/RH Spray water flow	BW

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4	Flow nozzle(AI SI Type316 L)	Steam	As per process requirement	For all pipe sizes except very large diameter Pipe	AUX. Steam flow	BW
5	Air foil	Air	As per process requirement	All duct sizes	(i) Primary air flow (ii)secondary air flow	BW BW
6	Any Other Services required.	Subject to Owner / Consultant's approval.				

4.13

Drive Control Philosophy

The Drive control & measurement philosophy for the project is detailed in this section.

1. Bi-directional drives (inching or open/close)
 - a) All bi-directional drives shall be operable from Remote i.e. from CCR.
 - b) Remote manual operation of all drives shall be carried out from OWS.
 - c) Remote Open/Close commands, generated in control system shall be issued to MCC module through interposing relays located in respective MCC module in the MCC room. Latching of commands shall be used in control system logic which shall be reset by Limit/Torque switch feedback. The Limit/Torque switch feedback from drive shall be directly wired to Control System.
 - d) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
 - e) Following signal exchange shall be envisaged between Drive & Control system:
 - Open Limit Switch (Both NO & NC contacts)
 - Close Limit Switch (Both NO & NC contacts)
 - Open Torque Actuation
 - Close Torque Actuation
 - Position feedback (4-20 mA, two wire electronic type) for inching drive
 - f) Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in/near MCC room):
 - Switchgear available
 - Switchgear disturbance
 - Open Command

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- Close Command

2. Unidirectional LT drives

- Unidirectional LT drives shall be operable only from Remote i.e. from CCR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
- Remote manual operation of all drives shall be carried out from OWS.
- Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays located in respective MCC modules.
- Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
- Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
- Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives greater than 90 KW. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules.
- Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in MCC room):
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Start Command
 - Stop Command
- All Numerical relays/Intelligent controllers for LT drives shall be interfaced to Control System through IEC 61850 protocol.

3. Solenoid Operated drives

- Solenoid operated drives shall be operable only from Remote i.e. from CCR.
- Remote manual operation of all drives shall be carried out from OWS.
- Remote Open/Close commands shall be generated in Control system & shall be issued to the Solenoid through interposing relays, located in Relay Panel.
- Necessary process interlocks shall be realized in Control system.

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e) Following signal exchange shall be envisaged between solenoid drive & Control system:

- Open Limit Position
- Close Limit Position
- Open Command
- Close Command

4.14 HT drives

1. HT drives shall be operable only from Remote i.e. from CCR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
2. Remote manual operation of all drives shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays located in respective MCC modules.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
5. Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
6. Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules
7. Following signal exchange shall be envisaged between MCC & Control system(Remote I/O cabinet of control system located in MCC room):
 - a) Switchgear available
 - b) Switchgear disturbance
 - c) Master Trip relay Operated
 - d) On Feedback
 - e) Off Feedback
 - f) Trip Feedback
 - g) Emergency stop feedback
 - h) Start Command
 - i) Stop Command
 - j) Current Feedback

8. All Numerical relays/Intelligent Controllers for HT drives shall be interfaced to Control System through IEC 61850 protocol.

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4.15 Variable Frequency Drives (VFD)

1. VFD shall be operable from Remote i.e. from CCR & from VFD Local Display unit. In addition, Local pushbutton shall be used only for emergency stopping of drive.
2. Remote manual operation of VFD shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to VFD Panel through interposing relays located in VFD Panel.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided in the field. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to VFD panel.
5. Necessary Electrical protections shall be realized at VFD module whereas process interlocks & protections shall be realized in Control system.
6. Following signal exchange shall be envisaged between VFD & Control system:
 - a) Switchgear available
 - b) Switchgear disturbance
 - c) On Feedback
 - d) Off Feedback
 - e) Trip Feedback
 - f) Emergency stop feedback
 - g) Start Command
 - h) Stop Command
 - i) Current Feedback
 - j) Speed feedback
 - k) Speed Setpoint
7. The VFD shall also be interfaced with control system via Modbus soft link.

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5 SG INTEGRAL CONTROL SYSTEM

The microprocessor based Control System shall be used for the safe and efficient operation of Steam Generator Protection in all regimes of operation. Implementation of all the control, monitoring, interlock and protection schemes for Steam Generator integral control system which include MFT scheme, Flame monitoring system, Burner management system, Boiler/Furnace protection, Furnace Purging etc. PLC or DCS shall be offered to implement the SG integral control system. The SG integral system shall be interfaced with Plant DCS through redundant data highway.

For all the OLCS & CLCS for SG and auxiliaries like Coordinated Master control, furnace draft control, Super heater and Re-heater steam temperature control, fuel oil flow/ fuel oil pressure control, combustion air flow control, pulveriser coal/ air temperature control, primary air pressure control, Fans start stop interlocks, SADC, Soot blower control etc. Control schemes and logics & write ups shall be provided to the Plant DCS supplier for implementation within Plant DCS system.

5.1 Control System Requirements

1. The SG Integral control system shall consists of the following System controls:
 - a) Burner Management System (BMS) including SG Protection System, Furnace Purging & Master Fuel Trip (MFT)
 - b) Coal Mill & Feeder Control Logics
 - c) Furnace flame monitoring system
 - d) Furnace Flame viewing & analysis system
 - e) Auxiliary Steam System
2. All hardware / software, whether or not specifically indicated in this specification shall fully meet operational / maintenance / safety requirement as well as statutory / international standards and proven practices.
3. The Control System shall function reliably under the environmental conditions as specified in Design Criteria/Philosophy of this specification. It shall be immune from the interference resulting from disturbance in power supply feeders, signal lines, inputs, outputs, etc. as experienced in a Power station.
4. The Control System shall have on-line simulation and testing facility. Further, it shall be possible to on-line configure and tune controllers through engineering workstation.
5. The system shall have the flexibility to easily reconfigure any controller at any time without requiring additional hardware or system wiring changes and without disabling other devices from their normal operation mode. Modifications shall not require switching off power to any part of the system.
6. Power supply to individual functional group shall be from redundant 24 V DC feeders with diode auctioneering and further sub-distribution.

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7. Independent and dedicated controllers (main and its 100% standby) shall be used for each of the System except for SG protection system where triple redundant controllers are to be used as per this specification. All the 100% hot / redundant backup controllers shall be identical in hardware and software implementation to their corresponding main controllers and shall be able to perform all its tasks. The backup controller shall track its corresponding main controller. There shall be an automatic and bumpless switchover from the main controller to its corresponding backup controller in case of main controller failure and vice versa without resulting in any change in control status. In case of switchover from main controller to the 100% hot backup controller, the back-up controller shall work as the main controller. Facility shall also be provided for manual switchover from main to 100% hot back-up controller and vice versa from the Engineer's Work Station.
8. The control system hardware design shall be such that it is able to withstand power line disturbances.
9. The loop / logic reaction time shall be suitable to match actual process requirements, subject to minimum requirement wherever specified.
10. The control system design shall ensure compliance of furnace safety related loop and logic in CLCS & OLCS as per NFPA requirements.

5.1.1 Burner Management System (BMS)

1. Fully proven microprocessor based system, based on hardware and software specially designed and proven for Burner Management application meeting the proven-ness criteria shall be used to achieve the Boiler protection action e.g. Master Fuel Trip (MFT), etc.
2. The BMS shall be used with automatic self-monitoring facility. All modules to be used in this system shall be of failsafe design. Any single fault either in primary sensor, I/O modules, multifunction controllers etc shall not result in loss of safety function. All faults shall be annunciated to the operator right at the time of its occurrence in the OWS.
3. Triple modular redundancy philosophy (TMR) hardware and software shall be used for safety tripping of the Boiler. The system shall be fail safe type with minimum Safety integrity Level 3 as defined in IEC 61508.
4. The MFT functions shall be implemented in a fault tolerant 2 out of 3 triple redundant configuration. Each of the three independent channels shall have its own dedicated processors, multifunction controllers, communication controllers, I/O modules, interface etc. All the primary sensors/instruments for unit / boiler protection shall be triple redundant. Signal for each trip input shall be time stamped with 1ms resolution for SOE at the input level itself, without any processing so as to enable analysis in sequence of event, the exact cause of trip.
5. The acquisition and conditioning of binary and analog protection criteria signals for MFT shall be carried out in each of the three triple redundant channels. Each channel shall compute the 2 out of 3 voting logic and issue a trip command. The

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trip signals of the three channels shall be fed to a failsafe 2 out of 3 relay tripping unit for each drive. The protection criteria for tripping shall be executed by a program which shall be identical in each of the triple redundant channel. The check back contact signals of each relay of the 2 out of 3 relay tripping unit shall be fed back to each of the triple redundant channels and shall be continuously monitored for equivalence in each of them. In case one of the independent channels or any of the triple redundant sensors is faulty, the same shall be alarmed and the balance two channels / sensors shall be operated in 1 out of 2 mode.

6. The BMS shall be designed to :

- a) Prevent any fuel firing unless a satisfactory purge sequence has first been completed.
- b) Prevent start-up of individual fuel firing equipment unless permissive interlocks have first been satisfied.
- c) Monitor and control proper equipment sequencing during its start-up and shutdown.
- d) Provide equipment status feedback and annunciator indication to the unit operator.
- e) Provide flame monitoring when fuel-firing equipment is in service and effect a burner trip or master fuel trip upon warranted firing conditions.
- f) Continually monitor boiler conditions and actuate a master fuel trip (MFT) during adverse operating conditions which could be hazardous to equipment and personnel.
- g) Reliably operate and minimize the number of false trips.
- h) Provide a master fuel trip relay independent of processors and I/O modules to provide a completely independent trip path.
- i) Provide all logic and safety interlocks in accordance with National Fire Protection Association (NFPA).
- j) Include a first out feature in all controllers to identify the cause of any burner trip or boiler trip.
- k) Provide a complete BMS diagnostic system for the operator to immediately identify any system module failure.
- l) Allow burners and igniters to be started, stopped and tripped on a burner basis.
- m) Allow the automatic start and stop of burners based on boiler load. The sequence of which burner shall be started or stopped shall be selected by the operator from OIU/LVS.

5.1.2 Secondary Air Damper Control System (SADC)

1. SADC system shall be used to achieve the following functions

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- a) Control of fuel air flow.
 - b) Control of auxiliary air flow at the oil elevations.
 - c) Control of wind box / furnace differential pressure.
 - d) Limit NO_x content in the flue gas by modulation over fire dampers, if provided
2. In case of tangentially fired boiler, SADC shall modulate fuel air dampers of each elevations based on the signal that is representative of the Coal feed rate. Further, the auxiliary air dampers at the oil elevations shall be modulated on fuel oil pressure signal whereas the auxiliary air dampers at all other elevations shall be modulated to maintain the wind box to furnace differential pressure.
 3. In order to limit the NO_x content in flue gas, SADC shall also include the control of over fire dampers (if provided). The secondary air damper controls and necessary interlocks to modulate or to open/close shall be incorporated as per the requirements of the boiler design in plant DCS.
 4. The secondary air damper control system shall also be provided even in case front or front and rear fired boiler.
 5. Individual position transmitters are to be provided for each of the secondary air dampers and the same shall be connected to Plant DCS.

5.1.3 Auxiliary Steam System

1. Auxiliary steam System shall be of integral type pressure reducing and de-superheating stations (PRDS) along with de-super heater getting spray water from Condensate Extraction Pump discharge.
2. The system shall consist of steam pressure control loop & steam temperature control loop. Auxiliary steam system shall be implemented through a set of redundant controller modules, I/O modules, redundant primary sensors etc. & suitably interface with other SG C&I controls and system shall have control provision from CCR.
3. Pressure and temperature measurements for control of Auxiliary steam system shall be in 2/3 voting circuit.
4. The system shall be provided with the pressure gauges, pressure transmitters, temperature elements and transmitters for monitoring and control purpose.

5.1.4 Binary Controls/ Open Loop Control System (OLCS) Functions

1. The OLCS shall include sequence control, interlock & protection for various plant auxiliaries/valves /dampers/drives etc. The sequence control shall provide safe and automatic start up and shut down of plant and of plant items associated with a plant group. The interlock and protection system shall ensure safe operation of plant/plant items at all times and shall automatically shut down plant/plants items when unsafe conditions arise.
2. The OLCS shall be arranged in the hierarchical control structure consisting of unit level, group level, subgroup level and drive level (as applicable).

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3. It shall be possible to perform automatic unit start up and shutdown by issuing minimum number of command from OWS / LVS. Thus, the unit level shall control all the Control System Blocks and issue appropriate start up and shutdown commands to various blocks of Control System.
4. The group level shall control a set of functional sub-groups of drives. Appropriate start-up and shut down commands shall be issued to the sub-group control and various check-backs shall be received from sub-groups of drives. Each sub-group shall execute the sequential start-up and shut down programs of a set of inter-related drives along with system interlocks and protections related to individual drive falling under that sub-group. The drive level shall accept commands from the sub-groups, push buttons (wherever provided) etc., and transmit them to the respective drive, after taking into account various interlocks and protections and the safety of that particular drive. For HT drive, first-up logic shall be incorporated to indicate the cause of protection / trip.
5. A sequence shall be used to move a set of groups and sub-groups from an initial steady state (for instance 'OFF') to a final steady state (for instance 'ON'). The sequence initiating command for the unit and group level shall be issued from OWS/LVS.
6. A sequence shall be made of steps. The steps shall be executed in predetermined order according to logic criteria and monitoring time consisting of the interlock & protection requirements and check back of previous step which shall act as pre-conditions before the sequence control can execute the command for that step.
7. Each step shall have a "waiting time" implying that the subsequent step would not be executed unless the specified time elapses. A monitoring time shall also be defined as the maximum time required in executing the commands of any step and the time required for appearance of check back signals. In case, this is not completed within the specified time, a message shall be displayed and programme shall not proceed further.
8. Manual intervention shall be possible at any stage of operation and the sequence control shall be able to continue at the correct point in the programme on return to automatic control. Protection commands shall have priority over manual commands, and manual commands shall prevail over auto commands.
9. Open or close priority shall be selectable for each drive.
10. The sequence start up mode shall be of the following types:
 - a) Automatic Mode
In this mode of operation, the sequence shall progress without involving any action from the operator. The sequence start / stop command shall be issued from the OWS / LVS.
 - b) Semi-Automatic Mode

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In this mode of operation, once the sequence is initialized, the step progressing shall be displayed on the OWS / LVS. But the step execution command shall be prevented and shall be sent by the operator via the keyboards. It shall be possible to bypass and / or simulate one or more criteria to enable the program to proceed. This facility shall allow the program to be executed even if some criteria are not fulfilled because of defective switching devices, etc., while the plant condition is satisfactory. All the criteria bypassed shall be logged and displayed. It shall be possible to put the system on the Auto-mode after operating it on semi-automatic mode for some steps or vice-versa, without disturbance to the sequence operation.

c) Operator Guide Mode / Test Mode

It shall be possible to use the sequential control in operator guide mode / test mode i.e. the complete system runs and receives input from the plant and the individual push button stations (where provided) / keyboards but its command output is blocked. The whole programme, in this case shall run in manual mode. This mode shall allow the operator to practice manual operation using step and criteria indications. The actual protection should remain valid during this mode of operation also.

11. The sequence shall be started by putting the sequence on 'auto' and on receipt of 'start' command from the OWS / LVS or from a higher-level group / protection action as defined. The sequence shall then progress as per the defined logics. It should be possible to select alternative operation in the same sequence depending on certain process / equipment condition. Some step can be automatically bypassed also based on certain process / equipment condition. When the expected results of the sequence are reached the sequence is considered as "END". If during sequence initialization or sequence progressing or during normal running of the drive, a shutdown criterion is present, the sequence shall be stopped and the shut down sequence initiated.
12. For the drives, the command shall be used through O/P module to MCC / SWGR / Actuator as applicable and input (status, SWGR and process) shall be acquired through input modules. The drive logic shall be implemented in the redundant controller. The status for the 11 KV, 6.6 KV drives and some other important drives shall also be wired in parallel to redundant input modules so that on failure of the single input modules, the information regarding the status of the affected drive remains available in OLCS.
13. The output modules shall have the feature that ensures that in case of failure, all the outputs are driven to zero. The 24V DC command outputs to drives for ON / OPEN, OFF / CLOSE shall be separate and independent and the inverted outputs shall not be employed. For inching type of drives, position transmitter shall be used.
14. The termination for ON / OPEN, OFF / CLOSE command for the drive actuator shall be performed. However ON/OPEN feedback, OFF/CLOSE feedback, Switch gear disturbance feed back as a minimum shall be monitored in OLCS.

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15. The drive function i.e. basic interlocks and protection logic of the drive shall be implemented in redundant controllers. The drive function shall ensure that protection signals for the safety of the drive shall be effective under all conditions and under all modes of operation. The different commands shall be performed according to the priority of protection 'OFF', protection 'ON', manual and automatic. The standard functions like running time monitoring, status signaling, alarm / drive annunciation, etc. shall be performed in drive function. The drive function shall prevent hunting of the actuator in the presence of both open and close commands for actuators of the valves and dampers. The drive function shall be implemented in dedicated standard software functional block

5.1.5 Analog Controls/ Close Loop Control System (CLCS) Functions

1. The CLCS shall continuously act on valves, dampers or other mechanical modulating devices such as hydraulic coupling etc., which alter the plant operation conditions. The system shall be designed to give stable control action in steady state condition and for load changes in step / ramp over the load range of 60% to 100% MCR with variation or parameters within permissible.
2. The controller capability shall, as a minimum, include (i) P, PI, PD and PID control functions and their variations (ii) cascade control (iii) feed forward control (iv) state-variable based predictive control for SH/RH temperature control (v) on-off control, (vi) ratio and bias control, (vii) logical operation etc. The loop reaction time (from change of output of the sensor of the transmitter/temperature element to the corresponding control command output) shall be within 250 ms. However, for faster loops such as feed water, furnace draft, PA header pressure control loop etc. the same shall be based on actual process requirement.
3. The loop response time, for conventional I/Os, is the cumulative response time inclusive of input scan time, Controller Execution time and output card throughput time (in other words loop response is the time taken by the system to read a change in field signal at the input card terminal, process the controller task associated with the input and to make the required change in the control output at the output terminal of the output card)
4. The control system shall be bumpless transferred to manual on the conditions such as Control power supply failure, failure of redundant controllers, field input signal not available, analog input exceeding preset value, etc. as minimum conditions.
5. Any switch over from auto to manual, manual to auto and switchover from TFT operation to auto manual station operation and vice versa shall be bumpless and without resulting in any change in the plant regulations and the same shall be reported to the operator.
6. Buffered analog output (positioning signal) of 4-20mA DC shall be used from CLCS to the respective E/P converters. For electrical actuators, pulse type output (bound less control) shall be preferred. CLCS shall also provide all the necessary outputs for indicators & recorders with output loop resistance of 500 ohms for each channel of the output module.

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7. The system being supplied shall be such that when permissible limits are exceeded, an automatic switchover from an operation governed by maximum efficiency, to an operation governed by safety and availability is affected.
8. For safety reasons, switchover logics associated with the modulating control loops shall be performed within the closed loop control equipment.
9. Time supervision facility shall be used to monitor the final control element.
10. It shall be possible to block the controller output on a pre-programmed basis.
11. All controllers shall be freely configurable with respect to requisite control algorithms.
12. Whenever, alternate measurement is available for a control input the alternate measurement value shall be automatically substituted in the control loop in case of loss of control input. All necessary software for switching and reconfiguration shall be used. In addition, such substitution shall be balance less and bumpless and shall be reported to the operator.

5.2 General Requirements

The requirements for Control System for SG integral control are indicated on functional basis in this specification. It is not the intent or purpose of this specification to specify all individual system components.

The control and automation system and the field instruments and actuators as well as its support systems, power supplies and data networks shall be immune to the electromagnetic interference and shall conform to the internationally accepted standards.

5.2.1 System Configuration

The SG integral control system shall basically consist of:

1. Distributed Processing units (Controllers) for SG Protection & MFT, Burner management System, Mill & Coal Feeder Logics.
2. I/O modules
3. Data communication system
4. System Programming & Documentation facility (Engineering Work Station)
5. Interfacing with plant DCS
6. Integrated Annunciation functions

5.2.2 System Expandability

Modular System design shall be adopted for SG control system in order to facilitate easy system expansion. The capability and facility for expansion through the addition of controller modules, I/O cards etc. shall be provided. The system shall have the capability to add any new control loops, groups / subgroups in control system, while the existing system is fully operational. The

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future expansion shall be expandable to allow at least 50% only by addition of extra modules without removing or modifying any existing hardware.

5.2.3 Online Maintenance

It shall be possible to remove / replace modules online (like I/O module, interface modules etc.) from its slot for maintenance purpose without switching off power supply to the corresponding rack. System design shall ensure that while doing so, undefined signalling and releases do not occur and controller operation is not affected in any way (including any control loop trip to manual, etc) except that information related to remove module is not available to controller. Further, it shall also be possible to remove / replace any of the redundant controller modules without switching off the power to the corresponding rack and this shall not result in system disturbance or loss of any controller function for the other controller. The on-line removal / insertion of controller, I/O modules etc. shall in no way jeopardize safety of plant and personnel

5.2.4 Fault Diagnostic

The control system shall include on-line self-surveillance, monitoring and diagnostic facility so that a failure / malfunction can be diagnosed automatically down to the level of individual channels of modules giving the details of the fault on the Engineers' Work Station (EWS) monitor and printers. The faults to be reported shall also include faults in main and standby power supplies, sensor fault, Controller fault, any channel fault in 2V3 channels, failure of links to other systems. These faults shall be identified by local indication on the faulty channel / module and on respective rack / cubicle. The diagnostic system shall ensure that the faults are detected before any significant change in any controller output has taken place.

5.2.5 Fault Tolerance & Controllability

1. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is jeopardized. Control System shall be designed to prevent abnormal swings due to loss of control system power supply, failure of any control system component, open circuits, instrument air supply failure etc. On any of these failures the control system output shall either remain in last position before failure or shall come to fully open / close or on / off state as required for the safety of plant / personnel / equipment. System shall be designed such that there shall be no upset when Power is restored.
2. No single failure either of equipment or power source shall be capable of rendering any part / system / sub-system of control system inoperative to any degree or loss of generation.
3. The system design shall ensure that no single failure, whatsoever in any part of Control system result in loss of communication.
4. The controlled variable response rate and controllability shall be limited by the characteristics of main equipment, which is being controlled, and control system

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shall not impose any limitations in the response rate or controllability. Controlled process variables shall return to normal values in a stable manner and without control loop interactions or cycling of generation when generation matches with load demand.

5.2.6 Signal Exchange

1. All the signal exchange between various functional groups of each control group shall be implemented through redundant main system bus and local system bus within a subsystem. It shall be ensured that any single failure in electronics involved for such communication e.g. communication controllers, bus interface modules, physical communication media, etc. does not result in loss of such signal exchange and there is no deterioration in specified system response and system parametric requirements. In case a controller utilizes some inputs generated / processed by any other controllers / functional group and the requirement of controller response time as specified is not met due to inadequate communication rate / procedure, then provide hardwired signal exchange for such inputs.
2. Control and Protection signal exchange between SG control system & Plant DCS, along with any other critical signal exchange shall be hardwired only. Protection signals like MFT shall necessarily be hardwired even for exchange between the same sub-systems.

5.2.7 Redundancy

The Following shall be completely redundant:

- All the parallel & serial communication buses
 - All the communication devices
 - All the Process controllers
 - All the Power Packs
 - Critical drives related I/O Modules.
1. The redundant communication buses between the process stations and the operator supervision stations shall follow different paths. The redundant processor shall be connected to the same I/O's of the processor that it is associated to and shall be able to carry out all the operations assigned to this processor. In the case of a processor failure, the redundant processor shall become operative within the cycle time, without causing any loss of data or the interruption of the process control. The switch between the processor being utilized and the reserve processor shall be bump less and shall be within 20 ms which shall not cause any interruptions or stopping of the station functions. Furthermore, this switch must also be signalled by a high priority alarm.
 2. The operator station shall be able to perform from any work station. The operator station electronic units shall be in dual configuration and independently connected to the system buses. In case of an operator stations failure, the station shall remain operative without the operator having to carry out any type

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of action. Each operator electronic unit and each process station shall be powered by redundant power packs those are able to power the entire load. In case of a failure, the switch between the power packs shall not cause stops or interruption in the carrying out of the station functions. The switch between the power packs shall be signalled by a high priority alarm.

3. In order to establish a high degree of system availability, the various control systems which comprise the overall unit control system shall be configured such that no single component failure can cause a failure or mal-operation of critical automatic or manual control functions. The failure of a redundant component shall be alarmed to the operator to allow on-line removal/replacement or at the first shutdown opportunity. The system's redundancy schemes shall be designed such that the transfer from any critical element to its redundant backup shall occur without upset to normal process control or to system displays, data collection, or other normal DCS functions within 50 m sec.
4. The signal distribution from sensors which are shared due to process restrictions between control loops, logics, monitoring purposes shall be as follows:-
 - a) In the case of multiple inputs to a card, input cards used shall be restricted to a maximum of 16 inputs per card for analog input and 32 for digital inputs.
 - b) In case there is either process redundancy (Left, Right) or transmitter or switches redundancy, the inputs shall be routed through independent input cards.
 - c) No two control loops/interlock loop shall share the inputs (either binary or analog) wide input cards if process signals are independently available.
 - d) Protective inputs for two drives shall not be allotted to the same input card.
 - e) Output cards shall be independent for each control loop.
 - f) For outputs to HT and LT motors, the following shall be adopted :
 - Each HT motor and unidirectional drives shall have dedicated output cards. No other drive shall be combined with HT motor drive output card. However indication outputs can be driven from this output card for the concerned logic loop.
 - Not more than two bidirectional drives shall share one output card.
 - For unidirectional drives, not more than one drive shall be allotted to one output card.
 - g) For signal distribution or fan-out, suitable electronic cards (opto couplers) shall be used.
 - h) The processors shall contain the logic required to group individual process and system alarms into common groups as well as the annunciation sequence logic.
5. Redundant components and equipment within given systems shall be distributed among processors and I/O cards to the extent practical.
6. Critical inputs shall be supplied with redundant sensors/transmitters with each input connected to different input cards. Where redundant inputs exist, the DCS

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shall be configured to automatically reject erroneous data. Where required, one-of-two, two-of-two, two-of-three, or median select schemes shall be utilized to ensure the integrity of critical inputs.

7. The use of redundant outputs driving the same final element or equipment shall generally be avoided in favour of failsafe design and redundancy of the plant equipment.
8. The operator stations shall be identical in capability and independently linked to the system. Although these stations shall be normally dedicated to a specific function, any station can replace the function of any other station at any time.
9. All power source and power conditioning equipment in the system shall be redundant.

5.2.8 System Spare Capacity

1. Following philosophy shall be followed for the spare capacity of the SG Control system:
 - a) Twenty (20) percent spare channels in each of the functional groups for each type of input/output modules fully wired up to marshalling / field termination cabinet TBs.
 - b) Ten percent (10%) installed spare I/O modules which may be capable of hot swapping.
 - c) Wired-in “usable” space for 20% modules in each of the system cabinets for mounting electronic modules shall be spared for future use. Empty slots between individual modules / group or group of modules, kept for ease in maintenance or for heat dissipation requirement as standard practice and shall not be considered as wired-in ‘usable’ space for I/O modules. Field Terminal assemblies, PCB / Connectors, corresponding to the I/O modules shall be used for above mentioned 20% blank space, distributed proportionally to main population.
 - d) Each controller shall have 40% spare functional capacity to implement additional function blocks, over and above implemented logic / loops. Further, each controller shall have spare capacity to handle minimum 40% additional inputs / outputs of each type, over and above implemented capacity. Under worst loading condition, Controller should not be loaded beyond 60%. Each of the corresponding communication controllers shall also have same spare capacity as that of controller.
 - e) The data communication system (including main system Bus and other bus system) shall have the capacity to handle the additions mentioned above.
 - f) Each Communication Network Switch shall have 20% spare ports.
 - g) Twenty (20) percent spare relays of each type and rating mounted and wired in relay cabinets. All contacts of relays shall be terminated in terminal blocks of relay cabinets. In each of the relay cabinets 20% spare terminal blocks shall be used so that additional relays can be mounted and wired.

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- h) For power distribution board 20% spare feeder fully wired ready for use with MCBs fuses, TBs etc. Other hardware such as signal distribution isolation, trip amplifiers etc. shall be provided with 20% spares wired ready for use.
2. Sufficient and additional software capacity shall be available in the system to take care of spares requirement as specified above to meet all functional requirements. The calculation for processor power and memory for all nodes should be furnished. Also, the dynamic processor load for all nodes either in terms of idling time or percentage load shall be available in VDU.
 3. The spare capacity as specified above shall be uniformly distributed throughout all functional groups. The system design shall ensure that above mentioned additions shall not require any additional controller / processor / peripheral drivers / cabinets in the system delivered at site. Further, these additions shall not deteriorate the system parametric requirement like response time / duty cycle etc. from those stipulated under this specification and shall meet other redundancy / functional requirement.

5.2.9 System Programming & Documentation facility

1. Programming facility (Engineering Workstation) shall be provided for Control system and system documentation.
2. The programming tools shall have in-built safety features that shall protect the system against inadvertent and unauthorized use of these tools. Necessary hard key locks and software locks, etc. shall be used for this. During on line programming, external plant / equipment should not be affected.
3. The system shall also have facility to permit the programmer to add text information at the beginning and end of each program, wherein programmer shall list out his name, time, date of change which has been made, name of the person who has authorized the change, etc.
4. Any modification done in Control System shall be suitably logged so that it can be traced to the user log-in ID and time of change
5. Structuring / configuring and tuning facilities shall be provided for structuring / modification, storing / loading, testing, tuning, monitoring, etc. of all the microprocessor based controllers of the control system. The configuration and tuning unit shall be hooked up with the system bus.
6. It shall be possible to configure the system with ease without any special knowledge of programming or high level languages. Control strategy shall be implemented using familiar and conventional automation function blocks (software implemented). Whenever any change in configuration is done, it shall be recorded and modified configurations shall be available for printing and documentation and shall be stored in non-volatile memory. The entire system configuration, tuning / fixed parameters shall be documented and printed in form of function diagrams and lists respectively.
7. On-line tuning of the control loops shall be possible without causing any disturbance in the execution of the control loops. Provision to store and retrieve

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on immediate and long term basis the system configuration, data base etc. on some device such as DVD shall be included. Facility shall be used to reload / down-load the system or controller module from the already stored data, on-line.

Table 5.1

Specifications for Engineering Work Station

S.N	Features	Minimum Requirements
1	Processor	Intel i5 or better with latest generation
2	Configuration	Tower
3	Internal Clock	3.2 GHz
4	Architecture	64 Bit
5	Video Card	PCI
6	System Memory	4 GB or better
7	Hard Drive	1 TB
8	Cache	2 MB
9	CD Drive	52X DVD R/RW
10	Audio Controller	16 bit
11	Operating System	WIN NT or higher
12	Graphic Accelerator	8 MB (minimum)
13	Monitor	
a	Type	TFT Color Monitor
b	Screen Diagonal	21"
c	Display	XGA or better
d	Resolution	1280 X 1024 32 bit color support
e	Degree of Protection	IP-30
f	Power supply	230 V, 50 Hz
g	Ambient Temperature	0-50 °C
h	Humidity	95% non condensable

5.2.10

Data Communication System

1. The Data Communication System shall include a redundant System Bus for major subsystems with hot back-up. The data highway shall be high speed digital links of speed preferable 10/100 M baud. Bus protocols at control levels shall conform to OPC compliant ISO-7 layer protocol in master less, token ring or token bus (as per IEEE 802) or any standard proven and acceptable protocol in deterministic mode. Extensive error checking (CRC-16/12) or error correcting codes shall be used in these levels to improve the reliability of communication.
2. Redundant communication controllers shall be used to handle the communication between each functional group of controllers of Control System and the System Bus. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station / module connected

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to the system bus shall not result in loss of any communication function to and from any other station / module.

5.2.11 Sequence of Event Recording System

1. The DCS system shall perform the SOE functions like stamping of SOE inputs / points with 1 ms resolution. The SOE function shall be built-in function of DCS.
2. SOE shall be capable of accepting minimum 512 inputs per unit including 10% spare channels (included in total 512 inputs).
3. The system shall monitor SOE inputs with a resolution of one millisecond at all times for all inputs including spare inputs. That is, all SOE points entering status change shall be reported and time tagged within 1 (one) millisecond of their occurrence. Input card shall be equipped with digital filters with filter delay shall be such that it should meet SOE time resolution of 1 msec (identical for all points) to eliminate contact bounce such that field contact which is changing state must remain in the new state for stipulated time to be reported as one event. The start of data collection for SOE report shall be reported to OWS within 1 sec of SOE data collection initiation.
4. SOE shall be envisaged as an integral part of DCS with 1 millisecond time resolution. The SOE data base shall be an integral part of the DCS database and same shall be made available at all the OWS / EWS resident on the network. Operator can access the SOE on activation of SOE alarm page. All SOE inputs shall have real time "time-stamping" following any tripping of major equipment, or sub-system or the plant as a whole.
5. The SOE system of Plant DCS shall collect process and report SOE inputs of SG control system for a consolidated master SOE system. Necessary communication with required hardware & software at SG control system end and engineering co-ordination with Plant DCS supplier shall be done for successful implementation of a consolidated master SOE system. Consolidated master SOE system shall be used by the Plant DCS supplier.
6. The system shall have provision of rejection of chattering inputs.
7. The system shall have the facility for adding a field adjustable software delay on as per point basis.
8. The system shall also include provision for historical storage and retrieval of SOE reports for 3 months period.
9. The SOE report collection shall begin on occurrence of change of status of any SOE point and shall be printed after an operator selectable time interval of 1 to 3 min. or 100 status changes have taken place after the first event. Adequate numbers of buffers shall be provided to prevent loss of data before transferring to HSR.
10. SOE reports shall include a list of major equipment trip in chronological order and include the points that initiated SOE collection. The inputs for SOE shall include
 - a. Hardwired inputs in input cards and

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b. Calculated points / generated points of Control System.

- 11.All the operator initiated actions such as trip inactivation (bypass) & trip activation (inline) shall form input to SER.
- 12.All the SOE inputs shall also be available for interlock / protection functions.
- 13.SOE of other systems (SG/TG integral control systems) shall also be integrated in this system. The SOE system shall collect process & report SOE inputs of SG & TG control system for a consolidated master SOE system. Necessary communication with required hardware & software and necessary engineering co-ordination with SG & TG Supplier shall be done for successful implementation of a consolidated master SOE list.
- 14.SOE time stamping shall occur at I/O level.
- 15.Self Diagnostic Features like scanner test (a periodic test for communication between several levels), functional test by simulating abnormal Conditions shall be provided.
- 16.One (1) no dedicated SOE viewing station with SOE Log printer shall be provided.

5.2.12 Historical Storage & Retrieval System

The HSRS of Plant DCS shall collect store and process system data from SG control system for a consolidated master HSRS system. Necessary communication with required hardware & software at SG control system end and engineering co-ordination with Plant DCS supplier shall be done for successful implementation of a consolidated master HSRS system.

5.2.13 Master & Slave Clock System

A Global Positioning Satellite (GPS) based Master Clock System shall be provided by the Plant DCS supplier. Necessary signal output for time synchronization from Master Clock System shall be made available to the SG control system to have common time reference.

5.2.14 Power Supply & Grounding

1. Redundant UPS power feeder for all 230VAC equipments and/or redundant feeders for 24 V DC are required for SG control system requirements.
2. Make suitable arrangements with redundant distribution boards for each system with proper auto change over scheme to change the load from one feeder to other, in case of one feeder failure.
3. All panels, desks, cabinets shall be used with a continuous bare copper ground bus. The ground bus shall be bolted/ welded to the panel structure and shall efficiently ground the entire structure. All individual cabinet grounds shall be connected to separate earthing riser to be provided for C&I system signal grounding. The grounding requirements of various parts of the C&I system shall be properly co-ordinated with design of plant earthing system.

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5.2.15 System Cabinets/Panels

1. All Control system modules, power supply components, other control devices (except field mounted sensors/transmitters) which are required for completeness of the system shall be housed in cabinets. All equipment and dedicated cabinets required for termination, marshalling and proper interface within the system and also with other systems shall also be provided.
2. The cabinet mounted equipments shall be fully assembled, installed in mounting racks, wired and fully tested as per specification requirements and approved drawings in the manufacturing works of a qualified manufacturer prior to shipment to the project site. It shall be ensured that the cabinets are complete and ready for installation before dispatch from manufacturing works. The installation work at project site for these cabinets should only involve connections through multi pair cables from marshalling cabinets (wherever provided) to system cabinets and inter-cabinet.
3. The Control system cabinets shall be grouped into physically separate cabinets as follows:
 - a) Control System Cabinets
 - b) Marshalling cabinets
 - c) Relay cabinets

However, in case the system design requires the termination cabinet independent from system cabinet, the marshalling cabinets can be combined with the termination cabinet. In case, the termination arrangement is part of the system cabinet, independent marshalling cabinets shall be provided.

4. A special note shall be indicated that termination of field cables directly to control system cabinets is not acceptable.
5. The Control system cabinets shall house all types of modules / hardware to achieve all functions of Control System including signal conditioning modules, controller modules, I/O modules, communication controller modules and all other requisite hardware for a complete system.

5.2.16 System Software Requirement

1. The system shall be provided with all licensed software packages with media required by the system for meeting the intent, functional/parametric requirements and performance requirements of the specification.
2. The system shall utilize a readily upgradeable, public domain software platform proven for real-time operation environment at the control and monitoring level overlaid with a relational database program. The desirable features are indicated below:
 - a) The software system shall be fully modular.
 - b) The software shall meet the following general requirements:
 - Simple, easy-to-learn editing language for editing and on-line operation.

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- Wide range of standard and non-standard peripheral support capability by modular controllers / supervisors.
 - Effective task scheduling and support of multiple priority structure including event based interrupt etc.
 - Effective debugging.
 - Provision for on-line editing and program development without interrupting on-line functions.
 - Self-diagnostic routines.
 - Efficient memory management and effective utilization of system time.
 - Quick start-up and loading.
 - Support of multiprogramming and multi-user operation.
3. Industry standard operating system like UNIX/WINDOWS NT etc. to ensure openness and connectivity with other system in industry standard protocols (TCP / IP etc.) shall be used. The system shall have user oriented programming language & graphic user interface.
 4. All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics / debug software, peripheral drivers software shall be used. Latest versions of standard PC-based software for database handling, word-processing, spread sheet, etc. and latest WINDOWS based packages etc. and any other standard language offered shall be furnished as a minimum. Systems having program development environments like EWS, Station LAN Server shall have high level programming support like Microsoft Visual Studio, Oracle, RDBMS etc.
 5. The programming language shall support Relational Data Base Management in a global and truly distributed Client-Server environment and shall have the following minimum features:
 - a) Modern high-level block structures type
 - b) Powerful, compact syntax
 - c) Logical organization that facilitates documentation, modification and maintenance of programs
 - d) Early detection of errors at compiles and run time
 - e) Fast debugging
 - f) Improved program reliability
 - g) Clearly defined data structure complemented by flexible user-declared data types
 - h) Fast execution.
 6. All application software for control system functioning like input scanning, acquisition, conditioning, processing & control along with communication among various Control System functional blocks shall be used.
 7. The system shall be provided with software locks and passwords to engineers at site for all operating & application software in order to prevent unauthorized access and only authorized engineers are able to do modifications at site.

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8. Two sets of all final / latest software on non-rewritable/non-editable media shall be used as back-up.

9. Software License

Software license shall be used for all software in the Control System. The software licenses shall be used for the project (e.g. organization or site license) and shall not be hardware / machine-specific. That is, if any hardware / machine is upgraded or changed, the same license shall hold good and it shall not be necessary to seek a new license / renew license due to up-gradation / change of hardware / machine in control system at site. All licenses shall be valid for the continuous service life of the plant.

In case the s/w license is dependent on no. of points, then quantity to be considered is 30% above the finally implemented points.

10. Software Upgrades

The system software's installed in the plant DCS shall be periodically upgraded with the new releases, that would be taking place after the system is commissioned.

5.2.17 Measurement Functions Of Control System

All the signals coming into / going out of the Control System shall be routed through marshalling cabinets. The input / output modules employed in the Controls System shall be separated from controller hardware.

5.2.17.1 Analog Signal Conditioning & Processing

1. The conditioning and processing functions to be performed as a minimum for the analog input coming for control and information purpose are:
 - a) Galvanic isolation of input signals for which power supply source is other than the measurement system of the control system.
 - b) Transmitter power supply with per point fuse protection or current limiting and power supply monitoring.
 - c) Transducer / transmitter signal output limit check
 - d) Implementation of multiple measurement schemes
 - e) Square root extraction
 - f) Pressure and temperature compensation.
 - g) On-line ADC gain and drift monitoring and correction at periodic intervals.
 - h) Linearization of temperature signals (from thermocouples and RTD through temperature transmitters).
 - i) Reasonability checks for all analog inputs.
 - j) Monitor sensor wire break / open circuit / short circuit and take suitable actions in logic / loop. (This shall include blocking of trip signals in case of RTD failure).
 - k) Rate of rise / fall calculation

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- l) LVM generation.
2. All analog signals for control purpose shall be acquired, validated, processed and their respective Controller data base updated at a maximum interval of 250 ms except for some fast-acting control loops for which the above referred time shall be as per process requirement. The validated analog inputs shall be converted into engineering units on per point basis. Analog input processing (scanning to alarm checking) shall be performed once every scan cycle.
 3. The analog 4-20 mA input cards shall have input loop resistance ≥ 250 ohm for interfacing transmitters / analyzers giving 4-20 mA DC signals along with superimposed HART interface signals. 4-20 mA DC signal shall only be used for control purpose and superimposed HART signal shall be used for configuration, maintenance, diagnostic and record keeping facility for electronic transmitters and Analyzers etc.
 4. Triple measurement scheme for analog inputs employing three independent transmitters connected to separate tapping points shall be employed for the most critical measurements. The three signals shall be auctioneered to determine the median / average value, which shall be used for control purpose. In case one transmitter fails or shows excessive deviation with respect to others, it shall be removed from computation of median / average value and the average of the other two transmitter outputs shall be used for controls. The control loop shall trip to manual when any two of the three transmitter signals fail. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.
 5. Dual measurement scheme for analog inputs employing two independent transmitters connected to separate tapping points / temperature element shall be employed for the remaining measurements used for analog control functions. The output of the redundant transmitters shall be continuously monitored for excessive deviation. In case the deviation is within limits, the mean value shall be used for the control loop. If the deviation becomes high (with both transmitters remaining healthy), the loop shall be automatically transferred to manual. However, if one transmitter fails and other transmitter remain healthy, then the output of the healthy transmitter shall be used for control. If the other transmitter also fails, loop shall trip to manual. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.
 6. Individual transmitter signal, their value and selected value for control/measurement shall be available in OWS.

5.2.17.2 Binary Signal Conditioning & Processing

1. The changeover type contacts (i.e. 'NC' + 'NO' together) shall be wired to the controller system for all the binary inputs required for control purposes, except for inputs from MCC / SWGR. The binary inputs required for information purposes only shall be wired to control system in the form of non-changeover type contacts.

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2. The conditioning and processing functions to be performed as a minimum for the binary inputs coming for control and information purposes are:
 - a) 24 VDC power supply for contact interrogation for all potential free contacts with per point fuse protection or suitable current limit feature / isolation through optocoupler.
 - b) Contact bounce filtering delay time of 15ms. However for SOE inputs, it shall be 4ms.
 - c) Facility for automatic pegging of the binary signal to logic one / zero or last correct value in case of failure of binary input module.
 - d) Binary signal distribution to different user shall be in such a way so as to ensures that a short / ground fault on one user is not reflected to the other user.
 - e) Implementation of multiple measurement schemes for signals for control purpose.
 - f) All binary signals shall be acquired, validated, processed, alarm checked and their data base updated within one second. In addition to this requirement, binary signals required for SOE shall have resolution of 1 millisecond.
 - g) Checking for excessive number of status changes for all binary / contact inputs and making it off-scan, if the total no. of changes exceeds a limit within pre-defined time.
 - h) The non-coincidence monitoring shall be used for binary inputs for all changeover signals.

5.2.18 Wiring Scheme for Inputs to Control System

1. Each of the triple redundant binary and analog inputs shall be wired to three separate input modules. In addition, for functions employing 2V3 controllers (e.g. BMS protection), each of the redundant binary and analog signals shall be wired to separate input modules associated with each controller. Similarly each of the dual redundant binary and analog inputs shall be wired to two separate input modules. These redundant modules shall be placed in different racks, which shall have separately fused power supply distribution. Implementation of multiple measurement schemes of these inputs shall be performed in the redundant hardware. Loss of one input module shall not affect the signal to other modules. Other channels of these modules can be used by other inputs of the same functional group.
2. No single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant input signals to control system. Similarly, no single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant output signal from the control system.
3. The single (i.e. non-redundant) binary and analog signal required for control purpose shall be wired as follows:
 - a) The on-off status of HT drives and Breakers with synchronization provision shall be wired to two input modules in parallel.

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- b) All analog and binary inputs including the limit switches of valves / dampers / MCC / SWGR, check-backs of all drives, SOE and information related signals should be wired to single input modules.
4. It is envisaged to use remote I/O modules in plant areas where it is required from location point of view. The remote I/O signals shall be connected to the respective functional groups through redundant extended I/O bus. The hardware independence of functional groups shall be applicable for remote I/O as well. The remote input / output modules shall be located in cubicles in respective areas. Remote input / output modules shall be designed in such a way to work continuously under the harsh environment expected to be encountered in these areas (high temp, dust level, humidity etc.). It shall be ensured that extending of I/O bus of functional group in field does not result in false signalling / noise pickups. Further, it shall in no way deteriorate the performance of that functional group and Control System.
 5. Power supply arrangement for these cubicles shall be similar to DCS System cabinets
 6. The measurement system of control system should be capable of acquiring data from various equipment and system in digital form through serial port, field bus/ Profibus, Ethernet connection using industry standard protocols. The control system shall include requisite modules for accepting such signals.
 7. The maximum number of inputs/outputs to be connected to each type of modules shall be as follows:

a) Analog input module	16
b) Analog output module	08
c) Binary input module	32
d) Binary output module	32
 8. The following requirements shall be met for analog/binary input / output modules as applicable:
 - a) Input filters to attenuate noise shall be used
 - b) All analog / binary inputs and outputs shall be capable of withstanding 500V DC common mode and 500V AC peak to peak between analog and digital parts. All analog outputs shall be short circuit proof.
 9. Any single sensor / transducer / transmitter failure alarm shall be used on Engineer's Station monitors for all sensors / transducers / transmitters. Similarly sensor break alarm for thermocouples etc. shall also be logged and displayed.

5.3 Redundancy in Measurements

Minimum redundancy requirement (1 out of 2 or 2 out of 3) of measurements and controls including compensation are given below. For critical Closed Loop controls 2 out of 3 sensors / transmitters shall be used including 2 out of 3 signals for compensation signals.

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Table 5.2
Redundancy Requirements

Parameter	Input Redundancy
Boiler Drum level	2 out of 3 (on each side of drum)
Boiler Drum pressure	2 out of 3
Feed water Flow	2 out of 3
Feed water Temperature	2 out of 3
SH Spray water flow (Left & Right)	2 out of 3
RH Spray water flow (Left & Right)	2 out of 3
Main steam Pressure	2 out of 3 (Left side)
Main steam Pressure	2 out of 3 (Right side)
Main steam Temperature	2 out of 3 (Left side)
Main steam Temperature	2 out of 3 (Right side)
BFP Suction Flow	1 out of 2
DP across feed control	2 out of 3
Secondary Air flow	1 out of 2 (Left & Right)
Coal air flow (at each elevation)	1 out of 2
Oxygen in Flue Gas	2 out of 3 (Before Economizer)
Furnace Pressure	2 out of 3
P.A. Header Pressure	2 out of 3
Mill air flow	1 out of 2
Mill outlet Temperature	1 out of 2
SH Outlet Steam temperature	2 out of 3 (Left& Right)
RH Outlet Steam Temperature	2 out of 3 (Left & Right)
Auxiliary Steam temperature	1 out of 2
Auxiliary Steam pressure	1 out of 2

1. For measurement of metal temperature of super-heater, re-heater and boiler drum, permanent / removable duplex type mineral insulated thermocouples terminated in junction boxes at boiler platforms shall be used. Super-heater tube metal thermocouples shall be used on every fourth tube connected to the intermediate super-heater outlet headers, the intermediate reheat outlet headers & the final super heater/ re- heater outlet header.
2. Bearing temperature of ID, FD, PA Fans, pulverizers and any other equipment driven by HT motors shall be used with direct mounted dial thermometers for both driven equipment and motor.
3. Duplex RTDs (PT-100) shall be used both for the driven equipment & HT motor bearing temperatures- for monitoring and interlocking in Plant DCS. In case RTD in pulverizer bearing cannot withstand vibration, suitable thermocouple like J-type thermocouple may be provided.
4. All HT motors windings shall be used with two nos. duplex RTDs (PT-100) per phase for monitoring and interlocking in Plant DCS.

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5. Redundant non-contact type speed sensors with transmitters shall be used with each Coal feeder and shall provide an output to the feeder speed control.
6. Monitoring and alarm provisions in the DCS shall be provided for Lube Oil Pressure and Temperature and other important parameters for subsystems of all major drives e.g. Pulverizer, ID Fans, PA and FD Fans etc.
7. A non-contact type no-Coal flow detector complete with amplifier and pick-up located at the outlet of each Coal feeder shall be used to detect no-Coal flow
8. Coal flow measurement with the help of conveyor speed and active load cells shall be used for each feeder. The Coal flow rate along with the integrator shall be made available in plant DCS.
9. Coal feeder shall be gravimetric type preferably based on variable voltage & frequency drive. The coal flow measuring system shall have the output 4-20mA DC for indication and control purposes. Weighing system of the equipment shall be based on load cell measurement and shall have the highest resolution by proper selection of load cell.
10. Measurement and totalization of oil flow shall be used with Coriolis mass flow measuring type instrument with 4-20mA DC output for Plant DCS indication and totalization. The Mass flow meter electronics shall have the facility for configuration to indicate Mass and Volumetric Flow rate.
11. In Coal Bunkers, Load Cell/Strain Gauge/Ultrasonic type level measuring system is required for displaying bunker level at the control room and generate the necessary isolated outputs for interlocking with Coal handling Plant for Coal filling operation.
12. Oxygen measurement in high temperature zones of boiler is required (in APH inlet & outlet on both side) for combustion control and performance analysis.
13. Temperature measuring devices shall be installed at different zones in the flue gas path including ID fan inlet and chimney inlet for monitoring at Plant DCS.
14. All motorized bypass valves & Bypass Dampers shall be inching type and shall be used with non-contact type position Transmitters.
15. Digital speed measurement with proximity pick-up shall be envisaged for the feeder. The control system shall be microprocessor based with the facility of on-line diagnosis of the system and integration with DCS through software link for monitoring facility of various faults and status of the feeder and feeder control system. Gravimetric feeder shall be controlled by 4-20mA DC signal and other interlocking signals from DCS. The system shall have facility for gravimetric and volumetric indications of coal flow as well as totalisation. In addition, separate instruments shall be provided for "coal flow /no coal flow" indication in DCS. Controller shall be provided with following minimum features:
16. Alphanumeric display of feed rate; material density, motor speed, total weight, automatic and manual calibration of the weighing system and adjustment of system drift, non volatile memory to store information and program data, alarm generation capability with date and time stamp, automatic transfer from gravimetric to volumetric in case of failure of load cell, status LED, keyboard for configuration. Running indication of clean out conveyor to be displayed in OWS.

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17. For measurement of pulverizer outlet temperature and flue gas temperature suitable abrasion resistant thermo wells shall be provided.
18. Adequate Pressure and Temperature gauges, depending upon the requirement shall be provided.
19. For all critical trip interlocks such as furnace pressure high and furnace pressure low minimum 3 numbers transmitters on each side (for deriving LVM contacts) shall be provided.
20. For lube oil protection of HT drives wherever applicable, 2 out of 3 logic shall be provided.
21. All initiating devices for starting and tripping of auxiliaries' viz. ID fan lube oil pump, FD fan lube oil pump, pulverizer lube oil pump etc. shall be provided for interlock and protection and associated annunciations.
22. Necessary pressure controller of Electromatic safety valve complete with all accessories like special cables, pressure sensing devices, solenoid valves, impulse piping etc shall be provided. A miniature electronic control station suitable for monitoring on the auxiliary control desk shall be furnished with indicating lights and switches to facilitate auto / remote / manual operation of the valve. Operation of the valve shall also be interface with DCS.
23. All local instruments related with Steam Generator and Fuel Oil System viz. pressure and temperature gauges, pressure and temperature switches shall be mounted on gauge boards located at convenient places.
24. Status of various strainers in the fuel oil line and lube oil line in the boiler area shall be monitored in DCS.
25. All pilot solenoid/solenoid operated valves, motorized valves, initiating devices and switches, sensors, transmitters, all flanges, gaskets, nuts, and bolts shall be provided.
26. All instruments for Performance Guarantee test measurements including tapping points with root valves for pressure measurement and temperature stubs with thermo wells are to be provided.
27. Local Stop push button shall be used for all HT and LT drives for emergency stopping of the drives. The contacts of the push button shall be wired directly to MCC to initiate trip & this signal shall be made available to Plant DCS/PLC for alarm annunciation/logging etc.

5.4 Other SG Related System/ Equipments

5.4.1 Steam Generator

1. For measurement of furnace draft using three pressure transmitters across the furnace, Two out of three logic shall be used.
2. Local measurement of furnace draft using minimum four numbers of draft gauges.
3. For sensing of high & low furnace draft six number of pressure switches (three on each side of furnace) shall be used and two out of three logic shall be used for tripping application.

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4. Flame sensing and control for each oil and gas burners with flame intensity indication in control room shall be provided along with necessary interlocks & protection against flame failure and dull flame.
5. Measurement of differential pressure between furnace and wind box shall be provided.
6. Measurement of differential pressure between furnace and scanner air pressure shall be provided along with Separate DP switch for alarm.
7. For measurement of metal temperature of primary and secondary super heater, adequate number of mineral insulated duplex type chromel-alumel thermocouples with stainless steel sheathing shall be provided. These shall be routed through suitable trays and terminated directly to temperature transmitter to be mounted in convenient and accessible location.

5.4.2 Steam Cycle

1. Measurement of steam pressure after primary super heater, de-superheater and secondary super heater, redundant pressure transmitters shall be used for the same.
2. Local measurement of steam pressure after super heater.
3. Measurement of temperature of steam after primary super heater, de-superheater and secondary super heater. Redundant temperature sensors shall be used for each application.
4. Local measurement of steam pressure at inlet to each steam coil air preheater.
5. Measurement of steam pressure at inlet to each steam coil air preheater.
6. Measurement and control of atomizing steam pressure to boiler.

5.4.3 Air System

1. Measurement of air pressure after FD fans.
2. Measurement of air pressure before and after air pre-heater.
3. Measurement of pressure of secondary air to burners.
4. Measurement of pressure of compressed air for atomization.
5. Measurement of pressure after PA fans.
6. Measurement of differential pressure across air preheater.
7. Measurement of seal air discharge pressure.
8. Sensing of low and very low air pressure after primary air fans using independent pressure switches.
9. Sensing of differential pressure between primary air heater and seal air header.
10. Local measurement of air pressure at the discharge of each FD fan. Sensing of low & very low air pressure after FD fans using independent pressure switches.
11. Local measurement of air pressure after seal air fans. Sensing of low seal air pressure at the header.
12. Local measurement of pressure at scanner air fan discharge. Sensing of low pressure at scanner

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13. Local measurement of differential pressure across all air filters. Sensing of high differential pressure across all air filters using separate switches.
14. Measurement of both primary air & secondary air temperature before and after the rotary air preheater.
15. Sensing of low temperature of both primary air & secondary air after air preheater using independent switches.
16. Measurement of secondary air temperature at outlet of each steam coil air preheater.
17. Measurement of hot air temperature to each mill.
18. Measurement of flow of air after FD fans using redundant flow transmitters.
19. Measurement of flow of primary air to each mill using redundant flow transmitters.
20. Local measurement of pressure of instrument air at the header. Sensing of low pressure for the same using independent pressure switch.
21. Measurement of atomizing air pressure to boiler.
22. Measurement of temperature in air preheater for both gas side as well as air side using thermocouples connected to a scanner in the control room and also to Boiler integral control system.
23. Measurement of differential pressure between furnace and wind box.

5.4.4 Flue Gas System

1. Measurement of flue gas pressure before & after super heater.
2. Measurement of flue gas pressure after economizer.
3. Measurement of flue gas pressure after air pre heater.
4. Measurement of flue gas pressure after ESPs.
5. Measurement of flue gas differential pressure across air pre heater.
6. Measurement of flue gas pressure at the discharge of each ID fan.
7. Measurement of flue gas temperature before & after super heater.
8. Measurement of flue gas temperature after economizer.
9. Measurement of flue gas temperature after air Pre heater.
10. Measurement of flue gas temperature after ESPs.

5.4.5 Soot Blowing System

1. Soot blowing control shall be implemented in Plant DCS and operated from operator's console. Soot blowing analog and sequential control logic shall be implemented in redundant of processors of Plant DCS. However outputs to the drives of soot blowing system shall be non-redundant.
2. Soot Blower system complete with provision for individual operation of any soot blower and facility to bypass any soot blower shall be used with following:
 - a) Automatic starting of each soot blower in the system
 - b) Cancelling the selection of any soot blower in the system when not required for operation.

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- c) Indication of the soot blower-selected to operate.
 - d) Capability to monitor all the essential parameter/status of the soot blowing system.
 - e) Capability to prevent continued soot blower operation if the system is not functioning properly.
 - f) The ability to operate two soot blowers located in opposite walls simultaneously.
 - g) Manual over-riding of the automatic operations.
 - h) To prevent automatic blowing when the parameters of soot blowing system are beyond permissible limits.
 - i) Indications of soot blower which has malfunctioned.
 - j) Control circuit for the retractable blowers shall be so designed as to prevent insertion of the blowers in to the combustion chamber unless the blowing medium is available.
 - k) Limit switches and Torque switches are to be connected to Plant DCS.
3. Soot Blower control system shall also provide controls for:
- a) Pressure control of steam.
 - b) Warm up control of the complete piping system which shall include flow control, drain temperature control etc.
 - c) Steam temperature control (if required)

5.4.6 Flame Monitoring System

1. The purpose of the system is to detect the individual burner/ type of flame and to enhance the boiler/furnace safety, to avoid spurious and unwarranted trips and to increase operational reliability, availability and efficiency of the Steam Generator such that the consumption of fuel oil shall be reduced to optimal minimum.
2. Flame monitoring system shall be microprocessor based, fail safe and easily maintainable which shall include flame detectors of proven design for the type of fuel, environmental condition and other conditions, of established reliability at all loads of the steam generator. It shall be designed to work under all adverse conditions such as wide variation in fuel/air input ratio, wide variation in fuel characteristics, variation in operating temperature, and maximum temperature under interruption of cooling air supply. The system shall conform to NFPA recommendation and location of detectors as per NEC requirements.
3. Flame detectors shall be working on the dynamic and static properties of primary combustion zone of each type of fuel and flicker frequency of flame. It shall pick up only the flame to which it is assigned and shall not respond to the adjacent and background flame or other radiations generated in the furnace. The design shall also take into account the absorption by a Coal shroud, recirculated dust or other deposition on the flame detector head & required protection of lens head against pitting. The complete system shall provide the discrimination between oil

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and Coal flame. Intensity indicators for main flame shall be used along with galvanically isolated 4-20 mA DC signals and hooked to the Plant DCS.

4. The system should be easily maintainable and include automatic self test facility at regular interval.
5. A portable flame detector testing kit shall be used with built in stabilizer, capable of simulating both oil and Coal flame, and testing of flame detector head unit at field. The testing kit shall also have facility for testing all type of electronic cards as being used in the flame monitoring system.
6. In case of tangentially fired boiler, arrange flame detectors in such a manner that Coal flame detectors are available both above and below each Coal burner and separate oil flame detectors are provided for each oil burner. In case of discriminating type flame detectors capable of detecting and discriminating both oil and Coal flame, with the help of a single scanner, the same can also be utilized for monitoring both oil and Coal flame. For any other type of firing i.e. non-tangential type the flame detectors shall be used for each Coal and oil burner responding only to the flame of its associated burner.
7. In cold start up test, capability of detectors to detect oil flame under varying oil pressure shall be checked. In load test, the detector shall be able to detect when only oil is present, only Coal is present and both Coal and oil are present. It shall be ensured that the detectors are able to detect the proven flame at very low load with oil guns withdrawn. The above tests shall be performed for every Coal and oil elevation.
8. Provision of scanner air for cooling the flame detectors by 100% redundant scanner air fans shall be used. The dampers associated with scanner air fans shall be pneumatically operated with DC solenoid valves.

5.4.7 Coal Feeders Control & Instrumentation

1. A minimum of two independent speed sensors, pulser units and associated amplifiers, etc. shall be used for each of the Coal feeders. Output from the speed sensors shall be used to provide at least four numbers isolated 4-20 mA DC analog signals corresponding to Coal flow rate in tons per hour and any other signals that may be required for the control of the Coal feeder. In addition, one pulser unit shall also be used with two pulse outputs-one for use in control system and the other for remote integrator.
2. Each Coal feeder shall receive signals from Plant DCS for feeder speed control. The signal to be provided by Plant DCS shall be in the form of galvanically isolated 4-20 mA DC. All required power amplifier units/interface devices to accept this 4-20 mA signal shall be included.
3. All associated electronics like buffer amplifiers, frequency to current converters etc. shall be used for each raw Coal (RC) feeder with local and remote speed indicators and integrators. The speed sensors and pulser units shall be totally enclosed, fire, dust and weather proof, suitable for the service conditions.

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4. The control cabinet shall be used with reset push buttons and individual lights to signal the individual internal trip conditions.
5. Each feeder shall be used with a four position switch located at the feeder for remote off, local run (when there is no Coal on conveyor) and calibration purpose.
6. If there is any electronic modules mounted local to the feeder body then these shall be suitable for operating in a non-air-conditioned area in a suitable enclosure to combat the effect of noise, vibration, entry of dust etc.
7. All necessary paddle switches and other detectors to monitor Coal on belt, feeder discharge plugged etc. should be provided to ensure safe operation of the feeders.

5.4.8 Electromatic Safety Valve

The Electromatic Safety Valve shall be an automatic electrically actuated pressure relief valve. It shall be possible to set the value for one percent or less differential between opening and closing pressure. The Electromatic safety valve shall be used complete with all accessories like pressure measuring devices, controller units, local PB station, solenoid assembly, impulse piping etc. Provision shall also be kept to operate the Electromatic relief valves from the Plant DCS OWS and miniature PB stations on the Emergency backup panel. The operation of the valve shall be accomplished by operator command or by means of pressure sensitive element which shall precisely and automatically relieve the pressures within very close limits.

5.4.9 Furnace Temperature Probes

Two numbers of furnace temperature probes shall be provided before platen super heater and / or before Reheater regions and shall be electrically operated, fully retractable type. The furnace temperature probes shall be furnished with complete actuating mechanism and all the logics required for the actuating mechanism. The probes shall be provided with position transmitters, limits switch & indicator for remote indication. Each temperature probe shall have a duplex thermocouple suitable for the measurement range. The logics for furnace temperature probe shall be implemented in the DCS.

5.4.10 Acoustic Pyrometer {TO BE DELETED, IF NOT APPLICABLE.}

1. Acoustic pyrometers shall be provided to determine the average flue gas temperatures and complete flue gas temperature profile at furnace exit plane (for FEGT measurements), at economizer outlet & in Super heater (SH) Area. Minimum eight numbers of acoustic transceivers shall be provided for Furnace temperature measurement in SH Area.
2. For each temperature measurement plan/section, a PC based system complete with all required software, comprising of minimum eight nos. of acoustic transreceivers, signal processor, interface unit, etc. shall be provided. The system shall be suitably interfaced with DDCMIS.
3. The system shall include all software & interface hardware required for

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presenting (in the HMI of DDCMIS) visual information on real time or historical gas temperatures including spatial temperature distribution profiles, individual path temperatures, temperature trends & average gas temperature within defined area.

4. The system shall be able to eliminate the varying high noise environment both in and out of an operating boiler.
5. The transit time of each of the associated transmitters/receivers shall be transmitted to the central processing unit (to be located at CER) for storage and analysis through suitable interface device. A temperature profile shall then be determined and displayed by analysing the mean temperature across every transit section using deconvolution technique. The time interval to take a complete cycle of eight transceivers should be less than one minute.
6. The measuring range should be sufficient to cover the entire regime of boiler operation and shall not be less than 1900°C. The mean temperature and profile temperature accuracy shall be $\pm 2\%$, & $\pm 4\%$ of reading respectively or better. Full colour TFT display and colour printer output shall be provided. The system shall also provide 4-20mA DC output to DDCMIS.
7. The transducers shall not be placed directly in the hot gas stream. The system shall be of proven design and it's performance must be proven using similar type of fuel. The components to be located at boiler area shall be able to withstand the stringent environmental condition expected at such locations with operating boiler.

5.4.11 Furnace & Flame Viewing System

1. The flame cameras shall be suitable for direct online continuous viewing in the central control room of the Coal and oil flame and condition of the furnace internals including slagging of the water walls and any other deterioration in the furnace condition.
2. The flame camera system shall consist of the following facilities/ components as a minimum: -
 - a) 21" High resolution color monitor.
 - b) Facility for optical zooming of lens from the monitor
 - c) Automatic Electronic shutter control mechanism
 - d) Built-in temperature sensor to measure temperature of camera tip.
 - e) Proper cooling arrangement (preferably air) and protection against
 - f) Cooling medium failure alarm.
 - g) Weatherproof local control box for mounting of electronics.
 - h) All necessary remote/ local programming tool.
 - i) All interconnecting cable and termination device.
 - j) Any other accessory to make the system completely operational.
3. The cameras and the total system shall be suitable for the furnace design, the firing arrangement, the fuel being fired considering the ash content of worst

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Coal. The cameras should be expected to withstand the temperature expected in the furnace of the boiler but shall not be less than 1600 deg C.

4. The viewing angle of the camera shall be commensurate with the furnace size, the camera location and the positioning of the burners. The system shall conform to PAL and number of TV lines shall be adequate for a clear image of the furnace.
5. The flame camera system shall have a record of trouble free performance of minimum one (1) year in a Coal-fired boiler of size 210/215/220/250 MW.
6. The system shall be capable of transmitting the image to the Plant DCS system where it should be possible to display the same on the monitors of operator workstation & LVS.

5.4.12 Mill & Air heater Fire Detection System

1. Adequate number of thermocouple type fire detection system for each mill and air heater shall be used as a composite and complete unit with all required signals and accessories with adequate redundancy.
2. The controls & protection required for the mill fire detection system and air heater fire detection system shall be implemented in the Plant DCS, using rate-of-rise algorithm taking care of manufacturer's recommendation.

5.4.13 Chemical Dosing System

1. Each dosing pump shall be used with glycerin filled type pressure gauge of proper range on discharge piping with isolation valves, fittings diaphragm seal, Snubber, etc. Each solution tank shall be used with level gauge glass with graduated scale. Level switch shall be used for low-level alarm and interlock. Alarm hooter shall be used for tank level low annunciation in local panel. The chemical feed system shall be operated and adjusted from the local panel and also through the Plant DCS from CCR.
2. Minimum field instruments, transmitters', switches etc. shall be used which are to be connected to the Plant DCS for remote monitoring from CCR.
 - a) Chemical storage tank level.
 - b) Dosing Pump Discharge Pressure at downstream of NRV.
 - c) Open Close indication of all Manual Valves from the Dosing system to the CTP and DMCW system.
3. Facility shall also be provided for start stop operation of the Agitator motors and Dosing pumps from the Operator Work Station in the CCR.
4. Dosing Pumps Remote Stroke Control facility from the CCR shall be used. Necessary local controller, drive unit as required shall be used for this purpose.

5.4.14 Electronic Remote Drum Level Monitoring System

In order to measure and monitor Boiler drum level, Electronic Water level Indicator working on principle of difference in electrical conductivity between

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steam and water shall be used. The monitoring system shall meet the following requirements as a minimum.

1. Each end of the drum shall have independent pressure vessels with adequate no. of electrodes covering the entire range for indication for each end of drum. Further, independent and separate pressure vessels shall also be used for each end of drum / vessels along with electrodes to provide validation for very low trip setting.
2. The sensing electrodes shall be placed in equal pitch. The maximum distance (gap) between two electrode shall be 50 mm and the electrodes shall be arranged in such a way that the last and the first electrode shall not be at any alarm or trip level. For a boiler of 210 MW and above unit, the number of electrodes shall not be less than 16 for indication and eight for validation.
3. Both indication and validation system shall be supplied with double isolation valves in water, steam, drain and vent lines with mechanical key interlock system, that is, the total number of key interlocks shall be four nos. per boiler. The provision of key interlock system shall ensure a fool proof safety feature and the details of the same shall be brought out clearly in the offer.
4. The detector unit (if not located locally), logic units, 2 x 100 % redundant power supply units / packs (to be located in control equipment room) shall be housed in separate and independent cubicle for pressure vessel on each side of the drum. The detector units, logic units etc. shall be independent for each pressure vessel.
5. Indication shall be used at field for both indication and validation system. Remote indication is to be provided for indication system at the CCR.
6. Each cubicle shall be used with 2 x 100% redundant power supply pack converters to be fed from two feeders of 24 V dc. These two power supplies shall be internally fused and failure of one power supply shall not affect the performance of the system. Self monitoring facility to detect and alarm the loss of power supply shall be used.
7. The pressure vessel shall be constructed in such a way that density level error between drum and pressure vessel shall not be more than 25 mm. All vent, drain and isolation valves shall meet 1.5 times the maximum design conditions.
8. Electrode assembly shall have blow out and leakage proof sealing arrangement. Field proven ceramic / zirconia probe insulation suitable for design pressure and temperature are to be used.
9. The system design shall be such that it shall ensure that failure of one probe circuit shall not affect another probe circuit and failure of any electrode shall not hamper the system function and operation. Further the entire system shall be of proven fail-safe design.
10. The logic shall be such that the trip and alarm relay circuits shall be independent for each for low, low-low, high and high-high levels of drum. Monitoring of set time for trip generation and provision of setting time delay shall be available in the system. Trip logic shall be independent and separate from fault finding logic.

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Provision shall be there to connect the alarm & trip signals to Plant DCS. Also the 4-20 mA DC output shall be available for drum level indication (both side) on Plant DCS.

11. The system shall have fault diagnostic features such as process fault, system hardware fault, probe failure, circuit board failure, shorted wire etc. Further the system shall be able to distinguish between a cable fault and an electrode fault.
12. The necessary relays and relay modules for the output contacts shall be of proven design and each contact shall be rated for 5A, 240 V AC/ 0.25 A, 220 V DC rating. All these contacts shall be SPDT type.

5.4.15 Acoustic Tube Leak Detection System

A Microprocessor based Acoustic Tube leak detection system with PC & A4 size Laser printer, working on the principle of Digital sound analysis techniques shall be provided by the bidder. This system as a minimum shall have the following features:

1. The system shall be capable of leak identification for the tube leak size of 2mm diameter.
2. A minimum of 20 sensors should be installed for tube leak detection.
3. Graphical display of audio frequency spectrum capable of displaying the size and location of detected leak.
4. Mimic display for location of the leak & Trend display to indicate the rate at which the leak is growing.
5. Alarm bar graph display (Overview of all sensor points) having different colour displays in case of Normal, Caution, Alarm, Wave guide blockage and system fault.
6. Alarm outputs which can be wired to DCS for attracting operator's attention in case of initiation of any leak.
7. User friendly MMI for selecting displays, printout in demand / time bases, alarm accept and audio selection with loud speaker.
8. History record of the previous data for trend analysis.

5.5 SG Auxiliaries

Following are indicative list of requirements for Control & Protection of SG Auxiliaries. All CLCS, measurement and Data Acquisition of SG auxiliaries instruments shall be implemented in Plant DCS.

5.5.1 ID Fans

1. Induced draught fan controls shall be implemented in DDCMIS for Induced draught control. The drive shall be compatible for 4-20 mA DC signals for regulation. The drive controls shall be blade pitch control with feedbacks to DDCMIS.

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2. For remote bearing temperature of fan & motor and motor winding temperatures monitoring, duplex RTD's shall be provided.
3. Vibration monitoring in X & Y directions at DE & NDE shall be provided. All vibration parameters shall be available in CCR.
4. Required Local instruments such as level, pressure, temperature gauges, Sight glass, pressure & flow switches etc. shall be provided.
5. Remote monitoring & alarm facility for the following parameters shall be provided in addition to bidder's recommended instruments:
 - a) Fan speed
 - b) Lube oil tank level
 - c) Lube oil pump discharge pressure.
 - d) DP across lube oil strainer-Alarm
 - e) Blade pitch angle (If applicable)
 - f) Fan & Motor bearing temperature
 - g) Lube oil cooler outlet temperature
 - h) Cooling water flow Low alarm

5.5.2 FD Fans

1. Inlet guide vane/blade pitch control to be operated by 4-20 mA DC signal from DDCMIS, complete with pneumatic actuator, I-to-P converter, Position transmitter etc. for control of Combustion Air Flow shall be provided
2. For remote bearing temperature of fan & motor and motor winding temperatures monitoring, duplex RTD's shall be provided.
3. Vibration monitoring in X & Y directions at DE & NDE shall be provided. All vibration parameters shall be monitored from CCR.
4. Required Local instruments such as level, pressure, temperature gauges, Sight glass, pressure & flow switches etc. shall be provided.
5. Remote monitoring & alarm facility for the following parameters shall be provided in addition to bidder's recommended instruments
 - a) Lube oil tank level
 - b) Lube oil pump discharge pressure.
 - c) DP across lube oil strainer-Alarm
 - d) Pitch control oil pressure (both control & power oil)
 - e) Fan & Motor bearing temperature

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f) Lube oil cooler outlet temperature

g) Cooling water flow Low alarm

5.5.3 PA Fans

1. Inlet guide vane/blade pitch control to be operated by 4-20 mA DC signal from DDCMIS, complete with pneumatic actuator, I-to-P converter, Position transmitter etc. for control of Combustion Air Flow shall be provided
2. For remote bearing temperature of fan & motor and motor winding temperatures monitoring, duplex RTD's shall be provided.
3. Vibration monitoring in X & Y directions at DE & NDE shall be provided. All vibration parameters shall be monitored from CCR.
4. Required Local instruments such as level, pressure, temperature gauges, Sight glass, pressure & flow switches etc. shall be provided.
5. Remote monitoring & alarm facility for the following parameters shall be provided in addition to bidder's recommended instruments
 - a) Lube oil tank level
 - b) Lube oil pump discharge pressure.
 - c) DP across lube oil strainer-Alarm
 - d) Pitch control oil pressure (both control & power oil)
 - e) Fan & Motor bearing temperature
 - f) Lube oil cooler outlet temperature
 - g) Cooling water flow Low alarm.

5.5.4 Seal Air Fans

1. Pneumatic actuator shall be provided for full open/full close dampers complete with I-to-P converter, Position transmitter, Solenoid valves, AFR etc.
2. For remote bearing temperature of fan & motor and motor winding temperatures monitoring, duplex RTD's shall be provided.
3. Vibration monitoring in X & Y directions at DE & NDE shall be provided. All vibration parameters shall be monitored from CCR.
4. Required Local instruments such as level, pressure, temperature gauges, Sight glass, pressure & flow switches etc. shall be provided
5. Remote monitoring and alarm facility for the following parameters shall be provided in addition to bidder's recommended instruments:
 - a) Seal air fan discharge pressure
 - b) Motor and fan bearing temperature

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5.5.5 Coal Mill

1. For remote bearing temperature & motor winding temperatures monitoring, duplex RTD's shall be provided.
2. Vibration monitoring in X & Y directions at DE & NDE shall be provided. All vibration parameters shall be monitored from CCR.
3. Temperature Elements & Gauges for lube oil & bearing temperatures, lube oil flow switch, Pressure switches for alarm/standby pump auto start, pressure gauges etc. shall be provided.
4. Remote monitoring and alarm facility for the following parameters shall be provided in addition to Bidder's recommended instruments:
 - a) DP across lube oil strainer –Alarm
 - b) Mill DP
 - c) Mill outlet temperature
 - d) Lube oil pressure
 - e) Lube oil cooler outlet temperature
 - f) Cooling water flow Low alarm

5.5.6 Coal Feeder

Remote monitoring and alarm facility for the following parameters shall be used as a minimum:

1. Coal bunker level
2. Remote operation and Open and Close indication for bunker to feeder isolating gate
3. Running indication of clean out conveyor
4. No Coal flow
5. Feeder Speed

5.5.7 Air Preheater

1. For emergency operation Air motor shall be provided. Low air pressure switch & Solenoid valve shall be provided for auto start of Air motor.
2. Support/Guide bearing oil circulation unit shall be provided with local instruments such as oil pressure switches, temperature switches, temperature elements, flow switches, local pressure & temperature gauges etc.
3. Thermocouples in Air & gas flow streams for APH fire sensing & RTD's for bearing temperature monitoring shall be provided.
4. Remote monitoring and alarm facility for the following parameters shall be provided in addition to bidder's recommended instruments:

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- a) O₂ measurements at each of air heater inlet and outlet in addition to the 3 nos. O₂ measurement before economiser.
- b) Differential Pressure Transmitter across air preheater.
- c) Pressure Transmitters and Temperature elements / transmitters at I/L and O/L on Flue gas path and air path.

5.5.8 SG Controls

1. CLCS controls shall be used through Plant DCS for the following control loops as minimum for which required sensors, transmitters, control valve & Valve positioner, damper etc. shall be used for controlling:

1. Combustion control
2. Furnace Draft control
3. Drum Level control
4. SH and RH steam Temperature control
5. Secondary Air Damper control
6. Soot Blower Steam Pressure control
7. Heavy Fuel Oil Pressure & Flow control
8. Light Oil Pressure & Flow control
9. Steam Coil Air-Preheater (SCAPH) Temperature control
10. SCAPH Tank Level control
11. Auxiliary Steam Header Pressure and Temperature Control
12. Mill Outlet Temperature control
13. Primary air (Mill air) header pressure control
14. Total air flow control
15. Primary air flow control
16. Atomizing steam pressure control
17. CBD Level Control
18. Air Heater average cold end temperature control
19. Oil Burner air flow control

The description of the few important closed loop control are indicated below:

a. Master Pressure Control

The function of this shall be basically to provide combustion demand signal for fuel and air flow controls, in order to maintain the steam pressure at plant header

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at a constant value during load changes. The output of master pressure control shall regulate total fuel flow and total air flow and shall work in conjunction with Burner Management System.

b. Air Flow Control

The combustion set point signal derived from the master pressure control shall be compared with total fuel (coal and oil) signal and a fixed signal corresponding to minimum air flow required for furnace purge and low load operation. The maximum value selected out of above shall be the set point for the air flow control. The air flow measurement shall be corrected for temperature and trimmed for oxygen present in the flue gas. The furnace shall be designed for air LEAD circuit ensuring air-rich-furnace. The output of air flow controller shall regulate FD fan inlet dampers. Proper biasing arrangement shall be provided for FD fans for equal load sharing.

c. Furnace Draft Control

The furnace pressure shall be controlled by controlling the ID fan blade pitch/vane. Three furnace pressure transmitters shall be provided and connected to three separate tap points on the furnace. The average value of the transmitters shall be compared in the controller with the set point and output of the controller shall vary ID fan blade pitch/vane position to maintain the desired furnace pressure. Total air flow may be used as feed forward signal for furnace draft control. The fan damper interlock shall be so arranged to always provide an open flow path between FD fan inlet and ID fan discharge under all combinations of running and idle fans.

The provision for biasing shall be provided for synchronized operation of both the ID fans.

d. Super heater Steam Temperature Control

Superheated steam temperature shall be maintained by injecting feed water spray between 30% MCR and 100% MCR or may be as recommended by the bidder.

Three temperature sensors shall be provided at the outlet of final super heater for measuring steam temperature. Median value shall provide healthy signal to the controllers. The final super heater outlet temperature shall be achieved by regulating Attenuation water flow. All the required feedback signals and other necessary corrective action shall also be considered to achieve optimum temperature regulation.

e. Air Preheater Cold End Temperature Control

The function of this loop is to control cold end temperature of air heater. This shall be achieved by measuring flue gas temperature at outlet of APH by using thermocouple and throttling the steam control valve in SCAPH line.

1. Other control loops include the following as a minimum:

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A. Fuel oil Temperature control

The fuel oil temperature control shall maintain the temperature at outlet of fuel oil heater by regulating steam inlet valve.

B. Atomizing Steam Header Pressure Control

Fuel oil atomizing steam header pressure shall be maintained at desired value by positioning atomizing steam control valve.

C. Continuous Blow down tank Level Control

The continuous blow down tank level control shall maintain the level in the tank at the desired value by modulating a control valve in the line from continuous blow down to intermittent blow down tank.

D. Fuel Oil Header Pressure Control:

The fuel oil header pressure control shall maintain the pressure at the outlet of fuel oil heaters by recirculating (bypass) optimum quantity of fuel oil (before the heaters) back to the storage tank.

2. Typical minimum requirement of Interlock and Protection has been stated below:

a) Boiler Starting Interlock

After ID and FD fans have been started, following condition should be fulfilled for light up of boiler:

- Purging of boiler at predetermined airflow for a predetermined time
- Resetting of MFR
- Permissive of starting Igniter

b) Purging conditions

- Either or both I.D Fans running
- Either or both F.D Fans running
- MFR in tripped position
- Air registers in purge position
- Air flow between 25% to 30% MCR
- No flame condition is true
- All fuel closed
- Boiler Tripping

c) Master Fuel Trip conditions

Boiler shall trip automatically through Master Fuel Relay (MFR) if any one of the following emergencies occurs:

- Boiler Drum Level Very High: 2 out of 3
- Boiler Drum Level Very Low : 2 out of 3
- Furnace Pressure Very High : 2 out of 3

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- Furnace Pressure Very Low : 2 out of 3
- Both ID Fans tripped : 2 out of 3
- Both FD Fans tripped : 2 out of 3
- Total Flame Failure : As per manufacturer's Recommendation

d) Tripping of MFR shall initiate the followings as minimum:

- Tripping of all oil burners
- Tripping of all pulverizers and Coal feeders
- Tripping of PA Fans
- HT supply to ESP
- Turbine trip

e) Followings sequence controls have been envisaged as minimum:

- Burner sequence
- Coal mills group
- ID, FD and PA fans
- Air Pre-heaters
- Coal Feeder Group
- Furnace Purging

5.5.9 SG Performance Optimization System

1. Each SG shall be used with a Combustion Control Optimization System to maximize combustion thermal efficiency and keeping the emission limit within predetermined limit during all regime of SG operation. The system shall be part of the Performance Optimization Package of Plant DCS. Functioning of the SG Combustion Optimization System shall be based on adaptive stochastic model of combustion process derived from the process inputs like flame intensity, Coal flow, air flow, Oxygen, Carbon monoxide and NOx. For this all inputs, logics, equipment design data, complete thermal design model of SG etc which shall be required for successful implementation of the Boiler Combustion Optimization System in the Plant DCS. System shall guide the operator in terms of most optimum air fuel ratio and shall also be capable to generate set point for air flow controller of combustion control system. System shall also have the capability of simultaneous firing of different grade of Coal by providing dynamic coordination of secondary air flow at different burner rows. Means shall be used to interface the signal with the combustion control system, if desired by the operator.
2. The Combustion Optimization System shall incorporate the complete thermal design model of the SG capable of both forward and backward calculation of complete SG thermal performance. The model shall be calibrated and made "Site Specific" based on series of field trials of thermal performance of the SG during startup and prior to trial operation. The input for the Combustion Optimization System shall be based on accurate and continuous on line measurement of the following:

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- a) Flue gas oxygen.
 - b) Other fluid temperature(s) entering and exiting various heat transfer banks.
 - c) Coal characteristics
3. The Combustion Optimization System shall be capable for continuous on-line calculation of the thermal performance of the SG for the operating conditions indicating performance prediction zonal absorption, metal temperature and shall have necessarily the following features:
- a) Fuel switching capability.
 - b) "WHAT IF" capability.
 - c) Selective soot blowing of furnace/super heater based on trends of zonal absorption.
 - d) Expert system diagnostics for quick identification of the 'Root Cause' of deviations from the predicted parameters.
 - e) The computer modeling and arriving at factors to make it "Site Specific".
4. Following minimum features have been envisaged for the system (the system shall be part of the PADO System of Plant DCS:
- a) Software for stochastic modeling and combustion control optimization.
 - b) Graphics for monitoring Fuel flow, Air flow, Oxygen, CO and NOx etc.
 - c) Setting of operator targets like set point for concentration limit of CO, NOx etc.
 - d) Validation of calculated variables. Provision for manual and auto bypass in case signal bad value, bad calculated variable and communication error etc.
 - e) Trend display for monitoring performance of controller. Graphic comparison of the actual model curve and curves with the reference model.
 - f) Initialization software to initialize initial characteristic curves of combustion, Input and Output configuration and communication link.
5. The System shall also include the following:-
- a) Boiler performance optimization packages including the optimized operation of soot blowing System.
 - b) Boiler stress condition analyzer.
- Interactive water and gas chemistry management system.

5.5.10 Other Auxiliary System

1. Complete and independent PLC based Control and Instrumentation system with all accessories & associated equipments and cables for the safe, efficient and reliable operation of the plant auxiliary systems such as ESP control and Auxiliary Boiler/ Auxiliary steam system etc.
2. All instruments and control equipments like primary and secondary instruments etc. which meet the requirements specified on field Instruments. In addition, all instrument devices like switches/transmitters/ controllers/ analyzers/ solenoid

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valves which are located in the field/hazardous locations shall be used with explosion proof enclosure suitable for hazardous areas described in National Electric Code (USA), Article 500, Class-I, Division-I. All field wiring should be through conduits. All fittings, cable glands etc. shall be strictly as per NEC recommendation article, 500 to 503.

3. ON/OFF control, indication, annunciation of incomers and bus-coupler are also to be performed for each of the above system as applicable.
4. Take special care for selecting the PLC for all the sub-systems from same make to the extent possible.

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6. DISTRIBUTED CONTROL SYSTEM (DCS)*{TO BE DELETED, IF ALREADY PROCURED UNDER TG PACKAGE.}***6.1 General Requirements**

1. The requirements for Distributed Control System are indicated on functional basis in this specification. The System shall be state of the art microprocessor based & of proven design, the performance & high availability having adequately demonstrated over a substantial period of successful operation.
2. The system shall have distributed intelligence architecture and shall comprise independent multifunction processors for execution of open loop and closed loop control and data acquisition functions.
3. If DCS & other common system/items (CMMS, STMS, Station LAN, SWAS, Master Clock System etc.) have been procured under TG package, then chapter-6 for DCS, and other common system/items shall be deleted from SG package.
4. The microprocessor based Distributed Control System shall have following capabilities:
 - a) Scan, acquire, validate, time-tag, process, store, update, archive, retrieve and display all analog and digital data and parameter.
 - b) Monitor real and calculated variables for multi-level alarm conditions.
 - c) Accept and execute operator's commands and pre-programmed routines and run-times.
 - d) Perform all open and closed loop control functions.
 - e) Display plant mimics, bar-graphs, control templates, point description, trend graphs (real time & history) in interactive mode with the operator.
 - f) Prepare and print logs and reports.
 - g) Perform performance calculation based on real-time and manually entered data.
 - h) Dynamically reconfigure itself on command from engineering station.
 - i) Run its own diagnostics, watch dogs, system checks and consequent fallback routines.
 - j) All system information and diagnostic alarm like failure of I/O channel, I/O card, Multifunction controller, communication modules, node failure, CPU loading, Network loading, workstation diagnostic etc. shall be annunciated and displayed at any workstation.
 - k) Dynamic data exchange (DDE) for communication with other computers
5. When more than one device utilizes the same signal for measurement and control, signal splitting shall be performed in such a way that disconnecting, shorting or failure of one receiver device shall not cause any upset at any other consumer point or cause any change in transmitter calibration.
6. Comprehensive self-diagnostic features shall be provided to facilities easy fault location and detection of failure without individually checking each module. On-

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line testing facility of control system while the unit is in operation shall be provided with suitable indication for easy identification of faulty module.

7. DCS offered shall have 'open' system architecture with open connectivity for viewing at remote locations without virus infection to control network and employing non-proprietary hardware/software. Latest hardware models & software versions shall be offered.
8. DCS shall be of distributed architecture type with VDU based operation. The entire system shall be bus organized and the plant operator shall run the plant through console consisting of LCD screens, Mouse and Keyboards. All the screens and key boards for ease of operation shall be of same design and shall enable the operator to view process data, control outputs, shut down status and to change all parameters necessary to control the plant.
9. The system software shall be governed by the operating system running in a real time mode. It shall meet all functional requirements specified in this specification as a minimum. The latest version of software at the time of SAT shall be supplied even if it is introduced after Contract finalization.
10. All the inputs shall be galvanically isolated, provided with suitable noise filter and routed through individual fuse. Isolation shall also be provided between operator console and related sub-systems connected to it. The digital outputs shall be routed through interposing relays. Each output shall be short circuit proof and protected by fuse.
11. The system shall be capable to detect open, short and earth fault conditions. The open sensor reading shall be either upscale or downscale and it shall depend on field requirement and shall be programmable from engineering station.

6.2 Design Requirements

6.2.1 System Expandability

Modular System design shall be adopted to facilitate easy system expansion. The system shall have the capability and facility for expansion through the addition of controller modules, I/O cards etc. The system shall have the capability to add any new control loops, groups / subgroups in control system, while the existing system is fully operational. The system shall be expandable to allow at least 50% future expansion only by addition of extra modules without removing or modifying any existing hardware.

6.2.2 Online Maintenance

It shall be possible to remove / replace modules online (like I/O module, interface modules etc.) from its slot for maintenance purpose without switching off power supply to the corresponding rack. System design shall ensure that while doing so, undefined signaling and releases do not occur and controller operation is not affected in any way (including any control loop trip to manual, etc) except that information related to remove module is not available to controller. Further, it shall also be possible to remove / replace any of the redundant controller

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modules without switching off the power to the corresponding rack and this shall not result in system disturbance or loss of any controller function for the other controller. The on-line removal / insertion of controller, I/O modules etc. shall in no way jeopardize safety of plant and personnel.

6.2.3 Fault Diagnostic

The control system shall include on-line self-surveillance, monitoring and diagnostic facility so that a failure / malfunction can be diagnosed automatically down to the level of individual channels of modules giving the details of the fault on the Engineers Work Station (EWS) monitor and printers. The faults to be reported shall also include faults in main and standby power supplies, sensor fault, Controller fault, any channel fault in 2V3 channels, failure of links to other systems. These faults shall be identified by local indication on the faulty channel / module and on respective rack / cubicle. The diagnostic system shall ensure that the faults are detected before any significant change in any controller output has taken place.

6.2.4 Fault Tolerance & Controllability

1. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is jeopardized. Control System shall be designed to prevent abnormal swings due to loss of control system power supply, failure of any control system component, open circuits, instrument air supply failure etc. On any of these failures the control system output shall either remain in last position before failure or shall come to fully open / close or on / off state as required for the safety of plant / personnel / equipment. System shall be designed such that there shall be no upset when Power is restored.
2. No single failure either of equipment or power source shall be capable of rendering any part / system / sub-system of control system inoperative to any degree or loss of generation.
3. The system design shall ensure that no single failure, whatsoever in any part of Control system result in loss of communication.
4. The controlled variable response rate and controllability shall be limited by the characteristics of main equipment, which is being controlled, and control system shall not impose any limitations in the response rate or controllability. Controlled process variables shall return to normal values in a stable manner and without control loop interactions or cycling of generation when generation matches with load demand.

6.2.5 Signal Exchange

1. All the signal exchange between various functional groups of each control group shall be implemented through redundant main system bus and local system bus within a subsystem as per standard practice. It shall be ensured that any single failure in electronics involved for such communication e.g. communication

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controllers, bus interface modules, physical communication media, etc. does not result in loss of such signal exchange and there is no deterioration in specified system response and system parametric requirements. In case a controller utilizes some inputs generated / processed by any other controllers / functional group and the requirement of controller response time as specified is not met due to inadequate communication rate / procedure, then the it shall provide hardwired signal exchange for such inputs.

2. However critical signal exchanges are found required shall be hardwired. Control and Protection signal exchange between control system of SG/TG and Plant DCS shall be hardwired only. Protection signals shall necessarily be hardwired even for exchange between the same sub-systems.

6.2.6 Redundancy

The Following shall be completely redundant:

- All the parallel & serial communication buses
- All the communication devices
- All the Process controllers
- Servers (if Server based system)
- All the Power Packs
- Critical drives related I/O Modules.

1. The redundant communication buses between the process stations and the operator supervision stations shall follow different paths. The redundant processor shall be connected to the same I/O's of the processor that it is associated to and shall be able to carry out all the operations assigned to this processor. In the case of a processor failure, the redundant processor shall become operative within the cycle time, without causing any loss of data or the interruption of the process control. The switch between the processor being utilized and the reserve processor shall be bump less and shall be within 20 ms which shall not cause any interruptions or stopping of the station functions. Furthermore, this switch must also be signalled by a high priority alarm.
2. The operator station shall be able to guarantee, from any work station, the complete control of the plant. The operator station electronic units shall be in dual configuration and independently connected to the system buses. In case of an operator stations failure, the station shall remain operative without the operator having to carry out any type of action. Each operator electronic unit and each process station shall be powered by redundant power packs those are able to power the entire load. In case of a failure, the switch between the power packs shall not cause stops or interruption in the carrying out of the station functions. The switch between the power packs shall be signalled by a high priority alarm.
3. In order to establish a high degree of system availability, the various control systems which comprise the overall unit control system shall be configured such that no single component failure can cause a failure or mal-operation of critical automatic or manual control functions. The failure of a redundant component

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shall be alarmed to the operator to allow on-line removal/replacement or at the first shutdown opportunity. The system's redundancy schemes shall be designed such that the transfer from any critical element to its redundant backup shall occur without upset to normal process control or to system displays, data collection, or other normal DCS functions within 50 m sec.

4. The signal distribution from sensors which are shared due to process restrictions between control loops, logics, monitoring purposes shall be as follows:-
 - a) In the case of multiple inputs to a card, input cards used shall be restricted to a maximum of 16 inputs per card for analog input and 32 for digital inputs.
 - b) In case there is either process redundancy (Left, Right) or transmitter or switches redundancy, the inputs shall be routed through independent input cards.
 - c) No two control loops/interlock loop shall share the inputs (either binary or analog) wide input cards if process signals are independently available.
 - d) Protective inputs for two drives shall not be allotted to the same input card.
 - e) Output cards shall be independent for each control loop.
 - f) For outputs to HT and LT motors, the following shall be adopted :
 - g) Each HT motor and unidirectional drives shall have dedicated output cards. No other drive shall be combined with HT motor drive output card. However indication outputs can be driven from this output card for the concerned logic loop.
 - h) Not more than two bidirectional drives shall share one output card.
 - i) For unidirectional drives, not more than one drive shall be allotted to one output card.
 - j) For signal distribution or fan-out, suitable electronic cards (opto couplers) shall be used.
 - k) The processors shall contain the logic required to group individual process and system alarms into common groups as well as the annunciation sequence logic.
5. Redundant components and equipment within given systems shall be distributed among processors and I/O cards to the extent practical.
6. Critical inputs shall be supplied with redundant sensors/transmitters with each input connected to different input cards. Where redundant inputs exist, the DCS shall be configured to automatically reject erroneous data. Where required, one-of-two, two-of-two, two-of-three, or median select schemes shall be utilized to ensure the integrity of critical inputs.
7. The use of redundant outputs driving the same final element or equipment shall generally be avoided in favour of failsafe design and redundancy of the plant equipment.
8. The operator stations shall be identical in capability and independently linked to the system. Although these stations shall be normally dedicated to a specific function, any station can replace the function of any other station at any time.

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9. All power source and power conditioning equipment in the system shall be redundant

6.2.7 System Spare Capacity

1. Following philosophy shall be followed for the spare capacity of the Distributed Control system:
 - a) Twenty (20) percent spare channels in each of the functional groups for each type of input/output modules fully wired up to marshalling / field termination cabinet TBs.
 - b) Ten percent (10%) installed spare I/O modules which may be capable of hot swapping.
 - c) Wired-in "usable" space for 20% modules in each of the system cabinets for mounting electronic modules shall be provided for future use. Empty slots between individual modules / group or group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice, shall not be considered as wired-in 'usable' space for I/O modules. Field Terminal assemblies, PCB / Connectors (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 20% blank space, distributed proportionally to main population.
 - d) Each controller shall have 40% spare functional capacity to implement additional function blocks, over and above implemented logic / loops. Further, each controller shall have spare capacity to handle minimum 40% additional inputs / outputs of each type, over and above implemented capacity. Under worst loading condition, Controller should not be loaded beyond 60%. Each of the corresponding communication controllers shall also have same spare capacity as that of controller.
 - e) The data communication system (including main system Bus and other bus system) shall have the capacity to handle the additions mentioned above.
 - f) Each Communication Network Switch shall have 20% spare ports.
 - g) Twenty (20) percent spare relays of each type and rating mounted and wired in relay cabinets. All contacts of relays shall be terminated in terminal blocks of relay cabinets. In each of the relay cabinets 20% spare terminal blocks shall be provided so that additional relays can be mounted and wired.
 - h) For power distribution board 20% spare feeder fully wired ready for use with MCBs fuses, TBs etc. Other hardware such as signal distribution isolation, trip amplifiers etc. shall be provided with 20% spares wired ready for use
2. Sufficient and additional software capacity shall be available in the system to take care of spares requirement as specified above to meet all functional requirements. The calculation for processor power and memory for all nodes should be furnished. Also, the dynamic processor load for all nodes either in terms of idling time or percentage load shall be available in VDU.
3. The spare capacity as specified above shall be uniformly distributed throughout all functional groups. The system design shall ensure that above mentioned additions shall not require any additional controller / processor / peripheral drivers

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/ cabinets in the system delivered at site. Further, these additions shall not deteriorate the system parametric requirement like response time / duty cycle etc. from those stipulated under this specification and shall meet other redundancy / functional requirement.

6.3 System Configuration

The Distributed Control System shall basically consist of the following:

- Control system including Auto Controls & Interlocks, Protection & Sequential control system.
- Measurement system
- Data Communication Bus system for control & communication with Process
- Man-Machine Interfacing System
- Maintenance Engineers System (Engineering Station)
- Software

The basic configuration of Distributed Control System shall be as indicated in the Drawings.

DCS system shall be independent for units yet connected at network level so that, even when system for any unit is not in service (in case of long term shutdown of a unit) or non- functional, the functioning of other unit or plant common systems shall not be disturbed.

6.3.1 Control System Requirements

The control system shall be broadly divided into SG - C&I, TG - C&I and BOP - C&I.

1. The SG- C&I part of DCS system shall perform the following function as minimum but not limited to:
 - a) Burner management system (BMS) including control & protection of coal mills, fuel oil system etc.
 - b) Analog control functions pertaining to secondary air damper control etc.
 - c) Soot blower control.
2. The TG- C&I part of DCS system shall perform the following functions:
 - a) Turbine protection system function (TPS)
 - b) Turbine governing system for main turbine
 - c) Turbine stress control system (TSCS)
 - d) Automatic turbine testing (ATT)
 - e) Automatic turbine run up system. (ATRS)
 - f) HP&LP bypass control system
 - g) Turbine generator control system
 - h) EHG, interlock & protection for turbine driven BFP
3. The BOP- C&I system shall perform the following functions:

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- a) Analog control functions, other than those covered in SG-C&I and TG-C&I, like co-ordinated master control, furnace draft control, SH/RH steam temperature control, FW flow control, heaters/deaerator/condenser level control, Auxiliary PRDS pressure & temperature control etc.
 - b) Binary control functions pertaining to main plant auxiliaries like FD/ID/PA fans, APH, BFP etc., Generator auxiliary systems and electrical breakers etc.
4. **Close Loop Control System (CLCS):** Modulating control functions for SG/TG/BOP system includes the CLCS SADC Control, Air/Fuel oil flow control Drum Level Control, FW Flow Control, SH/RH Temperature Control, Furnace pressure, wind box air damper, Auxiliary PRDS Coordinated Master Control, De-aerator Pressure & Level Control, HP/LP Bypass control, Hotwell Level Control, HP/LP heaters Level Control, BFP Scoop control, BFP & CEP minimum Recirculation Control & individual control and operation of modulating drives.
 5. **Open Loop Control System (OLCS):** Binary control functions pertaining to SG control system such as Sequence/ Interlock/ Protection of SG Auxiliaries includes the OLCS for FD Fan, ID Fan, APH, Soot Blowers etc. This includes controls of all HT drives, LT drives, motor operated valve, solenoid valves, Soot blower protection & auto-standby of HT & LT drives.

However the binary control functions pertaining to TG & BOP control system such as Sequence/ Interlock/ Protection of TG Auxiliaries includes the OLCS for the BFP, CEP, CW, ACW, ECW Drain & Vent Valves etc. and individual control & protection of Binary drives. This includes controls of all HT drives, LT drives, motor operated valve, solenoid valves, Electrical breaker, auto-standby of HT & LT drives.
 6. Time stamping of SOE inputs/points, Integration of BOP PLC's etc.
 7. Other Miscellaneous controls, signal processing etc.
 8. For each of the Functional Groups (FG), separate sets of controllers, I/O modules, communication controllers, power packs / modules, etc. shall be provided. Mixing of hardware of two or more FG's shall not be acceptable. However, splitting of any functional group in more than one FG's due to any limitation in system (e.g. limitation in handling number of inputs /outputs including spare capacity, limitation in implementation of number of functional blocks including, spare blocks etc.) shall be acceptable, subject to Consultant's approval. It may be noted that after splitting of the functional groups, each FG must have its own set of controllers, I/O modules, communication controllers, power packs / modules etc. It shall be ensured that failure of any set(s) of hardware of any FG does not affect other FG(s) and data communication between other FG(s) and MMI.
 9. The minimum functions to be realized in the Control System shall be as per requirements specified under subsequent clause of this specification. The system shall provided with all hardware /software, whether or not specifically indicated in this specification to fully meet operational / maintenance / safety requirement as well as statutory /international standards and proven practices.

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10. The Control System shall function reliably under the environmental conditions as specified in design philosophy & design criteria of this specification. It shall be immune from the interference resulting from disturbance in power supply feeders, signal lines, inputs, outputs, etc. as experienced in a power station.
11. The Control System shall have on-line simulation and testing facility. Further, it shall be possible to on-line configure and tune controllers through Engineering Station.
12. The system shall have the flexibility to easily reconfigure any controller at any time without requiring additional hardware or system wiring changes and without disabling other devices from their normal operation mode. Modifications shall not require switching off power to any part of the system.
13. Power supply to individual functional group shall be from redundant 24 V feeders with diode auctioneering and further sub-distribution.
14. The assignment of I/O channels for inputs / outputs, arrangement of modules within cabinet etc shall be identical. Further uniformity should be maintained for redundant stream of process equipment within a unit.
15. The application programs for the functional controllers shall be software based which shall be maintained even during power supply failure. The application program shall be alterable through the configuration and tuning station for all configuration and strategy changes, etc. and through the operator's console for set points / bias changes, device selection, etc. Parts replacement or parts removal shall not be required in order to accomplish changes in application programs including system tuning.
16. Independent and dedicated controllers (main and its 100% standby) shall be provided for each of the functional group (FG) of Control System. All the 100% hot / redundant backup controllers shall be identical in hardware and software implementation to their corresponding main controllers and shall be able to perform all its tasks. The backup controller shall track its corresponding main controller. There shall be an automatic and bumpless switchover from the main controller to its corresponding backup controller in case of main controller failure and vice versa without resulting in any change in control status. In case of switchover from main controller to the 100% hot backup controller, the back-up controller shall work as the main controller. Facility shall also be provided for manual switchover from main to 100% hot back-up controller and vice versa from the Engineering Work Station.
17. The loop / logic reaction time shall be suitable to match actual process requirements, subject to minimum requirement wherever specified.

6.3.1.1 Binary Controls/ Open Loop Control System (OLCS) Functions

1. These clauses are applicable for all the Binary controls of Systems for the systems of SG & TG which are to be implemented in Plant.
2. The OLCS shall include sequence control, interlock & protection for various plant auxiliaries/valves /dampers/drives etc. The sequence control shall provide safe and automatic start up and shut down of plant and of plant items associated with a plant group. The interlock and protection system shall ensure safe

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operation of plant/plant items at all times and shall automatically shut down plant/plant items when unsafe conditions arise.

3. The OLCS shall be arranged in the hierarchical control structure consisting of unit level, group level, subgroup level and drive level (as applicable).
4. It shall be possible to perform automatic unit start up and shutdown by issuing minimum number of command from OWS / LCD. Thus, the unit level shall control all the Control System Blocks and issue appropriate start up and shutdown commands to various blocks of Control System.
5. The group level shall control a set of functional sub-groups of drives. Appropriate start-up and shut down commands shall be issued to the sub-group control and various check-backs shall be received from sub-groups of drives. Each sub-group shall execute the sequential start-up and shut down programs of a set of inter-related drives along with system interlocks and protections related to individual drive falling under that sub-group. The drive level shall accept commands from the sub-groups, push buttons (wherever provided) etc., and transmit them to the respective drive, after taking into account various interlocks and protections and the safety of that particular drive. For HT drive, first-up logic shall be incorporated to indicate the cause of protection / trip.
6. A sequence shall be used to move a set of groups and sub-groups from an initial steady state (for instance 'OFF') to a final steady state (for instance 'ON'). The sequence initiating command for the unit and group level shall be issued from OWS/LCD.
7. A sequence shall be made of steps. The steps shall be executed in predetermined order according to logic criteria and monitoring time consisting of the interlock & protection requirements and check back of previous step which shall act as pre-conditions before the sequence control can execute the command for that step.
8. Each step shall have a "waiting time" implying that the subsequent step would not be executed unless the specified time elapses. A monitoring time shall also be defined as the maximum time required in executing the commands of any step and the time required for appearance of check back signals. In case, this is not completed within the specified time, a message shall be displayed and programme shall not proceed further.
9. Manual intervention shall be possible at any stage of operation and the sequence control shall be able to continue at the correct point in the programme on return to automatic control. Protection commands shall have priority over manual commands, and manual commands shall prevail over auto commands.
10. Open or close priority shall be selectable for each drive.
11. The sequence start up mode shall be of the following types:

a) Automatic Mode

In this mode of operation, the sequence shall progress without involving any action from the operator. The sequence start / stop command shall be issued from the OWS / LCD.

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b) Semi-Automatic Mode

In this mode of operation, once the sequence is initialized, the step progressing shall be displayed on the OWS / LCD. But the step execution command shall be prevented and shall be sent by the operator via the keyboards. It shall be possible to bypass and / or simulate one or more criteria to enable the program to proceed. This facility shall allow the program to be executed even if some criteria are not fulfilled because of defective switching devices, etc., while the plant condition is satisfactory. All the criteria bypassed shall be logged and displayed. It shall be possible to put the system on the Auto-mode after operating it on semi-automatic mode for some steps or vice-versa, without disturbance to the sequence operation.

c) Operator Guide Mode / Test Mode

It shall be possible to use the sequential control in operator guide mode / test mode i.e. the complete system runs and receives input from the plant and the individual push button stations (where provided) / keyboards but its command output is blocked. The whole programme, in this case shall run in manual mode. This mode shall allow the operator to practice manual operation using step and criteria indications. The actual protection should remain valid during this mode of operation also.

12. The sequence shall be started by putting the sequence on 'auto' and on receipt of 'start' command from the OWS / LCD or from a higher-level group / protection action as defined. The sequence shall then progress as per the defined logics. It should be possible to select alternative operation in the same sequence depending on certain process / equipment condition. Some step can be automatically bypassed also based on certain process / equipment condition. When the expected results of the sequence are reached the sequence is considered as "END". If during sequence initialization or sequence progressing or during normal running of the drive, a shutdown criterion is present, the sequence shall be stopped and the shut down sequence initiated.
13. For the drives, the command shall be provided through O/P module to MCC / SWGR / Actuator as applicable and input (status, SWGR and process) shall be acquired through input modules. The drive logic shall be implemented in the redundant controller. The status for the 11 KV, 3.3 KV drives and some other important drives shall also be wired in parallel to redundant input modules so that on failure of the single input modules, the information regarding the status of the affected drive remains available in OLCS.
14. The output modules shall have the feature that ensures that in case of failure, all the outputs are driven to zero. The 24V DC command outputs to drives for ON / OPEN, OFF / CLOSE shall be separate and independent and the inverted outputs shall not be employed. For inching type of drives, position transmitter shall be provided.
15. The termination for ON / OPEN, OFF / CLOSE command for the drive actuator

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shall be performed as specified in Chapter-4 Clause-4.13. However ON/OPEN feedback, OFF/CLOSE feedback, Switch gear disturbance feed back as a minimum shall be monitored in OLCS.

16. The drive function i.e. basic interlocks and protection logic of the drive shall be implemented in redundant controllers. The drive function shall ensure that protection signals for the safety of the drive shall be effective under all conditions and under all modes of operation. The different commands shall be performed according to the priority of protection 'OFF', protection 'ON', manual and automatic. The standard functions like running time monitoring, status signalling, alarm / drive annunciation, etc. shall be performed in drive function. The drive function shall prevent hunting of the actuator in the presence of both open and close commands for actuators of the valves and dampers. The drive function shall be implemented in dedicated standard software functional block

6.3.1.2 Analog Controls/ Close Loop Control System (CLCS) Functions

- These clauses are applicable for all the Analog controls of Systems included in for the systems of SG & TG which are to be implemented in Plant.
- The CLCS shall continuously act on valves, dampers or other mechanical modulating devices such as hydraulic coupling etc., which alter the plant operation conditions. The system shall be designed to give stable control action in steady state condition and for load changes in step / ramp over the load range of 60% to 100% MCR with variation or parameters within permissible limits.
- The controller capability shall, as a minimum, include (i) P, PI, PD and PID control functions and their variations (ii) cascade control (iii) feed forward control (iv) state-variable based predictive control for SH/RH temperature control (v) on-off control, (vi) ratio and bias control, (vii) logical operation etc. The loop reaction time (from change of output of the sensor of the transmitter/temperature element to the corresponding control command output) shall be within 250 ms. However, for faster loops such as feed water, furnace draft, PA header pressure control loop etc. the same shall be based on actual process requirement.
- The loop response time, for conventional I/Os, is the cumulative response time inclusive of input scan time, Controller Execution time and output card throughput time (in other words loop response is the time taken by the system to read a change in field signal at the input card terminal, process the controller task associated with the input and to make the required change in the control output at the output terminal of the output card)
- The control system shall be bumpless transferred to manual on the following conditions as a minimum. Control power supply failure, failure of redundant controllers, field input signal not available, analog input exceeding preset value, etc.
- Any switch over from auto to manual, manual to auto and vice versa shall be bumpless and without resulting in any change in the plant regulations and the same shall be reported to the operator and recorded automatically.
- Buffered analog output (positioning signal) of 4-20mA DC shall be provided from CLCS to the respective E/P converters. For electrical actuators, pulse type output

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(bound less control) shall be preferred. CLCS shall also provide all the necessary outputs for indicators & recorders with output loop resistance of 500 ohms for each channel of the output module.

8. The functional requirement of the CLCS loops as well as the detailed schemes shall be subject to purchaser approval.
9. The system being supplied shall be such that when permissible limits are exceeded, an automatic switchover from an operation governed by maximum efficiency, to an operation governed by safety and availability is affected.
10. For safety reasons, switchover logics associated with the modulating control loops shall be performed within the closed loop control equipment.
11. Time supervision facility shall be provided to monitor the final control element.
12. It shall be possible to block the controller output on a pre-programmed basis.
13. All controllers shall be freely configurable with respect to requisite control algorithms.
14. Whenever, alternate measurement is available for a control input the alternate measurement value shall be automatically substituted in the control loop in case of loss of control input. All necessary software for switching and reconfiguration shall be provided. In addition, such substitution shall be balance less and bumpless and shall be reported to the operator.

Table 6.1
Specifications for Controller

S.No.	Features	Minimum Requirements
1	Type	Microprocessor based, multi loop, multi function, dual redundant configuration.
2	No. of Loops	40 (maximum/per controller)
3	Word Length	32 bits
4	Register add cycle time	1 microsecond (typical)
5	Instruction Cycle time	75 microseconds (maximum)
6	I/O address capability	256 points (minimum)
7	Memory	RAM 12 MB (minimum) with battery backup
8	Redundancy Supported	Yes
9	Fall back transparent	Yes
10	Power Supply	24V, 5V DC
11	Mounting	Sub-rack
12	Indication	Processor status & fault display
13	Diagnostic	Invalid command checking, Automatic periodic illegal address detection,

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S.No.	Features	Minimum Requirements
		routine check and memory parity check, watch dog report to engineering terminal, time - out checking,

6.3.1.3 Guidelines for Functional Grouping of Plant DCS Controllers

The guidelines for functional grouping of controllers in Plant DCS shall be as described in this clause.

- Stream wise process redundancy is to be maintained in Plant DCS. That is, if there is more than one main equipment in a process block, these are to be allocated in different functional groups. For example, ID fan – A & B shall be allocated to two different functional groups, BFP- A, B & C shall be allocated to three different functional groups, etc. In the functional groups thus obtained, main equipment of similar stream shall be allocated. For example, if one functional group caters to Stream-A main equipments, all main equipments of Stream – A of the same block should be put together e.g. FD fan-A, ID fan-A should be put together. Further the auxiliaries of main equipment shall be allocated in the same functional group where corresponding main equipment is allocated e.g. Lube oil pump-A & Lube oil pump- B of FD fan –A should be allocated with FD fan-A.
- For different streams of process blocks defined below, separate sets of functional groups shall be provided. Where different streams of process blocks are not defined, separate sets functional groups shall be provided for the process blocks. The functions of two streams/process blocks should not be mixed in any case.
- The information signals of respective process areas shall be kept along with the main equipment.
- Electrical system of unit shall be a separate process block.
- The Plant DCS shall be divided into following major sub-systems:
 - BOP – SG
 - BOP – TG
 - Common System
 - Electrical system

For each of the above major sub-systems, the process blocks, along with major equipments/control loops in each block shall be as follows:

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A. BOP - SG

- **Air Block:** ID Fans- A & B, FD Fans-A & B, SA Fans– A & B, Primary APH –A & B along with flue gas temperature control/fire detection, stack path, Furnace draft control, Secondary SCAPH – A & B, Air Flow Control etc.
- **Steam & Water Block:** SG vents & drains, Main Steam/RH/SH valves along with temperature control, ECW Pumps- A & B along with DP control, Chemical Dosing, Feed water valves, SG misc. Drives, Coordinated Master Control, Feed Water Control, Group Control, RH Protection, SWAS, BCWP - A, B & C, etc.
- **Mills & feeder Block:** Mills/feeder – A, B, C, D, E, F, G & H controls for outlet temperature, Primary APH – A & B along with fire detection & temperature control, Primary SCAPH – A & B, etc.

B. BOP - TG

The BOP- TG shall include the following major equipments/controls:

- BFP – A, B & C
- CEP – A, B & C along with recirculation controls
- ACWP – A, B & C
- HP Heaters valves & Level control (all HP heaters should be kept in same Functional group)
- LP Heaters valves & Level control (all LP heaters should be kept in same Functional group)
- Hotwell level control
- ECW Pumps- A & B along with DP control
- TG misc. Valves/drives controls etc.

C. Common system

The Common systems shall include the following major equipments/controls:

- Compressed Air System block
- CW pumps – A, B & C (CW pumps shall be allocated to three different functional groups)
- LDO/HFO handling system block.

D. Electrical system

All Electrical breakers, bus couplers etc. shall be covered in this sub-system.

6. The major aspects to be considered shall be as follows:

- Hardware capacity, including spare capacity.
- Software capacity, including spare capacity.
- Response time/signal acquisition time requirement of Plant DCS.
- Parametric Requirement of Plant DCS.
- Tentative Functional grouping as described in Table 6.1A.

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7. The exact functional grouping shall be subject to approval. The equipments, logics, controls indicated in the functional grouping are tentative & shall be dependent on the design, recommended logics & controls of the SG & TG Vendors.

Table 6.1A
Functional Grouping of Controllers

S. No.	Functional Group	Functions
1	FG-01	FD Fan – A, ID Fan –A, SA Fan –A, Stack Path A & B, etc
2	FG-02	Furnace Draft Control, RAPH-A, RAPH – A Temperature Control, SCAPH –A, RAPH –A fire detection, etc.
3	FG-03	FD Fan – B, ID Fan –B, SA Fan –B, Stack Path C & D, etc.
4	FG-04	Air flow control, Fuel Flow Control, Coal Feeder Speed Control, HFO/LDO control, RAPH-B, RAPH- B Temperature Control, SCAPH –B, RAPH –B fire detection, etc.
5	FG-05	SG misc. drives, SG Drains & Vents, SG DMCWP –A, BSCP-A, Soot Blower Control, SADC, etc.
6	FG-06	Coordinated Master Control, Group Control, RH protection, Misc. Boiler Controls, etc.
7	FG-07	RH temp. Control, SH temp. control, RH/SH spray drains & vents, Eco. I/L valves, BSCP-B, Boiler Fill Pump-A, Aux. PRDS Control, etc.
8	FG-08	FW valves, SG DMCWP-B, SG misc. drives, BSCP-C, Boiler Fill Pump-B, Dosing system drives, etc.
9	FG-09	CEP-A, CEP-A recirculation system, etc.
10	FG-10	Hotwell level control, CEP – B, CEP – B recirculation control, GSC Minimum flow, etc.
11	FG-11	ACW –A, TG ECW –A, TG ECW CLCS, LP heaters CLCS, LP Heaters (valve) Drives, etc.
12	FG-12	CEP-B, CEP-B recirculation system, HP bypass system, etc.
13	FG-13	ACW –B, TG ECW –B, HP heaters CLCS, HP Heaters Drives (valves), LP Bypass system, etc.
14	FG-14	MDBFP, Deaerator Level control, Deaerator Pressure Control, Deaerator Overflow Control, Deaerator Drives (valves), CEP-C, CEP-C recirculation system, etc.
15	FG-15	ACW –C, TG Misc. Drives, etc.
16	FG-16	IA Compressor –A , CWP- A, HFO Transfer pump – A, LDO Transfer pump –A, Service Air Compressor – A, LDO System Misc. drives, etc.

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S. No.	Functional Group	Functions
17	FG-17	HFO Transfer pump -B Handling system, CWP – B, IA Compressor –B, LDO Transfer pump –B, Service Air Compressor – C, HFO Misc. drives, etc.
18	FG-18	CWP- C, HFO Transfer pump –C, IA Compressor –C, LDO Transfer pump –C, etc.
19	FG-19	Electrical systems, UPS, etc.
20	FG-20	Electrical Systems, 24 V DC system, etc.

6.3.2 Measurement System Requirements

All the signals coming into / going out of the Control System shall be routed through marshalling cabinets. The input / output modules employed in the Control System shall be separated from controller hardware.

6.3.2.1 Analog Signal Conditioning & Processing

- The conditioning and processing functions to be performed as a minimum for the analog input coming for control and information purpose are:
 - Galvanic isolation of input signals for which power supply source is other than the measurement system of the control system.
 - Transmitter power supply with per point fuse protection or current limiting and power supply monitoring.
 - Transducer / transmitter signal output limit check
 - Implementation of multiple measurement schemes
 - Square root extraction
 - Pressure and temperature compensation.
 - On-line ADC gain and drift monitoring and correction at periodic intervals.
 - Linearization of temperature signals (from thermocouples and RTD through temperature transmitters).
 - Reasonability checks for all analog inputs.
 - Monitor sensor wire break / open circuit / short circuit and take suitable actions in logic / loop. (This shall include blocking of trip signals in case of RTD failure).
 - Rate of rise / fall calculation
 - LVM generation.
- All analog signals for control purpose shall be acquired, validated, processed and their respective Controller data base updated at a maximum interval of 250 ms except for some fast-acting control loops for which the above referred time shall be as per process requirement. The validated analog inputs shall be converted into engineering units on per point basis. Analog input processing (scanning to alarm checking) shall be performed once every scan cycle.
- The analog 4-20 mA input cards shall have input loop resistance ≥ 250 ohm for interfacing transmitters / analyzers giving 4-20 mA DC signals along with

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superimposed HART interface signals. 4-20 mA DC signal shall only be used for control purpose and superimposed HART signal shall be used for configuration, maintenance, diagnostic and record keeping facility for electronic transmitters and Analysers etc.

4. Triple measurement scheme for analog inputs employing three independent transmitters connected to separate tapping points shall be employed for the most critical measurements. The three signals shall be auctioneered to determine the median / average value, which shall be used for control purpose. In case one transmitter fails or shows excessive deviation with respect to others, it shall be removed from computation of median / average value and the average of the other two transmitter outputs shall be used for controls. The control loop shall trip to manual when any two of the three transmitter signals fail. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.
5. Dual measurement scheme for analog inputs employing two independent transmitters connected to separate tapping points / temperature element shall be employed for the remaining measurements used for analog control functions. The output of the redundant transmitters shall be continuously monitored for excessive deviation. In case the deviation is within limits, the mean value shall be used for the control loop. If the deviation becomes high (with both transmitters remaining healthy), the loop shall be automatically transferred to manual. However, if one transmitter fails and other transmitter remain healthy, then the output of the healthy transmitter shall be used for control. If the other transmitter also fails, loop shall trip to manual. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.
6. Individual transmitter signal, their value and selected value for control/measurement shall be available in OWS.

6.3.2.2 Binary Signal Conditioning & Processing

1. The changeover type contacts (i.e. 'NC' + 'NO' together) shall be wired to the controller system for all the binary inputs required for control purposes. The binary inputs required for information purposes only shall be wired to control system in the form of non-changeover type contacts.
2. The conditioning and processing functions to be performed as a minimum for the binary inputs coming for control and information purposes are:
 - a) 24 V DC power supply for contact interrogation for all potential free contacts with per point fuse protection or suitable current limit feature / isolation through opto-coupler.
 - b) Contact bounce filtering delay time of 15 ms. However for SOE inputs, it shall be such that it should meet SOE time resolution of 1 ms.
 - c) Facility for automatic pegging of the binary signal to logic one / zero or last correct value in case of failure of binary input module.

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- d) Binary signal distribution to different user shall be in such a way so as to ensures that a short / ground fault on one user is not reflected to the other user.
- e) Implementation of multiple measurement schemes for signals for control purpose.
- f) All binary signals shall be acquired, validated, processed, alarm checked and their data base updated within one second. In addition to this requirement, binary signals required for SOE shall have resolution of 1 millisecond.
- g) Checking for excessive number of status changes for all binary / contact inputs and making it off-scan, if the total no. of changes exceeds a limit within pre-defined time.
- h) The non-coincidence monitoring shall be provided for binary inputs for all changeover signals.

6.3.2.3 Wiring Scheme for Inputs to Control System

1. Each of the triple redundant binary and analog inputs shall be wired to three separate input modules. In addition, for functions employing 2V3 controllers, each of the redundant binary and analog signals shall be wired to separate input modules associated with each controller. Similarly each of the dual redundant binary and analog inputs shall be wired to two separate input modules. These redundant modules shall be placed in different racks, which shall have separately fused power supply distribution. Implementation of multiple measurement schemes of these inputs shall be performed in the redundant hardware. Loss of one input module shall not affect the signal to other modules. Other channels of these modules can be used by other inputs of the same functional group.
2. No single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant input signals to control system. Similarly, no single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant output signal from the control system.
3. The single (i.e. non-redundant) binary and analog signal required for control purpose shall be wired as follows:
 - a) The on-off status of HT drives and Breakers with synchronization provision shall be wired to two input modules in parallel.
 - b) All analog and binary inputs including the limit switches of valves / dampers / MCC / SWGR, check-backs of all drives, SOE and information related signals should be wired to single input modules.
4. It is envisaged to use remote I/O modules in plant areas where it is required from location point of view. The remote I/O signals shall be connected to the respective functional groups through redundant extended I/O bus. The hardware independence of functional groups shall be applicable for remote I/O as well. The remote input / output modules shall be located in cubicles in respective areas. Remote input / output modules shall be designed in such a way to work continuously under the harsh environment expected to be encountered in these

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areas (high temp, dust level, humidity etc.). It shall be ensured that extending of I/O bus of functional group in field does not result in false signalling / noise pickups. Further, it shall in no way deteriorate the performance of that functional group and Control System.

5. Power supply arrangement for these cubicles shall be similar to DCS System cabinets
6. The measurement system of control system should be capable of acquiring data from various equipment and system in digital form through serial port, Field bus/ Profibus, Ethernet connection using industry standard protocols. The control system shall include requisite modules for accepting such signals.
7. The maximum number of inputs/outputs to be connected to each type of modules shall be as follows:

a) Analog input module	16
b) Analog output module	08
c) Binary input module	32
d) Binary output module	32
8. The following requirements shall be met for analog/binary input / output modules as applicable:
 - a) Input filters to attenuate noise shall be provided
 - b) All analog / binary inputs and outputs shall be capable of withstanding 500V DC common mode and 500V AC peak to peak between analog and digital parts. All analog outputs shall be short circuit proof.
9. Any single sensor / transducer / transmitter failure alarm shall be provided on Engineer's Station monitors for all sensors / transducers / transmitters. Similarly sensor break alarm for thermocouples etc. shall also be logged and displayed.

Table 6.2**Specifications for High Level Analog Input Modules**

S.No.	Features	Minimum Requirements
1	No. of Inputs/module	16
2	Type of Input(Linear)	4-20 mA & 1-5 V
3	Accuracy	0.1% or better
4	A/D Converter	Integrating, 15 bit + Sign or better
5	Temperature Effect	0.01%/Deg. C or better
6	CMRR	60 dB (at 50 Hz) or better
7	NMRR	20 dB (at 50 Hz) or better
8	Stability	0.03%/year or better
9	Diagnostic	<ul style="list-style-type: none"> Limit check A/D converter fault Channel fault Wire break Short Circuit

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S.No.	Features	Minimum Requirements
		<ul style="list-style-type: none"> Auto Gain Correction

Table 6.3**Specifications for Low Level Analog Input Modules**

S.No.	Features	Minimum Requirements
1	No. of Inputs/module	16
2	Type of Input (Grounded & Un-grounded)	Thermocouple (J,K,R,S,T) RTD (Pt-100) {Two wire & three wire}
3	Cold Junction Compensation	On module/Local RTD
4	Accuracy	0.1% or better (Linearized)
5	A/D Converter	Integrating, 15 bit + Sign or better
6	Temperature Effect	0.01%/Deg. C or better
7	CMRR	60 dB (at 50 Hz) or better
8	NMRR	20 dB (at 50 Hz) or better
9	Stability	0.03%/year or better
10	Diagnostic	<ul style="list-style-type: none"> A/D converter fault Channel fault Wire break Short Circuit Auto Gain Correction

Table 6.4**Specifications for Binary Input Modules (Slow Scan)**

S.No.	Features	Minimum Requirements
1	No. of Inputs/module	32
2	Type of Input	24 / 48 V DC NO/NC/Change Over Contacts
3	Input Current	5-10 mA
4	Diagnostic	<ul style="list-style-type: none"> Input Simulation Wire Break detection Short Circuit

Table 6.5**Specifications for Binary Input Modules (Fast Scan SOE)**

S.No.	Features	Minimum Requirements
Same as Table 6.4 above but resolution 1 milli Second		

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Table 6.6**Specifications for Pulse Input Modules**

S.No.	Features	Minimum Requirements
Same as Table 6.4 above but, with 16 channels/module (maximum) and Leading/Trailing edge detection. Minimum Pulse width 1 milli Second.		

Table 6.7**Specifications for Analog Output Modules**

S.No.	Features	Minimum Requirements
1	No. of Points/module	08
2	Type of Output(Linear)	4-20 mA
3	Accuracy	0.4% or better
4	Load	600 Ohms (current) 1000 Ohms (Voltage)
5	Diagnostic	• Channel fault

Table 6.8**Specifications for Binary Output Modules**

S.No.	Features	Minimum Requirements
1	No. of Points/module	32
2	Type of Output	Relay with one changeover contact
3	Contact Rating	60VA
4	Contact Voltage Rating	60 Volts
5	Switching Frequency	2 Hz
6	Contact Life	1 million operations

6.3.3**Data Communication Bus System Requirements**

The System offered shall be an open system and shall conform to Open Industry Standard (IEEE). A redundant 10 / 100 MBPS Ethernet based high speed switched fault tolerant Data Communication System shall be deployed that provides for multiple simultaneous bi-directional communications. Communication shall be full duplex and with TCP-IP protocol. All interfaces links of controllers, gateways, MMI stations, switches and all other communication devices on the network shall be dual so that a single point failure shall not lead to system shutdown. Network shall be capable of handshaking with any third party system following standard protocol. The primary objective shall be centralized monitoring, presentation & report of data for information and analysis of entire plant. All the functional groups shall be connected to a common high-speed data network for global distribution and peer-to-peer data communication. Any data shall be available at any point on the network as and when required. The control system shall be modular, expandable and flexible so the expansion of the system is possible by adding extra stations on the data communication bus. Comprehensive self-diagnostic features have been envisaged to facilitate easy

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fault location and detection of hardware and software while the unit is in operation. It shall be able to direct intelligent routing of messages without the drawbacks of traffic jamming etc.

The Data Communication System shall include a Redundant System Bus for major subsystems with hot back-up. The data highway shall be high speed digital links of speed preferable 10/100 MBPS. Bus protocols at control levels shall conform to OPC compliant ISO-7 layer protocol in master less, token ring or token bus (as per IEEE 802) or any standard proven and acceptable protocol in deterministic mode. Extensive error checking (CRC-16/12) or error correcting codes shall be used in these levels to improve the reliability of communication.

The Data Communication System shall have following minimum features:

1. Redundant communication controllers shall be provided to handle the communication between each functional group of controllers of Control System and the System Bus. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station / module connected to the system bus shall not result in loss of any communication function to and from any other station / module.
2. If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.
3. Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bumpless and the same shall be suitably alarmed / logged. The above changeover shall not result in any data loss.
4. The design and installation of the system bus shall take care of the environmental conditions and hazardous area classification as applicable to similar services.
5. Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 50% spare capacity shall be available for future expansion.
6. Passive coaxial cables or fibre optic cables shall be employed for System Bus. It may proposed with other type of cables as per their standard also which shall be subject to Consultant's approval. However the following buses shall be fibre-optic only.
 - a) System bus connections between Control Room & Control Equipment Room.
 - b) System bus from locally mounted control system cabinets / OWS to central location.
 - c) I/O Bus from remote I/Os to centrally located system cabinets. The redundant buses shall be physically separate and shall be routed separately.
7. If UTP / STP cables are used, then it shall routed with flexible conduit.

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8. In case of any distance or other limitation in the Data Communication System, then it shall be provide with special type of cables like optical fibres with repeaters as required to make the system fully operational.
9. Serial device interface module shall be capable of providing communication interface with serial devices. The Modbus interface shall support MODBUS RTU protocol and use EIA-422/485 multi loop configuration by establishing direct digital communication. The nominal capacity of a link shall not be less than 5000 digital and 200 analog inputs. The acquired & transmitted data shall integrate seamlessly with DCS database. The physical medium of communication can be twisted wire, coaxial or fibre optic cable, depending on transmission distance and surrounding electrical interference.
10. In redundant network, the communication cables of each network shall be uniquely colour coded.

6.3.3.1 DCS System Interfacing Requirements

Following Interfacing facility shall be provided for DCS System.

1. One (1) no. independent Redundant Bi-directional OPC/ Soft Link, for monitoring, operation & effective control of the system (without time delay), with Ethernet based TCP-IP protocol for SG integral Control System.
2. One (1) no. independent Redundant Bi-directional OPC/Soft Link, for monitoring, operation & effective control of the system (without time delay), with Ethernet based TCP-IP protocol for TG integral Control System.
3. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Coal Handling Plant Control System.
4. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Ash Handling Plant Control System.
5. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Water Treatment & Effluent Treatment Plant Control System.
6. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Raw Water Intake Pump house Control System.
7. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Hydrogen Generation Plant Control System.
8. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Substation Automation System.
9. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the ESP Control System.
10. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for Water Lance System.
11. One (1) no. independent Redundant Bi-directional OPC/Soft Link with Ethernet based TCP-IP protocol for the Emergency DG Control System.
12. One (1) no. independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for Turbine Supervisory Instrumentation (TSI) System.

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13. One (1) no. independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for Online Tube Cleaning System.
14. One (1) no. independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for Turbine Lube Oil Purification System.
15. One (1) no. independent Redundant Uni-directional OPC/Soft Link with Ethernet based TCP-IP protocol for AC & Ventilation Control System.
16. One (1) no. independent Redundant Uni-directional OPC/Soft Link with Ethernet based TCP-IP protocol for Fire Detection & Protection System.
17. One (1) no. independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for MIS system.
18. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for Computerized Maintenance Management System (CMMS).
19. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for PADO system.
20. One (1) no. independent Redundant Bi-directional Communication Link with Ethernet based TCP-IP protocol for Vibration Monitoring & Analysis System.
21. One (1) no. independent Redundant Uni-directional Communication Link with RS-485 Modbus Protocol for interfacing with SWAS.
22. One (1) no. independent Redundant Uni-directional Communication Link with RS-485 Modbus Protocol for interfacing with CEMS.
23. One (1) no. independent Redundant Uni-directional Communication Link with RS-485 Modbus Protocol for interfacing with Instrument & Service Air Compressors (NTA-1 Package).
24. Uni-directional Communication Link with IEC 61850 Protocol for interfacing with Numerical Protection relays.
25. Redundant Bi-Directional Communication Link with RS-485 Modbus Protocol for interfacing with Variable Frequency Drives.
26. Any other Communication Link as required for proper functioning of Complete System.
27. Two (2) nos. Redundant Bi-directional communication OPC Link with Ethernet based TCP-IP protocol as spare provision.
28. Two (2) nos. Redundant Uni-directional communication OPC Link with Ethernet based TCP-IP protocol as spare provision.
29. Two (2) nos. Uni-directional Communication Link with RS-485 Modbus Protocol as Spare Provision.
30. Four (4) nos. Uni-directional Communication Link with IEC 61850 Protocol as Spare Provision.

6.3.4 Man-Machine Interfacing System

1. Man-Machine interface system shall be designed and engineered for safe, efficient, reliable and convenient operation. MMI shall employ high performance, non-priority open system architecture to ensure fast access and response time

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and compatibility with other system and portability of third party software. MMI System shall be used primarily for the following functions:

- a) As operator interface for control operation for the plant for accepting data from and issuing commands to control system etc.
- b) To perform plant supervisory, monitoring and information functions.
2. No single failure in MMI System shall lead to non-availability of more than one OWS or one LCD or one printer. In such an event i.e. single failure leading to non-availability of any OWS / LCD, it shall be possible to operate the entire plant in all regimes of operation including emergency conditions from each of the other available OWS / LCD.
3. The Plant data pertaining to one unit shall be available in the MMI of the respective unit. Data from common system shall be available in the MMI of units. Further, suitable displays with selection facility shall be provided for common system drives so that all common system drives can be controlled from any of the unit.

6.3.4.1 Operator Interface Requirements

1. The Operator interface of the MMI system shall consist of TFT Monitor, Mouse, Keyboards of OWS, LCD, Printers, etc. as follows:
 - a) Six (6) Nos. OWS with 21" TFT Monitors, Optical Mouse, Keyboard etc. for Unit Operation.
 - b) Two (2) Nos. OWS with 21" TFT Monitors, Optical Mouse, Keyboard etc. for Common system Operation
 - c) Two (2) Nos. OWS with 21" TFT Monitors, Optical Mouse, Keyboard etc. for Shift In Charge Engineer.
 - d) Two (2) Nos. 65" LCD with work station for display control and all other accessories, for Operation & Monitoring.
 - e) One (1) No. 65" LCD with work station for display control and all other accessories, for Operation & Monitoring of Plant Common System.
 - f) One (1) No. 65" LCD with work station for display control and all other accessories, for Operation & Monitoring of Plant Electrical System.
 - g) Two (2) Nos. Dot Matrix Printer (A3 size) for Alarm Printing.
 - h) Two (2) Nos. Dot Matrix Printer (A3 size) for Log Printing.
 - i) Two (2) Nos. Color Laser Jet Printer (A3 size) for Hard Copy Printing.
 - j) One (1) No. Color Laser Jet Printer (A4 size) for Shift In charge Station.
2. All OWS / LCD of the MMI System shall be fully interchangeable i.e. all operator functions including control, monitoring and operation of any plant area shall be possible from any of the OWS / LCD at any point of time without the necessity of any action like downloading of additional files. Each OWS / LCD shall be able to access all control information related data under all operating conditions including a single processor / computer failure in the MMI System. Further, simultaneous operation of at least two drives of control system shall be possible

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from a single display without calling additional display for multiple drive operation.

3. The operator functions for each OWS / LCD shall as a minimum include control system operation (A/M selection, raise / lower, set point / bias change, on / off, open / close operation, mode / device selection, bypassing criteria, sequence auto, start / stop selection, drive auto selection, local-remote / other multi-position selection etc.), alarm acknowledge, call all kind of displays, logs, summaries, calculation results etc., printing of logs and reports, retrieval of historical data and any other functions required for smooth operation, control and management of information.
4. All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays and other operator functions.
5. The display selection process shall be optimized so that the desired display can be selected with the minimum number of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
6. The system shall have built-in safety features that shall allow certain functions and entry fields with a function to be under password control to protect against inadvertent and unauthorised use of these functions. Assignment of allowable functions and entry field shall be on the basis of user profile. The system security shall contain various user levels with specific rights, which shall be changeable by the programmer.
7. Set points and other entries made shall be automatically checked for validity of range.
8. In addition to the OWS & LCD, minimum amount of conventional instrumentation (i.e. Push button Stations etc.) shall be provided as per standard practice for safe shut-down of the unit.

6.3.4.2 MMI System Functional Requirements

The MMI System shall be designed as an on-line system which shall process, display and store Information to provide the operator, either automatically or on demand. The Following functions shall be performed by MMI system as a minimum:

1. Plant Control Displays

Various displays on the OWS / LCD shall as a minimum include P&ID displays or mimic, bar chart displays, X-Y and X-T plot (trend) displays, operator guidance message displays, group displays, plant start-up / shut-down message displays, system status displays etc. Number of displays and the exact functionality shall be on as required basis.

Minimum contents and functionality of various types of displays shall be as under:-

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a) Mimic Display

These displays shall depict the process in graphical form and shall cover all the drives operable from DCS and all process areas being monitored therein. There shall be two types of mimic display, broadly, i.e. Overview displays and sub-area / individual displays. Operation of sequences and drives shall generally be carried out through the sub-area / individual displays.

Facility of adding a user specific symbol to the standard library shall be possible. It shall be possible to go to a predefined trend display on selecting a field on any analog point on the displays.

b) Control Tile Display

In this display the drives of a loop shall be displayed with related parameters such as process value, set point, deviation for the loop along with facility for any selections (like A/M selection, valve selector etc.) and the command output, disturbance status and the position feedback signals, for each drive. It shall be possible to call this display as a Pop-up window from the controlled drives in main mimics.

c) Trend Display (X-T Plots)

These displays shall show the trend of analog points with respect to time. These displays shall be continuous curve plot and not point plots. Time spans of displays shall have operator selectable intervals of 5, 10, 15, 30, 60 minutes, 8, 24 and 72 hours. In addition, zoom in / out, stretching facilities etc. shall be provided. Sufficient buffer space shall be provided to store data for minimum 500 points at MMI system scan rate for 72 hours.

d) X-Y Plot Display

There shall be fifteen number of such X-Y plot displays each of one page, pre-programmed in the system. At any instant of time, this page shall include up to 3 independent X-Y point Plots (values of X and Y variables) of up to three equipment typically in the form of a cross 'X'. Operating curves shall be superimposed over the X-Y plot. Alphanumeric information shall be overlaid to indicate X and Y scales, point identification, current operation point value with engineering units, etc. Two or three pairs of X and Y variables having common operating curves shall be displayed on one display page only. In such cases distinct symbols shall be used to show operating point for each. The balance shall be programmable at site.

e) X-Y Plot Display using stored data

This type of display shall show the analog trend of X-axis variable with Y-axis variable with facility to select time period. Ten numbers of such displays, each of one page shall be pre-programmed in the system.

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f) Sequence Display

Sequence chain displays for each group and sub-group shall be used to trace the sequence of a control chain as well as to facilitate the operator interventions and enable mode changes / auto selection. Sequence chain display shall present complete sequence chain, in functional blocks, steps being carried out, criteria, running time, monitoring time, waiting time, operating mode, various parameters with associated engineering units for each step and criteria. It shall be possible to display a list of missing criteria for each sequence chain on Operator's demand. The sequence chain display shall automatically move forward when the auto sequence is in operation.

g) Drive Level Display

For each drive (both binary & modulating) a drive level display shall be provided which shall indicate the value / status of drive related inputs / outputs, permissive and protection conditions, the drive level logic and other drive related information including individual drive faults and disturbance criteria. It should be possible to call these displays as pop-up displays.

h) CLCS Display

The loop schematic for each loop shall be available in a display form which shall show the individual analog and binary values (input / output and intermediate) and the loop tuning parameters also.

i) Group Display

The group display shall present point information including point ID, description, current value, range, function group, quality tag and engineering unit of a group of points. (Number of points in a page shall be minimum 20).

j) Bar Graph Display

Horizontal and vertical bar charts shall be provided for the display of related points. Number of bars in a display shall be limited only due to visibility and resolution and no restriction shall be there in the numbers otherwise.

k) Alarm/Fault Analysis Display

In order to guide the operator in case of a process fault / alarm, a fault analysis display shall be provided so that the cause of the alarm, is presented to the operator. For each alarm, various reasons for the cause of the alarm shall be displayed.

l) Alarm Querying facility

On each display, one icon shall be provided. Clicking this icon shall lead to a display indicating all the lamp boxes and list of alarms in each box along with its status. Clicking on the alarm text of a lamp box shall give detailed list along with status of the individual alarm if it is a group alarm.

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m) Point Detail Display

From any display, i.e. mimic alarm or any other group display, facility shall be provided to select any point for point detail display. This display shall include all the database attributes of the point. For field I/Os, the termination and interconnection details up to field sensors shall additionally be available. In the point detail display of calculated point, by simple clicking of point or through soft key it shall be possible to display the calculation used and to get further details of any other calculated points used in the calculation.

n) LCD Display

In addition, top area of the LCD (around 300mm), shall be reserved for display of soft replica of Conventional annunciation fascia (for permanent viewing i.e., not operator changeable). LCD based overview display shall be provided, which shall be overlaid across all LCD for viewing as video wall.

2. Log/ Summaries/ Reports

The system shall generate three basic types of reports / logs i.e., Event activated, Time activated and Operator demand log and summaries. The system shall have the facility for viewing of the logs / summaries on the OWS / LCD as well as for their copying in formats compatible to be used with MS-Office or similar tools.

The system shall be designed for automatic printing of all the reports / logs with a provision of inhibition of the print function for each log separately, with selectable duration and selectable page / group of each log. Manual printing of time-actuated log shall also be possible.

Automatic switching of any log function from a pre-selected primary printer to a pre-selected secondary printer (defined on a per log basis) shall be possible. However, change in the assignment of the printers shall be possible through OWS/EWS.

a) Event Activated Logs

Event activated logs shall as a minimum include alarm log, trip analysis log, start-up log, control related logs and operator action log. All operator actions, modification in database etc. shall be logged (with historical storage) along with the username responsible for that action.

The trip analysis log shall record 30-100 pre-trip and 30-100 post-trip readings, operator selectable at site for the pre-defined parameters (not less than 250 points), sub-divided in to 25 groups. The data collection rate shall be of scan rate 2 minutes (operator selectable at site).

The system shall be capable of generating and printing TG start-up logs, the functionality of which shall be similar to the trip analysis log.

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b) Time Activated Logs

Time activated logs shall include shift log and daily log as a minimum. Each of these shall provide hourly record of a minimum 250 points sub divided into 25 groups

c) Operator Demand Logs

Operator demand logs shall include, as a minimum, digital trend log, maintenance data log. Summary log, performance logs and some special logs.

The system shall be capable of generating and printing trend log for a minimum of 80 groups of 15 points each.

Maintenance Data Log (MDL) shall provide schedule of preventive maintenance and routine equipment inspection for 100 numbers of equipment per unit and for auxiliary plant. The data in MDL shall include current status, total running time, running time since last maintenance, running time in current financial year, loss due to downtime etc.

Performance log shall provide results of performance calculations.

d) Various Summaries

Various summaries shall include off scan summary, constants summary, point quality summary, substituted values summary, peripheral status summary, alarm annunciation group summary, etc. These summaries shall also be available process area or sub-area wise, as well as based on any other data base criterion like functional group number, cabinet number, type of signal etc.

e) Generated Reports

It shall be possible to generate certain reports in some of the PC's on the station LAN, which shall constitute partly off-line data entered there-in and on-line information collected from the system. There shall be provision of generation of minimum ten (10) such reports per PC on the LAN.

f) Log Generation Utility

The system shall have a log generation utility to generate a log / report having following facilities as a minimum:

- Define format of the log like header information, time, date etc.
- Selection of any point (scanned and calculated) from the data base and assign it to a log group.
- Selection of log data collection process initiating event, collection intervals (1, 2, 3, 5, 10, 30 & 60 minutes) for each point of a particular log group. Facility shall also be provided for selection of 100 points at a collection interval of 1, 2, 3, 5, 10 and 30 seconds.

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- Assignment of log printout initiation on event or time including selection of the printing interval for particular log group and time of printing. (For time initiated logs).
- Assignment of number of samples to be collected for each point.
- Select points for which minimum, maximum accumulation over a selected period, average, etc., values can be printed. Also facility shall be provided to tag the time at which the parameter passed through maximum / minimum.

It shall be possible to define 100 log groups of 15 points each. Any log group can have any point from the database. One log shall include at the maximum 10 such groups.

3. Alarm Monitoring & Reporting

- The system shall display history of alarms in chronological order on any of the OWS. The MMI system shall have the capability to store a minimum of 1000 alarms each with paging features allowing the operator to view any page. The system shall have all alarm functions and related function keys like alarm acknowledge, reset, paging, summaries etc. Other design features like set point / dead band adjustments, provision of alarm priority, manual inhibition and automatic inhibition based on predefined logic etc., shall be provided. The alarm display / report format shall be subject to approval.
- Facility of audio annunciation including voice audio shall be provided in OWS upon the occurrence of alarms irrespective of whether alarms are displayed or not. Facility to disable the audio annunciation per OWS shall be provided under the security level of Maintenance or Administrator.
- At least four levels of alarm priority shall be available which shall be displayed in different colour. It shall be possible to display and print alarms of any of the four levels only on a per OWS basis.
- Alarm boxes shall be provided in each display to alert the operator about an alarm when he is viewing some other picture. Number of alarm boxes shall be for each process area and with priority therein.
- Features viz. root cause analysis, alarm filtering, alarm cut out and display of alarms on LCD shall be provided.

4. Calculations

- All the algebraic / logical calculations related to analog points e.g. sum / difference / average / maximum / minimum / integration, selection of one analog point out of two based on status of digital point, duration for which an analog point is above / below a threshold, digital point (e.g. AND / OR / COMPARE etc.), transformations , like running average, periodic average, weighted average, hourly / daily maximum / minimum (or for a specified duration) and time of maximum / minimum, flow calculations, time projection or rate of change calculations, duration in alarm (or duration in a band), number of transgression of a point in a band etc. shall be provided. All the calculated values of the plant shall be available in the database and can be

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assigned to all functions just like any scanned point. It should be possible to add new algorithm for basic calculations to the standard library.

- b) Using one hour average data of process parameters, the system shall have the capability to calculate present value, expected value and deviations for parameters like plant heat rate (net and gross), boiler efficiency, major drives efficiency calculation, auxiliary power consumption. The performance calculation package shall be based on latest codes & standards as applicable like ASME, BS & HEI.
- c) Provision shall be made, including all required custom programmed software, for performing the calculations described in this clause. All calculations shall use a high level language. Calculations shall be made using floating point arithmetic. These equations shall be changeable on line at the job site.
- d) An extensive set of steam property subroutines based on the latest ASME steam tables shall be included. The calculation results shall automatically be quality coded according to the worst quality of any of the inputs to each calculation. The results of these calculations shall be available through the data base, for appropriate logs and operator displays.
- e) Calculation for monitoring the performance of the unit shall be performed. These calculations are categorized into two classes.
 - i. Class I calculations include those calculations that are made every scan cycle, generally for the purpose of detecting and alarming unit malfunctions. The following class I calculations shall be included:
 - Cold reheat steam approach to saturation temperature
 - Drum Water Saturation Temperature rate of change
 - First stage superheat outlet temperature approach to saturation temperature
 - Turbine steam metal temperature differences
 - Turbine metal temperature rates of change
 - Feed water individual heater terminal temperature difference.
 - Excess air deviation from standard.
 - Feed water leaving each heater temperatures deviation from standard
 - Turbine steam supply accounting.
 - Metal Temperature differences for SH'Y' , RH 'Y' region and any specific location.
 - ii. Class II calculations include those calculations that are made to determine the performance of individual items of equipment and the overall unit. Class II calculations shall be performed on-line using averaged data which is accumulated over a period of time. This time period shall be selectively adjustable from 10 to 30 minutes. The system shall also collect this averaged data. The operator shall be able to input coal analysis data into the computer for the class II calculations.

Class II turbine performance calculations shall comply with the recommendations of ASME Performance Test Code Report PTC 6S-

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latest, Simplified procedure for Routine Performance Test of Steam Turbines. The vendor shall be responsible for altering his standard performance programme to comply with this specification and to conform to the cycle of these units.

Boiler efficiency shall be computed by the heat loss method and the input-output method. Percentage deviation between the two methods shall be calculated as recommended in the ASME Test Code PTC 4.1-latest as applicable, Steam Generating Units. If the test codes require measured data that is not actually available in the process, manually substituted values shall be used.

The following Class II calculations shall be performed.

- Unit heat rate
- Boiler Efficiency
- Operating Hours
- Air Heater Performance
- Economizer Performance
- Deaerator Performance
- HP & LP turbine enthalpy drop efficiency
- LP turbine enthalpy drop efficiency (using dry exhaust)
- Turbine heat rate
- Feed water heater performance
- Condenser performance
- Plant Load/Availability Factors
- Unit Availability Calculations
- Deviations from Expected Values for Each Calculations

5. Quality Tags

- a) The system shall identify and tag the quality of all data (scanned and calculated points) in a way that makes all users (control, calculations, logs, display, etc.) aware of its quality. Quality of data other than 'good' shall be clearly identified in all printouts and displays by appending quality character to the value / status of point. The quality tagging shall include good, bad, substitute, doubtful, missing, etc.
- b) Typically 'Good' shall designate variable that satisfies all tests for quality, 'Substitute' designating a value that has been manually substituted, 'missing' and 'bad' designating an open circuit, transducer limit violation on both upper & lower side, etc. for analog inputs & open fuses, excessive number of chattering etc for digital inputs

6. Database

- c) The database shall be organized in such a way that searching / querying & sorting of any field shall be possible. There shall be minimum 10 process areas and each database point shall have various attributes.

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- d) Based on these attributes & its combinations, the sorting / searching of the data shall be done.
- e) The attributes shall include as a minimum single point ID, additional tag number, description, current value, quality tag, engineering unit (if applicable), alarm limits, dead band, alarm cut out point identifier, variable limit point identifier, conversion constants, electrical signal value & unit, alarm status, scan status, historical / long term storage frequency, plant area / sub area hardware details, reference of logic / loop diagram number & page etc.
- f) All the points i.e. I/O's, OLCS/CLCS, generated signals, computed signals of calculations, OPC tags, shall be identified by unique tag throughout the networked DCS system/ sub-systems including station LAN.

7. Messaging System

It shall be possible to send pre-defined messages either periodically or on occurrence of certain events in the form of

- a) Operator guidance message to OWS / LCD.
- b) E-mail messages to various clients on the station LAN.
- c) Messages to pre selected Mobile numbers

Adequate safety in the system shall be built up to avoid any unauthorized access to DCS system. All necessary Hardware & Software shall be provided to achieve the same.

6.3.4.3 MMI System Hardware Requirements

1. The MMI system shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.
2. The Workstation / Servers employed for HMIPIS implementation shall be based on industry standard hardware and software, which shall ensure easy connectivity with other systems and third party software.
3. Power Fail auto Restart facility with automatic time update shall be provided.
4. Necessary hardware and software for quick backup and restore shall be provided.
5. Minimum amount of conventional mosaic compatible hardware devices mounted on draw out portion of Control Desks.
6. All the peripherals shall conform to the following minimum requirement but the exact make & model shall be subject to approval.

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A) Operator Workstation**Table 6.9****Specifications for Operator Workstations**

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better /64 bit latest generation
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	1 TB
4	Monitor Support	Dual
5	CD Drive	52X Read/Write
6	Power Supply	230 V 50 HZ
7	Keyboard	ASCII
8	Pointing Device	Optical Mouse
9	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

B) Servers**Table 6.10****Specifications for Servers**

S.No.	Features	Minimum Requirements
1	Processor	64 bit latest generation
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	3 X1 TB ultra wide SCSI/7200 RPM, Hot swappable
4	RAID	SCSI-channels, hardware RAID level 5 implemented
5	Monitor Support	Dual
6	CD Drive	52X Read/Write
7	Power Supply	Redundant Hot swappable, 230 V 50Hz 1-phase
8	Removable Bulk storage Drive	1 TB minimum
9	No. of Removable bulk storage media for above	10 nos.
10	Keyboard	ASCII
11	Pointing Device	Optical Mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

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C) LCD Screen

LCD display complete with control units & associated accessories shall be supplied as per the following specifications.

Table 6.11
Specifications for LCD

S.No.	Features	Minimum Requirements
1	Viewable Picture Area	65 inch measured diagonally
2	Resolution	1920 X 1080
3	Aspect Ratio	16:9
4	Display Colors	16.9 million colors
5	LCD Panel	Active matrix TFT LCD
6	Contrast Ratio	800:1
7	Brightness	500 cd/m2, Anti-glare
8	Viewing Angle	178° Horizontal & Vertical both
9	Computer Interface	VGA, DVI-D, HDMI,
10	Cabinet Material	ABS
11	Finish	Black
12	Mounting	Fixed Wall Mounting
13	Power supply	230 V, 50 Hz, 1-phase
14	Accessories	Universal Tilt wall mount stand, IR Remote, Power cord

Other Features of LCD

- LCD shall be designed for continuous viewing (24 hours in a day) under normal room ambient lighting without any need to darken the room. Suitable darkening of the projection screen for light absorption shall be provided for this purpose.
- The screen should be flicker free and there shall not be any screen burn-in due to display of same information for a long time.
- Auto brightness adjustment between each screen shall be provided.
- The control unit shall interface with the unit LAN. The control units shall have dual Ethernet connection with the respective Unit LANs and shall be located in the LCD panel.
- Suitable facility shall be provided to the Operator for transferring the screens, without any need of changing of hardware / wiring or software.
- Master control unit shall be capable of projecting MMI displays over a part of screen to multiple screens. Any communication of windows shall be possible. Facility for overlays shall be provided.
- The LCD Screens shall have additional features to work in association with multiple numbers of plant cameras also to be supplied under this package.

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D) Printers

Table 6.12

Specifications for Dot Matrix Printer

S.No.	Features	Minimum Requirements
1	Type	Heavy duty (at least 50000 pages/month)
2	No. of Needles	24 pin
3	Printing Speed	300 characters per second/ 1000 Lines per minute
4	Character dimension	9 x 8
5	Buffer	80 KB (minimum)
6	Local Memory	RAM with battery backup
7	Communication Port	Ethernet/RS-232/parallel
8	Power supply	230 V, 50 Hz, 1-phase
9	Paper size	132 column continuous fan fold type/A4/A3
10	Paper input capacity	continuous
11	Character sets	ASCII, IBM, Italics,
12	Transfer distance	200 mtrs. Minimum
13	Print features	Graphic print, Emphasized, double width, underlined, subscript, superscript, double strike, backspace, margin etc.
14	Reliability	MTBF > 8000 hrs.
15	Noise Level	Less than 60 dBA
16	Ribbon Life	2 million characters
17	Diagnostics	Self diagnostic, LED error code display, Audio alarm – paper exhausted
18	No. of Copies	Minimum Original + 3
19	Accessories	Printer stand Table top receiving station Interface cable Paper tear box Ribbon

Table 6.13

Specifications for Laser jet Printer

S.N	Features	Minimum Requirements
1	Type	Electro-Laser photographic, Table top type
2	Printing speed	Monochrome : 24 ppm – A4 Color : 6 ppm – A4
3	Printer Memory	256 MB (minimum)
4	Resolution	1200 X 1200 DPI in color
5	No. of Color (Basic)	4 nos.
6	Duty cycle	Monochrome 75000 pages/month
7	Power supply	230 V, 50Hz, 1-phase

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S.N	Features	Minimum Requirements
8	Paper size	A3/A4
9	Print media	Plain paper, Transparency, Thick stock, Glossy stock, Envelopes
10	Communication Port	Ethernet port/ Parallel port
11	Paper input capacity	500 pages
12	Others	Auto duplex function

6.3.5

Maintenance Engineer Station (Engineering Work Station)

- The system shall be provided with programming facility (Engineering Workstation) for Control system and system documentation. Three (3) Nos. of EWS shall be provided on per unit basis placed in Engineering Room. The system shall be complete with monitor, keyboard & Optical mouse.
- The system shall be also provide minimum Two (2) Nos. of Laptop computers with latest hardware configuration and loaded with suitable operating & application program as a backup portable programming and configuration station.
- Each station shall be equipped with DVD writer for archiving of the configuration.
- EWS shall have all the features of OWS and in addition shall have the following capabilities as a minimum:
 - To generate control software through logic diagrams without any programming knowledge
 - To generate graphic display and control displays, facility to change/enter all the attributes of analog and digital I/O points, calculated and Boolean variables and constants like scan rate, process range
 - To test, configure/reconfigure process interface modules/cards
 - CLCS tuning
 - To accumulate I&C faults to analyse downtimes and time to repair
 - To run offline system diagnostic programmes
 - On- line fault detection through diagnostics
 - Other maintenance Engineer's functions.
 - Online modification/addition of loops without hampering of smooth operation of plant. In case of errors in programming at engineering station, same shall be notified along with suggested corrections by the system itself, before loading.
- The programming tools shall have in-built safety features that shall protect the system against inadvertent and unauthorized use of these tools. Necessary hard key locks and software locks, etc. shall be provided for this. During on line programming, external plant / equipment should not be affected.
- The system shall also have facility to permit the programmer to add text information at the beginning and end of each program, wherein programmer shall list out his name, time, date of change which has been made, name of the person who has authorized the change, etc.

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7. Any modification done in Control System shall be suitably logged so that it can be traced to the user log-in ID and time of change. Facility for modifications shall be user friendly
8. Structuring / configuring and tuning facilities shall be provided for structuring / modification, storing / loading, testing, tuning, monitoring, etc. of all the microprocessor based controllers of the control system. The configuration and tuning unit shall be hooked up with the system bus. In case different hardware is employed for different parts of control systems and it is not possible to provide structuring/ configuration and tuning of these from the same station, then the system shall be provided with necessary number of stations for the purpose.
9. It shall be possible to configure the system with ease without any special knowledge of programming or high level languages. Control strategy shall be implemented using familiar and conventional automation function blocks (software implemented). Whenever any change in configuration is done, it shall be recorded and modified configurations shall be available for printing and documentation and shall be stored in non-volatile memory. The entire system configuration, tuning / fixed parameters shall be documented and printed in form of function diagrams and lists respectively.
10. On-line tuning of the control loops shall be possible without causing any disturbance in the execution of the control loops. Provision to store and retrieve on immediate and long term basis the system configuration, data base etc. on some device such as DVD shall be included. Facility shall be provided to reload / down-load the system or controller module from the already stored data, on-line.
11. The Engineering station shall be equipped with system/software to calculate the tuning constants i.e. P, I & D values of control loops automatically. Facility shall be provided to conduct open loop tests (i.e. controller in manual mode) and close loop tests (i.e. controller in auto mode) on control loops through GUI based user interface. It shall be possible for the user to adjust the step size of disturbance, sample time and duration of test. Facility shall be provided to choose the type of process to be tuned i.e. PI, PID etc., controller type i.e. regulating or tracking and the type of process being controlled i.e. Integrating, non-integrating etc. Further it shall also be possible to calculate the tuning constants by capturing the process changes during normal process disturbance (without conducting any test). The calculation of tuning constants shall follow internationally accepted tuning procedures.
12. Online system shall be provided for programmed development / modification to achieve various functions including development, modification and testing of software of MMI, generation and modification of graphics, logs, and HSRs functions in an interactive manner, MMI Database modification / creations, down loading the software with associated data base from the console and other features necessary for system maintenance. Also facility shall be provided to print system fault as detected by the online self-diagnostic routine.
13. The system shall have the facility to generate the associated documentation for both the Control System & MMI. The document, to be generated by the system

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shall include P&ID drawings, control loop drawings, sequence drawings, signal distribution list / drawings, system interconnection drawings, cabinets general arrangement drawings, measurement list, drive schedule, alarm schedule, system hardware and functional configuration drawings for displays, logs, trends, graphics etc. The system shall also include all required software and hardware tools for creating, modifying and printing CAD drawings to achieve paperless documentation for DCS.

Table 6.14
Specifications for Engineering Workstations

S.No.	Features	Minimum Requirements
1	Processor	64 bit latest generation
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	1 TB
4	CD Drive	52X DVD Read/Write
5	Power Supply	230 V 50 HZ 1-phase
6	Keyboard	ASCII
7	Pointing Device	Optical Mouse
8	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

Table 6.15
Specifications for Engineering Laptop

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better latest generation
2	Memory	4 GB DDR3 SDRAM expandable to 6 GB
3	Hard Disk	SATA2/ 1 TB/7200 RPM
4	CD Drive	52X combo CD/DVD Read/Write
5	Power Supply	230 V, 50 HZ, 1-Phase
6	Communication Ports	2 Nos. USB 1 No. Ethernet 2 Nos. Serial Port 1 Nos. Parallel port
7	Screen	15.4" TFT LCD screen
8	Battery	6-cell, LI-Ion Battery

6.3.6 Software Requirements

1. The system shall be provided with all licensed software packages with media required by the system for meeting the intent, functional / parametric requirements and performance requirements of the specification.
2. The system shall utilize a readily upgradeable, public domain software platform proven for real-time operation environment at the control and monitoring level

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overlaid with a relational database program. The desirable features are indicated below:

- a) The software system shall be fully modular.
- b) The software shall meet the following general requirements:
 - Simple, easy-to-learn editing language for editing and on-line operation.
 - Wide range of standard and non-standard peripheral support capability by modular controllers / supervisors.
 - Effective task scheduling and support of multiple priority structure including event based interrupt etc.
 - Effective debugging.
 - Provision for on-line editing and program development without interrupting on-line functions.
 - Self-diagnostic routines.
 - Efficient memory management and effective utilization of system time.
 - Quick start-up and loading.
 - Support of multiprogramming and multi-user operation.
3. Industry standard operating system like UNIX/WINDOWS NT etc. to ensure openness and connectivity with other system in industry standard protocols (TCP / IP etc.) shall be provided. The system shall have user oriented programming language & graphic user interface.
4. All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics / debug software, peripheral drivers software shall be provided. Latest versions of standard PC-based software for database handling, word-processing, spread sheet, Anti-virus etc. and latest WINDOWS based packages etc. and any other standard language offered shall be furnished as a minimum. Systems having program development environments like EWS, Station LAN Server shall have high level programming support like Microsoft Visual Studio, Oracle, RDBMS etc.
5. The programming language shall support Relational Data Base Management in a global and truly distributed Client-Server environment and shall have the following minimum features:
 - a) Modern high-level block structures type
 - b) Powerful, compact syntax
 - c) Logical organization that facilitates documentation, modification and maintenance of programs
 - d) Early detection of errors at compiles and run time
 - e) Fast debugging
 - f) Improved program reliability

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- g) Clearly defined data structure complemented by flexible user-declared data types
 - h) Fast execution.
6. All application software for control system functioning like input scanning, acquisition, conditioning, processing & control along with communication among various Control System functional blocks shall be provided.
 7. The system shall be provided with software locks and passwords to engineers at site for all operating & application software in order to prevent unauthorized access and only authorized engineers are able to do modifications at site.
 8. Two sets of all final / latest software on non-rewritable/non-editable media shall be provided as back-up.
 9. **Software License**
 - a) The system shall be provided with software license for all software being used in the DCS system. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware / machine-specific. That is, if any hardware / machine is upgraded or changed, the same license shall hold good / renew license due to up-gradation / change of hardware / machine in control system at site. All licenses shall be valid for the continuous service life of the plant.
 - b) In case the s/w license is dependent on no. of points, then quantity to be considered is 30% above the finally implemented points.

10. Software Upgrades

The system software's installed in the plant DCS, shall be periodically upgrades with the new releases, that would be taking place after the system is commissioned.

6.4 DCS Sub-Systems

The DCS shall consist of the following broad sub-systems, functionally independent of each other except for mutual signal exchange.

- Sequence of Event Recording System (SOE)
- Integrated Annunciation system
- Historical storage & Retrieval system (HSRS)
- Plant Performance Analysis, Diagnostic & Optimization system (PADO)
- Management Information System (MIS)

6.4.1 Sequence Of Event Recording System

1. The DCS system shall also perform the SOE functions like stamping of SOE inputs / points with 1 ms resolution. The SOE function shall be built-in function of DCS.
2. SOE shall be capable of accepting minimum 512 inputs per unit including 10% spare channels (included in total 512 inputs).

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3. The system shall monitor SOE inputs with a resolution of one millisecond at all times for all inputs including spare inputs. That is, all SOE points entering status change shall be reported and time tagged within 1 (one) millisecond of their occurrence. Input card shall be equipped with digital filters with filter delay such that it should meet SOE time resolution of 1msec (identical for all points) to eliminate contact bounce such that field contact which is changing state must remain in the new state for stipulated time to be reported as one event. The start of data collection for SOE report shall be reported to OWS within 1 sec of SOE data collection initiation.
4. SER is envisaged as an integral part of DCS with 1 millisecond time resolution. The SER data base shall be an integral part of the DCS database and same shall be made available at all the OWS / EWS resident on the network. Operator can access the SER on activation of SER alarm page. All SER inputs shall have real time "time-stamping" following any tripping of major equipment, or sub-system or the plant as a whole.
5. The system shall also have provision of rejection of chattering inputs.
6. In addition to above, facility for adding a field adjustable software delay on a per point basis shall be provided.
7. The system shall also include provision for historical storage and retrieval of SOE reports for 3 months period.
8. The SOE report collection shall begin on occurrence of change of status of any SOE point and shall be printed after an operator selectable time interval of 1 to 3 min. or 100 status changes have taken place after the first event. Adequate numbers of buffers shall be provided to prevent loss of data before transferring to HSR.
9. The SOE reports shall also include a list of major equipment trip in chronological order and include the points that initiated SOE collection. The inputs for SOE shall include
 - a) Hardwired inputs in input cards and
 - b) Calculated points / generated points of Control System.
10. Further, all the operator initiated actions such as trip inactivation (bypass) & trip activation (inline) shall form input to SER.
11. All the SOE inputs shall also be available for interlock / protection functions.
12. SOE of other systems (SG/TG integral control systems) shall also be integrated in this system. The SOE system shall collect process & report SOE inputs of SG & TG control system for a consolidated master SOE system. Necessary communication with required hardware & software and necessary engineering co-ordination with SG & TG Supplier shall be done for successful implementation of a consolidated master SOE list.
13. SOE time stamping shall occur at I/O level.

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14. Self Diagnostic Features like scanner test (a periodic test for communication between several levels), functional test by simulating abnormal Conditions shall be provided.
15. One (1) no dedicated SOE viewing station with SOE Log printer shall be provided for each unit.

Table 6.16
Specifications for SOE Station

S.No.	Features	Minimum Requirements
1	Processor	64 bit latest generation
2	Configuration	Tower
3	Internal Clock	3.2 GHz or better
4	Memory	4 GB RAM expandable to 6 GB
5	Hard disk	2 TB/7200 RPM
6	CD Drive	52X Combo CD/DVD read/write
7	Graphic Accelerator	16 MB
8	Communication Port	2 serial port, 1 parallel port, 4 USB port, dual 100 MBPS Ethernet port
9	Monitor support	dual
10	Keyboard	QWERTY 101 keys Keyboard
11	Pointing Device	Optical mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz.

Table 6.17
Specifications for SOE Log Printer

S.No.	Features	Minimum Requirements
1	Type	Heavy duty Dot Matrix Printer
2	No. of Needles	24 pin
3	Printing Speed	300 characters per second/ 1000 Lines per minute
4	Character dimension	9 x 8
5	Buffer	80 KB (minimum)
6	Local Memory	RAM with battery backup
7	Communication Port	Ethernet/RS-232/parallel
8	Power supply	230 V, 50 Hz, 1-phase
9	Paper size	132 column continuous fan fold type
10	Paper input capacity	continuous
11	Character sets	ASCII, IBM, Italics,
12	Transfer distance	200 mtrs. Minimum
13	Print features	Graphic print, Emphasized, double width, underlined, subscript, superscript, double strike, backspace, margin etc.

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S.No.	Features	Minimum Requirements
14	Reliability	MTBF > 8000 hrs.
15	Noise Level	Less than 60 dBA
16	Ribbon Life	2 million characters
17	Diagnostics	Self diagnostic, LED error code display, Audio alarm – paper exhausted
18	No. of Copies	Minimum Original + 3
19	Accessories	Printer stand Table top receiving station Interface cable Paper tear box Ribbon

6.4.2 Annunciation System

- The LCD annunciation shall emulate salient features of conventional hardware annunciations while presenting more flexibility.
- The annunciation system shall be implemented as an in built function of DCS. The field contacts shall be acquired through DCS only. The annunciation points shall be presented on topmost area of LCD screens. The annunciation area shall be divided into multiple “alarm bands”. There shall be 3 nos. of alarm bands in each LCD screens.
- The annunciation functionality shall be implemented through the LCD as described below as a minimum:
 - There shall be one alarm for each alarm window. Group alarms shall be provided only for pre-defined system/field faults. The alarm text is to be displayed only when alarm is present. A top up window shall be associated with each alarm window which shall show tag no. of alarm point when cursor is brought over the alarm window.
 - Hooters/speakers (not PC Speakers) of different frequencies shall be available for reporting new alarms & resetting of alarms etc. All flashing windows shall flash together (synchronized) in any LCD screen. Suitable means shall be provided to distinguish between new alarms & return to normal message.
 - Annunciation points shall be distributed on various LCD screens based on process area.
 - No fixed space shall be fixed for any alarm band. Once a particular alarm band is full the new alarm on this band shall be reported by shifting old alarm on left side band one by one on FIFO basis. A scroll bar shall be provided to view older alarms.
 - The hooter alarms sound shall be different for different units.
 - Facility shall be provided by which the operator can view details of the alarms, acknowledge the alarm, acknowledge the hooter etc. by clicking on the pop up window options.

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4. The above annunciation features shall also be replicated on all OWS.

6.4.3 Historical Storage & Retrieval System(HSRS)

1. Historical storage and retrieval facility shall allow collect and store data and parameters including trends, alarms and events from DCS data base periodically and automatically to removable data storage devices once every 24 hour for long term storage and retrieval.
2. HSRS of other systems (SG integral control systems) shall also be integrated in this system. The HSR system shall collect, process & report HSR inputs of SG control system for a Consolidated master HSR system. Necessary communication with required hardware & software and necessary engineering co-ordination with SG Supplier shall be done for successful implementation of a consolidated master HSRS.
3. Provision shall be made to notify the operator when the disk is certain percentage full.
4. The data to be stored in the system shall include alarm & event list, periodic plant data, selected logs/trends/reports etc. Exact data/information to be stored and frequency of data storage & retrieval shall be as possible.
5. Historical storage should permit trending of all analog inputs with time scale selectable as 1 sec., 10 sec., 30 sec., 1 min., 5 min., 30 min., 1 hour, 8 hours & 24 hours. Vertical Range (parameter range) shall be freely programmable. It shall be possible to map real time & history trend on the same trend group display. History data shall be for minimum 30 days & after expiry shall automatically/manually transferred to the external storage device such as DVD writer or external hard disk.
6. The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on OWS / LCD or printer in form of trend / report by specifying date, time & period through point IDs / group of points. Further, suitable index files / directories shall also be provided to facilitate the same.
7. The System shall store following data as a minimum:

a) Periodic Plant Data

- 1000 analog points with 1 sec rate
- 1000 analog points with 5 sec rate
- Balance analog points with 30 sec rate
- Binary points on status change (with suitable protection against excessive status change)

b) Logs & Reports

- All hourly, shift, daily, monthly, yearly logs
- All alarm logs
- All control related logs
- All event based logs

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- Pre-Trip & Post-trip logs
- Start up logs
- SOE Reports
- Maintenance data log

Apart from this other logs comprised of computed data such as running hour logs of drives, fuel consumption log, water consumption log, Auxiliary power consumption log, metal temperature logs or calculated values like efficiency etc.

8. Dedicated Redundant workstation with dot matrix & Laser jet printer shall be provided (per unit) for historical storage & retrieval system.
9. Provision for export of data to Excel spreadsheet package shall be available.

Table 6.18**Specifications for HSRS Station**

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better 64 bit latest generation
2	Configuration	Tower
3	Internal Clock	3.2 GHz or better
4	Memory	4 GB RAM expandable to 6 GB
5	Hard disk	2 TB/7200 RPM
6	CD Drive	52X DVD read/write
7	Graphic Accelerator	16 MB
8	Communication Port	2 serial port, 1 parallel port, 4 USB port, dual 100 MBPS Ethernet port
9	Monitor support	Dual
10	Keyboard	QWERTY 101 keys Keyboard
11	Pointing Device	Optical mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz.

Table 6.19**Specifications for HSRS Log Printer**

S.No.	Features	Minimum Requirements
Same as Table 6.17		

Table 6.20**Specifications for HSRS Laser Jet Printer**

S.N	Features	Minimum Requirements
Same as Table 6.13		

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6.4.4 Plant Performance Analysis, Diagnostic & Optimization System

6.4.4.1 General

1. PADO system shall provide critical analysis of the plant performance and guidance for optimisation on continuous on-line basis. The system shall analyse dynamically the status of the process and the equipment of the power generating units and shall automatically generate the operator guidance instructions for remedial actions for maintaining the process and the system / equipment in the plant to their optimum performance.
2. PADO shall incorporate the complete thermal design model of the plant and shall use the measured data from the plant DCS acquired through a suitable interface.
3. The system to be provided shall include all necessary hardware, software, firmware and interfaces required for implementing a fully functional PADO system. PADO shall include but not limited to the details specified in subsequent paragraphs.
4. PADO system shall be independent for each unit.

6.4.4.2 Functional Requirements

PADO system shall provide following functional requirements:

- Performance analysis and monitoring of systems and components
- System and performance diagnosis
- System and performance Optimisation
- Emission analysis and monitoring
- Boiler performance optimisation
- Boiler Stress Condition Analysis
- Regenerative cycle performance Optimisation
- Interactive water and steam chemistry management system

1. Performance Analysis & Monitoring of Systems & Components

Performance analysis and monitoring of systems and components shall involve and facilitate the following:

- a) Computation of thermal performance status of the plant and efficiency of generation.
- b) Computation of all the key system performance indicators at system level such as heat rate, plant and equipment efficiency, generator output and controllable losses.
- c) Computation of all the key system performance indicators at major component. This shall include the following:
 - Assessment of boiler operation based on efficiency, excess air and cleanliness factors of super heater, re heater and economiser.
 - Turbine performance evaluation considering efficiency, enthalpies, steam flow and gland leakage flow estimation.

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- Air Pre-heater performance involving efficiency and pressure losses.
 - Condenser performance based on heat duty and heat transfer co-efficient and cleanliness factors.
 - Performance of re-generative heaters by computing extraction flows, drain flows, terminal temperature difference and drain cooling approach.
- d) Analyse the impact of individual component performance on overall losses or gains in total unit generation along with computation and display of cost of individual loss/gain.
- e) Performing detailed analysis of each component including computation of key performance indicators such as efficiency, heat transfer co-efficient, TTD, DCA and fouling factor.
- f) Visualisation of individual component efficiencies & performances and display of the same.
- g) Visualisation of impact of incremental change of the major process parameters including but not limited to the following on boiler efficiency, turbine heat rate and unit heat rate etc. through 'What If' query facility for operator:
- Main Steam pressure
 - Super heater Spray flow
 - Re heater Spray flow
 - Economiser Inlet Temperature
 - Excess Air
 - Coal Analysis
 - Surface effective for super heater, re heater and economiser
- h) Performance computations to be carried out at specified intervals based on time averaged data during steady state operating conditions.
- i) Computations to be based on process signals, equipment status, design criteria and manual input data (where ever needed). Raw measured value for process signals shall be reconciled before usage.

2. Systems & Performance Diagnosis

- a) System and performance diagnosis shall involve detection of the abnormalities and diagnosis of system and component performance degradation up to component level to pin-pointing root cause of abnormalities existing in the process and guiding the operating personnel to attend to the same.
- b) Diagnosis function involves the following:
- Equipment health diagnosis for high/ low pressure, temperature, level & vibration etc.

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- Plant performance diagnosis for boiler, turbine, condenser, feed water and regenerative heating system
 - Identifying degradation of measuring instrument for important parameters using data validation checks.
- c) Diagnosis based on expert system in the form of “Fault Trees” / Neural and Bayesian belief networks etc. Expert systems shall draw inferences based on knowledge base, on-line measured data and computed performance indices.
- d) Diagnosis system shall be capable to provide following helps:
- Avoiding a possible trip
 - Maintaining process parameters within safe limits thereby enhancing the life of the equipment
 - Drawing the operator’s attention to the degradation of the equipment and instruments
- 3. Systems & Performance Optimization**
- System and performance optimisation involves optimisation of set points for controllable parameters by recommending to the operator the optimum set points for optimising the given process or activity at the measured operating condition using state of the art optimisation techniques.
- 4. Emission Analysis & Optimization**
- Emission analysis and monitoring functions involves the following:
- a) Monitoring, tracking and analysing plant emissions such as SO₂, NO_x, CO, CO₂ etc. in real time.
 - b) Monitor and analyse ESP & Stack conditions such as temperature, humidity, gas flow rate and opacity.
 - c) Facilitate obtaining lowest emissions by recommending optimal damper position to minimise the NO_x level measured at the stack while maintaining the CO value and unburnt carbon below desired permissible limits.
 - d) Facilitate obtaining lowest emissions while maintaining combustion efficiency.
 - e) Facilitate to set alarms to highlight conditions that violate pre-defined conditions
- 5. Boiler Performance Optimization System (BPOS)**
- BPOS shall enable operating personnel to improve boiler performance and optimise fuel consumption including optimised operation of Soot Blowing system. This system shall have following features:
- a) Incorporates the complete thermal design model of the boiler capable of both forward and backward computation of complete boiler thermal performance.

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- b) Boiler thermal design model calibrated to made “Site- specific” based on series of field trials of thermal performance of the boiler during start up and prior to trial operation.
- c) BPOS to function continuously taking into consideration the performance of furnace, super heater, economiser, air heater and pulveriser based on the continuous on-line measurement of the including but not limited to the following parameters:
 - Flue gas temperature at ECO I/L
 - Flue gas oxygen content
 - Other fluid temperature(s) entering and exiting various heat transfer surfaces
 - Coal Characteristics
- d) BPOS shall be capable for continuous on-line calculation of the thermal performance of the boiler for the operating conditions indicating performance prediction zonal absorption, metal temperature and shall have the following features:
 - Fuel switching capability
 - “What If” query capability
 - Selective soot blowing of furnace/Super heater based on trends of zonal absorption.
- e) Expert system diagnostics for quick identification of the Root Cause of deviations from the predicted parameters.

6. Boiler Stress Condition Analysis (BSCA)

- a) BSCA monitors the thermal stresses and assess life exhaustion in thick walled components like super heater and re heater outlet headers by estimating the expended life due to low cycle fatigue and creep.
- b) BSCA shall guide the operator during start- up and shut down regarding controlling of rate of heating or cooling of metal within specified limits and also guides the margins available for the rate of steam generation (for fuel firing) during start-up.

7. Regenerative Cycle Performance Optimization System (RCPOS)

Regenerative cycle performance optimisation system shall involve the following:

- a) Analysis of deviation of performance of the turbine cycle by examining the deviation of important parameters of the turbine cycle.
- b) Analysis of actual efficiency of individual stages of turbine.
- c) Evaluation of LPH & HPH performance by comparing current values of TTD/ DCA to the reference values.
- d) Heater level evaluation

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8. Interactive Steam & Water Chemistry Management System

- a) Interactive water and steam chemistry management system shall be capable of guiding the operator for appropriate chemical dosing to maintain the chemical balance, optimal blow down and carry out further investigation as advised by the system.
- b) The system shall have following features:
 - Monitoring of various steam and water parameters at certain pre-determined points in the flow cycle and warning the operator about any distinct aberration and guiding on precautionary as well as corrective actions to be taken.
 - The system shall use “Decision Trees” and “Fault Trees” or other suitable methods for each parameter to diagnose deviations in controlled parameters in order to find the root cause and advise corrective actions.
- c) The system shall provide following benefit to the user/operator:
 - Minimisation of makeup water consumption
 - Decrease in consumption of dosing chemicals
 - Prevention of carryover of impurities into the turbine
 - Decline in degradation of turbine components
 - Lessening of boiler tube scale formation

Reduction in energy consumption

6.4.4.3 Design Requirements

1. PADO system shall be based on Client- Server and expert system. The system shall operate on a commonly used hardware platform and network operating system.
2. System shall be suitable for simultaneous use by multiple users.
3. The system shall be suitable for a wide range of tagging systems and in particular KKS tagging system.
4. The system shall be password protected. It shall be possible to organise system users into groups and each group shall have a separate security profile. It shall be possible to provide additional personal security settings for individuals within a group.
5. The system shall be able to obtain requisite plant system / equipment and process data from the plant DCS. To meet the above requirement, PADO system shall be interfaced with Plant DCS through redundant bi-directional communication link.
6. The system shall have facility to store bulk data with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user friendly utilities to retrieve and analyze stored data.
7. Each PADO system shall include all hardware and software as required for proper functioning of the system including:

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- a) One (1) No. Redundant Server (with monitor, keyboard, Mouse etc.) per unit
 - b) One (1) No. User Workstation (with monitor, keyboard, mouse, Colour Printer etc.) per unit.
 - c) PADO Software with required user License's
 - d) Bulk Data Storage & Retrieval facility
 - e) Redundant OPC communication Link with all necessary hardware & software.
8. All software licenses shall be valid for entire life of the plant. It shall be possible to upgrade the installed system with latest available version of the software model without any additional hardware/software requirements during entire life of the plant.

Table 6.21
Specifications for PADO Server

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better /64 bit latest generation
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	2X1TB ultra wide SCSI/7200 RPM, Hot swappable
4	RAID	SCSI-channels, hardware RAID level 5 implemented
5	Monitor Support	Dual
6	CD Drive	52X Read/Write
7	Power Supply	Redundant Hot swappable, 230 V, 50Hz, 1-Phase
8	Removable Bulk storage Drive	1 TB minimum
9	Removable bulk storage media for above	10 nos.
10	Keyboard	ASCII
11	Pointing Device	Optical Mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

Table 6.22
Specifications for PADO Workstation

S.No.	Features	Minimum Requirements
Same as Table 6.16		

Table 6.23
Specifications for PADO Laser jet Printer

S.No.	Features	Minimum Requirements
Same as Table 6.13		

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6.4.5 Management Information System

1. An integrated Management Information System (MIS) shall be provided for the plant. System shall be able to provide information related to the following aspects to management personnel:
 - a) Plant Operation Information (Dynamic Mimics)
 - b) Plant Maintenance related Information
 - c) Environmental Information
2. MIS shall provide following plant information:
 - a) Environmental and hazard management
 - b) Equipment maintenance history
 - c) Fault cause analysis
 - d) On job information report
 - e) Plant Operation history
 - f) Plant performance details
 - g) Any other plant operation data/ details
3. MIS shall be based on client server & relational data base environment. The system shall operate on commonly used hardware platform & network operating system.
4. System shall be suitable for simultaneously used by multiple users. It should have at least 20 user licenses.
5. The system shall be password protected. It shall be possible to organize system users into groups and each group shall have a separate security profile. It shall be possible to provide additional personal security settings for individuals within a group.
6. MIS processing shall be carried out in an independent server interfaced with plant DCS, All BOP & offsite plant PLC control systems, Plant Performance Analysis, diagnostics & optimization system (PADO), Computerized Maintenance management system (CMMS) for polling of plant operational and performance data, and maintenance details. Plant environmental data shall be obtained from DCS. The MIS system server shall be connected with station LAN and all user PCs shall be connected with the station LAN.
7. The system shall have facility to store bulk data with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user friendly utilities to retrieve and analyze stored data.
8. MIS shall include all hardware and software as required for proper functioning of the system including
 - a) One (1) No. Redundant Server (with monitor, keyboard, Mouse, colour printer etc.) per unit

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- b) Twenty (20) Nos. (to be finalized by purchaser during detail engineering) User Workstation (with monitor, keyboard, mouse, etc.)
 - c) 42" LCD Monitor for display in different areas of plant such as Conference Room, station Entrance etc. These display boards shall include the following minimum parameters along with engineering units:
 - Unit MW
 - Unit frequency
 - Unit auxiliary power consumption
 - Station-Total MW (common)
 - Station-Total auxiliary power consumption (common).
 - d) MIS Software with minimum 50 nos. user License's
 - e) Bulk Data Storage & Retrieval facility
 - f) Redundant OPC communication Link with all necessary hardware & software.
 - g) Servers & user PC's operating licenses
9. All software licenses shall be valid for entire life of the plant. It shall be possible to upgrade the installed system with latest available version of the software model without any additional hardware/software requirements during entire life of the plant.

Table 6.24**Specifications for MIS Server**

S.No.	Features	Minimum Requirements
Same as Table 6.21		

Table 6.25**Specifications for MIS Workstation**

S.No.	Features	Minimum Requirements
Same as Table 6.16		

Table 6.26**Specifications for MIS Laser jet Printer**

S.No.	Features	Minimum Requirements
Same as Table 6.13		

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Table 6.27
Specifications for MIS LCD Monitor

S.No.	Features	Minimum Requirements
1	Viewable Picture Area	42 inch measured diagonally
2	Resolution	1920 X 1080
3	Aspect Ratio	16:9
4	Display Colors	16.9 million colors
5	LCD Panel	Active matrix TFT LCD
6	Contrast Ratio	800:1
7	Brightness	500 cd/m2, Anti-glare
8	Viewing Angle	178° Horizontal & Vertical both
9	Computer Interface	VGA, DVI-D, HDMI,
10	Cabinet Material	ABS
11	Finish	Black
12	Mounting	Fixed Wall Mounting
13	Power supply	230 V, 50 Hz, 1-phase
14	Accessories	Universal Tilt wall mount stand, IR Remote, Power cord

6.5 DCS Power Supply Requirements

1. Redundant UPS power feeder shall be provided for all 230VAC equipments and/or redundant feeders for 24 V DC for DCS requirements. The necessary cabling & termination at both ends for receiving the power supply shall be furnished as per the contact requirement.
2. The DCS shall work on 24 V DC Power supply & Computers and peripherals shall work on single phase AC supply from UPS.
3. All power supply in the System cabinets shall be redundant and shall have auto change over facility or diode auctioneering. Power supply monitoring shall be provided in the DCS.
4. The power supply shall be provided with suitable arrangements with redundant distribution boards for each system with proper auto change over scheme to change the load from one feeder to other, in case of one feeder failure.
5. Redundant DC feeders (One each from DCDB) shall supply each of the connected loads. The exact rating & number of feeders of each DCDB shall be approved by the purchaser/consultant. However, 25% spare feeders (minimum 1 no.) of each rating shall be provided in each DCDB.
6. Redundant AC UPS feeders (One each from UPS ACDB) shall supply each of the connected loads. The exact rating & number of feeders of each UPS ACDB shall be subject to approval. However, 25% spare feeders (minimum 1 no.) of each rating shall be provided in each UPS ACDB.

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6.6 DCS System Cabinets/Panels

1. All Control system modules, power supply components, other control devices which are required for completeness of the system shall be housed in cabinets. All equipment and dedicated cabinets required for termination, marshalling and proper interface within system and also with other systems shall also be provided.
2. The cabinet mounted equipments shall be fully assembled, installed in mounting racks, wired and fully tested as per specification requirements and approved drawings in the manufacturing works of a qualified manufacturer prior to shipment to the project site. It shall be ensure that the cabinets are complete and ready for installation before dispatch from manufacturing works. The installation work at project site for these cabinets should only involve connections through multi pair cables from marshalling cabinets (wherever provided) to system cabinets and inter-cabinet.
3. The Control system cabinets shall be grouped into physically separate cabinets as follows:
 - a) Control System Cabinets
 - b) Marshalling Cabinets
 - c) Relay Cabinets

However, in case the system design requires the termination cabinet independent from system cabinet, the marshalling cabinets can be combined with the termination cabinet. In case, the termination arrangement is part of the system cabinet, independent marshalling cabinets shall be provided.

4. A special note shall be indicated that in case termination of field cables directly to control system cabinet is not acceptable.
5. The Control system cabinets shall house all types of modules / hardware to achieve all functions of Control System including signal conditioning modules, controller modules, I/O modules, communication controller modules and all other requisite hardware for a complete system.

6.7 DCS System Response Requirements

DCS System response requirement (Under worst loading conditions) shall be as follows:

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Table 6.29**DCS System Response Requirements**

S.No.	Parameter/Function	Requirement
1	Scanning rate of Analog Signals	Maximum 1 sec for measurement
2	Scanning rate of digital signals	Maximum. 100 ms
3	Scanning rate of pulse signals	Maximum 100 ms
4	Loop execution time for CLCS	Maximum 250 ms (For all Loops)
5	Loop execution time for OLCS	Maximum 100 ms (For all Loops)
6	Controller output update for CLCS	Every 250 ms (For all CLCS Loops)
7	Controller output update for OLCS	Every 100 ms (For all OLCS Loops)
8	Updating rate of Analog display	Maximum 2 seconds (for measurement)
9	Updating rate of Analog display	Maximum 1 second for OLCS/CLCS
10	Updating rate of Digital value display	Maximum 4 seconds (for measurement)
11	Updating rate of Digital value display	Maximum 1 second for OLCS/CLCS
12	Time for display in CRT screen	Maximum 1-2 seconds on demand
13	Keyboard command execution time	Maximum 1 sec
14	Controller Loading	Maximum 60 %
15	Data Bus Loading	Maximum 50 %

Table 6.30**DCS System Display Response Requirements**

S.No.	Parameter/Function	Requirement
1	All control related displays	1-2 seconds
2	Point details display (single point)	1-2 seconds
3	Bar chart display (20 points, current display)	2-3 seconds
4	Plant mimic display of fair complexity with a minimum of 120 nos. of dynamic data items	2-3 seconds
5	Group review display (20 points, current values)	2-3 seconds
6	X-Y Plot display (2 X-Y Plot & single display requiring both history as well current data)	2-3 seconds
7	X-T Plot display (Trend of six analog points and a single display requiring both history as well as current data)	3-4 seconds
8	Plant summary display (e.g. bad points summary, limit check removed point summary. Assume the whole database search is required & summary display contains ten points)	3-4 seconds

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6.7.1 Performance Requirement for Close Loop Control System

Table 6.31
Performance Requirement for CLCS

S.No.	Load/Rate of load change (% of MCR per min.)	Maximum Deviation of Parameters from Set Point					
		Throttle pressure deviation (Kg/cm ²)	Flue gas oxygen deviation (% O ₂)	Furnace pressure deviation (mmwcl)	S.H. steam temperature deviation (Deg.C)	R.H. steam temperature deviation (Deg.C)	*Drum Level deviation (mmwcl)
A	Steady state condition						
1	90% to 100%	± 2.0	± 0.4	± 8.0	± 5.0	± 5.0	± 15.0
2	60%	± 2.0	± 0.4	± 8.0	± 5.0	± 5.0	± 15.0
B	Ramp test (change for max. duration of five minutes)						
1	± 3%	± 3.0	± 0.6/-0.4	± 12.0	± 8.0	± 8.0	± 25.0
2	± 5%	± 3.0	± 0.8/-0.4	± 12.0	± 10.0	± 10.0	± 30.0
3	± 10%	± 4.0	± 0.1/-0.5	± 15.0	± 15.0	± 15.0	± 50.0
C	Step Load changes						
1	From 100% to 80% at the rate of 10% per minute	± 5.0	± 1.5/-0.5	± 20.0	± 15.0	± 15.0	± 50.0

Notes:

1. Sufficient time shall be allowed as setting period between conducting the tests. Plant operating condition, i.e. main equipment status, availability of auxiliaries, operational and equipment constraints, which can influence the test, shall also be recorded.
2. Control system shall be running in the coordinated master control (CMC) mode i.e. boiler master, fuel flow, air flow, feed water and turbine load control shall be in automatic mode. Load set point, maximum and minimum load set point, rate of raise / lower of load shall be set through the TFT, keyboard/conventional console.
3. The the control system shall be responsive and stable and shall maintain the deviation of controlled variables from set point within the limits specified so that the equipment being controlled shall operate as specified over the range required. The controls shall operate automatically, with no assistance from the operator. The controller shall successfully demonstrate the performance of

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Closed Loop Control Systems before acceptance and taking over of this system.

4. Applicable for Drum type boiler.

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7. PROGRAMMABLE LOGIC CONTROL (PLC)**7.1 General Technical & Design Requirements**

Programmable Logic Controller (PLC) shall be microprocessor-based system. The PLC shall be versatile, expandable, user friendly and latest state of art technology. The system shall be envisaged for the purpose of sequential operation, protection and interlock, data acquisition system, alarm functions, closed loop control and data archiving for fully automatic operation. Logic controller shall be used with adequate and reliable protection safeguard for various equipments and to assist the operator for easy safe and efficient starting and stopping of various drives in the process. The system shall be designed by selecting high-grade components of proven quality and proper design of system electronics. The system shall be able to operate satisfactorily with reference to the specified environmental conditions as indicated in the specification.

1. The system shall be modular in construction and expandable in future by adding additional electronic modules, which shall be easily accessible for maintenance and repair. The modules shall preferably be Rack/Rail mounted. The types of modules shall be kept to minimum possible in order to have interchangeability and spares inventory.
2. The system shall have extensive self-diagnostic hardware and software features for easy and fast maintenance of the PLC. Safety barriers shall be used for intrinsically safe input / output circuits.
3. The PLC shall have very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and electromagnetic disturbances expected in a power plant.
4. The system shall be programmed as per the logic requirements required for the functioning of the systems and equipment.
5. Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.
6. On-line replacement of any module shall be possible in such a way that the removal and addition of the module shall be possible without de-energizing the system or causing any interruption in the system while replacing a faulty module except for the inputs /outputs which are being handled by that module. However, in case of triple modular redundant or dual PLC configurations, there shall not be any process upset while replacement.
7. PLC shall be used with 20% hard wired installed spare I/O Channels.
8. The system shall be capable of handling the long-term storage of data for 15 days and retrieval.
9. The system shall be used with programming and diagnostic facility. Each PLC shall be used with one no. Laptop of latest configuration with programming software & communication cable.

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7.2 PLC System Configuration

PLC shall consist of following sub systems:

7.2.1 Input/output Sub system

1. I/O subsystem shall be suitable for accepting discrete inputs, BCD inputs and analog inputs. The I/O modules shall be mounted in the I/O racks.
2. Each I/O shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 500 V DC.
3. Each module shall have LED for each digital I/O channel to indicate the status of each input / output. Redundancy in I/O level shall be maintained as per the process requirement.
4. PLC inputs shall be used with potential free dry contacts. All the inputs shall be double ended i.e., two wires per input and not common return for all inputs. The contact interrogation voltage for input contacts shall be 24V DC minimum. Each input channel shall be protected by separate fuse.
5. Output contacts from the PLC shall be potential free dry contacts. Each output shall be short-circuit proof and protected by fuse.
6. Visual indication of fuse blown must be provided for each input and output channel.
7. There shall be at least 20% spare capacity available on input & output modules, over and above the system requirement.
8. All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
9. PLC shall have the following monitoring features:
 - a) Power supply monitoring.
 - b) Contact Bounce filtering.
 - c) Optical isolation between input and output signals with the internal circuits.
 - d) In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode.
 - e) Further, keying-in of individual wire connectors shall be used to ensure that only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs.

7.2.2 Processor Sub system

1. The processor sub system shall include CPU, memory, power supply, communication interface etc.
2. Dedicated PLC's shall be envisaged for each Auxiliary system. The processor shall have capability to implement all the control functions required. The processor shall have sufficient memory for storage of the program instructions as

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applicable to the logic requirements. CPU shall be of 32/64 bit or upgraded version of microprocessor.

3. Memory shall be non-volatile, preferably EEPROM type. However, in case volatile memory is provided, battery backup shall be used for a minimum of three months to keep the stored program intact. A battery drain indication shall be used at least one week before the battery gets drained. Memory shall be used with adequate capacity with 40% spare capacity under worst loading condition.
4. The healthiness of processor hardware and software shall be continuously monitored by watchdog timer.
5. PLC's shall be used as a minimum with dual redundant processor subsystem including CPU, memory and power supply. Redundancy shall be used such that, in case of failure of the main processor, the standby processor shall take over automatically and vice - versa. The changeover shall be bumpless and shall not result any process or system upset.
6. In case of failure of complete processor system i.e., both processors, outputs shall take fail safe state automatically.
7. The scan time of programmable controller shall be of the order of 100 milliseconds or better. Scan time of PLC is defined as the cycle time taken by the system to read input, process input executing logic and update control output for all the logics configured within the system. Other activities like diagnostic routines, output / dump of data to peripherals, or any other activity which consume processor time shall also be accounted while computing scan time.

7.2.3 Communication Sub system

1. The communication subsystem shall provide reliable and high speed data transfer between the processor subsystem, I/O subsystem, PLC console and other devices connected to the system.
2. Redundancy in communication subsystem shall be used, such that on the failure of the active device, communication link or bus, the redundant device communication link or bus shall take-over automatically without interrupting the system operation. The communication bus shall be of coaxial / Fiber optic type.
3. Information about the failed device shall be displayed locally as well as on the PLC console. It shall be possible to manually switch-over the communication from main bus device to redundant bus device without interrupting the PLC functions.
4. The PLC shall have provisions of communication interface facility with Plant DCS system in order to make the entire system operational from CCR. Bi-directional, Redundant soft links shall be used in the PLC for the connectivity with the Plant DCS.
5. Following are also included in the system:
 - a) Cables required for interfacing with DCS.
 - b) Implementation of Tags and establishing the Link.
 - c) Any other software/hardware required.

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7.2.4 System Power Supply

1. For PLC system, redundant 24 V DC power supply shall be used. The required power supply cable shall be used from the UPS DCDB & ACDB for SG integral control system
2. For separately mounted I/O racks, separate power supplies shall be used. Power supply module shall be of ample capacity to supply all modules. In addition 20% spare capacity for future shall be used. All the drives shall be switched ON/OFF through 24V DC coupling relays to be provided in HT/LT SWGR panels.
3. For the Operator Stations and Engineering Station the power supply shall be from the 230 VAC UPS system.

7.2.5 PLC Console

1. PLC Console or operating panel/display panel shall be used as operator Interface station for control and monitoring of the plant. This shall be done through dynamic mimic displays and control displays.
2. PLC console shall also be used for program storage, display, fault diagnostic and alarm monitoring. It shall be possible to modify, add or delete the application program on-line without affecting the outputs. It should be possible to modify or create new displays from PLC Console.
3. Isolation shall be used between programming terminal and related subsystems, if there is any possibility of high voltage from TFT being transmitted to other subsystems.
4. The PLC system shall have provision to shift the Operator Station/ Engineering Station to the CCR in future with third party interactive communication facility.

7.2.6 Displays

The system shall be capable of reading the status of equipments, acquiring the analog signals, displaying the status in the form of mimic diagram, video trend, bar graph, periodic display, alarm display, alarm overview display, logs such as hourly/shift/daily logs, alarm logs etc.

Displays include plant mimic diagrams, which shall include the complete auxiliary plant system indicating each major components of the system and the operating status of individual equipment and devices

7.2.7 Alarms

1. The system shall display history of alarms in chronological order of occurrence on the Operator Station TFT. At least three (3) levels of alarm priority shall be available which shall be displayed in different color. It should be possible to display and print alarms. System shall have all alarm related functional keys like acknowledge, reset etc. Other design features like set point / dead band adjustment, alarm priority, manual and automatic inhibition based on predefined logic etc. shall be used.

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2. The alarm display shall be built bottom up with the most recent alarm at the top of the list. When a point returns to normal, the associated alarm line shall change color suitably and on acknowledgement, the line shall be blanked out.
3. The alarms below the blank lines shall move upward to fill the empty lines. If the capacity of the OWS display page is exceeded, alarm history shall be stored in memory to accept the over- flow. This alarm history shall be displayed upon operator demand.
4. When a point goes into an alarm state and appears on the alarm screen, the time of alarm shall flash until acknowledged by the operator. Acknowledgement by the operator shall cause the time to stop flashing. All alarm initiations and return to normal, shall be logged on a printer.

7.2.8 System Software

1. Complete licensed software for PLC based system including the communication software system shall be supplied and implemented to meet completely the specification requirements.
2. Application software shall be built based on approved logic diagram, graphics etc and shall include controls, graphics, logs, trends, history, report generation etc.
3. The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics.
4. Diagnostic software shall have the capability to provide information about the failed module / system either in the form of a system configuration display or provide information in the form of a statement.
5. The software's shall not be machine specific. All software licenses shall be valid for the continuous service life of the plant and equipment.
6. Password security shall be used in order to ensure security level to the plant operation.

7.2.9 Peripherals

Following Peripherals shall be used for PLC:

1. VDU/ TFT shall be multi-sync, 21" color monitor with intelligent terminal and key board. TFT shall be used with graphic and mimic capabilities with minimum 64 distinct colors. The graphic resolution shall be 600x 1280 dots minimum with 0.25 mm dot pixel and refresh rate shall be 85 Hz or better
2. Suitable optical filter for minimum secondary glare shall be used.
3. One number black & white laser printer shall be used for printing A4 size paper. Printing speed shall be minimum 24 ppm. The printer shall be heavy-duty type with minimum 50,000 pages/month printing capability, 600 dpi resolution, 128 MB memory and 3000 sheet input capability.

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8. COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM (CMMS)*{TO BE DELETED, IF ALREADY PROCURED UNDER TG PACKAGE.}***8.1 General**

1. A completely integrated computerised maintenance management system (CMMS) with relevant data base completely populated and system customised for power plant application shall be used. The system includes all necessary hardware, software, firmware and interfaces required for implementing a fully functional CMMS system suitable for integrated maintenance management function for a modern power generation utility.
2. CMMS system shall be common for the equipment/systems for the whole plant including all the units and the plant common systems.
3. If CMMS is procured under TG Package then it shall be deleted from SG package.

8.2 Functional Requirement

CMMS shall meet following functional requirements:

8.2.1 Asset Management & Asset Register Function

1. Asset management function shall facilitate the creation of an asset register which shall hold the comprehensive details of each asset/ equipment. It shall have following features:
 - a) Building the location details and it's hierarchy
 - b) Building the equipment, it's hierarchy and specification details including drawings.
 - c) Creating hierarchies identifying operating locations as a part of multiple systems.
 - d) Defining relationship between equipment, location and system.
 - e) Building spare parts and sub-assembly catalogues of the asset/equipment.
 - f) Tracking the equipment, movements, associated costs, histories of planned and un-planned maintenance & failures.
 - g) Facility to launch condition based preventive maintenance work orders based on preset equipment- wise upper and lower limits.
 - h) Links to inventory management and purchase functions.
2. The asset management facility shall be capable of performing the following:
 - a) Control the company's list of maintainable assets through an asset register.
 - b) Control the accounting of assets, purchase price, depreciation rates etc.
 - c) Control maintenance inventory (stores management, requisition and purchasing).

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8.2.2 Inventory Management Function

Inventory management function shall have following features:

1. Specifying attributes and then ability to search by attribute for items, equipment and locations
2. Tracking of stocked and non-stocked items through multiple stores.
3. Tracking of items, costs and balances by bin, lot and storeroom.
4. Stock replenishment when inventory falls below minimum levels
5. Automatic reorder of items through “ lights out replenishment”
6. Tracking of items by last cost, average cost or user definable standard cost.
7. Usage of ABC analysis to assign inventory item prioritising.
8. Employing just in time methodologies to generate purchase orders.
9. Identifying out of stock items and making substitutions with alternate parts, vendor and location tracking capabilities.
10. View of work order reservations for inventory items
11. Linked up with asset register.

8.2.3 Work Order Function

Work order function shall have following features:

1. Viewing comprehensive and detailed planning information such as following:
 - a) Work Plans
 - b) Schedules (Target and scheduled date tracking)
 - c) Costs
 - d) Labour, materials, Skill set / crafts, Special tools requirement etc.
 - e) Equipment
 - f) Failure analysis
2. Recording of maintenance work and closure of work orders.
3. Scheduling of work orders based on real time criticality and logistics.
4. Sequencing of work orders for multiple equipment based on location and / or equipment.
5. Comparison of real time budgets or estimates with actual and historical data.
6. Tracking of equipment down time.
7. Tracking of equipment failure history with cause and remedy. Facility for generation of micro-level failure/ cause stratification diagram.

8.2.4 Job Planning Function

Job planning function shall have following features:

1. Tracking of costs by operation or job plan
2. Linking job plans sequentially, each with it's own parts, labour and tool estimates.

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3. Duplicate job plans for modification and use as templates

8.2.5 Resource Planning Function

Resource function shall allow to maintain detailed resource information to plan and analyze maintenance work related to company, service contract, tools etc.

8.2.6 Schedule Planning Function

Scheduling function shall enable to forecast future preventive maintenance dates for resource planning.

8.2.7 Preventive Maintenance Function

1. Preventive maintenance schedule shall be capable of performing the following:
 - a) Allows each asset / equipment to have a defined maintenance profile
 - b) Helps to schedule planned preventive maintenance routines
 - c) Control preventive maintenance procedures
 - d) Control the issue and documentation of planned and un-planned maintenance work.
2. Preventive maintenance function shall have following features:
 - a) Generation of preventive maintenance work-orders on demand, batched or automatically.
 - b) Generation of preventive maintenance work-orders for planned shut downs.
 - c) Sequence multiple job plans and consolidate multiple procedures on one preventive maintenance schedule.
 - d) Facilitates clustering of PM work orders for various departments / divisions to take reduced planned equipment downtime.
 - e) Capable of generating PM work orders on the basis of fixed frequency intervals or run hours.
 - f) Reservation of inventory for scheduled PM works.

8.2.8 Purchasing Function

Purchasing function shall have following features:

1. Creation of purchase requisitions or purchase orders either from scratch or from the inventory or work order modules
2. Create RFQs for multiple vendor bids
3. Automatic release of agreement Purchase orders
4. Creation of special orders for parts not stocked in inventory.
5. Elimination of costly "Maverick Buying" by establishment of approved vendors.
6. Direct issue of purchase orders and issue parts and services directly to work orders for the expense off items.
7. Analyzing of vendor performance before ordering of parts

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8. Use of invoice matching
9. Defining multiple tax rates to budget for interstate and international purchasing
10. Auto re-orders PR/PO generation for the spares, when stock falls below re-order level.
11. PR to PO consolidation to group PRs by vendor into single purchase order.
12. Line item /Purchase order status generation-Initiated (Unapproved), Approved, Partial receipt, Completion of receipt, Invoice matched, Cancelled etc.

8.2.9**Personnel Function**

Personnel function shall have following features:

1. Creation of employee details including employment and personnel information tracked.
2. Assignment details like department, preferred staff and available weekly work hours tracked.
3. Craft / salary rates-employees can be expensed to work orders by an average craft rate or actual hourly rates.
4. Training / certifications of employees tracked by the system.
5. Security levels-each employee can be assigned access security levels for each of the functional areas in the system.

8.2.10**Financial Function**

Financial function shall have following features:

1. Facility for supporting double entry accounting for integration with any financial system.
2. Creation of user defined financial calendars to correlate directly with accounting periods.

8.2.11**Other Functions**

Other facilities required are as follows:

1. Interface to MS project/Primavera to permit planning of work carried out in CMMS system to MS project/Primavera for scheduling. Work progress can then be tracked in CMMS and used to update the project.
2. CAD / Image viewing capability to enable users to store, mark up and view drawings, scanned images, word documents etc.
3. Account code or project budgeting to enable users to set up periodical project budgets. The system shall then be able to track actual and committed costs against budgeted costs
4. Interfacing with existing On Line Integrated Material Management System (OLIMMS)

8.2.12**Reporting Functions**

Reporting facilities required are as follows:

1. Standard Reports-Generation of standard reports on work orders, safety plans, inventory values and other critical points about maintenance operations.

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2. Report types- Capabilities shall include columnar reports, forms, Bar Charts, Pie Charts, Cross tabs etc.
3. Report generation- Crystal reports.
4. Data export capability via crystal reports to Text, Excel, Word documents, E-mail, HTML & ODBC etc.

8.3 Design Requirements

1. CMMS shall be based on client server & relational data base environment. The system shall operate on commonly used hardware platform & network operating system.
2. System shall be suitable for simultaneously used by multiple users. It should have at least 20 user licenses.
3. The system shall be password protected. It shall be possible to organize system users into groups and each group shall have a separate security profile. It shall be possible to provide additional personal security settings for individuals within a group.
4. CMMS processing shall be carried out in an independent server interfaced with plant DCS, All BOP & offsite plant PLC control systems. Further CMMS system shall be interfaced with MIS system server for transmission of maintenance related details for usage with MIS. To meet the above requirements CMMS system shall be interfaced with all control systems through redundant communication links. The CMMS system server shall be connected with station LAN and all user PCs shall be connected to CMMS server through station LAN.
5. The system shall have facility to store bulk data with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user friendly utilities to retrieve and analyze stored data.
6. Wherever required same user workstations shall be used for CMMS & MIS systems. Together with MIS system total 50 nos. user workstations shall be provided.
7. All software licenses shall be valid for entire life of the plant. It shall be possible to upgrade the installed system with latest available version of the software model without any additional hardware/software requirements during entire life of the plant.

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9. SMART TRANSMITTER MAINTENANCE STATION (STMS)*{TO BE DELETED, IF ALREADY PROCURED UNDER TG PACKAGE.}***9.1 General**

A dedicated standalone PC based Smart Transmitter Maintenance Station (STMS) for each unit shall be provided for centralized configuration, maintenance, diagnostic and record keeping of all electronic smart transmitters, smart positioners & Analyzers. Transmitter signals shall be wired parallel to DCS and HART modules of STMS, which shall be connected to PC through suitable communication modules. Complete diagnostic, record keeping, calibration and configuration, event and log reports, historical data base records of all transmitters shall be possible from the STMS.

9.2 Design Requirements

1. The signals from each of the transmitter shall be wired in parallel to DCS and to HART interface modules. The DCS shall necessarily use 4-20 mA analog signals and superimposed digital signal shall be used in HART interface modules.
2. The multiplexed signal from HART interface modules shall be hooked up to a PC through associated communication modules, converters, etc. The communication module shall provide data on RS-485 link at a minimum speed of 19.2 K baud. If HART interface modules has integral communication module to provide RS-485 link, the same shall also be acceptable. In all HART interface modules, provision for connecting at least 30% extra transmitters over and above the engineered quantity shall be kept for future additions.
3. An RS-485 to RS-232 Converter shall be provided for interfacing HART data of transmitters to PC station. This converter shall also provide proper isolation to ensure data integrity.
4. Any failure / short / open-circuit and / or removal of any of the cards /devices / cables in this centralized configuration, maintenance, diagnostics and record keeping system, including failure / removal of HART interface modules, communication modules, converter, etc. shall, in no way, affect the 4-20mA analog signals being used in DCS. Further, the HART interface modules shall be organized in such way that separate cards are used for signals going to different DCS cabinets.
5. Suitable redundant & diode auctioneered 24V power supply packs / modules and redundant feeders shall be provided to feed all modules / devices. These power supply packs / modules shall be fed from redundant feeders of UPS system or from 24V DC power supply system.
6. All modules / cards / power supplies shall be mounted in cabinets to be located in Control Equipment Room. The PC station and printer shall be located in Engineering Room.

9.3 Functional Requirements

The system shall have following functionalities as a minimum:

1. Constant scanning to monitor faults or changes to instrument configuration.

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2. Purchaser-defined and standard calibration and configuration procedures for all transmitters.
3. Constant signal data collection facilities to maintain continuously updated records.
4. Automatic tracking of configuration changes made in the field, such as may be introduced by hand-held communicator. All configuration function associated with hand-held communicators shall be available in the system.
5. Event and log reports on screen as well as on printer.
6. Any addition / deletion of transmitter shall be reported on printer and logged in hard disk

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10. STATION WIDE LOCAL AREA NETWORK*{TO BE DELETED, IF ALREADY PROCURED UNDER TG PACKAGE.}***10.1 General**

1. A plant wide Local Area Network (LAN) encompassing the different plant buildings shall be provided. The Station LAN shall interconnect the buildings together and shall facilitate the smooth transfer of Data from one building to the other.
2. A plant wide Fibre Optic high speed (100/1000 MBPS) back bone & work groups is envisaged. This network is used by different users for viewing selective plant graphics & data on real time basis, historical data & trends, MIS reports & CMMS data.
3. The MMI of unit & common system, all BOP & offsite PLC's, PADO, CMMS, MIS, CCTV etc. Shall be connected to station wide redundant Ethernet LAN. The interface with these systems shall be through OPC client-server architecture. PC stations shall also be connected to this LAN to monitor data.
4. For achieving this, the above requirement all necessary hardware & interfaces such as the Station LAN Server, LAN Switches (main & secondary) with suitable number of ports, electric / optic and optic / electric converters / trans-receivers etc., software and data communication cables shall be provided. The redundant unit LANs of the each unit shall be connected through the station LAN switch and server. It shall be ensured that failure of this network component(s) shall in no way affect individual unit operation & monitoring function in any way.
5. The Station LAN shall connect following buildings:
 - a) Station Building- Central Control Room
 - b) Service Building
 - c) Coal Handling Plant
 - d) Ash Handling Plant
 - e) ESP Control Room
 - f) CW Pump House
 - g) Water Treatment & effluent Treatment Plant
 - h) Air Compressor House
 - i) Hydrogen Generation Plant (if applicable)
 - j) Workshop
 - k) Stores
 - l) Switchyard Control Building
 - m) Any other plant area/ building where Station LAN needs to be provided for the purpose of CMMS, MIS or for Plant security/ surveillance system.

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6. The LAN network to be provided for all user points in all the rooms in the buildings.
7. The various buildings shall be interconnected through the use of minimum 4 Core single mode fibre and shall be connected to the main switch in the CCR in a STAR topology.
8. Each building shall be provided with a 12.U high wall-mountable communications cabinet complete with glass door, 6 way power distribution unit, shelves and force ventilation. All units are to be supplied with cage nuts and bolts to house LAN switches.
9. Inter building wiring shall be a minimum of Category 5E STP cable manufactured, tested and verified to ISO11801 EIA/TIA standard. Internal building wiring shall be of the structured cabling type and shall incorporate patch panels on every floor or as required.
10. A minimum of two RJ-45 ports shall be provided for each specified location. Category 5E shuttered modules shall be used in pre-assembled faceplates to save installation time. Modules shall include a slide label system.
11. If Station Wide LAN is procured under TG package, then it shall be deleted from SG package.

10.2 Design & Functional Requirements

1. The station LAN shall be achieved through the station LAN Server and High capacity Ethernet switch (station LAN switch). The Station LAN server shall have the hardware and shall maintain a combined plant database (complete database from each unit MMI updated at 1 sec.) and data from other systems through industry standard protocols and formats, on an Open standard RDBMS package like Oracle Enterprise version or equivalent, for open access to the same from any PC station in the plant running a suitable client software. This server shall function as a database server for the Plant Wide LAN.
2. The LAN shall be of the Gigabit type (1000 MBPS) and shall utilize standard IEEE 806.3 protocols such as Ethernet.
3. The Station LAN Switch shall be a layer-III switch & shall have hot pluggable redundant power supply, Gigabit back plane (switch fabric) capability, 1000 MBPS per port minimum data speed, fibre optic and UTP cable connectivity and Gigabit ports and shall support expandability / Stackability through a dedicated high speed expansion port. It shall support minimum Four numbers virtual LANs as a minimum and shall be routable, remotely manageable and configurable. The switch shall have extensive self diagnostic and logging facilities and shall use structured cabling facilities. The Station LAN switch shall be suitably sized to provide additional ports for connecting Servers / PC-stations etc. In future and fibre optic ports for connectivity and DCS TCP/IP ports for interconnection to standard third party sub-systems.
4. Network Monitoring & Management tool shall be provided so that loading etc. on the LAN switch can be ascertained.

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5. The station wide LAN shall connected to IT LAN, through which the CMMS server data shall be made available to existing Online Integrated Maintenance Management System (OLIMMS). Also the PC stations for various plant personnel shall be connected to station LAN for monitoring data of all units as well as that of common systems & offsite systems. These Connections shall be through Firewall.
6. Redundant Hardware Firewalls in failover mode with intrusion prevention system (IPS) features shall be provided to ensure security of network & prevent unauthorised access.
7. Firewall shall have minimum three zones. One inside (DCS network), one outside (IT LAN/ OLIMMS network) & the De-militarized zone (DMZ). Station LAN Servers shall be placed in DMZ zone. Data required for intranet (plant PC Network) & for OLIMMS shall be made available to the redundant station LAN Servers.
8. Station LAN switch shall be provided with a network based intrusion detection system (IDS) of a make different from IPS provided with Firewall to achieve a multi layered defence mechanism against intrusion as well as to guard against possible misuse/attack from within LAN.

10.3 Security Features Requirements

1. Firewall

- a) Firewall appliance should facilitate multi-vendor, multi-application environment and should support third-party products on open alliance. It should support Active-Active configuration.
- b) The firewall should contain following features:
 - Stateful inspection of packets.
 - NAT functionality, including dynamic and static NAT translations
 - Latest version of SNMP
- c) The firewall must send log information to a separate log server via an encrypted connection. Firewall logging must not impact firewall performance.
- d) Remote network access to the firewall should only be possible through the administration interface.
- e) The firewall administration station must be capable of pushing firewall security policies and configurations to individual or multiple firewalls through a secure, encrypted connection to the firewall administration interfaces.
- f) Graphical User Interface (GUI) and a Command Line Interface (CLI) for making changes to the firewall rules set should be provided. (Access to the firewalls via the GUI or the CLI must be through a secure encrypted channel).
- g) Any changes or commands issued by an authenticated user should be logged to a database configured on any of the machines in the LAN. The

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administration station must allow for a hierarchical architecture for rules set administration and viewing of firewall configurations Management.

h) Firewall should also meet the following requirements.

- The firewall must not support any unencrypted means of access to the firewall.
- It should Monitors ALL network traffic-traffic at Firewalls (Internet and external networks) and detects known threat through deep packet inspection.
- Detects unknown threats via anomaly scanning.
- Detect unknown threats via behaviour pattern to protect from zero day attacks.
- Keeps up-to-date on new threats and vulnerabilities.

2. Intrusion detection system (IDS) & Intrusion Protection System (IPS)

In order to inspect all inbound and outbound network activity and identify suspicious patterns that may indicate a network or system attack from someone attempting to break into or compromise a system on the Station LAN Network, the recommended IDS/IPS should contain the following features as a minimum:

- a) Able to analyze, detect and report on security related events.
- b) Able to inspect traffic and to drop malicious traffic based on the configuration of security policy.
- c) Able to inspect the content of network packets for unique Sequences/signatures.
- d) Able to detect and prevent known types of attacks such as worm or Trojan infections and hacks.
- e) Able to prevent denial of service (DOS) and Distributed Denial of Service attacks.
- f) Able to prevent abnormal behaviours by monitoring and learning normal network behaviours.
- g) Keeps up-to-date on new threats and vulnerabilities.
- h) Should provide user friendly interface to queries and reports on threats and event data so that security administrators can gain a better understanding of their ability to protect their network.
- i) Should provide detailed activity logs for auditing.
- j) Able to detect known threats via deep-packet inspection.
- k) Able to defect unknown threats via anomaly scanning.
- l) Able to detect unknown threats via behaviour pattern to protect from zero day attacks.

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10.4 Network Monitoring & Management Requirements

The network monitoring & management software should contain the following features as a minimum:

1. Graphical user interface (GUI) management.
2. Automated discovery and display of Ethernet topology and devices.
3. Real-Time SNMP Support
4. Monitor traffic flow through the device
5. View a device image indicating which ports are active and which modules are installed. If a particular network device is down, it should give the tools like ping/telnet options in the same screen to further diagnose the problem.
6. Real-time activity and utilization statistics and graphical trends.
7. Facility of providing pre-defined actions like e-mail, SMS etc. upon any event generated in the network.
8. Facility of viewing logical graphs of devices like routers, web servers, according to the needs.
9. The following parameters should be monitored.
 - a) Device status
 - b) Port Status
 - c) CPU utilization
 - d) Memory Utilization
 - e) All port utilization including uplink ports.

Table - 10.1
Specifications for Station LAN Switch

S.No.	Features	Minimum Requirements
1	Type	Layer-3 Ethernet Managed type
2	Ports	24/48 RJ45 connectors for 100 Base-T/1000 Base-TX; Two (2) 10BASE-T/100BASE-TX/1000BASE-T ports; 2 mini-GBIC ports; console port; auto medium dependent interface (MDI) and MDI crossover (MDI-X); RPS port for connecting to redundant power supply unit
3	Cabling Type	Unshielded twisted pair (UTP) Category 5 or better for 10BASE-T/100BASE-TX; UTP Category 5 Ethernet or better for 1000BASE-T
4	Switching Capacity	17.6 GBPS non-blocking
5	Management interface	One 10/100/1000 Mbps RJ-45 out-of-band management port

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S.No.	Features	Minimum Requirements
		One DB9 serial console port (straight-through)
6	Management Methods	SNMP, SSH, RMON, RADIUS etc.
7	Optical Transceiver	SFP/ XFP- 1 GBPS/10 GBPS
8	Power supply	Redundant
9	Standards compliance	802.3 10 BASE-T Ethernet, 802.3u 100 BASE-TX Fast Ethernet 802.3ab 1000 BASE-T Gigabit Ethernet 802.3z Gigabit Ethernet, 802.3x flow control, 802.3ad; 802.1D Spanning Tree Protocol (STP), 802.1Q/p VLAN, 802.1w Rapid STP, 802.1s Multiple STP, 802.1x port access authentication
10	Enclosure protection class	IP 67
11	Mounting	DIN Rail or Direct panel mounting

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11. STEAM & WATER ANALYSIS SYSTEM (SWAS)*{TO BE DELETED, IF ALREADY PROCURED UNDER TG PACKAGE.}***11.1 General Requirements**

1. The steam and water analysis system shall be designed to monitor the chemistry of the steam and water cycle to ensure the desired quality. The online chemical analysis for pH, Conductivity, hydrazine, sodium ion, Silica, dissolved oxygen, chloride, phosphate etc. Shall be carried out in the plant cycle at strategic points. Information from the analyser shall be used to control the high pressure and low pressure dosing system. Long term monitoring and trending of essential elements shall be carried out, to provide an indication of the general condition of the mechanical plant.
2. The sample points, their location, type of chemical analysis to be carried out for each sample, measurement ranges etc., shall be as per plant standards. The SWAS as a composite system includes sample probes, sample piping, safety valves, ball valves, relief valves, grab sample collection facility, pressure, temperature, level, flow indications, coolers, on line analysers etc. The SWAS shall include the following:
 - a) Sample conditioning panel with all accessories.
 - b) Analyzer Panel housing cells, analyzers, monitors etc.
 - c) The sample conditioning and analyser panels shall be physically separated from each other. Analyser panel shall be located in a separate air-conditioned room. Sample conditioning panel shall be walk in corridor type/open rack type. All SWAS panels shall be designed for ready access of components for easy maintenance.
 - d) PC based station for display of information & alarms to the operator, to be located in SWAS room (connected to station LAN)
3. The SWAS system should be unitised and located at the ground floor of TG building.

11.2 Design Requirements

1. Design criteria for continuous on line analytical measurements of important plant media such as water, steam shall be based on microprocessor based instruments only.
2. Separate Steam and Water Analysis System shall be furnished for continuous monitoring and control of water and steam purity in the plant cycle of each Unit and at other important points as specified in this specification.
3. The sampling system shall obtain samples from steam and water system, which shall be adequately conditioned and fed to analyzers for continuous analysis and provide parallel facility for grab sampling as specified.

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4. The system shall be designed in accordance with the recommendations in ASME PTC 19.11 Part II, Water and Steam in Power Cycle, ASTM standards - 31 water and ASTM D1066-69 standard method of sampling steam.
5. The equipment shall be constructed to operate accurately and safely under the operating conditions described or implied in this specification, without undue heating, vibration, wear, corrosion or other operating troubles.
6. All parts subject to high pressure or temperature or other severe duty shall be of materials suitable for the service.
7. All piping, tubing, fittings and other wetted parts in the sampling and analyzing system shall be of SS 316 or other suitable material for the service. No plastics or rubber shall be permitted except within analyzers as furnished by the manufacturer.
8. All SWAS system components and accessories shall be from the latest proven product range of qualified manufacturers.
9. To ensure operation under adverse conditions the equipments mounted outside the Sampling and Analysis Room shall be designed for outdoor conditions.
10. Sample room located instruments and electronic hardware shall be required to operate normally in an air-conditioned area.
11. However, they shall also be able to operate indefinitely with ambient room temperature between + 5°C to + 55°C and relative humidity up to 95%, during air conditioning failure.

11.3

Sample stream Requirements

SWAS shall be provided in accordance with the following guidelines:

Table 11.1

Guideline for Analytical requirements

S.No.	Stream	Analysis
1	Make up water	<ul style="list-style-type: none"> Specific Conductivity Cation Conductivity
2	Hotwell	<ul style="list-style-type: none"> Specific Conductivity (both sides) Cation Conductivity (both sides)
3	CEP Discharge	<ul style="list-style-type: none"> pH Specific Conductivity Cation Conductivity Dissolved Oxygen Sodium
4	Deaerator Outlet	<ul style="list-style-type: none"> Dissolved Oxygen
5	Feed water at Economizer Inlet	<ul style="list-style-type: none"> pH Specific Conductivity Cation Conductivity Silica Hydrazine Dissolved Oxygen
6	Main Steam	<ul style="list-style-type: none"> pH Specific Conductivity

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S.No.	Stream	Analysis
		<ul style="list-style-type: none"> • Cation Conductivity • Sodium • Silica
7	Saturated Steam	<ul style="list-style-type: none"> • pH • Specific Conductivity • Cation Conductivity • Sodium
8	Reheated Steam	<ul style="list-style-type: none"> • Cation Conductivity
9	Condenser Cooling Water	<ul style="list-style-type: none"> • pH • Specific Conductivity

11.4 Sample Conditioning System

- The sample conditioning system shall provide samples at 250C or a preset temperature required by the analyzer with in tolerance of +/- 1 0C, at a pressure of about 2 Kg/cm² and at a flow rate as required by individual Analyzer/stream.
- Sample conditioning system shall be designed and constructed to receive and condition all samples as required by the respective analyzers connected to the sample streams. This shall include all conditioning equipment mentioned herein and covers the following:
 - Primary Sample Cooling in the field
 - High Pressure reduction in the field
 - Two (2) nos. racks shall be provided per unit for mounting primary coolers & high pressure reducing elements in the field.
 - Sample filtering
 - Secondary sample cooling & temperature control
 - Pressure reduction & control as required
 - Flow rate control & measurement
 - Other treatment as required by individual analyzers or mentioned herein
- Sample line to analyzers shall incorporate an anti-siphon design to prevent possibility of running dry because of a broken or plugged sample line.

11.4.1 Primary Sample Cooling

- Primary cooling of all samples having temperature in excess of 45 °C shall be accomplished by passing each sample through one or more individual sample coolers of shell and tube heat exchanger type.
- The primary coolers shall use plant auxiliary cooling water.
- The overall capacity (flow rate and heat transfer capacity) for both sides of cooler/ coolers in cascade shall be adequate to cool all samples to within ± 5 °C of the cooling water inlet temperature for the combined flows of each required analyzer sample plus a manual grab sample flow rate of 500 CC/Min.

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4. Provision shall be kept for adjustment of the temperature of each sample line individually to an optimum value.
5. Sample coolers shall be of submerged helical coil type of shell and tube design with removable shell meeting the intent of ASTM D1192-64 (Equipment for Sampling Industrial Water and Steam). Sample tubing and coils in the coolers shall be continuous and shall extend through the cooling jacket. The sample tubing shall be of seamless type with no welded or other joints inside the cooling jacket. Unions shall be provided to facilitate removal of coils.
6. All sample tubing, fittings and other components wetted by the samples shall be constructed of SS 316.
7. Primary cooler/s shall be removable without disturbing the sample coil connections.
8. Primary cooler shall be protected on the cooling water side by relief valve on the water header. The cooling water header is provided with pressure gauge and isolating valves.
9. Provision shall be made for draining the heat exchanger shell. The drain line shall be valved and piped to waste drain header.

11.4.2 High Pressure Reducing Element

1. Pressure reduction of samples above 40 kg/cm² shall be accomplished by means of a "variable rod-in-tube capillary" or equivalent capable of discharging low flow at low pressure into a sample stream as per the requirements of all samples/analyzers under all operating conditions.
2. The device shall be designed for inlet pressure of 350 kg/cm² operating temperatures of 65 °C and flow rate of not less than 2000 milliliters per minute. The device shall be sized for maximum required sample flow rate under all operating conditions (i.e. from 25% of rated operating pressure onwards to accommodate starting conditions).

11.4.3 Sample Filtering

Sample particulate removal shall be accomplished by passing samples through cartridge type filters with 316 stainless steel body or Y-Strainer. The filter elements shall be capable of retaining particulates of 40 microns and larger. The filter elements shall be installed immediately after the sample shut off valve.

11.4.4 Temperature Switch & Solenoid Valve

Thermostat and Solenoid Valves shall be provided in the sample line downstream of sample filter and upstream of the Secondary Cooler. The thermostat shall be a bimetallic sensor to operate a micro-switch when a preset temperature is reached. This shall close the Solenoid Valve through logic, when sample temperature is above preset value (60 °C).

11.4.5 Secondary Sample Cooling

1. Secondary Cooler shall be employed to cool the sample from approximately 45 °C to 25 °C +/- 1 °C. The secondary coolers shall also be of submerged helical coil type of shell and tube design. The secondary cooler shall use chilled water at

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20 OC. Chilled water for secondary cooler shall be provided by packaged refrigeration unit (chillers). Secondary cooler shall be protected by a relief valve on the cooling water jacket of each cooler in addition to a relief valve at the cooling water header. Provision shall be made for heat exchanger shell drain duly valved and piped to waste drain header.

2. Alternatively, secondary cooling may also be proposed with field proven isothermal bath.

11.4.6 Chilled Water System

1. Each chiller unit shall be designed with sufficient refrigeration capacity to ensure each sample stream temperature to 25 OC \pm 1 OC when all streams are simultaneously at maximum flow rate and maximum temperature. The chiller capacity shall have a provision of 25% spare capacity for future samples.
2. Suitable temperature monitoring and control systems shall be provided for maintaining the chilled water temperature at chiller outlet at 20 OC or at a designed preset value and within the desired band.
3. The compressor shall be readily accessible for service and shall include low noise hermetically sealed motors. Compressor assembly shall also include crank case heaters, suction and discharge valves, oil sight glasses, forced feed lubrication system and an integrated motor protection system along with the necessary instruments.
4. The condenser shall be water cooled, cleanable shell and tube with water regulating valve. The cooling water shall be supplied from closed cooling water system at a maximum temperature of 40°C and a maximum flow rate of 100 litres per minute.
5. Chiller shall be of the direct expansion type with refrigerant tubes inside a shell, completely insulated and to be constructed in accordance with the ASME code for unfired pressure vessels.
6. Refrigerant circuit shall be complete with a thermostatic expansion valve, liquid line solenoid valve, sight glasses, filter-dryer, refrigerant shut-off and charging valves.
7. The chiller water pump shall be of the centrifugal type, close coupled, bronze fitted construction, complete with motor. Pump & motor shall be designed for continuous operation.
8. Vibration dampeners shall be mounted between the packaged chiller and the channel base.
9. Cooling water and chilled water piping shall be provided with block valves.
10. The chiller system shall be provided with 100% redundant chilled water pumps with suction and discharge pressure gauges and temperature gauges; Chilled water circulation pump with 100% standby facility; Storage tank automatic water make up with manual by-pass facility, temperature indicator, level gauge and drain and overflow connection, in addition to any other instruments/equipments required for smooth, convenient operation of the system.

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11.4.7 Sample Pressure Conditioning

1. Pressure reduction of samples above 40 kg/cm² shall be accomplished by using high pressure reducing element.
2. All samples below 40 kg/cm² pressure shall be provided with back-pressure (upstream pressure) regulating valves (PCV).
3. Each sample line shall have Pressure Indicator and Temperature Indicator upstream of pressure reducer. The gauge shall be 100 mm dial with suitable stainless steel wetted parts. Casing shall be stainless steel construction.
4. Each sample line shall include a safety relief valve set at about 3 kg/cm²g, upstream of the rate set valve, having stainless steel wetted parts.

11.4.8 Flow Restricting Element

Flow Restricting Element located at grab sample line tapped from common samples to analyzers shall be provided for all samples, to maintain constant sample flow at a preset sample inlet pressure.

11.4.9 Other Requirement

The Steam and Water Analysis system shall be provided with the sample shut off valves, blow down valves, solenoid actuated valves, pressure reducing valves, safety relief valves, back pressure regulating valves, high pressure reducing valves etc. The requirements of the important valves are specified as under:

1. The sample shut off valves, blow down valves and pressure reducing valves shall have stellite spindle tip and shall be suitable for an operating pressure of 400 bars and an operating temperature of 400°C.
2. The back pressure regulating valve shall be globe type and shall be suitable for a pressure range of 0 - 50 psi. The back pressure regulating valve shall consist of a range spring and a diaphragm assembly. The back pressure of the regulating valve is adjusted to the required set point by the range spring. In case of any excess pressure the diaphragm shall be lifted to release the excess pressure to maintain back pressure equal to the set value.

11.5 Sample Pumps

1. Two (2) nos. of sample pumps for each generating unit, along with necessary pipes, valves, etc. shall be provided for condenser cooling water samples. Sampling pump motor shall be adequately rated for continuous service duty and shall meet the requirement for drive motors as per international codes and standards.
2. Pump start/stop shall be done from local. All necessary accessories including power supply, wiring and grounding for control and safe operation of the pumping system.

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11.6 Sample Patch Board

1. A quick disconnect patch board area shall be furnished on the SWAS panel. The patch board shall allow sample to be routed to any analyzer through quick disconnect valve at patch board on the sample conditioning panel. The area shall consist of a patch board with bulk head tube fittings with double end shut-off and hose inserts. Body protector plugs shall be provided for each bulkhead tube fittings.
2. The plugs shall be of type 316 SS construction. Sufficient length of 6mm ID, 9.5mm OD tygon tubing shall be provided for complete spanning of the patch board area for interconnection of the bulkhead tube fittings. Each connection shall be provided with a Phenolic name plate engraved with a legend.

11.7 Grab Sample

Grab sample valves on the SWAS panel front shall be furnished to allow grab sample flow to be directed to either a drain header or through grab sample nozzles to the sample trough. Approximately 300 mm of flexible tubing shall be furnished for each sample to allow grab sample collection and prevent splashing. Valve body and trim shall be of SS-316.

11.8 Sample Sink

A continuous sink, located at the place of grab sample analysis, shall be provided. The sink shall be of 316 stainlesssteel, 14 gauge minimum. The sample sink shall be connected to waste drain header. Sample sink shall contain an integral stainless steel ledge to accommodate sample container. DM water connection shall be provided for cleaning of sample containers.

11.9 Analyzers

All Analyzers shall be of microprocessor-based design. The general technical specification of the analyzers is provided in this section. Each analyzer shall be indicated with the sample flow requirement and the total quantity of cooling water required for the system.

Table 11.2
Specifications for Conductivity Analyzer

S.No.	Features	Minimum Requirements
A	Sensor	
1	Type of Cell	Continuous flow through type. Removable type cells for Hotwell
2	Conductivity Range	0 - 1 $\mu\text{S}/\text{cm}$ to 0 - 10,000 $\mu\text{S}/\text{cm}$
3	Cell Constant	0.01/0.1/1.0 depending upon range

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S.No.	Features	Minimum Requirements
4	Temperature Compensation	Manual in steps of 0.1 °C selectable and Automatic (Integral) up to 0 - 120 °C with Pt-100 Sensor
5	Process Connection	Screwed
6	Wetted Parts	Electrodes: HASTALLOY Insulators: KYNAR and VITON
7	Pressure rating	10 Kg/cm ²
8	Accessories	Tee/Vessel (PVC or Hastalloy)
9	Cable	Up to transmitter in flexible conduit
B	Transmitter	
1	Type	Microprocessor based
2	Mounting	Flush Panel
3	Protection Class	As per TS requirement
4	Output	4-20 mA DC (isolated)
5	Display	<ul style="list-style-type: none"> Digital Display of process variable in Engineering Unit, Temperature, Alarm Status Red / Green LED Character Height 18 mm
6	Zero/span Adjustment	Front Panel Membrane type Keyboard
7	Temperature Compensation	Manual or Automatic- Compensation selectable through keyboard
8	Diagnostics	Self diagnostic programme for electronics, measuring electrode, open wiring etc
9	Alarm	Dual alarm set point, hysteresis and time delay adjustable on membrane keyboard.
10	Enclosure	Polypropylene
11	Cable Termination	Internal (cable entry through conduit)
12	Accuracy	± 0.25% of measured range

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S.No.	Features	Minimum Requirements
13	Response Time	less than 1 sec.
14	Measuring Cycle	less than 5 sec.
15	Repeatability	± 0.95 % output range
16	Stability	± 0.5 % of output range / month non-cumulative
17	Power Supply	230 V AC, 50 Hz, 1-phase
18	Operating Temp	0 - 60°C
19	Accessories	<ul style="list-style-type: none"> For Cation conductivity analyzer Dual Ion- Exchange column, resin, etc. (minimum 12 months requirements) Phenolic Nameplate Portable test Kit.
20	Applicable Standard	ASME PTC 19.11 except as modified in this specification.

Table 11.3
Specifications for pH Analyzer

S.No.	Features	Minimum Requirements
A	Sensor	
1	Type of Cell	Continuous flow through type.
2	Temperature Compensation	Manual in steps of 0.1 °C selectable and Automatic (Integral) up to 0 – 120 °C with Pt-100 Sensor
3	Process Connection	Screwed
4	Pre Amplifier	Integral
5	Pressure rating	10 Kg/cm ²
6	Range	0 – 14 pH
7	Measuring	Glass, ORP or Antimony Electrodes
8	Liquid Junction	Ceramic / Kynar or Equivalent
9	Accessories	Tee/Vessel (PVC or Hastalloy)

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S.No.	Features	Minimum Requirements
10	Cable	Up to transmitter in flexible conduit
11	Applicable Standard	IS: 6804 except as modified in this specification.
B	Transmitter	
1	Type	Microprocessor based
2	Mounting	Flush Panel
3	Protection class	As per TS requirement
4	Output	4-20mA DC (isolated)
5	Display	<ul style="list-style-type: none"> Digital Display of process variable in Engineering Unit, Temperature, Alarm Status Red / Green LED Character Height 18 mm
6	Calibration	Computer assisted 2 point calibration – within pH 0 to 14 for zero with standard buffer solutions.
7	Temp. Compensation	Manual or Automatic – selectable through keyboard
8	Diagnostic	Self diagnostic for “Calibration required”/“calibration O.K.”, electrode checking etc.
9	Alarm	Dual alarm set point, hysteresis and time delay adjustment on membrane keyboard.
10	Enclosure	Polypropylene
11	Cable Termination	Internal (cable entry through conduit)
12	Accuracy	± 0.02 pH or better
13	Repeatability	$\pm 0.1\%$ or better
14	Response Time	7 seconds for FSD or better
15	Stability	$< \pm 0.001$ pH per week
16	Power Supply	230 V AC, 50 Hz

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S.No.	Features	Minimum Requirements
17	Operating Temp.	0 - 60°C
18	Accessories	<ul style="list-style-type: none"> • Ultrasonic Electrode Cleaner. • Phenolic nameplate giving tag number, service, etc. • Pre-amplifier, special cable. Ultrasonic cleaner, etc. • Buffer tablets. • Sample coolers, flow and pressure Regulators, standard pH solutions, SS impulse tubing & fittings, isolation and drain valves as required, electrode holders, RFI/EMI shielded, whether & corrosion proof casing, alarm settings & indications on monitor, sample rate set valves and other accessories as required

Table 11.4
Specifications for Silica Analyzer

S.No.	Features	Minimum Requirements
1	Type	"Multi Channel" Calorimetric Analyzer (With auto reagent shut-off feature in case of sample loss or power loss) built in phosphate inhibition feature and Microprocessor based.
2	Operating range	0-50/500/5000 µg/litre (field adjustable)
3	Output	4-20 mA DC (isolated) into 600 ohm
4	Readout	Digital indicating meter for direct Readout
5	Accuracy	± 1% of F.S.D or better
6	Reproducibility	± 2% of F.S.D or better
7	Calibration	Manual and Automatic 2 point zero & slope Programmable 1 – 240 hrs
8	Response time	< 16 minutes (including sample switching)
9	Operating ambient	0-60°C temperature
10	Ambient humidity	Up to 95% relative humidity

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S.No.	Features	Minimum Requirements
11	Mounting	Flush panel
12	Life of light source	10,000 hours (min.)
13	Power supply	240V, 50Hz, 1 Phase
14	Alarm Facility	2 HI and 2 LO independently adjustable over span.
15	Alarm for	<ul style="list-style-type: none"> • Monitor mal-function • Monitor on standby • Monitor auto-zeroing • Concentration high • Loss of sample • Concentration low • Loss of reagent
16	Preferred features	<ul style="list-style-type: none"> • Hi and Lo alarm LED visible from front. • Power supply on/failure LED visible from front. • user friendly menu operated programming • Serial interface
17	Accessories	<ul style="list-style-type: none"> • Reagent cabinet • Sample strainer • Reagent Reservoir etc. • Phenolic nameplate • Reagents and consumables • Special cables up to transmitter with flexible conduit • Chilling Plant (if required) • Automatic temperature compensation between 5 to 50 Deg.C • Automatic serving provision • SS tubing and vessels • All chemical reagents for 12 months operation of analyzer • Sample rate set valves • Comprehensive diagnostic & alarm features • Others as required
18	Applicable Standard	ASME PTC 19.11 except as modified in this specification.

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Table 11.5
Specifications for Sodium Analyzer

S.No.	Features	Minimum Requirements
1	Type of cell	Continuous Flow through Sample
2	Flow Chamber	Flexi Glass Body or equivalent
3	Operating Range	0.05-1.0ppm
4	Measuring Electrode	Sodium Selective Glass Electrode
5	Output	4-20mA DC (isolated) into 600 ohms
6	Temperature	Automatic up to 60 Deg. C Compensation
7	Read Out	Digital Indicating meter
8	Accuracy	± 0.01 ppb/2.5% or better
9	Response Time	2 minutes or better
10	Operating Ambient	0-60 ⁰ C
11	Ambient Humidity	Up to 95% relative humidity
12	Mounting	Flush panel
13	Calibration	Manual through Zeroing Solution
14	Power Supply	230 V, 50 Hz 1 Phase
15	Alarm Facility	2 HI and 2 LO independently adjustable over span.
16	Serial Interface	To be provided as per requirement
17	Error Reports	<ul style="list-style-type: none"> Excessive zero drift Lack of sample Slope value out of the acceptable range Temperature & flow over-range or under-range
18	Accessories	<ul style="list-style-type: none"> Phenolic tag plate etc. Sample filter. Pressure regulator & flow meter Automatic calibration kit Reagents and consumable Special cables up to transmitter with flexible conduit Others as required

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Table 11.6
Specifications for Hydrazine Analyzer

S.No.	Features	Minimum Requirements
1	Type	Continuous Electrochemical
2	Operating Range	0-50, 0-100, 0-200 ppb
3	Output	4-20 mA DC linear and 1-5 volts
4	Readout	Digital Indicating Meter, linear read-out
5	Accuracy	+/- 4% of FSD or better
6	Reproducibility	2% of FSD or better
7	Drift	2ppm/month or better
8	Temperature Compensation	Automatic up to 120° C
9	Operating Temperature Ambient	0-60° C (maximum)
10	Response Time	2 minutes or better
11	Mounting	Flush panel
12	Pressure rating	0 - 5 Kg/Sq. cm
13	Power Supply	230 V 50 Hz, 1 Phase
14	Alarm Facility	2 HI and 2 LO, Independently adjustable over span.
15	Preferred Feature	<ul style="list-style-type: none"> • HI and LO alarm LED visible from front • Power supply on/failure LED visible from front • All chemical reagents for 12 months operation etc. • Phenolic nameplate etc. • High sensitivity • Self cleaning electrode

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Table 11.7
Specifications for Dissolved Oxygen Analyzer

S.No.	Features	Minimum Requirements
1	Type	Continuous Flow through Sample Electro-chemical, Microprocessor based
2	Range	0-0.1, 0-1.0, 0-10.0 ppb manually selectable range
3	Enclosure	IP-55 or better
4	Output	4-20mA DC isolated to load of 600 ohms (minimum)
5	Temperature Compensation	Automatic up to 65° C
6	Ambient Temp.	0-60° C
7	Readout	Digital indicating meter
8	Accuracy	Better than \pm 5% of full scale for Transmitter
9	Sensor Response Time	Automatic up to 60 °C
10	Mounting	Flush Panel
11	Readable Distance	3 meter (minimum)
12	Power Supply	230V AC, Single Phase, 50Hz
13	Sample	Flow rate approx. 500 ml/minute
14	Alarm facility	2 HI & 2 LO independently adjustable over entire span Contact rating, 5A, 230 V AC/0.5A, 220V DC
15	Preferred Feature	<ul style="list-style-type: none"> • HI and LO Alarm LEED visible from front. • Power supply on/failure LED visible from front. • In-built calibration facility
16	Accessories	<ul style="list-style-type: none"> • Phenolic nameplate giving tag no., service etc. • reagent Cabinet (if applicable) • Reagent Reservoir (if applicable) • Other as per requirement including piping etc.

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Table 11.8
Specifications for Phosphate Analyzer

S.No.	Features	Minimum Requirements
1	Type of Cell	Colorimetric / flow through
2	Flow Chamber	Plexi Glass Body or equivalent
3	Operating Range	0.1-10 / 20 / 50 Selectable manually
4	Output	4-20mA DC linear
5	Temperature Compensation	Automatic
6	Read Out	Digital Indicating meter
7	Accuracy	$\pm 1\%$ of scale range or better
8	Response Time	90% in 3 minutes or better
9	Operating Temperature Ambient	0-60° C
10	Ambient Humidity	Up to 95% relative humidity
11	Mounting	Flush Panel
12	Calibration	Manual through Zeroing solution / Automatic 2 point zero & slope programmable
13	Power Supply	230V AC, Single Phase, 50Hz
14	Alarm facility	2 HI & 2 LO independently adjustable over entire span Contact rating, 5A, 230 V AC/0.5A, 220V DC
15	Accessories	<ul style="list-style-type: none"> • Phenolic tag plate etc. • Sample filter. • Pressure regulator and flow meter • Automatic calibration kit • Reagents and consumables.

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Table 11.9
Specifications for Chloride Analyzer

S.No.	Features	Minimum Requirements
1	Type of Cell	Continuous flow through sample type
2	Flow Chamber	Flexi Glass Body or equivalent
3	Operating Range	0-10 , 0 – 100, 0 -1000 ppb, manually selectable
4	Output	4-20mA DC linear
5	Temperature Compensation	Automatic
6	Read Out	Digital Indicating meter
7	Accuracy	\pm 1% of scale range or better
8	Sensitivity	Better than 1 ppb
9	Response Time	90% in 3 minutes or better
10	Operating Ambient Temperature	0-60° C
11	Ambient Humidity	Up to 95% relative humidity
12	Mounting	Flush Panel
13	Calibration	Manual through Zeroing solution Automatic 2 point zero & slope programmable
14	Power Supply	230V AC, Single Phase, 50Hz
15	Alarm facility	2 HI & 2 LO independently adjustable over entire span Contact rating, 5A, 230 V AC/0.5A, 220V DC
16	Accessories	<ul style="list-style-type: none"> • Phenolic tag plate etc. • Sample filter. • Pressure regulator and flow meter • Automatic calibration kit • Reagents and consumables.

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11.10 SWAS Panels

1. The SWAS Panels shall have two sections namely sample conditioning section and analyzer section. The first section shall be the wet section of SWAS panels which shall be called as the "Sample Table". The second section shall be the dry section housing the analytical transmitters, signal conditioning devices and other requisite accessories.
2. All monitoring instruments and controls for sampling system shall be located on the front panel and shall be grouped accordingly to function in a logical and orderly fashion. There shall be a general progression of flow from top-to-bottom and left-to-right to minimize sample line length, purge times and material exposed to sample. Similarly, the conditioning components for each stream shall be grouped together wherever possible.
3. Indicating instruments such as pressure, temperature and flow shall be arranged in a vertical line directly above the grab sample valve. Sufficient clearance shall be maintained between instruments banks of adjacent sample points so that there is no confusion in reading these instruments.
4. Sample conditioning & analyzer panels shall be designed for ready access of components. Panel design shall ensure that:-
 - a) Parts subject to wear, corrosion or other deteriorations or requiring adjustments, inspection or repair are readily accessible and capable of convenient removal, when required.
 - b) Individual components or groups of components mounted on sub-panels can be removed for replacement or repair without the need of prior removal of components of other healthy streams.
 - c) Flow meters, pressure gauges and temperature indicators can be removed for repair or replacement from the front of the panel without disturbing any piping.
 - d) Filter elements and pressure reducing elements can be easily disassembled for periodic cleaning.
5. SWAS panels shall be designed based on human engineering considerations fully keeping in view the convenience of operation and maintenance personnel.
6. Each sample inlet shall be provided with bulkhead type tubing connection and an isolation valve or block valve suitable for sample operating conditions. A blow down connection and suitable blow down valve shall be furnished upstream of each isolating valve. Blow down valves shall be manifolded into a suitable blow down header. Strainers, filters, relief valves etc. shall be provided as specified and as required to properly protect the coolers, valves, analyzer elements etc.
7. All drains shall be piped into two separate drain headers. One header shall be called "Waste Drain Header" and shall receive all drains which contain substances not wanted in the plant heat cycle water. The other header shall be called "recoverable drain header" and shall receive all other drains not containing

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unwanted substances. All drains shall be headered as indicated above. Vendor shall pipe the waste drain header to the building drain system.

11.11 Constructional Features

1. The SWAS panel (wet panel) shall be constructed of 3 mm thick steel plates except for the extreme top of the Sample Table and Analyzer Panel (Dry Panel) which shall be of 2 mm sheet steel. The counter top, sample sink and front section above the counter top shall be 2.5 mm type 304 or 316 stainless steel.
2. The sample table shall be of free standing, open rack whereas the Dry Panel shall be of free standing, totally enclosed construction with back doors.
3. All SWAS panels shall be furnished with 100 mm base angle for bolting to 100 mm high concrete curb.
4. Following panels are to be provided:
 - a) Sample conditioning panel : 5000 (W) x 2300 (H) x 2400 (D) mm
(Wet Panel)
 - b) Analyzer Panel : 3000 (W) x 2300 (H) x 2400 (D) mm
(Dry Panel)

The dimensions given above are tentative only.

5. Panel sections shall be reinforced to ensure true surfaces and adequate support for instruments and equipment. All equipment and piping shall be firmly anchored and supported from within the respective panel section to ensure vibration free operation.
6. Doors and equipment arrangement shall be such that all items are readily accessible for maintenance and repair. Doors shall have concealed type hinges and three point type latches to assure tight closing. Doors shall have turned back edges and additional bracing where required to assure rigidity.
7. All surfaces shall be free from waves, bellies, or other imperfections. All stainless steel surfaces shall have uniform finish. All exterior steel surfaces shall be sand blasted, ground smooth, filled, primed, sanded and finished with smooth backed enamel.

11.12 Piping, Tubing & Accessories

11.12.1 Internal Piping & Tubing

1. All internal piping, tubing and system components required for making the system complete shall be shop installed and tested as per applicable codes, prior to shipment to project site.
2. All tubing and wiring shall be located behind the face of the panel with projections allowed only for indicator faces, valve handles, manual grab sample lines etc. The physical arrangement of the tubing and wiring shall, in all cases, be so as to permit easy access for maintenance of all items of equipments.
3. All piping and tubing materials, fabrication, erection and application of piping materials shall be in accordance with the latest applicable requirements of the

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code for pressure piping (ANSI B 31.1,B36.19) and all other applicable regulations.

4. Unless otherwise specified, fittings used with pipe 50 mm and smaller shall be socket welding type, and fittings used with larger pipe shall be butt-welding type. All fittings shall be constructed of materials equivalent to the pipe with which they are used.
5. All piping and tubing shall be neatly installed and securely braced to ensure adequate mechanical rigidity. Routing and support of tubing shall be such that expansion and contraction of tubing or equipment mounted in the sample table do not impose any excessive stress on the tubing.
6. Special tools shall be used for all bending and forming operations. Bends in tubing shall be based on the requirement of the code for Pressure Piping (ANSI B 31.1), concerning tube thinning at the bends. Tubing shall be carefully handled to avoid flat spots, kinks and short bends. Any tubing so damaged shall not be used in this sample table.
7. All piping and tubing shall be blown with oil free compressed air after installation and before attachment to equipment at either end.
8. All piping and tubing terminal connections shall be suitably capped after completion of installation and tests to prevent entry of foreign materials during transit, storage etc.
9. All piping and tubing shall be installed so as to ensure easy accessibility for any maintenance or repair that may be required. High density tubing runs shall not interfere with accessibility to any system component and shall not impair system function.

11.12.2 Sample Piping

1. This shall include piping, fittings, valves and accessories from tapping point's up to SWAS conditioning panel located in SWAS rooms on as required basis. All sample piping shall be 3/4" NB seamless type of material ASTM A213 TP 316 H, conforming to ANSI B36.19. The schedule number shall be suitable for the particular application.
2. All fittings shall be socket welding type and of material ASTM A182 F316H conforming to ANSI B 16.11.
3. Single and multi tubes shall run with the minimum number of changes in direction. Suitable identification tags shall be provided for easy check up and for proper connections.
4. The valves to be used in sample piping shall be of globe type, forged construction and stainless steel conforming to ASTM A182. The pressure temperature ratings shall be as per ANSI B16.34. The valve design shall be such that the seats can be reconditioned and stem and disc can be replaced without removing valve body from the line

11.12.3 Material Specification for Piping

The material for piping to be furnished and installed for SWAS shall be as indicated below:-

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Table 11.10
Specifications for Piping Material

S.No.	Piping System	Material Requirement
1	Piping from the sample inlet bulk-head fittings the shut-off valve for low pressure samples	Stainless Steel, ASTM A-213 Type 304 or 316, 16 BWG tubing
2	Piping from the sample inlet bulk-head fittings to the pressure reducing valves for high pressure samples and sample blow down piping	Stainless Steel, ASTM A-213 Type 304 or 316, 14 BWG tubing
3	Blow down header	Stainless Steel, ASTM A-312 Type 304 or 316, Sch. 160
4	Miscellaneous drains receiver header	Stainless Steel, ASTM A-312 Type 304 or 316, 16 BWG tubing
5	Piping from the shut-off valves for low pressure samples and from the pressure reducing valves for high pressure samples to the terminal points including branch piping	Stainless Steel, ASTM A-312 Type 304 or 316, 16 BWG tubing
6	Closed cooling water piping except grab sample	Carbon Steel, ASTM A-53 Gr. A, Sch. 40
7	Sample through drain piping and waste header piping	Carbon Steel, ASTM A-53 Gr. A, Sch. 40

11.13 Wiring

1. All control and instrumentation wiring used within the SWAS panel sections shall conform to NEC and NEMA standards. All measurement and control circuits shall be factory wired and tested by energizing at operating voltage.
2. All electric connections shall be made between devices within the SWAS panel sections and shall be made to suitable terminal blocks, if devices are to be connected to equipment outside the SWAS panel.
3. All electrical connections shall enter and leave through the top or bottom of the panels.
4. High impedance circuits shall be connected using shielded or co-axial wire suitable for the service. Terminals shall be furnished for termination of shield.
5. Wiring in the sampling section shall be routed in covered metallic trays located as distant as is practicable from sampling lines and drains with due care taken to isolate electric wiring, termination etc. from liquid areas.

11.14 Power Supply & Grounding

Power supply to all instruments and control systems shall be through UPS and separately fused, it should be possible to disconnect any instrument without interrupting power supply to any other equipment/device.

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11.15 Lighting & Receptacles

1. Sample table and analyzer section shall be provided with rapid start, low noise, fluorescent strip fixtures installed in a continuous row along the top of each section.
2. The panel shall have a ceiling mounted fluorescent illumination. Light switches shall be provided within the panel sections at suitable locations.
3. Three receptacles shall be provided on the front of the sample table below the work surface. These shall be equally spaced. Two more receptacles shall be provided inside the sample table and one receptacle shall be installed inside the panel.
4. Wiring for lighting and receptacles shall be run in flexible metallic conduits.

11.16 Control & Monitoring System

All alarm shall be available on the panel for the entire SWAS system, with repeat facility for each alarm in DCS, in the Control Room.

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12. CONTINUOUS STACK EMISSION MONITORING SYSTEM**12.1 General**

1. A fully certified Continuous Emission Monitoring System (CEMS) shall be provided at the stack to determine emissions of dust, SO_x, NO_x, CO, CO₂ etc as per state Pollution Control Board requirements.
2. A CEMS shall be provided to measure stack emissions and produce all required data logging and reporting. The analyzer system shall include microprocessor based in-situ and sampling type analyzers, a fully programmed controller, auto calibration accessories and mounting hardware for installation to provide a complete and operable system. The data logging and reporting system shall store a data for a stipulated number of years and shall be able to produce reports of required format.
3. All analysers at stack shall be located at an elevation as per state pollution control board norms and shall be accessible for maintenance.
4. CEMS shall be provided with all interconnection tubing and cabling between probe and analyser/analyser panel and cabling from analyser / analyser panel to local junction box. All the calibration gases required for one year continuous operation shall be provided. The calibration gas container material shall not contaminate the calibration gas. Auto gas calibration facility shall be provided.

12.2 Design Requirements

1. A PC based Continuous Stack Emission System shall be provided for monitoring. All output signals of all stack monitoring analysers shall be connected to plant DCS /MIS as applicable for monitoring, archiving and report generation for environmental monitoring authorities. DCS / MIS shall be equipped with necessary calculations and report generation software packages for generation of reports for submission to environmental monitoring authorities.
2. Air purge system associated with each analyser shall be adequate to keep analyser optical windows, probe elements, source elements and gas interface tubing free of particulate and other contaminants on the continuous basis.
3. A fully assembled environmentally controlled shelter shall be provided at the bottom of the chimney to house the stack gas monitoring analysers as well as all equipment required to condition the sample gas.
4. Flue gas analyzer instruments shall be provided with following common requirements:

Table 12.1**Common Requirements of Analyzers**

S.No.	Features	Minimum Requirements
1	Analog Output	4 – 20 mA DC, HART compatible
2	Binary Output	2 NO + 2 NC for alarm
3	Zero & Span Adjustment	To be provided
4	Ambient Temperature	60 Deg C
5	Local Indication	Digital

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S.No.	Features	Minimum Requirements
6	Enclosure Type/ Material	Weather & Dust Proof IP67/ SS 316
7	Type of Electronics	Microprocessor Based with self diagnostic
8	Calibration	Auto & Manual
9	Error Diagnostic	To be provided
10	Digital Signal Transmission	Modbus protocol / Ethernet TCP / IP Protocol

5. Sampling type systems (if applicable) shall be provided with dual sample probes along with all required accessories such as redundant heavy duty pumps with continuous rated motors, moisture detection facility, prefabricated heated sample lines from probes to analyzer panel, solenoid valves, filters, coolers along with level switch in gas coolers for auto drain purpose & flow meter etc.

12.3

Technical Requirements of Analyzer Shelter

The Analyzer Shelter shall be a completely assembled unit suitable for installation on a concrete Pad or as a stand-alone unit. All internal piping and tubing shall terminate in bulkhead connections. Internal wiring shall terminate in external junction boxes. All equipment including tubing, conduit fittings, junction boxes, etc. shall be installed so as not to interfere with the removal of analyzers, sample handling systems and related equipment. Accessibility for maintenance shall be the prime consideration.

12.3.1

Construction Features

- The Analyzer Shelter shall consist of a self-framing exterior skin assembled on a rigid primed and painted steel superstructure. All materials used in the construction shall be non- combustible.
- Wall panels design to be completely weather resistant. The design shall allow for thermal expansion / contraction of the structure over the complete range of ambient temperatures applicable for the location without causing harmful buckling or opening of joints, etc. Materials of construction shall be 2mm thick SS sheet for external walls and 18 gauge galvanized steel for internal walls with ribbed interlocking. The ribbed interlocking shall provide a strong column for the sheets on the side valves, where the "U" profile created at the edges, when interlocked with the second sheet, increases the section modulus of ribbing.
- The wall panels of the shelter shall be insulated and designed for the given ambient conditions by glass/ rock wool of appx. 100 mm insulation thickness.
- Roof panels design and construction to be completely weather resistant. The design shall allow for thermal expansion / contraction of the structure over the complete range of ambient temperatures applicable for the location without causing harmful buckling or opening of joints, etc
- The base structure of the shelter shall be constructed using ISMC (1501125)/ISMB (100) welded properly and adequately sized to ensure structural rigidity to prevent deformation during dragging, lifting, loading and unloading of the shelter.
- The roof panels shall be provided with 80 mm thick rock wool insulation.

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7. The analyzer house shall have two doors; one as the main entrance and the other as the emergency exit. The doors are to be mounted on special hinges to ensure gas-tight construction of the shelter. Doors shall be sturdy, double-walled, insulated with rock wool and open to the outside. Each door shall have a window with transparent toughened safety glass. The main entrance shall carry a plate indicating the Plant/Unit number and the tag- list of all the analyzers inside the shelter.
8. All tubes and cable entries to the shelter shall be through Multi-cable Transit Blocks - to ensure gas tightness of the shelter.
9. The floor is to be fabricated with anti-slip sheet and sealed continuously to ensure no loss of pressure.
10. Analyzer Shelter shall meet the standards of the Uniform Building Code with the following design loads:
 - a) Roof : 20 lb. / sq ft live load
 - b) Wind : 35 lb. / sq ft at 0-30 ft above grade elevation.
 - c) Seismic Zone : As applicable for the site

12.3.2 Painting

1. Preliminary cleaning involving removing of grease, oil, paint and dirt, which prevent pickling acid from coming in contact with the scale or mist.
2. Structural painting shall include scraping, chemical cleaning, one coat of etch primer, one coat of Epoxy Zinc Chromate Red Oxide primer and two coats of Epoxy finish Paint. The surface coating shall take sufficient care of removing all the contaminants thus ensuring against premature and complete coating failure. Precautions to be taken to avoid air bubbles and uneven coat thickness.
3. The internal walls shall be powder coated.
4. Painting for the shelter shall be completed in every respect before despatch. No painting shall be done at site except touch-up of scratches made during site erection.

12.3.3 Environmental Conditioning

Analyzer shelters shall be environmentally conditioned to keep the inside atmosphere of the shelter at a constant temperature of 24 degree \pm 3 deg. C. to obtain repeatability and reliability of the analyzers and also a comfortable working environment for workman. For this purpose either a 'Skid Mounted' type air conditioning unit or 'Split Type' air conditioner shall be provided.

12.3.4 Illumination

1. Illumination level in the shelters shall be at a minimum of 300 lux at 750mm elevation inside the shelter. Maintenance factor shall be 0.65.
2. External Dome type lighting shall be under the overhangs to provide sufficient illumination for maintenance work.

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3. Power switches for internal and external lighting shall be provided near to the main entrance on the outside of the shelter.

12.3.5 Other Requirements

1. Fire Detection & Protection: Necessary fire detection & protection measures for the analyzer shelter shall be provided as per NFPA requirement.
2. Power distribution board for distribution of power for all individual consumers such as individual analyzers, auxiliary equipment inside and around the shelter, lighting receptacles shall be provided. Each of the main systems shall have an individual isolation circuit breaker mounted next to the individual power users
3. Telephone connection shall be provided inside the shelter.

12.4 Technical Requirements of Analyzers

Table 12.2

Specifications for carbon monoxide (CO) analyzer

S.N	Features	Minimum Requirements
1	Type of Instrument	In-Situ Type
2	Principle of Measurement	IR absorption
3	Measurement Range	0-200, 0 – 1000 ppm programmable
4	Accuracy	+/- 2% of F.S
5	Linearity	+/- 1% of F.S
6	Repeatability	< /= 0.5% of Span
7	Response Time	Less than 3 seconds to 90% of final value
8	Zero Drift	< 1% span/week
9	Span Drift	< 1% of measured value/week
10	Operating Temperature Range	0 – 300 °C
11	Purging System	Purging System to be provided with heavy duty blowers & shutter mechanism for automatic isolation of lens during purge air failure.
12	Diagnostic	<ul style="list-style-type: none"> • IR light transmittance • Intensity Indicator • Detector Level Indicator • Microprocessor Status Indicator • Calibration check

Table 12.3

Specifications for carbon dioxide (CO₂) analyzer

S.N	Features	Minimum Requirements
1	Type of Instrument	In-Situ/ Sample Extraction Type
2	Principle of Measurement	NDIR absorption
3	Measurement Range	0 – 40% programmable
4	Accuracy	+/- 1% of F.S
5	Linearity	+/- 1% of F.S

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S.N	Features	Minimum Requirements
6	Repeatability	$\leq 0.5\%$ of Span
7	Response Time	Less than 3 seconds to 90% of final value
8	Temperature Drift	$\pm 1\%$ in 24 hrs.
9	Zero Drift	$< 1\%$ span/week
10	Span Drift	$< 1\%$ of measured value/week
11	Operating Temperature Range	0 – 300 °C
12	Temperature Compensation	Automatic
13	Filter	Ceramic 3.5 micron (if extraction type)
14	Purging System	Purging System to be provided with heavy duty blowers & shutter mechanism for automatic isolation of lens during purge air failure.
15	Diagnostic	Error diagnostic to be provided

Table 12.4

Specifications for SO_x – NO_x (combined) analyzer

S.N	Features	Minimum Requirements
1	Type of Instrument	Sampling Type
2	Principle of Measurement	Radiation absorption
3	Measurement Range	0 - 300, 0 – 1000 mg/Nm ³ selectable
4	Accuracy	$\pm 1\%$ of F.S
5	Linearity	$\pm 1\%$ of F.S
6	Repeatability	$\leq 1\%$ of Span
7	Response Time	Less than 3 seconds to 90% of final value
8	Temperature Drift	$\pm 1\%$ /10°C
9	Zero Drift	$< 1\%$ span/week
10	Span Drift	$< 1\%$ of measured value/week
11	Operating Temperature Range	0 – 300 °C
12	Filter	Ceramic 3.5 micron
13	Temperature Compensation	Automatic
14	Purging System	Required with Auto scavenging facility
15	Diagnostic	Error diagnostic to be provided

TABLE 12.5

Specifications for Dust Density/ Opacity Analyzer

S.N	Features	Minimum Requirements
1	Type of Instrument	In situ dry-type visible light (through LED)
2	Principle of Measurement	Transmission & Absorption
3	Measurement Range	0 – 1000 mg/Nm ³
4	Accuracy	$\pm 0.2\%$ of F.S
5	Resolution	0.1 mg/Nm ³
6	Linearity	$\pm 1\%$ of F.S

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S.N	Features	Minimum Requirements
7	Repeatability	< / = 1 % of Span
8	Response Time	Less than 3 seconds to 90% of final value
9	Temperature Drift	+ / - 1 % /10°C
10	Zero Drift	< 1 % span/week
11	Span Drift	< 1 % of measured value/week
12	Operating Temperature Range	0 – 300 °C
13	Temperature Compensation	Automatic
14	Purging System	Purging System to be provided with heavy duty blowers & shutter mechanism for automatic isolation of lens during purge air failure.
15	Diagnostic	Error diagnostic to be provided

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13. VIBRATION MONITORING SYSTEM**13.1 General**

1. The vibration monitoring system shall provide health of rotating machines on continuous on-line basis and shall guide the plant maintenance personnel regarding the nature of fault and the maintenance action required.
2. The system to be provided shall include all necessary hardware, software, firmware and interfaces, all special and field signal cabling required for implementing a fully functional system. System shall include but not limited to the details specified in subsequent paragraphs/Clauses.
3. Vibration monitoring system shall be independent for each unit.

13.2 Design & Functional Requirements

1. The vibration monitoring system shall provide condition monitoring the bearings of all critical machines, equipments with HT drives and their driven equipment. These shall include but not limited to the following:
 - a) ID Fans
 - b) FD Fans
 - c) PA Fans
 - d) Any other device with HT motor
2. The vibration monitoring system shall be complete with vibration sensors, Key Phasor sensors, signal conditioning cards, amplifiers, special cables, vibration monitor (if required) etc. together with all necessary equipment and accessories.
3. Vibration sensors shall be provided for measurement in both X (horizontal) and Y (vertical) axis at 90° angle to each other for each bearing.
4. For bearings of high speed machines (= / >1500 rpm) accelerometer type sensor and for low speed machines (<1500 rpm) velocity type sensor shall be provided.
5. Necessary, one or two stage integrators for obtaining vibration measurement in terms of displacement shall be provided in the system.
6. Vibration monitoring system shall provide the vibration measurement in the form of 4 - 20 mA DC signal to be directly connected by hardwired cable to plant DCS for monitoring. Limit value generation (soft) for alarm and protection applications for the auxiliaries and their drive equipment shall be carried out in DCS or applicable control system (PLC).
7. Vibration monitoring system shall be an independent microprocessor based system (PC based). The system shall be interfaced with Plant DCS system through redundant communication link in addition to hardwired signal exchange. The system shall interface with plant DCS for any process signals which may be required to perform condition monitoring functions through soft link.
8. The Vibration Monitoring system shall have Following minimum features:
 - a) Bar graph and point display indicating the set points.

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- b) Graphical plant and machine area representation with location of sensors and the current value.
 - c) Diagnostic of the system and sensors. Alarm to be retransmitted to DCS.
 - d) Current and history trend with resolution of 10 msec.
 - e) Spectral band and waveform plotting
 - f) Multiple trends display including process value for data correlation.
 - g) Orbit and time base plotting.
 - h) Shaft centreline plot indicating position of a machine rotor.
 - i) Bode and polar plot.
 - j) Date and Time stamped alarm list.
 - k) Log and Report generation.
 - l) Provision for beeping icon in case of appearance of alarm.
 - m) Export and import of DCS data. Both way redundant communication links with the DCS shall be provided.
 - n) Electronic documentation.
9. The system shall have facility to store bulk data for 5 years duration with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/ back up media and provide user friendly utilities to retrieve and analyze stored data.
10. Data collected in the system shall also be accessed by CMMS resident on the Station LAN for condition based maintenance.
11. The system shall be time synchronised with GPS based master clock.
12. The vibration transducers shall be installed in accordance with API-670 requirements.
13. Two nos. (One for each unit) vibration monitoring cum programming stations shall be provided in Central Control Room.

13.3 Technical Requirements

13.3.1 Vibration Sensors

1. Inductance/ piezoelectric type transducers shall be used. The sensors shall be either velocity or accelerometer type. However, the sensor type shall be selected taking into consideration equipment manufacturer's recommendation. Vibration sensors as recommended by main equipment manufacturers shall be installed both in horizontal (X) and vertical (Y) directions at each bearing housing of pump and motor. One number key-phasor (proximity type) shall also be provided for each equipment i.e. Pump/ Fan.
2. The vibration sensors shall have wide frequency response to monitor the harmonics and be housed in stainless steel enclosure conforming to protection

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degree of IP-67. Sensor shall be provided with all accessories like mounting pad/cube, Low noise cables & conduits, Extension cables, Junction boxes, Prefab connectors etc.

- Vibration transducers shall be complete with all required pre-amplifier / driver/charge amplifier as necessary for proper operation of the entire vibration monitoring system.

Table 13.1
Specifications for Vibration Sensor

S.N	Features	Minimum Requirements
1	Sensitivity	4 mv/mm/sec
2	Measurement range	0 to 25.4 mm/s pk
3	Frequency Range (+/- 10%)	3 – 1000 Hz
4	Resolution	0.1 mm/s pk
5	Linearity	+/- 1%
6	Temperature Range	0 – 60 °C
7	Sensing Element	Ceramic
8	Sensing Geometry	shear
9	Housing material	SS 316
10	Sealing	Welded hermetic
11	Electrical connection type/ position	Molded Integral cable / Top
12	Excitation Voltage	12 – 30 V DC
13	Cable type/length	Polyurethane/ 10 ft.

Table 13.2
Specifications for Key Phasor Sensor

S.N	Features	Minimum Requirements
1	Type	Proximity non-contact type
2	Sensitivity	200 mv/mil
3	Measurement range	0 to 20 mil
4	Frequency Range	0 – 10 KHz
6	Linearity	+/- 1%
7	Temperature Range	0 – 60 °C
8	Probe tip material	Polyphenylene sulfide
9	Probe body material	SS 316
10	Electrical connection type/ position	Molded Integral cable 1 metre length with connector for extension / Top
11	Excitation Voltage	24 V DC from monitoring unit
12	Cable type	Polyurethane

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13.3.2 Vibration Monitors/ Signal Conditioning Modules

1. The vibration monitors/ modules shall be micro-processor based with extensive self diagnostic facility. Monitoring module shall be fully software configurable.
2. One buffered 4-20 mA signal for connection to Plant DCS, and one buffered raw signal for use in vibration monitoring system shall be made available from each measuring point channel of monitor/ module. The signal shall be suitable for use as an input to DCS for analog monitoring, linear in proportion to vibration velocity as well as displacement. Monitor shall provide vibration indication calibrated in velocity units along with provisions of changing to displacement unit (field-programmable) for each measurement point in both horizontal & vertical planes.
3. Monitoring modules shall allow "hot" insertion or removal.
4. The maximum no. of channels per monitor/ module shall be four. The allocation of channels shall be such that loss of one monitor shall not affect more than one side of the bearing of one machine.
5. Sensor fault, monitor fault, power supply fault monitoring shall be provided. On sensor fault / wire break in the sensor circuit, the system shall have the feature of identifying the same through suitable means like the output being forced to a value less than 4 mA, to enable 'bad' signal detection. In case, such a feature is not available, then suitable contact shall be provided from the monitor for sensor fault/ wire break in sensor circuit.
6. Programmable high pass and low pass filtering facility shall be available to improve the frequency response.
7. All the calibration of the monitors/ modules and transducers shall be possible from the front panel.
8. All incoming and outgoing signals shall be connected through a terminal block or connection mounted at the back of the monitor.
9. In addition to the above, the monitor/ module shall contain all other required signal conditioning devices and accessories required for proper functioning.
10. Sensitivity of vibration monitoring module shall be 100 mV/mil or better
11. The Vibration monitoring system shall have an accuracy of +/- 1 % of Full Scale.
12. Input frequency shall be user programmable.

13.3.3 Power Supplies

1. System shall have provision to receive two numbers 230 V, 50 Hz feeders from purchaser UPS, further conversion and distribution shall be in done as per scope. If required, redundant external Power supply shall be provided to ensure that failure of one power supply shall not affect any monitoring function in the system. Also any power supply failure/ earth fault in any of the monitors shall be isolated without affecting other monitors/ common power supply. However, if any power supply modules internal to the monitors are envisaged, the failure of one such module should not affect more than one monitor.

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2. Power supply monitoring feature with suitable indication and external alarms shall be provided.

13.3.4 Cables, Conduits & Junction box

1. Each transducer shall be furnished with low noise cable in flexible conduit, as indicated earlier, in actual length as required. Conduit fittings shall be furnished or connection to vibration transducer. The other end of the flexible conduit shall be connected to a suitable junction box. The flexible conduit shall not be directly terminated to the vibration transducer to avoid any damages due to vibration. Pre-wired plug-in- type connector shall be provided for connection of the low noise cable to the vibration transducer. Terminals shall be provided for terminating the low noise cable to the junction box.
2. Provision of suitable canopy on the JB and panels installed in open area shall be provided.

Table 13.3

Specifications for Flexible Conduits

S.N	Features	Minimum Requirements
1	Type	Stainless steel flexible conduit
2	Material	AISI 304
3	Formation	Single overlapped/Square Locked
4	Minimum Bending Diameter	75 mm
5	Flexibility	Should not be permanently distorted when bent in complete turn round on a cylinder of 75 mm diameter.
6	Tensile strength	400 N or better
7	Diameter & length	As per requirement

13.3.5 Programming Functions

Suitable means shall be provided for programming the components of the system. This shall include range change, set point change, sensor fault detection/ monitoring related functions etc.

13.3.6 System Cabinet/ Monitor Racks

1. The system mounting rack shall preferably be 19" EIA rack mount for monitor based systems. The system mounting rack shall house monitor modules, indicating units, power supplies. Rack shall be fully factory wired up to rear terminal block. The Internal arrangement shall take into consideration aspects of access/ ease of maintenance etc.
2. Panel shall be provided with necessary Isolation transformers, MCBs, switch etc. Power and signal cable shall be routed in separate raceways.
3. All necessary accessory items and electrical materials shall be installed in the monitoring panels as required for completeness of the panels. These shall include but not be limited to the following:
 - a) Terminal blocks with identification tags.
 - b) Terminal lugs and wire markers at both ends of all wires.

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c) Panel hardware including vibration isolating devices

d) Grounding bus

4. Incoming cables from the field shall be terminated in suitable terminal blocks in logical sequence.
5. Each vibration monitor and mounting rack shall have nameplate engraved to indicate the main equipment to which the module is catering and the bearing details.
6. In case of monitor based system, the front door shall be of glass, for the portion where the monitors are mounted to enable viewing of the same.

13.3.7

Wiring

1. All instrument wiring used within the panels shall conform to NEC and NEMA standards and shall be factory installed and tested at the works.
2. Signal circuit shields shall be grounded at the system cabinet end only or as recommended by manufacturer.
3. All internal wiring (except low level instrument wiring) shall be National Electric Code Type SIS, Polymeric / Elastomeric insulated, copper stranded conductor & switchboard wire.
4. Panel wiring shall have a flame resistant insulation with adequately sized copper conductor based on current carrying capacities as set forth by the National Electric Code.

13.3.8

Terminal Blocks

1. For all inputs to the system emanating from the field or "others" systems, the system shall be furnished with screw less cage clamp type terminals suitable for core size of 0.5/1.5 square mm. stranded conductor.
2. At least 20 per cent spare unused terminals shall be provided, for circuit modifications and for termination of all conductors in a multi conductor control cable

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14. FIELD INSTRUMENTS & FINAL CONTROL ELEMENTS**14.1 General Requirements**

1. All instruments shall be of proven reliability, accuracy, repeatability requiring a minimum of maintenance. They shall comply with the acceptable international standards.
2. Every panel mounted instrument requiring power supply shall be used with a pair of easily replaceable glass cartridge fuses of suitable rating. Every instrument shall be used with a grounding terminal and shall be suitably connected to the panel grounding bus.
3. All local gauges as well as transmitters, sensors, and switches for parameters like pressure, temperature, level, flow etc. as required for the safe and efficient operation and maintenance as well as for operator and management information (including all computation) of equipment shall be used.
4. The necessary root valves, impulse piping, drain cocks, gauge-zeroing cocks, valve manifolds and all the other accessories required for mounting/erection of these local instruments shall be furnished, even if not specifically asked for, on as required basis. The contacts of equipment mounted instruments, sensors, switches etc. for external connection including spare contacts shall be wired out in flexible/rigid conduits, independently to suitably located common junction boxes. The proposal shall include the necessary cables, flexible conduits, junction boxes and accessories for the above purpose. Double root valves shall be used for all pressure tapings where the pressure exceeds 40 kg/sq cm.
5. For protection purposes, transmitters can be considered in place of switches.

14.2 Pressure / Differential Pressure / Flow / Level Transmitter**Table 14.1****Specifications for Pressure / Differential Pressure / Flow / Level Transmitter**

S.N	Features	Minimum Requirements
1	Type	Microprocessor based 2 wire type, HART protocol compatible
2	Sensor Type	Capacitive/ Piezo-electric
3	Output Signal	4-20 mA signals superimposed with HART signal.
4	Signal Processing Unit	Microprocessor based
5	Overpressure	150% of max. operating pressure. For vacuum service, the element shall have under – range protection to full vacuum
6	Turn-down Ratio	10:1 for vacuum / very low pressure applications. 100:1 for other applications.
7	Stability	± 0.1% of calibrated span for six months up to 70 Kg/cm ² and ± 0.25% for range more than 70 Kg/cm ² (g).
8	Span and Zero drift	± 0.015% per deg. C at max span & 0.11% per deg. C at min. span.

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S.N	Features	Minimum Requirements
9	Enclosure Class	Weather proof as per IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500
10	Zero & span adjustability	Continuous, tamper proof, remote as well as manual from instrument with zero suppression and elevation facility.
11	Local Indicator	To be provided
12	Display	Digital LCD Integral Display (minimum 5 digit) Engineering Unit
13	Process connection	½ " NPT (F)
14	Electrical Connection	½ " NPT
15	MOC of Electrical Housing	Aluminum Alloy or better
16	Ambient Temperature	65 Deg. C
17	Operating Voltage	16 – 48 Volts DC
18	Load	600 Ohms (minimum) at 24 Volts DC
19	Accuracy	± 0.075% of span or better
20	Response Time	100 millisecond or better
21	Adjustment/ calibration/ maintenance	Port/provision for Centralised PC based system maintenance.
22	Diagnostic	Self Indicating feature
23	Accessories	Diaphragm seal, pulsation damper, siphon, 3-valve or 5valve manifolds.

1. All transmitters shall be equipped with all necessary accessories like valve manifolds, mounting bracket etc. Pulsation dampeners shall be used where the process media is unstable for measurement such as at the discharge of a pump. For absolute pressure transmitter, 2 valve manifold; for gauge / vacuum pressure transmitter, 3 valve manifolds and for DP / level / flow transmitter, 5-valve manifold shall be provided. In case if it becomes necessary to use a DP transmitter for pressure measurement then a 3 valve manifold shall be used in place of 2 valve manifold.
2. Pressure transmitter shall have easily accessible span, zero and time constant adjustments. A range suppression / elevation device shall be used wherever required.
3. For pressure / differential pressure transmitter, proof pressure shall be 200% of maximum static process pressure.
4. All transmitter cases shall be dust – tight and rugged. Weather – proof and explosion – proof cases shall be used in outdoor and hazardous areas respectively. Protection clause shall be of IP 67 or better.
5. Transmitters for pressure / DP measurements of liquid and steam shall always be installed below the sampling point, preferably with the connection at the top.
6. Transmitters for pressure / DP measurements for gases and air shall always be installed above the sampling point, preferably with the connection at the bottom.

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7. Transmitters with diaphragm seal system shall be considered when
 - a) The process temperature is outside of the normal operating ranges of the transmitter and cannot be brought into those limits with impulse piping.
 - b) The process is corrosive and would require frequent transmitter replacement or unusual materials of construction or
 - c) The process contains suspended solids or is viscous and may plug the impulse piping or
 - d) There is a need to make density or interface measurements or
 - e) The process medium may freeze or solidify in transmitter or impulse piping.
8. Diaphragm seal shall be either capillary type or direct mounted type depending upon the application. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.
9. Differential pressure type level transmitters shall be used for range above 1219 mm, for services requiring purge or where liquid might boil in external portions.
10. Differential pressure type level transmitters for use on corrosive service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type DP transmitter shall be considered for special application. Diaphragm material shall normally be stainless steel or any other special alloy.
11. Differential pressure type flow transmitters shall have in-built square-root extractors.

14.3 Temperature Transmitter

Table 14.2

Specifications for Temperature Transmitter

S.N	Features	Minimum Requirements
1	Type	2-Wire, Smart (HART)
2	Output Signal	4-20 mA signals superimposed with HART signal.
3	Signal Processing Unit	Microprocessor based
4	Accuracy	± 0.075 % of span or better
5	Local Indicator	To be provided
6	Display	Digital LCD Integral Display (minimum 5 digit) Engineering Unit
7	Input	Ohm input from Pt-100 RTD/ mV signal from thermocouples

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S.N	Features	Minimum Requirements
8	Stability	± 0.1 % of reading or 0.1° C, whichever is greater, for 24 months for RTDs. ± 0.1 % of reading or 0.1 °C, whichever is greater, for 12 months for thermocouples
9	Output	4-20 mA DC, linear
10	Load	600 Ohms (minimum) at 24 Volts DC
11	Power Supply	24 VDC, 2- Wire Loop Power
12	MOC of Electrical Housing	Aluminum Alloy or better
13	Enclosure Class	Weather proof as per IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500

- The temperature transmitter of following types (2-wire Loop Powered temperature transmitter) compatible with thermocouples and RTDs shall be used. Cold junction temperature compensation of the thermocouples shall be performed in the temperature transmitter itself.

Single Input DIN-rail mounted Temperature Transmitter

These shall be suitable for mounting on DIN-rails in Panels/JBs in air conditioned room. This temperature transmitter shall be the ones which are especially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category.

Dual-input Temperature Transmitter with Indicator

These shall be suitable for mounting on pipes/ supports. Indicator shall be used with these transmitters. These transmitters shall have bump-less change over facility to second sensor in case first sensor fails .This changeover is to be alarmed. Protection class shall be IP67 minimum.

- Transmitters shall be used with following features:
 - Sensor drifts alarm for sensor failure prediction
 - Differential & average temperature measurement if required.
 - Automatic switch-over to back-up sensor on primary sensor failure.
 - Accepts any combination of two sensor types (RTDs, T/Cs, mV or ohms)
 - Ambient temperature compensation
 - Fault detection for electronics & sensors with fail-safe alarming.
 - Provision of built-in CJC

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3. Transmitters to be used for RTD sensors shall be used with RTD EMF correction features so that it shall detect and eliminate EMF errors which are the result of small voltage produced by RTD sensing elements.
4. The product and make shall be selected so that with one make of transmitter all applications with respect to measuring range, temperature sensor (resistance thermometer / thermocouple) and connection type (2/3/4) wire connection of resistance thermometers) shall be covered.
5. Transmitters shall be capable of communication with HART (Highway Addressable Remote Transducer) communicator. HART communicator shall be used with transmitters for tuning / configuring / diagnosing / maintenance of the transmitters. It shall meet the intrinsic safety requirement if required depending upon the application.
6. All transmitters' cases shall be dust-tight and rugged. Weather-proof and explosion-proof cases shall be used in outer and hazardous areas respectively.

14.4

Thermocouple

Table 14.3
Specifications for Thermocouple

S.N	Features		Minimum Requirements
1	Wire Gauge		16 AWG (for K type) 24 AWG (for R type)
2	Protective tube		O.D. 8 mm Material SS 316 seamless Filling – Compacted Magnesium Oxide (Purity above 99.4)
3	Loading		Shall be spring loaded to ensure positive contact with the well. Prevention of rotation of the insert with respect to head and resultant twisting of leads shall be ensured.
4	Accuracy		As per ANSI MC 96.1 / IEC 751 / IS-2054 / 2055.
5	Characteristic		Linear with respect to temperature within +/- ½ per cent of top range value.
6	Reference		For temperature vs. mV characteristics, following IS shall be applicable : Type K IS – 2054 Type R IS - 2055
7	Head	Type	IP-65 universal screwed type (Explosion proof for NEC class-1, division-1 area)

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S.N	Features		Minimum Requirements
		Material	Die-cast aluminium or better material painted with black enamel paint.
		Terminal Block	Brass screw type / silver plated on ceramic head.
		Cable Connection	½ " NPT gland & grommet
		Cover	Screwed cover with suitable gasket & SS Chain
8	Instrument connection to Well		½ " NPT
9	Accessories	a)	Adjustable nipple-union-nipple {1/2" Sch. 80 X1/2" NPT (M)} with thermowell connection
		b)	Compression fittings/union
		c)	Flanges etc. (For flanged connection only)
		d)	SS 316 forged/barstock thermowell as per ASME PTC code. Process connection M33X2 (M) in general or 1 ½ " Flanged for Flue gas/ Furnace air etc. application

- The following types of sensors shall be used for the different temperature ranges:
 - For measurement of temperatures of up to max. 1100 °C, rapid-responded sheathed thermocouples with insulated tip, 16 AWG wire, as Chromel-Alumel (NiCr-NiAl, ISA type K) measuring element, with admissible deviation of thermo voltage of half the values stated in IS-2054, or DIN 43710.
 - For measurement of temperature between 1100°C and 1300°C, 24 AWG, Platinum Rhodium (13%) – Platinum (ISA type R) measuring elements, with admissible deviation of thermo voltage of half the values stated in IS-2055, or DIN-43710.
- All thermocouples shall be duplex type with tip grounded. Thermoelectric properties and accuracy shall be as per ANSI MC 96.1 / IS-2054 / 2055.
- The design of thermocouple assemblies shall be such that replacement on line is possible.
- Gas-tight ceramic sheaths partially reinforced with stainless steel sheath shall be used as protective tube for Pt Rh – Pt thermocouples. For other type of

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thermocouple stainless steel tubes shall be used as protective sheaths. For measuring temperature of high pressure process fluid, tapered protection sheath made from solid bar stock shall be used.

5. The time-constant of thermocouples shall suit the process requirement.
6. The thermocouples shall be supplied with factory tested and calibrated assemblies. The assemblies shall be complete with thermo well, sensing element, connection lead, duplex terminal block, extension nipple, compression fittings / unions / flanges etc. to meet all functional requirements. The thermocouples equipped with thermo well shall be spring loaded for positive contact with the well.
7. The duplex terminal block shall be constructed with high temperature ceramic base with brass screw type terminals.
8. Thermocouple shall be suitable for steam, water or any other liquid application. For air & flue gas service, suitable protection tubes shall be used for the thermocouples.
9. All thermocouples shall be terminated to the nearest junction boxes. The cold junction compensation shall be implemented within the measuring module level, no local/ field cold junction compensation box is allowed.

14.5

Resistance Temperature Detector (RTD)

Table 14.4

Specifications for RTD

S.No.	Features	Minimum Requirements
1	Type	3 / 4 wire , Pt-100 (100 ohm at 0 deg C) (as per DIN 43760)
2	No. of Element	Duplex
3	Housing/Head	IP-65/Diecast Aluminium. Plug in connectors are to be provided for external signal cable connection
4	Sheathing of RTD	Metal sheathed , mineral insulated, ceramic packed
5	Calibration and accuracy	As per DIN-43670 Class-A for RTD
6	Stability	Zero & span drift within 0.1% of span for a 6 month period.
7	Characteristic	Linear with respect to temp, within $\pm 1/2$ percent of top range value
8	Standard	As per DIN-43670 for RTD & ASME PTC-19.3 for Thermowell
9	Accessories	a) Adjustable Nipple-Union-Nipple with thermo well connection / plug in connectors

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S.No.	Features	Minimum Requirements
		b) Compression fittings / unions
		c) Flanges etc.
		d) Thermowell as per requirement

1. RTDs shall be of duplex, platinum three / four wire type with a nominal resistance of 100 ohms at 0°C and conform to DIN 43760 / BS 1904.
2. Stability of RTD over full range shall be better than 0.05 ohms and the repeatability figure shall be better than 0.02 ohms. Accuracy shall be of the order of 0.15% or better and response time shall be less than 20 seconds with thermo well.
3. The protective-sheath material shall be SS 316, seamless tubes using compacted magnesium oxide packing for insulation. The insulation resistance at 540°C shall not be less than 5 mega-ohms.

14.6

Metal Temperature Thermocouple

Table 14.5

Specifications for Metal Temperature Thermocouple

S.No.	Features	Minimum Requirements
1	Measuring medium	Metal Temperature
2	Type	K-Type
3	Wire Gauge	16 AWG
4	No. of Element	Duplex with separate hot junctions, ungrounded type
5	Sheathing/Insulation/Dia.	Metal sheathed (SS 321) , mineral insulated (Magnesium oxide), ceramic packed, 8 mm Dia.
6	Bending Radius	30 mm (minimum)
7	Cold End Sealing	SS pot seal with color coded PTFE headed sleeve insulated flexible tails. Sealing compound – Epoxy Resin
8	Standard	ANSI MC 96.01
9	Thermocouple Length	30 Mtrs. (minimum)
10	Accessories	1/2" BSP SS sliding end connector, weld pad, weld on clamps of heat resistant steel SS310.

1. For metal temperature measurement, care shall be taken for proper contact with metal surface. The thermocouples sheath for metal temperature measurement shall have to be thermally insulated to avoid radiation / conduction / convection

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loss. Thermocouple assembly for metal temperature measurement shall suit the functional requirement.

2. The thermocouple shall be attached to the heater tube surface by being furnished with stainless steel welding pads or by the use of thermocouple attachment blocks. The multiple holes in these blocks shall allow for spare thermocouple element for quick replacement.
3. For boiler metal temperature measurement, the lead wires shall have to be brought into nearest Junction Boxes which are located in accessible safe zones, using suitable protection pipes.
4. For measurement of wall temperatures at boiler tubes, sheathed thermocouples, dia 3.0 mm NiCr-Ni single thermocouples shall be used. The thermocouple line shall be designed as Teflon-insulated stranded conductor, provided with glass filament insulation and stainless steel wire braiding. The thermocouple shall be welded to the compensation line outside of the boiler insulation, with the welding point spilled hermetically in a coupling element. The area of the boiler penetration shall be designed with an anti-kink spring of stainless steel and a line-fixing sleeve of stainless steel, encapsulated in synthetic resin.
5. The differential temperature "inside / centre" of the wall shall be measured by means of sheathed thermocouples NiCr-Ni, dia 3.2 mm. For this special protective sleeve shall be used. Particular emphasis shall be put on compliance with the stipulated depth of the bores in the tube wall material.
6. For detection of leakage of various drain valves, drain pipe metal temperature thermocouples and for SH, RH metal temperature thermocouples shall be used.

14.7

Cold junction Compensation (CJC) Boxes

Table 14.6A

Cold Junction Compensation (CJC) Boxes

S.No.	Medium	MOC
1	Reference Temp	60°C (+/- 1.3°C) for type K thermocouple 60°C (+/- 2°C) for type R thermocouple
2	Effect of ambient temp. variation	+/- 0.1% per 10°C
3	Material	4 mm thick fiberglass reinforced polyester with polyurethane paint and glazed finish
4	Protection class	IP 55
5	Cable entry	Bottom with gland plate suitable for cable used along with blanking facility.
6	Temp. Control	Automatic with remote temp. monitoring
7	Power supply	24VDC

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14.8 Thermowell for Temperature Elements

1. The design of the thermo well shall take into consideration the temperature, pressure, medium and fluid velocity specified in the process in accordance with ASME Standard PTC 19.3.
2. Thermo wells shall, in general, be of SS 316 and shall be drilled from bar stock except for air and flue gas services. However, selection of thermo well material shall be as per following guideline.
3. Welded type thermo wells with 38 mm O.D. for welding & ½" NPT internal threads shall be used for pressure above 100 kg / sq cm or temperature above 400 deg C. Socket weld type thermo well with 34 mm O.D. for welding & ½" NPT internal thread, shall be used for pressure between 40-100 kg/cm² and temperature up to 400°C. Screwed type thermo wells with ½" NPT internal threads & M33X2 (M) outer threads shall be used for pressure below 40 kg/cm² and temperature below 400°C. For pipes having probability of prolonged vibration, seal welding may be done all around after tightening the thermo well within the base.

Table 14.6B

Thermowell MOC Selection

S.No.	Medium	MOC
1	Preheater	Black Steel, SS446
2	Steam lines	SS 316 and pipe material compatible for high temperature steam
3	Water lines	Low carbon steel/ SS316
4	Boiler Tubes	SS304 / SS309 / SS310

4. Thermo well manufacturing drawing covering material specification, dimensional details, details of special treatment, finish etc. as well as test procedure. Material certificate shall have to be furnished for each thermo well.
5. Wherever any approval is necessary from any recognized body / authority during manufacturing of high pressure wells.
6. The thermo well immersion depth (U) shall be sufficient to eliminate conduction error. A general rule which may be followed is to use an immersion length equaling a minimum of 10 times the diameter of the protective tube or well. In general, immersion length of thermo wells for different line sizes shall be as follows:

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Table 14.6C
Thermowell Immersion Length

S.No.	Line Size	Immersion Length
1	From 4" to 6"	65 mm
2	From 8" & onwards	140 mm
3	Vessels	400 mm

14.9

Pressure Gauge/ Differential Pressure Gauge/Draft Gauge

Table 14.7
Specification for Pressure Gauge/ DP Gauge/ Draft Gauge

S.No.	Feature	Minimum Requirement
1	Type	Bourdon / Bellows / Diaphragm
2	Sensing Element Material	AISI 316 SS
3	Movement Material	AISI 304 SS
4	Case Material / Protection Class	SS / IP 65
5	Dial Size	150 mm For Special application like drum pressure, Main Steam pressure etc. 250 mm shall be used
6	Scale	Black lettering on white background in 270 °C arc
7	Range Selection	Normally operate at 75% of its maximum pressure range. Instruments measuring varying pressures shall operate in a band of 60% of its maximum pressure range.
8	Over range Protection	150% of maximum range by internal stop. External stop below zero.
9	Adjustment	External Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
10	Stop at Max. Reading	Shall be used
11	Element Connection	Argon welding
12	Process Connection	½" NPT(M) bottom connection for local mounting, back connection for panel mounting
13	Accuracy	+/- 1.0 % of full scale or better
14	Operating Ambient Temperature	50 °C (Max. continuous)
15	Safety Feature	Neoprene Safety Diaphragm (Blowout disc) at the back
16	Window	Shatter-proof glass
17	Chemical Seal Unit	SS 316 Flange and Diaphragm, PTFE coated / block, Silicon Oil filling fluid
18	Accessories	Snubber for pulsating fluid applications / 3-

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S.No.	Feature	Minimum Requirement
		way gauge cock / 2-valve manifold / Pigtail / Siphon for steam service / Gauge Saver, if maximum or Design Pressure is very high than the Operating Pressure / Counter Flanges / Bolts, Nuts, Gaskets / SS Tag Plate

1. Directly connected pressure measuring instruments shall be diaphragm, bourdon or bellow type elements depending upon the services conditions. In general, diaphragm elements shall be used in the range of 0 to 1000 mm water column pressure, bellow type element for ranges of 0 to 1 Kg/cm² and bourdon type element for ranges greater than 1 Kg/cm².
2. Primary element material shall be corrosion resistant to process fluid or diaphragm seals shall be used for protection.
3. For draft measurement Teflon coated beryllium copper diaphragm shall be used.
4. Snubber shall be floating pin type, externally mounted and externally adjustable. It shall be used for all pulsating services.
5. Diaphragm seals, filled type or mechanical type shall be furnished where plugging of the element may occur or where suitable material is not available in highly corrosive services. When chemical seals are required, they shall be the clean out type with flushing connection.
6. Over-range protection shall be used to at least 150 % of range. For vacuum service, the element shall have under-range protection to full vacuum
7. Ranges of the gauges shall be so selected that the gauge normally operates in the middle third of the scale and conform to IS 3624 standard dials, wherever necessary.
8. The sensing elements for all gauges shall be properly aged and factory tested to remove all residual stresses and shall be SS 316 with forged socket and tip of the same material. Elements above 70 Kg/sq. cm range shall be bored instead of drawn.

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14.10 Temperature Gauge

Table 14.8
Specification for Temperature Gauge

S.No.	Feature	Minimum Requirement
1	Type	Mercury filled
2	Sensing Element material	Bourdon AISI 316 SS
3	Movement Materials	AISI 304 SS
4	Case Material/Protection class	SS / IP65
5	Capillary Armouring	SS Flexible
6	Capillary	SS 316 (5 mtr. Length for Local & 15 metre for panel Mounting)
7	Bulb/Stem Diameter	12 mm
8	Dial Size	150 mm
9	Window	Shatterproof glass
10	Scale	Black lettering on white background in 270 °C arc
11	Adjustment	Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
12	Pointer	Externally Adjustable
13	Range Selection	Normal Process Temperature – approximately two third of Temperature range.
14	Stop at Max. Reading	Shall be used
15	Over range Protection	150% of FSD
16	Instrument Connection	Bottom connection for local mounting, back connection for panel mounting.
17	Process Connection	½" NPT with Thermowell
18	Performance :-	
a	Accuracy	+/-1.0% of full scale or better
b	Repeatability	Less than 0.5% of full range
c	Response Time	30 seconds (max.) with Thermowell and 15 seconds Bare.
19	Operating Ambient Temperature	50 °C (Max. continuous)
20	Accessories	Mounting brackets, Bolts, Nuts, Gaskets / SS Tag plate, SS Thermowell etc.

- Temperature gauges shall be dial thermometers (liquid spring / steam pressure spring / metal expansion thermometer), either rigid stem or capillary tube depending upon application; if this is not possible for design reasons, industry type liquid – in – glass thermometers shall be used.
- Case shall have back or bottom connection with adjustable gland to permit adjustment of thermometer into the thermo well.

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3. Thermometer stem adjustable gland with union connection and bushing shall be suitable for ½ inch NPT connection.
4. Bi-metallic type dial thermometer, if used, shall be hermetically sealed, back or bottom connection type, with 150 mm dial.
5. The gauges shall be used with automatic ambient temperature compensation.
6. Scale ranges shall be selected so that normal process temperature in middle two – third of full scale range.

14.11 Level Gauge

Table 14.9
Specification for Level Gauge

S.No.	Feature	Minimum Requirement
1	Sensing Element & material	Tempered toughened Borosilicate gauge glass steel Armored reflex or transparent type
2	Body Material	Forged carbon steel / 304 SS
3	End Connection	Process connection as per ASME PTC and drain / vent 15 NB
4	Accuracy	+ 2 %
5	Scale	Linear vertical
6	Range Selection	Cover 125 % of max. of scale
7	Over Range Test	Test pressure for the assembly shall be 1.5 to the Maximum design pressure at 38 degree C
8	Housing	CS / 304 SS leak - proof
9	Identification	Engraved with service legend or or laminated phenolic Name plate
10	Packing	PTFE Teflon
11	Illumination	220 V, 50 Hz, 25 / 40 Watts either with deflector or diffuser (for transparent type level gauge) / 220V , 50 Hz, 25 /40 Watts with red and green filter for bicolor gauge
12	Accessories	Gasket for all KEL – F shield for transparent type vent and drain valves of CS / SS as per requirement
13	Others	Anti – Frost extension for low temperature service. Heating / cooling arrangement

1. Level gauges shall be steel armoured reflex or transparent or bi –colour type, top and bottom connection as per pressure vessel standard of ASME PTC code and 15 mm NB (1/2 inch NPT) Drain and Vent connection.
2. Body material and cover material shall normally be forged carbon steel, 304 stainlesssteel or other superior material.
3. Reflex type gauges shall be used for clean and colorless liquids and transparent type for other liquids. For boiler and condensate services, treated water, the

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transparent type with KEL – F shields shall be used to avoid their attack on the glands.

4. The gauge glass must have a rating equal to or more than the vessel design pressure and temperature.
5. The maximum length of a single gauge glass shall not exceed 1400 mm. Where large range is required, multiple gauges of preferably equal lengths shall be used with 50 mm over – lapping in visibility.
6. The visibility shall cover the operating level range and the maximum and minimum ranges expected considering start – up conditions as well as alarm and shut down points. Internal heating shall be used for viscous liquids. Integral illuminators shall be used for transparent gauges, if necessary.
7. Stand – pipes shall be used for multi – gauge glass and level controller installation and on horizontal drum or exchanger with top and bottom connections to have visibility of the complete span. The stand pipe shall not be used with block valves.
8. Primary isolation valves shall be used In addition to the gauge glass valves unless otherwise specified. When the process fluid may create lugging or leakage problem, gauge valves may be omitted. For low temperature liquid having high vapor pressure at ambient temperature, isolation and gauge valves shall not be permissible. Safety valve shall be used at the vent connection of the gauge glass where isolation is required.
9. For high pressure service such as boiler water etc., the gauge glass shall be multi – port illuminated type (Bi – colour type). Indication of water space shall be ‘green’ and indication of steam space shall be ‘red’.
10. Bi – colour level gauges shall have following features:
 - a) Temperature equalizing column expansion bend and chain patterned hand – wheel
 - b) Certification by Inspectorate of Boiler

14.12 Pressure/ Differential Pressure Switch

Table 14.10
Specification for Pressure/DP Switch

S.No.	Feature	Minimum Requirement
1	Type	Piston for high pressure application Bellow/Diaphragm for low pressure application
2	Sensing Element material	AISI 316 SS
3	Wetted Parts material	AISI 316 SS
4	Case Material	Epoxy coated Die Cast Aluminium
5	Setter Scale	Black graduation on white linear scale. Graduation 0 – 100% with red pointer for set points.
6	Over range for Pressure / Vacuum Switch	150% of maximum pressure

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S.No.	Feature	Minimum Requirement
7	Set Point	Adjustable throughout switch operating range.
8	Static Pressure for Differential Pressure Switch	Maximum Line Pressure or Static Pressure on either side without permanent deformation or loss of accuracy.
9	Adjustments	Internal – set point Differential adjustable feature
10	Process Connection	½" NPT(M) bottom connected
11	Switch Configuration	2 SPDT / 1 DPDT
12	Switch Rating	230 V, 5A AC / 220 V, 0.25 A DC/24 V, 2A DC
13	Switch Type	Snap acting, shock and vibration-proof
14	Cable Connection	½ " ET conduit connections or compression gland
15	Enclosure Class	Weather proof as per IP 65 with corrosion resistance coating.
16	Accuracy	1% of span up to 3Kg/cm ² 0.5% of span for more than 3 Kg/cm ² .
17	Repeatability	0.5% of span
18	Accessories	
a)		Snubber for pulsating fluid application.
b)		Tag Number, service engraved in SS tag plate
c)		Teflon back-up sheath protection, as required.
d)		i) Remote diaphragm seal with SS 316 armored capillary for typical application. MOC of seal material shall be as per process fluid requirement. ii) Silver coated diaphragm for corrosive services like chlorinated water.
e)		Retention ring and screws for surface mounting.
f)		3-way Gauge Cock (SS 316) for PS / 5-Valve Manifold (SS 316) for DPS.
g)		Mounting bracket / Clamp for 2 " pipe, bolt & nut.

1. The pressure switches shall have sensing elements made of copper alloy or stainless steel sealed diaphragm and piston actuated for high pressure service and bellows for low pressure / vacuum service.
2. Low differential pressure switches for low static pressure ranges shall be diaphragm type with snap action switch elements.
3. Low differential pressure switches for high static pressure shall be elbows and torque tube type and snap – action switch elements and metric scale dial indicators.

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4. For corrosive, viscous process fluids diaphragm sealed with completely filled inert liquid shall be used. Material of diaphragm and wetted parts shall be selected considering the nature of process fluid.
5. The sensing elements shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand at least 150 % the full scale pressure without any damage or permanent deformation.
6. Actuation set point, dead band shall be internally adjustable throughout the range with tamper proof facilities.
7. Electrical connection for the switch devices shall be suitable for plug in type connection.
8. Process connection shall be ½ inch NPT. Process piping connections shall include necessary union, nut, nipple, tail pipe, isolation valve and test connection to permit servicing, testing, calibration and removal of the instrument device.
9. Instrument for steam & hot water service, shall be connected through siphon, of stainless steel or suitable material. Pulsation dampeners shall be used for all pulsating fluids.
10. Pressure switches shall be tested as per BS – 6134.

14.13 Conductivity Type Level Switch

Table 14.11
Specification for Conductivity Type Level Switch

S.No.	Feature	Minimum Requirement
1	Sensing elements	Conductivity type
2	Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
6	Probe length	As per requirement
7	Mounting	Flanged- on external cage
8	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact
9	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
10	Enclosure	IP 65
11	Housing	Cast aluminum epoxy coated weather proof
12	Ambient Temperature	60°C (max.)
13	Electrical Connection	Plug-in type
14	Cable connection	½ " NPT with cable gland
15	Set point	Adjustable
16	Accessories	All mounting accessories

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14.14 Capacitance Type Level Switch

Table 14.12
Specification for Capacitance Type Level Switch

S.No.	Feature	Minimum Requirement
1	Type	Capacitance type
2	Probe	Rod or Suspended Electrode
3	Material	SS 316
4	Insulation	PTFE/PP/Kynar part/full as required
5	Repeatability	± 0.5 % of full range or better
6	Accuracy	± 0.5 % of full scale or better
7	Working temperature	As per process requirement
8	Probe length	As per requirement
9	Probe Mounting	1 ½" Flanged
10	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact
11	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
12	Enclosure	IP 65
13	Housing	Cast aluminum epoxy coated weather proof
14	Cable connection	½ " NPT with Cable gland
15	Ambient Temperature	60°C (max.)
16	Electrical Connection	Plug-in type
17	Accessories	Counter flange, Cable gland, Prefab cable etc.
14	Set point	Adjustable
15	Accessories	All mounting accessories

14.15 Float/Displacer Type Level Switch

Table 14.13
Specification for Float/Displacer Type Level Switch

S.No.	Feature	Minimum Requirement
1	Type	Float/Displacer type
2	Float/Stem/Displacer Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
7	Process connection	As per requirement
8	Over-range proof	150% of max. design pressure
9	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact
10	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V

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S.No.	Feature	Minimum Requirement
		DC
11	Enclosure	IP 65
12	Hydro Test	Chamber – 100% at 1.5 times rated pressure or as per ANSI flange rating Float – 1.1 times of operating pressure
13	Electrical Connection	Plug-in socket
14	Accessories	All mounting accessories

- Level Switch shall work on gland less magnetically coupled float or displacer operated mechanism having separate float chamber.
- Float, stem and displacer shall be 316 stainless steel.
- Level switch body, cage and process connections shall be designed to withstand the maximum pressure and temperature of the operating fluid.
- A setting adjustment on the level set point of + / - 25 mm shall be used. The adjustment shall be made externally to the switch.
- The accuracy & repeatability of the switch shall be within +/- 0.5 % of full-scale range. On – Off differential shall be adjustable.
- Process connections of the cage shall be 25 NB male plain nipples connected through socket / welded isolation valves of adequate rating.
- Level switch connections shall also include 15 NB test and drain connections to permit servicing, testing, calibration of the instrument.
- The switching elements shall be snap-acting, shock-proof and vibration-proof. All switches shall have two electrically isolated SPDT contacts with provision of external adjustment of set points and dead bands. The contact ratings shall be 5 amps at 240 V AC 50 Hz or 0.25 amps at 220 V DC.
- Switch enclosures shall be cast aluminium, weather-proof, NEMA -4X type with cable entry through compression type cable glands / ¾ "NPT conduit connections. Switches located in hazardous areas shall have dust-ignition-proof enclosure as per NEC article 500 provisions.

14.16

Ultrasonic Level Transmitter

Table 14.14
Specification for Ultrasonic Transmitter

S.No.	Feature	Minimum Requirement
1	Application	Level measurement in silos, sump water level etc.
2	Medium	Coarse, hard solid materials like ash etc. Materials may be slowly falling through the detection range.
3	Type	Non contact Microprocessor based 2 wire type, HART protocol compatible Ultrasonic Transmitter

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S.No.	Feature	Minimum Requirement
4	Principle	Time of flight
4	Sensor Material	Corrosion resistant material to suit individual application requirement.
5	False signal tolerance	Transmitter shall be capable of ignoring false echoes from internal tank / sumps obstructions such as pipes, heating coils or agitator blades. Also transmitters shall have adjustable damping circuitry.
7	Range	Capable of covering the complete level span of tank/vessel taking care of blocking distance, frequency, attenuation due to surface, obstructions, vapours etc.
8	Output	4 – 20 mA DC with 600 ohms load with HART compatibility.
9	Display	minimum 4 characters display with Integral keypad, access protected by user code.
10	Diagnostics	Loss of echo alarm etc.
11	Resolution	+/- 0.1 % of range or better
12	Accuracy	+/- 2 mm or 0.2% of span
13	Repeatability	3 mm or better
14	Operating temperature	0 to 60° C
15	Power supply	24 V DC + / - 10 %
16	Mounting	Flanged connection at top of covers / side walls as per requirement.
17	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

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1. The power and frequency of transmission for the transmitter shall be selected to assure a sufficient signal / noise ratio.
2. The transmitter shall be designed with an electronic circuit having the features such as temperature compensation, rejection of unnecessary echoes and noises and adjusting 'zero' and 'span'. It shall consist of sensors, electronic unit and accessories.

14.17

Guided Wave Radar Type Level Transmitter

Table 14.15
Specification for Guided Wave Radar Type Transmitter

S.No.	Feature	Minimum Requirement
1	Application	Level measurement of vessel under vacuum or low pressure application
3	Type	Guided wave radar
4	Principle	TDR (Time domain reflectometry)
5	Probe Material	SS 316
6	Accuracy	5 mm or better
7	Resolution	+/- 0.1 % of range or better
8	Signal Output	4 – 20 mA DC with 600 ohms load with HART compatibility
9	Power Supply	24 V DC + / - 10 %
10	Display	Integral
11	Mounting	External cage type
12	Transmitter housing Protection Class	IP-65 with corrosion resistance coating
13	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

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14.18 Flow Switch

Table 14.16
Specification for Flow Switch

S.No.	Feature	Minimum Requirement
1	Type	Vane actuated/Differential bellow type
2	Vane/bellow Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
7	Process connection	As per requirement
8	Over-range proof	150% of max. design pressure
9	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact, shock & vibration proof
10	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
11	Enclosure	Cast Aluminium/IP 65
12	Cable connection	Compression type cable gland/ ½" NPT Conduit connection
13	Electrical Connection	Plug-in socket
14	Accessories	All mounting accessories

14.19 Rotameter

Table 14.17
Specification for Rotameter

S.No.	Feature	Minimum Requirement
1	Type	Variable area Linear scale
2	Fluid media	Water/Oil
3	Float Material	SS 316
4	Accuracy	± 2 % of full scale or better
5	Working temperature	0 to 70°C
6	Process connection	As per requirement
7	Over-range proof	150% of max. design pressure
8	Enclosure	Transparent toughened glass/IP 65
9	Accessories	Flange, orifice in case of bypass Rotameter

Rotameter shall be used for low flow & low viscosity applications of liquid.

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14.20 Sight Glass Indicator (Flow Glass)

Table 14.18
Specification for Flow Glass

S.No.	Feature	Minimum Requirement
1	Application	Online observation of fluid flow in Pipeline
2	Type	Double window for pressurized pipe with rotary wheel for installation in horizontal or vertical pipeline. Full view for non-pressurized pipeline.
3	Size	Double window up to 12" and 600 lbs rating. Full view up to 6" and 150 lbs rating.
3	Body Material	SS 316
4	Glass	Pyrex tempered glass
	Others	Rotor & wetted parts shall be bronze All accessories shall be SS316
5	Protection class	IP-65
6	Connection	Screwed up to 50 NB size Flanged ANSI 150 RF – above 50 NB size
7	Accessories	Name plates, mating flanges with gasket, bolts & nuts etc.

14.21 Flow Elements

a) Orifice Plate

Table 14.19
Specification for Orifice Plate

S.No.	Feature	Minimum Requirement
1	Type	Concentric as per ASME PTC – 19.5 (Part III); ISA RP – 3.2, 960; BS – 1042; ISO 5167
2	Material	SS 316
3	Thickness	3 mm for main pipe diameter up to 300 mm and 6 mm for main pipe dia above 300 mm.
3	Beta ratio	0.34 to 0.7
4	Tapping's	Flanged weld neck 3 pairs of tappings.
5	Material of Branch Pipe	Same as main pipe
6	Root Valve type	Globe
7	Root Valve material	SS 316
8	Root Valve size	1"
9	Accessories	Root valves, flanges, vent / drain hole (as required)

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1. Each orifice plate shall be used with a handle on which the orifice diameter, pipe diameter and pressure tap distances are stamped. This information shall be so located that it can be read without removing the orifice plate from pipe line.
2. The standard primary element shall be thin plate, square-edge concentric orifice plate mounted between a pair of weld-neck type orifice flanges with flange taps. The minimum pressure rating of flanges shall be 300 pounds ANSI. The material of the orifice plates shall be SS 316 in general. Orifice plates shall be not less than 3 mm thick for nominal pipe diameters up to and including 300 mm, and not less than 6 mm thick above 300 mm NB pipe.
3. Quadrant edge or quarter circle orifice plates shall be used for highly viscous liquids and for pipe Reynolds Number below 10,000. Conical entrance type of orifice plates shall preferably be used for very highly viscous liquids up to Reynolds Number below 250. Vent and drain holes shall be used wherever necessary.
4. Orifice diameter shall be selected, so that d/D ratio is between 0.20 to 0.70 for gas and steam and up to 0.75 for liquids.
5. Metering orifices shall not be installed in lines less than 1 ½" (40 mm) the lines shall be blown to the 1 ½ " (40 mm) size for the meter run, keeping the d/D ratio within limits.
6. Restriction orifices and integral orifice transmitters do not require upstream or downstream straight pipe runs.
7. The orifice plate shall be supplied and fitted in conformity with ISO. When the pipe diameter is larger than the value specified in ISO, the restriction ratio shall be decided by extending the specific curve externally.
8. The length of straight pipe run required for metering accuracy shall be in conformity with ISO. When it is extremely difficult to comply with the standard, a minimum straight length of 10D (D = pipe inner diameter) on the upper stream and a minimum length of 5D on the downstream shall be considered.
9. All orifice plates shall be supplied with matching flanges of material and pressure rating not less than the rating of the associated pipe system.
10. For pipeline sizes of 500 mm and less, the orifice plates shall be an integral unit comprising of carrier ring assembly, tapping arrangement on both upstream as well down stream side. For line sizes more than 500 mm, the orifice plate shall be disc type. For disc type orifice plate, suitable corner tapping arrangement on both upstream as well as downstream side shall be used. All tapping arrangements shall be complete with a piece of impulse pipe line and a shut – off valve suitable for specified line pressure.
11. For steam applications, orifice plate shall be supplied with a pair of steam condensation chambers suitable for specified line pressure.
12. Data sheets, sizing calculation, fabrication & sheets for the elements shall be submitted for approval and finalization.

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b) Flow Nozzle

Table 14.20
Specification for Flow Nozzle

S.No.	Feature	Minimum Requirement
1	Type	Long Radius welded type ASME PTC 19.5 (Part III) or BS – 1042
2	Material	Same as Pipe material
3	Thickness	Suitable for intended application
3	Beta ratio	Around 0.7
4	Tapping's	D and D/2 (3 nos. tappings)
5	Material of Branch Pipe	Same as main pipe
6	Root Valve type	Globe
7	Root Valve material	SS 316
8	Root Valve size	1"
9	Accessories	Root Valves, Vent & Drain Hole

- The branch pipes for holding the flow nozzle shall also be furnished along with the flow nozzle.
- Flow nozzles in high pressure pipes shall be subject to a test according to DIN 50049, 3.1C, considering the technical guideline. The test of flow nozzles shall contain:
 - Check of drawings
 - X-ray testing of the circular bead or colour soaking or ultra-sonic testing
 - Test of sizes.
- Flow nozzle shall be used with a permanent mark indicating:
 - Measuring point number
 - Direction of flow
 - Plus and minus tapping
 - Material

Moreover, the actual inside pipe diameter "D" and the diameter of the flow nozzle shall be stated on the identification plate.

- The supplier shall provide the following documents:
 - Design drawings of the flow nozzle
 - Calculation documents
 - Fabrication, assembly and installation drawings
 - Test reports.
- For measurements of steam, balancing vessels shall be used. Balancing vessels shall be used for flow measurement in steam system based on the differential

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pressure method to ensure a defined water column. The balance vessels shall be arranged on the same geodetic level. If this is not possible for design reasons, the level difference shall be taken into account during calibration

c) Venturi

Table 14.21
Specification for Venturi

S.No.	Feature	Minimum Requirement
1	Design standard	BS 1042/ISO5167
2	Material	SS 316
3	Type	Fabricated Machine Cast
4	Mounting	Flanged
5	Root Valve type	Ball
6	Root Valve material	SS 316
7	Root Valve size	1/2"
8	Accessories	All required mounting accessories & piezometric ring with 4 nos. tapping's for choke removal & screwed cap/plug on the ring

14.22

Oxygen Analyzer

Table 14.22
Specification for Oxygen Analyzer

S.N	Feature	Minimum Requirement
1	Type	In-situ Heated type
2	Principle	Partial pressure using Zirconium oxide cell
3	Sensor Type	Zirconium Oxide cell
4	Measurement Range	0.01 to 10 % O ₂
5	Accuracy	+/- 0.2 % of full scale
6	Linearity	+/- 1% of full scale
7	Response time	3 seconds or less (Up to 90% of full scale)
8	Drift	+/- 0.005% per 2 Deg. Centigrade temp. change
9	Operating Temperature Range	0-1600 *C
10	Temperature compensation	Automatic
11	Sample filter	Ceramic 3.5 micron
12	Zero & Span Adjustment	Required
13	Ambient Temperature	60 *C
14	Indication	Digital
15	Enclosure Type/Material	Weather & Dust proof IP-65/ SS 316
16	Type of Electronics	Microprocessor based with self diagnostic facility
17	Calibration	Auto & manual
18	Output signals	Analog: 4-20 mA DC Binary: 2 NO + 2 NC for Alarms

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S.N	Feature	Minimum Requirement
19	Digital Signal transmission	RS-232 or RS-485 OR as per requirement to suit connection protocol of Plant DCS
20	Other requirement	HART Communication protocol compatibility & suitable for connection to Smart Transmitter Maintenance system. Purging System

14.23

Carbon Monoxide Analyzer

Table 14.23

Specification for Carbon Monoxide Analyzer

S.N	Feature	Minimum Requirement
1	Type	In-situ type
2	Principle	IR Double beam absorption
3	Sensor Type	IR
4	Measurement Range	0-999 ppm selectable
5	Accuracy	+/- 0.2 % of full scale
6	Linearity	+/- 1% of full scale
7	Response time	3 seconds or less (Up to 90% of full scale)
8	Drift	+/- 0.005% per 2 Deg. Centigrade temp. change
9	Operating Temperature Range	0-1600 *C
10	Temperature compensation	Automatic
11	Sample filter	Ceramic 3.5 micron
12	Zero & Span Adjustment	Required
13	Ambient Temperature	60*C
14	Indication	Digital
15	Enclosure Type/Material	Weather & Dust proof IP-65/ SS 316
16	Type of Electronics	Microprocessor based with self diagnostic facility
17	Calibration	Auto & manual
18	Output signals	Analog: 4-20 mA DC Binary: 2 NO + 2 NC for Alarms
19	Digital Signal transmission	RS-232 or RS-485 OR as per requirement to suit connection protocol of Plant DCS
20	Other requirement	HART Communication protocol compatibility & suitable for connection to Smart Transmitter Maintenance system. Purging System.

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14.24 Control Valves

14.24.1 Introduction

The control valves and accessories equipment furnished by the Supplier shall be designed, constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Boiler & Pressure Vessel code, Indian Boiler Regulation (IBR) & ISA or acceptable equal standards.

14.24.2 Control Valve Design & Sizing

1. The design of all valve bodies shall meet the specification requirements and shall conform to the requirements of ANSI for dimensions, material thickness and material specification for their respective pressure classes.
2. The valve sizing shall be suitable for obtaining maximum flow conditions with valve opening at approximately 80% of total valve stem travel and minimum flow conditions with valve stem travel not less than 10% of total valve travel. All the valves shall be capable of handling at least 120% of the required maximum flow. Further, the valve stem travel range from minimum flow condition to maximum flow condition shall not be less than 50% of the total valve stem travel. The sizing shall be in accordance with the latest edition of ISA Handbook on control valves. While deciding the size of valves, Supplier shall ensure that valves outlet velocity does not exceed 8 m / sec. for liquid services, 150 m/sec. for steam services and 50% of sonic velocity for flashing services. Manufacturer shall furnish the sizing calculations clearly indicating the outlet velocity achieved with the valve size selected by him as well as noise calculations.
3. Control valves for steam and water applications shall be designed to prevent cavitations, wire drawing, flashing on the downstream side of valve and downstream piping. Thus for cavitations / flashing service, only valve with anti-cavitations trim shall be used. Detailed calculations to establish whether cavitations shall occur or not for any given application shall be furnished.
4. Trim shall be multistage type having sufficient number of discrete pressure drop turns (stages) to ensure elimination of vibration, erosive – action, cavitations. Identify the number of pressure drop turns in the given equipment and shall also provide calculation demonstrating compliance to the trim exit velocity.
5. To prevent flow induced vibration and to protect the valve internals from foreign particles such as weld slag flow, direction shall be a flow to close (over the plug) configuration for liquid applications. To maximize noise attenuating benefits and to allow for constant fluid expansion, flow direction shall be under the plug for steam and gas applications.
6. Control valves for application such as SH spray control, RH spray control, Heavy oil pressuring & control system shall have permissible leakage rate as per leakage class V. All other control valves such as low and high range feed control valves etc shall have leakage rate as per leakage class IV.

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7. The control valve induced noise shall be limited to 85 dBA at 1 meter from the valve surface under actual operating conditions. The noise abatement shall be achieved by valve body and trim design and not by use of silencers.
8. The characteristic of the control valves shall be determined based on the application / service.
9. On supply air or electrical failure for pneumatic / electrical drive, the valve shall remain full closed, open or stay – put position as per process safety requirement.

14.24.3 Valve Construction

1. Proper selection of valve type and material of construction to meet operating requirement.
2. All valves shall be of globe body design and straightaway pattern with single or double port unless otherwise recommended by the manufacturer to be of angle body type. Rotary valve may alternatively be offered when pressure or pressure drops permit.
3. Valves with high lift cage guided plugs & quick charge trims shall be supplied.
4. Cast iron valves are not acceptable.
5. Bonnet joints for all control valves shall be of the flanged and bolted type for easy dis-assembly. Bonnet joints of internal threaded or union type shall not be acceptable.
6. Plug shall be of one – piece construction either cast, forged or machined from solid bar stock. Plug shall be screwed and pinned to valve stems or shall be integral with the valve stems.
7. All valves connected to vacuum on down stream side shall be used with packing suitable for vacuum applications (e.g. double vee type chevron packing).
8. Valve characteristic shall match with the process characteristics.
9. Extension bonnets shall be used when the maximum temperature of flowing fluid is greater than 280 degree celcius.
10. Flanged valves shall be rated at not less than ANSI pressure class of 300 lbs.
11. Teflon shall be used for valve gland packing to suit process requirement.
12. The valve body shall be marked to show direction of flow.

14.24.4 Valve Materials

1. The control valve body material shall be
 - a) Carbon steel as per ASTM – A216 GR WCB for non – corrosive, non – flashing and non – cavitations services below 275 deg c temperature like Auxiliary Steam flow to Deaerator, CRH flow to Deaerator, Condensate flow to Deaerator etc.
 - b) Alloy steel as per ASTM – A217 GR WC 9 for severe flashing / cavitations services like low load and full load feed water control, HP and LP heaters emergency drains, Deaerator overflow drain to Hotwell etc.

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- c) Alloy steel as per ASTM A – 217 GR WC 6 for low flashing / cavitations services like HP heaters & LP heaters normal drain control, drain cooler normal level control, gland steam cooler minimum flow etc.
- d) 316 SS for condensate service below 300 deg C like condensate normal and emergency make – up controls etc.

2. The control valve trim material shall be

- a) 17 – 4 PH SS for severe services listed under item D.1, 2nd point & 3rd point above
- b) 316 SS for services listed at D.1, 4th point above and
- c) 316 SS with stellite faced guide parts and bushings for remaining applications.

14.24.5 End Preparation

Valve body ends shall be either butt welded / socket welded, flanged or screwed. The welded ends wherever required shall be butt welded type as per ANSI B 16.25 for control valves of sizes 65 mm and above. For valves sizes 50 mm and below welded ends shall be socket welded as per ANSI B 16.11. Flanged ends wherever required shall be of ANSI pressure – temperature class equal to or greater than that of the control valve body.

14.24.6 Valve Actuator

1. The regulating control valves shall be furnished with pneumatic actuators. The supplier shall be responsible for proper selection and sizing of valve actuators in accordance with the pressure drop and maximum shut off pressure and leakage class requirements. The valve actuators shall be capable of operating at 60 °C continuously.
2. Valve actuators and stems shall be adequate to handle the unbalanced forces occurring under the specified flow conditions or the maximum differential pressure specified. An adequate allowance for stem force, at least 0.15 kg / cm² per linear millimeter of seating surface, shall be used in the selection of the actuator to ensure tight seating unless otherwise specified.
3. The travel time of the pneumatic actuators shall not exceed 10 seconds.
4. For quick opening / closing services (such as fuel oil shut – off valve), the actuator shall be pilot solenoid operated pneumatic drive; the rating of solenoid shall be 24 V DC.
5. Selection of actuator shall be such that it meets the requirements of thrust / torque, stroke length, angular movement, full scale travel time, repeatability & accurate positioning for successful operation of final control element.
6. All the actuators shall have also provision for manual operation during emergency / maintenance along with graduated local position indicator.

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14.24.7 Control Valve Accessory Devices

All control valve accessories such as air locks, hand wheels / hand-jacks, limit switches, SMART positioners, diffusers, external volume chambers, reversible pilot for positioners, tubing and air sets, solenoid valves and junction boxes etc. shall be used as per the requirements.

Table 14.24(i)
Specification for E-to-P converter

S.N	Feature	Minimum Requirement
1	Air Supply	1.5 Kg/Sq. cm
2	Input Signal	4-20 mA DC
3	Output Signal	0.2 to 1.0 Kg/ Sq. cm
4	Linearity	0.5 % of span or better
5	Hysteresis	0.1 % of span or better
6	Ambient Temperature Effect (-20 to +60 *C)	<0.2 % of span per Degree centigrade
7	Mounting	Close to Actuator
8	Protection class	IP-65
9	Enclosure	Die cast Aluminium
10	Drift	+/- 2% of set point per hour

Table 14.24(ii)
Specification for Smart Positioners

S.No.	Feature	Minimum Requirement
1	Input	4-20 mA DC
2	Power Supply	24 V DC Loop powered
3	Type of Electronics	Microprocessor based with self diagnostic facility & digital communication by means of HART Protocol
4	Valve position sensing	Non-Contact type with 4-20 mA DC Output
5	Enclosure Type/Material	Weather & Dust proof to IP-65/ Die cast Aluminium
6	Ambient conditions	Suitable for - 30 to +80 *C temperature & 0-95% Humidity
7	Operating Range	Suitable for Full range & Split Range operation
8	Modes of operation	Suitable for Direct & reverse valve action
9	Flow characteristics	Suitable for Linear & Equal percentage Characteristics
10	Fail safe/Freeze feature	Required
11	Air Capacity	Sufficient to handle the Valves Selected/Boosters to be supplied if required.
12	Air supply pressure	To suite the Air Supply Pressure / Quality available
13	Process Connection	1/4" NPT
14	Characteristic Deviation	< =0.5% of span

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S.No.	Feature	Minimum Requirement
15	Ambient Temperature effect	< = 0.01 %/Deg C or better
16	Configuration	Remote Calibration, Auto & Manual Calibration shall be possible
17	Cable Entry	½" NPT, Side or Bottom Entry to avoid water ingress
18	Accessories	a) Display with push buttons for configuration and Display on the positioner itself (Password Protected / Hardware Lock).
		b) For Supply & Output Pressure, Filter Regulator and other accessories shall be used as on required basis for making system complete
		c) Valves Mounting Assembly For Sliding Stem / Rotary / Single Acting / Double Acting on required basis

1. SMART positioner shall be a Double stage positioner. The first stage of the positioner shall be typically a flapper-nozzle that serves as a high-gain pre-amplifier. This sensitivity shall be maintained over a wide range of dynamic conditions. Second stage shall be a power amplifier that provides power to drive the actuator. Preferably this shall be a pneumatic relay. Spool Driven type SMART positioners are not preferred due to Higher Dead Band and Poor responsiveness. The SMART positioner shall have pressure sensors to measure the pneumatic outputs to the actuator.
2. The control algorithm for the positioner shall use feedback signal from the motion of the pneumatic relay beam instead of pressure feedback to minimize pneumatic related effects and for stable and smooth response of the control valve. The SMART positioner shall have user adjustable tuning sets to identify the optimum tuning for the total valve assembly. SMART Positioner with HART Communication facility shall communicate all the valve diagnostics to Plant DCS.

Table 14.24(iii)
Specification for Air Filter Regulator (AFR)

S.No.	Feature	Minimum Requirement
1	Type	Constant Bleed type
2	Inlet Pressure	10 Kg/Sq. cm (maximum)
3	Output	Adjustable from 0-2 Kg/Sq. cm or 0-7 Kg/Sq. cm (Continuous) as required
4	Filter Element	5 microns
5	Filter Element Material	Phosphor Bronze
6	Bowl Material	Metallic
7	Drain	Automatic
8	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
9	Process connection	¼ " NPT

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S.No.	Feature	Minimum Requirement
10	Accessories	All mounting accessories. 2" dial size Pressure gauge.

Table 14.24(iv)
Specification for Position Transmitter

S.No.	Feature	Minimum Requirement
1	Power Supply	24 V DC Loop powered
2	Type	Non-Contact/ LVDT type
3	Output	4-20 mA DC/ Linear
4	Accuracy	+/- 1%
5	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
6	Cable Entry	½" NPT, Side or Bottom Entry to avoid water ingress.
7	Accessories	All mounting accessories

Table 14.24(v)
Specification for Limit Switch (Non Contact Type)

S.No.	Feature	Minimum Requirement
1	Type	Non-contact type inductive Proximity/Namur type
2	Sensing distance	10 mm minimum
3	Hysteresis	Maximum 10% of sensing distance
4	Indicator	LED indication
5	Protection class	IP 67
6	Integral Cable	1 mtr.
7	Power supply	24 V DC/ 8 V DC
8	Mounting	Flush mounting with check nut
9	Other Feature	Explosion proof enclosures shall be used wherever required by the application. Shock & Vibration proof.

14.24.8 Test & Examination

- All valves shall be tested in accordance with the quality assurance programme agreed which shall meet the requirement of IBR and other applicable codes.
- The tests shall include but not but limited to the following:
 - Non-destructive test as per ANSI B – 16.34.
 - Hydrostatic shell test in accordance with ANSI B16.34 prior to seal leakage test.
 - Valve closure test and seal leakage test in accordance with ANSI B16.34 and as per the leakage class indicated under clause no. B.6.

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- d) Functional test: The fully assembled valves including actuators control devices and accessories shall be functionally tested to demonstrate times from open to close position.
 - e) All control valves shall be tested with the positioners for accuracy of positioning and reproducibility over the full range of travel.
 - f) CV Test: CV test shall be carried out as type test on each size, type and design of the valves as per AISA 75.02 standard.
 - g) Magnetic particle inspection shall be performed on all machined surfaces of valves having ASA rating of 1500 lbs ASA or greater. All carbon steel valves with 1500 lbs ASA or greater shall receive 100% radio graphic examination in accordance with ASTM – E71.
3. The certificate shall be in the prescribed forms III A & III C and shall be endorsed by an Inspection Authority recognized by the Indian Boiler Regulations.

14.24.9 Pneumatic Power Cylinder

Table 14.25
Specification for Pneumatic Power Cylinder

S.No.	Feature		Minimum Requirement
1	Applicable standard		ISO 6431
2	Mounting Type		Fixed Position mounting/ Trunion mounting
3	Material	Cylinder	Seamless Steel Tube
		Piston rod	Hard Chrome Plated Steel
		Tie rod	Stainless steel
		End Cover	Cast Iron
		Sealing	Polyurathane
4	Control Signal		4-20 mA DC signal to Smart positioner with HART protocol for modulating purpose. Solenoid valve operating on pneumatic line for open & closing purpose of ON-OFF Damper.
5	Supply Air		0-7 Kg/cm ²
6	Accuracy		Better than +/- 1%
7	Repeatability		Better than 0.5 % of full travel
8	Hysteresis		Less than +/- 0.2% of full travel
9	Dead Band		+/- 0.1%
10	Selection		Based upon thrust/torque, stroke length, angular movement, full scale travel time, repeatability, space factor etc. Provision for air-to-open or air-to-close operation
11	Accessories		Air lock relay, hand wheel, AFR, Volume booster, Limit switch, Positioner, Solenoid valve, position transmitter & all required mounting accessories etc.
12	Fail safe operation		Stay put for regulating duty

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14.25 Solenoid Valves

Table 14.26
Specification for Solenoid Valves

S.No.	Feature	Minimum Requirement
1	Operating Principle	Electromagnetic (noiseless), Pilot operated
2	Coil Voltage Rating	24 V DC (in general)/220 V DC/230 V AC/110 V AC as required
3	Ways	3 ways in general others as required
4	Port size	¼ " NPT all ports
5	Body	SS Bar stock/Brass
6	Trim	AISI 316 SS
7	Manual Operation	In built
8	Duty	Suitable for continuous Energisation
9	Sealing	Airtight & leak proof
10	Coil Enclosure	SS 316/Moulded type
11	Insulation class	Class H
12	Coil Casing	IP-67
13	Mounting	Suitable for mounting On pipe or in panel
14	Cable connection	½ " NPT Cable gland
15	Accessories	Mounting Bracket, nuts, bolts etc.
16	Other Features	LED Indication

14.26 Dew Point Meter

Table 14.27
Specification for Dew Point Meter

S.No.	Feature	Minimum Requirement
1	Type	Sensor- Hyper Thin Film high capacitance Al ₂ O ₃ , Transmitter- Microprocessor based 2-wire loop powered
2	Accuracy	± 5.5°F (± 3°C)
3	Repeatability	± 0.9°F (± 0.5°C)
4	Storage temperature	-40°F to + 176°F (-40°C to + 80°C)
5	Local Indication	To be provided
6	Input Resolution	0.1°C dew point
7	Power Supply	24 VDC
8	Output	4 - 20mA
9	Enclosure material	Die – cast Aluminium
10	Enclosure protection	Weatherproof IP 65
11	Electrical connections	½ " NPT
12	Process connection	As per requirement
13	Accessories	All required mounting accessories.

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14.27 Speed Probe

Table 14.28
Specification for Speed Probe

S.N	Feature	Minimum Requirement
1	Type	Proximity type (inductive / NAMUR)
2	Frequency Response	0-10 KHz
3	Housing	SS 316/ Polyurethane tip
4	Sensing distance	10 mm minimum (2mm for embedded type)
5	Enclosure class	IP67
6	Power supply	24 V DC/8 V DC (for NAMUR)
7	Cable	Integral Cable 6 mtr.
8	Mounting	Flush with check nut
9	Accessories	Flexible conduit, Non-conductive mounting plates etc.

14.28 Speed Transmitter

Table 14.29
Specification for Speed Transmitter

S.No.	Feature	Minimum Requirement
1	Type	Microprocessor based Programmable
2	Enclosure Protection	IP-67
3	Accuracy	+/- 1 RPM
4	Power Supply	24 V DC
5	Range	Programmable
6	Resolution	0.1 RPM
7	Output	4-20 mA
8	Input signal	Pulse Input from Proximity Probe
9	Display	LCD display

14.29 Flow/No Flow Detector Switch

Table 14.30
Specification for Flow/No Flow detector switch

S.No.	Feature	Minimum Requirement
1	Operating Principle	Microwave
2	Detection Range	Adjustable
3	Power Supply	230 V AC, 50 Hz
4	Housing	SS 316

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S.No.	Feature	Minimum Requirement
5	Protection Class	IP 67
6	Output	Potential free contact output
7	Contact Rating	5A, 240 V AC; 0.5A, 220 VDC
8	Time delay for contact Changeover	Adjustable
9	Accessories	All required mounting accessories

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15. PROCESS CONNECTION PIPING

Installation and testing of all required material for completeness of impulse piping system, sample piping system and air piping system as per the requirements of this clause on as required basis for the connection of instruments and control equipment to the process and make the system complete.

Control and instrument piping & connections shall generally be designed in accordance with the following criteria and these criteria shall be closely co-ordinated with Mechanical Piping / Erector to fulfill the Mechanical Design Criteria also. This is a guideline for Piping design & selection.

1. Pressure connections and piping up to the root valves for all pressure indicators, pressure switches, pressure transmitters, etc., shall be as indicated for miscellaneous piping.
2. Temperature indicators, temperature controllers, temperature switches, temperature detectors, and test well connections shall be as follows:
 - a) Main steam -- 40 mm NPT.
 - b) Extraction steam -- 40 mm NPT.
 - c) Boiler feed water -- 32 mm NPT.
 - d) Reheat steam -- 40 mm NPT.
 - e) All others -- 19 mm NPT.
3. Draft pressure connections on steam generator walls and ducts shall be 50 mm pipe couplings.
4. Flow transmitter connections and piping up to the root valves shall be 25 mm for all piping except orifice flanges, where 15 mm piping and valves shall be used.
5. Level switch connections and piping up to root valves shall be 25mm.
6. Level controllers and level transmitters of the displacement type shall have connections and piping up to root valves of 50 mm.
7. Level controllers and level transmitters of the differential pressure type shall have connections and piping up to root valves of 25 mm.
8. Instrument columns at tanks and pressure vessels shall generally be 65 mm minimum.

15.1 Design Pressure and Temperature

Instrument primary piping design pressure and temperature shall be selected consistent with the requirements discussed in Mechanical Design Criteria of this specification, for the process pipe to which the instrument primary piping is connected. The following general criteria shall also apply:

Instrument primary piping for steam and other systems shall be designed for 1-½ times the maximum sustained process pressure and temperature (plus 20°C).

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15.2 Sizes of Instrument Primary Piping

Instrument primary piping shall not be smaller than the connection at the process pipe root valve and/or the following (metric sizes are nominal):-

1. 20 mm for pressure measurement piping with a design pressure equal to or less than 42.0 bar and a design temperature equal to or less than 400°C.
2. 25 mm for pressure measurement piping with a design pressure greater than 42.0 bars or a design temperature greater than 400°C.
3. Flow and level measurement by differential pressure shall also use primary piping conforming to the above requirements; however, flange tap connections may be of 13 mm size.
4. Float actuated level switch devices shall be supported on connecting piping not smaller than 25 mm.
5. Level controllers and transmitters of the displacement float type shall be supported on connecting piping not smaller than 50 mm.
6. Instrument columns for float actuated level switches and displacement float devices shall be piping of not less than 65 mm.
7. Primary piping internal diameter shall not be less than 8 mm between the process connection and instrument blow down valve.

15.3 Materials for Instrument Primary Piping

Material for instrument primary piping connecting to the root valve shall preferably be the same as that used in the process system to which it is connected. Higher strength materials may be substituted in the interest of standardization; however, welding procedures at the point of joining the instrument primary piping to the process piping must be appropriate to the combination of materials involved. Copper may be used only for compressed air services that use copper process piping.

15.4 Insulation of Instrument Primary Piping

Instrument primary piping connecting to high temperature systems, which might become hot enough to injure personnel during blow down of the instrument line, shall be insulated where such hazard exists. Insulation materials, exterior finish, and metal lagging shall conform to the standards adopted for the process piping.

All materials supplied shall be suitable for intended service, process operating conditions and type of instruments used and shall fully conform to the requirements of this specification.

15.5 Process Connection Size

Size of tapping point, stub no and size of Root valves for different type of measurements.

These shall be as follows:

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Table 15.1
Process Connection Stub & Root valve

S.No.	Quantity of root valves (Nos.)	Size of stub and root valves	Service condition
A. Pressure and Differential pressure measurement			
1	2	25NB	> = 62 bar or 425degree C
2	1	15NB	< 62 bar and 425 degree C
B. Level Gauge and Switch			
1	2	25 NB	> = 62 bar or 425 degree C
2	1	25NB	< 62 bar and 425 degree C
C. Level Transmitter (Displacement Type)			
1	2	40NB	> = 62 bar or 425degree C
2	1	40NB	< 62 bar and 425 degree C
D. Stand pipe for Level measuring instrument			
1	2	80 NB	> = 62 bar or 425degree C
2	1	80 NB	< 62 bar and 425 degree C
E. Flow measurement			
1	2	25NB	> = 62 bar or 425degree C
F. Level measurement			
1	1	25NB	< 62 bar and 425 degree C
G. Sampling system measurement (system and water service)			
1	2	25 NB	> = 62 bar or 425degree C
2	1	25 NB	< 62 bar and 425 degree C

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15.6

Impulse Piping, Tubing, Fittings, Valves & Valve Manifolds

All impulse pipes shall be of seamless type conforming to ANSI B36.10 for schedule numbers, sizes and dimensions etc. The material of the impulse pipe shall be same as that of main process pipe. For various applications specification of impulse pipe materials and associated fittings and valves shall be as given in Table –15.2 (Process Connection Piping).

Table 15.2
Process Connection piping

S.No.	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
1	Main steam/ Saturated steam	SCH.XX S 21.34m m OD	1.7 mm ODX 1.65HK	SS 316	ASTM-A- 335-Gr- P-22 (alloy steel)	ASTM-A- 182-Gr-F- 22	ASTM-A- 182-Gr-F- 22
						9000 LBS	2500 SPL. Class
2.	Boiler Fuel Gas/Air System	SCH.80 21.3 mm OD (pipe through out)		SS 316	ASTM-A- 106-Gr-B (carbon steel)	ASTM-A- 105-Gr-II	ASTM-A- 105-Gr-II
						3000LBS	150LBS
4	Water system	SCH.80 21.34m m OD	12.7 mm ODX 1.65mm THK	SS316	ASTM-A- 106-Gr-B (carbon steel)	ASTM-A- 105-Gr-II	ASTM-A- 105-Gr-II
						3000LBS	400LBS
5.	Instrument air system	SCH.40 21.34m m OD(pipe through out)	12.7 mm ODX 1.65mm THK	SS316	IS 1239 Heavy Class (Galvaniz ed)	ASTM-A- 105-Gr-II	ASTM-A- 105-Gr-II
						3000LBS	150LBS
6.	Service air system	SCH.40 21.34m	12.7 mm ODX	SS 316	IS 1239 Heavy	ASTM-A- 105-Gr-II	ASTM-A- 105-Gr-II

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S.No.	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
		m OD	1.65mm THK		Class (Black)	3000LBS	150LBS

Notes:-

1. Impulse pipe thickness shall be selected as per ANSI B 36.10. based on the schedule indicated against each service.
2. Wherever impulse tubes are provided, all the fittings required for these shall be SS316. The following guidelines shall also be considered along with the Table 15.2 for size, material and rating for impulse line/tube fittings and accessories:

a) Impulse line / tube fittings and accessories

- Nipple shall be used for root valve size more than ½ inch and the nipple size shall be same as the root valve size. Reducer / adapter shall be used to suit instrument connection, where nipple, root valve size is more than ½ inch.
- Bulk head fitting socket welded type to be provided at instrument rack / enclosure.

b) Fittings

- All fittings except the last fitting connecting to the instrument shall be socket welded. The size of the fittings shall be same as the impulse line size.
- The fitting connecting to the instrument shall have a size and thread to suit the instrument connection.

c) Drain

Drain shall be used for all water / steam and non-inflammable / non-corrosive fluids only.

d) Drain Valve

- Two numbers of globe drain valves shall be used for process conditions of 425 degree C or 62 bar and higher.
- One number globe drain valve shall be used for process conditions of less than 425 degree C and 62 bar.
- The valve size shall be same as impulse piping / tubing size.

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e) Funnel with drain header

- This shall be used in the racks for blowing / draining out the process fluid in the impulse tubings.
- The size of drain header shall be 1"
- When instruments are mounted local to the tapping point and are not mounted in rack, or panel or enclosure. The drains shall be connected to the nearest floor level or plant drain.

f) Instrument Valves

- Type of the valve shall be needle valve with built in drain valve.
- Sizing of the valve shall be ½".

g) Right / left threaded fittings

- This shall be used for installation / removal of instruments without disturbing the tubing / piping.
- A suitable adapter shall be used to install the instruments on ½" right-left threaded fittings.

A ½" vent line with a ½" isolation valve shall be used in the instrument rack for air and compressible fluids or other wise if the installation call for eg., for liquid service where the transmitter is located at a higher elevation than the tapping point.

Stainless steel tube shall be used inside enclosures and racks from tee connection to valve manifold and then to instrument. For high pressure/temperature applications the material shall be ASTM A 213 TP 316H and for other applications material shall be ASTM A 213 TP 316L. The wall thickness of the tube shall be in accordance with the ANSI B31.1 standard.

All fittings shall be forged steel and shall conform to ANSI B16.11. The material of forged tube fittings for shaped application (e.g. tee, elbow etc.) shall be ASTM A182 Gr. 316 H for high pressure/ temperature applications (as defined above) and ASTM A182 Gr. 316L for other applications. The material for bar stock tube fitting (for straight application) shall be 316 SS. Metal thickness in the fittings shall be adequate to provide actual bursting strength equal to or greater than those of the impulse pipe or SS tube, with which they are to be used.

The disc and seat ring materials of carbon steel and alloy steel valves shall be ASTM A-105 and ASTM A-182, Gr. F22, hard faced with stellite (minimum hardness - 350 BHN.) The surface finish of 16 RMS or greater is required in the area of stem packing. The valve design shall be such that the seats can be re-conditioned and stem and disc may be replaced without removing the valve body from the line.

The valve manifolds shall be of 316 s Furnishing Recommended protection interlock logics stainless steel with pressure rating suitable for intended application. 2-valve manifold and 3 valve manifold shall be used for pressure

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measurements using pressure transmitters/ pressure switches and differential pressure transmitters/ switches respectively. 5-valve manifold shall be used for remaining applications like DP, flow and level measurements.

For Pressure/D.P gauges in fluid application two-way globe valve on each impulse line to the instrument and in air/flue gas application two way gate valve on each impulse line to the instrument shall be used near the instrument. These shall be in addition to the three way gauge cock provided along with the pressure/D.P gauges.

Table 15.3**Specification for Seamless SS Pipe**

S.No.	Property	Requirement
1	Reference	ASTM A-312 TP-316
2	Material Grade	TP-316
3	Type	Seamless/Plain end
4	Size	½" NB
5	Schedule	40/60/80
6	Standard Length	5 metre

Table 15.4**Specification for Seamless SS Pipe Fittings**

S.No.	Property	Requirement
1	Reference	ASTM A-182 F-316
2	End Connection	Socket welded
3	Type	Forged conforming to ANSI B16.11
4	Size	½" NB
5	Rating	3000/6000/9000 lbs
6	Type of Fittings	Reducing coupling, Male-Female reducer, Straight coupling, Equal Tee, Three Piece Union, Elbow, Cap etc.

Table 15.5A**Specification for Seamless SS Tube (1/2")**

S.No.	Property	Requirement
1	Reference	ASTM A-213 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	½" OD X 2.1 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture.

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S.No.	Property	Requirement
		Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness
8	Test	Flare, Hardness, Ball & Bubble test
9	Standard Length	5 metre

Table 15.5B

Specification for Seamless SS Tube (1/4")

S.No.	Property	Requirement
1	Reference	ASTM A-269 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	1/4" OD X 1.2 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness
8	Test	Flare, Hardness, Ball & Bubble test
9	Standard Length	5 metre

Table 15.6

Specification for Seamless SS Tube Fittings

S.No.	Property	Requirement
1	Reference	ASTM A-182
2	Material Grade	SS 316 forged
3	Type	Double ferrule double compression
4	Ferrule	SS 316
5	Size	To suit SS tubing & NPT end connection
6	Type of fittings	Male/Female connectors, elbow, Equal & Unequal Tee, Cross, Straight connector, bulk head unions, etc. as required to suit the installation.

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Table 15.7
Specification for Instrument Valve Manifolds

S.No.	Property	Requirement
1	Type	Two valve manifold/Three Valve Manifold Five valve manifold
2	Mounting	Remote 2" pipe mounting
3	Construction	Single Block (Bar Stock)
4	Material	Forged body & bonnet AISI 316 SS
5	Ports	½" NPT
6	Rating	420 Kg/ cm2 at ambient
7	Packing	PTFE Wafer
8	Seat & Stem	AISI 316 SS
9	Plug	AISI 316 SS free to turn on stem/ 17-4 PH
10	Handle	AISI 316 SS
11	Connection	Straight
12	Accessories	Plug for all ports Mounting Bracket, nut, bolts etc.

Table 15.8
Specification for Condensate Pot

S.No.	Property	Requirement
1	Reference	ASTM A 182 F22/ ASTM A105
2	Material	Alloy Steel/Carbon Steel as per application
3	Construction	Drilled Bar stock
4	End Connection	3 nos. ½" SW
5	Accessories	Vent Valve

15.7

Air Supply Piping

1. All pneumatic piping, fittings, valves, air filter cum regulator and other accessories required for instrument air for the various pneumatic devices/ instruments shall be used.
2. This shall include as a minimum air supply to pneumatically operated control valves, actuators, instruments, continuous and intermittent purging requirements of Local Instrument Enclosures (LIE) etc.
3. For individual supply line and control signal line to control valve, 1/4 inch size light drawn tempered copper tubing conforming to ASTM B75 shall be used. The thickness of copper tubing shall not be less than 0.065 inch and shall be PVC coated. The fittings to be used with copper tubes shall be of cast brass, screwed type.
4. All other air supply lines of 1/2 inch to 2 inch shall be of carbon steel hot dipped galvanized inside and outside as per IS-1239, heavy duty with threaded ends. The threads shall be as per ASA B.2.1. Fittings material shall be of forged carbon

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steel A234 Gr. WPB galvanized inside and outside, screwed as per ASA B2.1. Dimensions of fittings shall be as per ASA B16.11 of rating 3000 lbs.

5. In the boiler area the 2 inch head shall be used up to top most elevation of boiler floor and from this 2 inch header, 1 inch sub-header shall be branched off at each floor with isolation valve. From this 1 inch sub-header, branch line of 1/2 inch, with isolation valve shall be used up to various devices. Similar air supply piping shall be done in the turbine area also. Similar system is to be followed for service air required for intermittent purging in the Local Instrument Enclosures (LIEs) etc.
6. Instrument air filter cum regulator set with mounting accessories shall be used for each pneumatic device requiring air supply. The filter regulators shall be suitable for 10 kg/ sq.cm max. inlet pressure. The filter shall be of size 5 microns and of material sintered bronze. The air set shall have 2 inch size pressure gauge and built in filter housing blow down valve. The end connection shall be as per the requirement.
7. All the isolation valves in the air supply line shall be gate valves as per ASTM B62 inside screw rising stem, screwed female ends as per ASA B2.1. Valve bonnet shall be union type & trim material shall be stainless steel, body rating 150 pounds ASA. The valve sizes shall be 1/2 inch to 2 inch.
8. Purge Air Connection for Air and Flue Gas Applications
 - a) The continuous purging with instrument air shall be done, for all air and flue gas measurements excepting instrument air and service air instruments, at the process source connection end. Necessary arrangements required for continuous purging shall be used inside all the air and flue gas local instrument enclosures.
 - b) For intermittent purging with service air, necessary arrangements inside all the air and flue gas Local Instrument enclosures/racks shall be used. The SS three way valve provided in the SS tubing shall be used for isolating the transmitter and connecting the service air quick disconnect line.
 - c) One air filter regulator, purge Rotameter and blow down device per instrument shall be used in the transmitter rack/enclosure.

Table 15.9
Specification for Instrument Air Header

S.No.	Property	Requirement	
		For Panel	For Field
1	Material	SS 316	SS 316
2	Inter Connection	2" NPT (M)	1" NPT (M)
3	Header Take-Off	SS 316	SS 316
4	Take-Off Connection	½" NPT (M)	½" NPT (M)
5	Take-Off Valve	½" Ball Valve SS 316	½" Ball Valve SS 316
6	Drain	½" Ball Valve SS 316 at the lowest point	½" Ball Valve SS 316 at the lowest point

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Table 15.10
Specification for CS Pipe

S.No.	Property	Requirement
1	Reference	ASTM A-106 Gr. C
2	Material	Cold Drawn Seamless CS
3	Type	Seamless/ threaded ends as per ASA B2.1/ Hot dip Galvanised from Inside & outside as per IS-1239
4	Size	½ " to 2" NB
5	Schedule	80/160
6	Standard Length	5 metre

Table 15.11
Specification for CS Pipe Fittings

S.No.	Property	Requirement
1	Reference	ASTM A-234/ ASA B16.11
2	Type	Forged/ hot dip galvanised from inside & outside
3	Size	½ " to 2" (as required)
4	Rating	3000/6000/9000 lbs.
5	End Connection	Threaded as per ASA B2.1
6	Type of Fittings	Reducing Coupling, Male-Female reducer/ Straight Coupling/ Equal Tee/ Three piece Union/ Elbow/ Cap etc.

Table 15.12
Specification for CS Globe Valve

S.No.	Property	Requirement
1	Reference	ASTM A-105/ASTM B62
2	Type	Globe
3	Construction	Forged body cadmium plated
4	Rating	PN 40/PN 160/ PN 320/ PN 400
5	End Connection	Screwed Female ends as per ASA B2.1
6	Material	Body- Carbon steel Stem- Hardened Steel Plug- AISI 316 SS Seat- SS Stellite
7	Size	½ " to 2 " as required
8	Packing	Teflon/Grafoil as required
9	Hand wheel	CS
10	Yoke	ASTM A105
11	Design Standard	As per ANSI B16.34

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16. INSTRUMENTATION CABLES & ACCESSORIES

16.1 Specifications of Instrumentation Cables

16.1.1 Common Requirements

Table 16.1

Specification of Instrumentation Cables- Common Requirement

SNo.	Property	Requirement
1	Voltage grade	1100 V (Peak Value)
2	Codes and Standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6 , VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification
3	Continuous operation suitability	At 70 deg. C for all types of cables, while 205 deg C for Type-C cables
4	Progressive automatic on-line sequential marking of length in meters.	To be provided at every one meter on outer sheath.
5	Marking to read 'FRLS'	To be provided at every 5 meters on outer sheath except for type-C cable.
6	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet.
7	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8	Ovality at any cross-section	Not more than 1.0 mm
9	Others	a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name , insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacture to be provided. b) Cables shall be suitable for laying in conduits, duct, trenches, racks and underground-buried installation c) Repaired cables shall not be acceptable

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16.1.2 Specific Requirements

Table 16.2

Specification of Instrumentation Cables- Specific Requirement

SNo.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
A.	Conductors				
i.	Cross section area	0.5 Sq. mm			
ii.	Conductor material	ANSI type KX	ANSI type SX	High conductivity annealed tin coated copper	ANSI type KX
iii.	Colour code	Yellow-red	Black-Red	As per VDE-0815	Yellow-red
iv.	Conductor Grade	As per ANSI MC 96.1		Electrolytic	As per ANSI MC 96.1
v.	No. & dia. of stands	7x0.3 Sq. mm (nom)			
vi.	No. of Pairs	2, 6	2	4, 8, 12, 16, 24, 48,	2
vii.	Max. conductor resistance per Km (in ohm) at 20 deg. C	As per ANSI MC 96.1		73.4 (loop)	As per ANSI MC 96.1
viii.	Reference Standard	As per ANSI MC 96.1		VDE 0815	As per ANSI MC 96.1
B.	Insulation				
i.	Material	PVC type YI 3 with FRLS properties			Teflon (i.e. extruded FEP)
ii.	Thickness in mm (Min/Nom/Max)	0.25 / 0.3 / 0.35			0.4 / 0.50
iii.	Volume Receptivity (Min) in ohm-cm	1x10 ¹⁴ at 20 deg. C & 1x 10 ¹¹ at 70 deg.			---
iv.	Voltage rating	1100 V peak operating voltage			
v.	Reference Standard	VDE 0207 Part 4			VDE 0207 part 6 & ASTM D 2116.
vi.	Core diameter above insulation	Suitable for cage clamp connector			
C.	Pairing & Twisting				
i.	Max. lay of pairs (mm)	50			
ii.	Single layer of numbered binder tape on each pair provided	Yes			
iii.	Unit formation of four pairs with printing of	NA		Yes	NA

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SNo.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
	no. of Unit provided				
iv.	Conductor / pair identification as per VDE0815	NA		To be provided	NA
D.	Shielding				
i.	Type of shielding	Al-Mylar tape			
ii.	Individual pair shielding	No		To be provided for Type-F cable	No
iii.	Minimum thickness of individual pair shielding	No		28 micron	No
iv.	Overall cable assembly shielding	To be provided			
v.	Minimum thickness of overall cable assembly shielding	55 micron			
vi.	Shielding coverage	100% with at least 20% overlap			
vii.	Drain wire provided for individual shield	NA		Yes (for F-type) 7 -strand 20 AWG (0.51 mm ²) annealed Tin coated copper	NA
viii.	Drain wire provided for overall shield	Yes (for F-type) 7 -strand 20 AWG (0.51 mm ²) annealed Tin coated copper			
E.	Fillers				
i.	Non-hygrosopic, flame retardant	To be provided			
F.	Outer Sheath				
i.	Material	Extruded PVC compound YM1 with FRLS properties			Teflon (i.e. extruded FRP)
ii.	Minimum thickness at any point	1.8mm			0.4 mm
iii.	Nominal Thickness at any point	> 1.8mm			0.5mm
iv.	Color	Blue			
v.	Resistant to water, fungus, termite & rodent attack	Required			

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SNo.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
vi.	Oxygen index as per ASTM D-2863	Not less than 29%			NA
vii.	Temperature index as per ASTM D-2863	Not less than 250 deg. C			NA
viii.	Acid gas generation by weight as per IEC-60754-1	Maximum 20 %			NA
ix.	Smoke Density rating as per ASTM D-2843	Maximum 60% (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as ASTM D-2843)			NA
x.	Reference Standard	VDE 207 part 5			VDE 207 Part 6 & ASTM D 2116
xi.	Armour	Galvanised steel wire armoured type conforming to IS-3975			
G. Electrical Parameters					
i.	Mutual capacitance between Conductors. At 0.8KHz (Max.)	200 nF / Km		120 nF / Km for F type 1000 nF / Km for G-type	200 nF / Km
ii.	Insulation resistance (Min.)	100 M ohm / Km			
iii.	Cross talk Figure (min.) at 0.8 KHz	60 dB		60 dB	NA
iv.	Characteristics impedance (Max) At 1 KHz	NA		320 ohm for F type 340 ohm for G type	NA
v.	Attenuation Figure at 1 KHz	NA		1.2 dB / Km	NA
H. Complete Cable					
i.	Complete Cable assembly	Shall pass Swedish chimney test as per SEN-SS 4241475 class F3.			NA
ii.	Flammability	Shall pass flammability test as per IEEE-383 read in conjunction to this specification			NA
I. Accessories					
i.	Cable accessories of flame retardant quality	Yes. (Accessories such as harnessing components, markers, bedding, cable jointer, binding tape etc.)			

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SNo.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
J.	Cable Drum				
i.	Type	Non-returnable wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.			
ii.	Outermost layer covered with waterproof paper	Yes			
iii.	Painting	Entire surface to be painted			
iv.	Length	1000m + 5% for up to & including 12 pairs 500m + 5% for above 12 pairs			

16.1.3

Type Test

Table 16.3
Type Test Requirement for Cables

S.No.	Item	Test Requirement	Standard
1	Conductor	Resistance Test Diameter test Tin coating test (drain wire)	VDE – 0815 IS – 10801 IS - 8130
2	Insulation	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
3	Inner sheath	Loss of mass Heat shock Hot deformation Shrinkage Cold bend / Cold impact test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
4	Outer sheath	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming Colour fastness to water Cold bend / Cold impact test Oxygen Index test Smoke Density test Acid gas generation test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831 IS – 5831 IS – 5831 ASTM D – 2863 ASTM D – 2843 IEC – 754 – I
5	Filters	Oxygen Index test Smoke Density test	ASTM D – 2863 ASTM D – 2843

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S.No.	Item	Test Requirement	Standard
		Acid gas generation test	IEC – 754 – 1
6	AL-MYLAR Shield	Continuity test Shield thickness Overlap test	Yes Yes Yes
6	Overall cable	Flammability Noise interference Dimensional checks Cross talk Mutual capacitance HV test Drain wire continuity	IEEE 383 & IEC – 332 IEEE -TRANSACTION IS – 10810 VDE – 0472 VDE – 0472 VDE – 0815

16.1.4 Routine Test

To be carried out by supplier during various stages of manufacture.

1. Insulation & jackets: All tests as per IS – 5831 except insulation resistance, voltage & spark test shall be as per BS – 5308, Part II
2. Armor test as per IS – 3975
3. Conductor resistance
4. Cable capacitance and L/R ratio.

16.1.5 Acceptance Test

These following tests shall be carried out as acceptance test:

1. Continuity test
2. Voltage test as per BS – 5308 Part II
3. Conductor resistance and drain wire resistance
4. Cable capacitance and L/R ratio test.
5. Tests for uniformity of galvanization of armor as per IS – 2633
6. Oxygen and temperature index test as per ASTM D – 2863
7. Dimensional checks for overall diameter and under armour / over armour diameter.
8. Checking of drum length & overall length tolerances.

Immediately after completion of electrical tests, the ends of the cable shall be sealed to prevent ingress of moisture with suitable PVC / Rubber caps

16.2 Specifications of Optical Fibre Cables (OFC)

1. OFC shall be installed on cable tray, duct bank, cable trench installation as necessary. For outdoor applications the cable shall be armoured with Poly Ethylene sheathing. In all cases cable shall be routed through suitable grade HDPE permanently lubricated protection pipe as per IS-4984, IS-12235 & TEC.G/CDS-08/01 of suitable size @ 53% fill factor.
2. The optical fibre core shall be of ultrapure fused silica glass coated with UV cured acrylate suitable to withstand temperature of about 80 deg. Centigrade continuously.

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3. OFC shall be 4 / 8 / 12 core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor / indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multi-mode fibres on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties & to be identified with the manufacturer's name, year of manufacture, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
4. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. steel central member, Loose buffer tube design, 4 fibres per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly or better material etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile 1000 N minimum. The compressive strength of cable shall be 3000N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 DegC to 70 DegC.
5. The splicing loss of any two fibres in any case shall not exceed 0.10 db/splice.
6. The total additional attenuation above the nominal attenuation due to regular splices, repair splices, connectors, temperature variation, ageing etc. shall be indicated.
7. Fibre coloring shall conform to EIA/TIA-598. The color-coding shall be permanent thus withstanding normal handling; e.g., during termination, testing, or cable relocation. Refer to EIA – 359 for color identification and coding.
8. Cables shall be designed & tested in accordance with ISO 11801, TIA-568 & ICEA 596 and Performance specifications shall be measured in accordance with the Fibre Optic test procedures(EIA/TIA -455 documents) test procedures of IEC-60793 & IEC-60794
9. The OFC shall generally conform to the following specifications

Table 16.4A
Specifications for Single Mode Optical Fibre

S.No.	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@1310 nm	0.4 dB/km
		@1550 nm	0.3 dB/km
2	Mode field Diameter	@1310 nm	9.2 ± 0.4 μm
		@1550 nm	10.4 ± 0.8 μm
3	Maximum Cable Cut-off Wavelength		1260 nm
4	Maximum Zero Dispersion Wavelength		1321.5 nm
5	Minimum Zero Dispersion Wavelength		1301.5 nm
6	Maximum Zero Dispersion Slope		0.092 ps/nm ² ·km
7	Maximum Polarization Mode Dispersion		0.2 ps/√km

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S.No.	Feature		Minimum Requirement
8	Gigabit Ethernet Length 1000BASE-LX		2-5000 mtrs.
9	Ten Gigabit Ethernet Length	10GBASE-LX	2-10000 mtrs.
		10GBASE-LX4	2-10000 mtrs.
10	Maximum Core/cladding Concentricity Error		0.5 μm
11	Cladding Diameter		125.0 ± 1.0 μm
12	Cladding Non-circularity		1 %
13	Coating Diameter		245 ± 5 μm
14	Maximum Coating Concentricity Error		12.5 μm
15	Temperature Dependence (-60 to +85C)		0.05 dB/km
16	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		0.05 dB/km
17	Minimum Proof Test		100 kpsi
18	Bending Induced Attenuation (100 turns, 75mm diameter)		0.5 dB

Table 16.4B
Specifications for Multi Mode Optical Fibre

S.No.	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@850 nm	3 dB/km
		@1300 nm	0.7 dB/km
2	Overfilled Launch Bandwidth	@850 nm	200 MHz·km
		@1300 nm	500 MHz·km
3	Gigabit Ethernet Length	1000BASE-SX	2-300 mtrs.
		1000BASE-LX	2-550 mtrs.
4	Ten Gigabit Ethernet Length	10GBASE-SR	2-33 mtrs.
		10GBASE-LX4	2-300 mtrs.
5	Numerical Aperture		0.275 ± 0.015
6	Core Diameter		62.5 ± 3.0 μm
7	Maximum Core Non-circularity		6 %
8	Maximum Core/cladding Concentricity Error		3 μm
9	Cladding Diameter		125.0 ± 2.0 μm
10	Cladding Non-circularity		2 %
11	Coating Diameter		245 ± 10 μm
12	Maximum Coating Concentricity Error		12.5 μm

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S.No.	Feature	Minimum Requirement
13	Temperature Dependence (-60 to + 85C)	0.2 dB/km
14	Temperature & Humidity Cycling (-10 to + 85C, 4 to 90% RH)	0.2 dB/km
15	Minimum Proof Test	100 kpsi
16	Bending Induced Attenuation (100 turns, 75mm diameter)	0.5 dB

10. The cables shall be supplied in non-returnable strong wooden (or alternatively steel) drums provided with lagging of adequate strength, constructed to protect the cable against any damage and displacement during transit, storage and subsequent handling and stringing operations in the field.

11. Test on Fibre optic cable:

Table 16.4C
Type Test Requirement for Fibre Optic Cables

S.No.	Test Requirement	Standard
A	Optical Characteristics of Fibres	
1	Attenuation	IEEE Std. 1138 IEEE STD. P1222 (EIA/TIA – 455-61,78A) (IEC 793-1-C1A,B,C)
2	Cut off wavelength	IEEE STD. 1138 IEEE STD P1222 (EIA-455-80, 170) (IEC-793-1-C7A,B)
3	Fibre Dispersion	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-168A,169A,175A) (IEC-793-1-C5A,B,C)
4	Frequency Response	IEC-793-1-C2B
5	Mode Field Diameter	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-164A,165A,167A) (EIA-455-174) (IEC 793-1-C9A,B,C,D)
6	Temperature Cycling	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-69A) (IEC 793-1-D1)
B	Mechanical Characteristics of Fibres	
1	Abrasion	IEC 793-1-B4
2	Core Concentricity	IEC 793-1-A3
3	Macro Bending	EIA/TIA-455-62A (IEC 793-1-C11)

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S.No.	Test Requirement	Standard
4	Micro Bending	IEC-793-1-C3
C	Proof Test	IEC-793-1-B1
D	Strippability	IEC 793-1-B6
E	Visual Examination	EIA/TIA-455-13 (IEC 793-1-B5)

16.3

Instrumentation Cable Interconnection & Termination Philosophy

The cable interconnection philosophy to be adopted shall be such that expensive grouping of signals by large scale use of field mounted Group Junction Boxes (JBs) at strategic locations. (Where large concentrations of signals are available, e.g. valves limit and torque switches, switchgear) is done and consequently cable with higher number of pairs are extensively used. The details of termination to be followed are mentioned in the following Table:

Table 16.5
Instrumentation Cable Interconnection & Termination Philosophy

S.No.	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
1.	Limit, Torque switches of valves / dampers / drives (integral junction box)	Marshalling cubicle / Marshalling cum Termination Cubicle / Local group JB	Plug-in connector	Posts mount cage clamp type	G
2.	Transmitters, E/P converters, process actuated switches mounted in LIE / LIR	Integral junction box of LIE / LIR	Plug-in connector	Cage clamp (rail mount)	F, G
3.	RTD heads	Local junction Box	Plug-in connector	Cage clamp (Rail mount) type	F
4.	Thermocouples	Junction Box	Plug in connector	Cage clamp (Rail mount) type	A, B, C*
5.	Other Field Mounted Instrument	Local JB / Group JB	Plug in connector	Screwed, Cage clamp (Rail mount) type	F (For analog signals) G (For Binary Signals)
6.	Junction Box (For Thermocouples)	Marshalling Cubicle / Marshalling	Cage clamp (Rail mount)	Screwed, Cage clamp (Rail mount) type	A, C*. These signals shall

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S.No.	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
	for interlock and protection	cum Termination Cabinet	type		preferably through 6 pair cable
7.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Group JB	Cage clamp (Rail mount) type	Cage clamp (Rail mount) type	F, G
8.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Marshalling Cubical / Marshalling cum termination Cabinet	Cage clamp (Rail mount) type	Posts mount cage clamp type	F, G
9.	Marshalling Cubical / Termination Cabinet	Electronic system cabinet	Cage clamp post mounted type	Plug-in connector / Other System as per manufacturer's Standard	Internal Wiring

Notes:

1. Normally 10% spare cores shall be used when the numbers of pairs of cables are more than four pairs.
2. For analog signals, individual pair shielding & overall shielding & for binary signals only overall shielding of instrumentation cables shall be used.
3. * For high temperature applications only.
4. Instrument Cabling for instruments / equipment of specialized / proprietary Control System shall be as per manufacturer's standard.

16.4**Terminal Blocks**

1. All terminal blocks shall be rail mounted/post mounted, cage clamp type with high quality non-flammable insulating material of melamine suitable for working temperature of 105 deg. C. The terminal blocks in field mounted junction boxes, temperature transmitters, instrument enclosures/racks, etc. shall be suitable for cage clamp connections. The terminal blocks in Control Equipment Room logic / termination / marshalling cubicles shall be suitable for the post mounted cage clamp connection at the field input end. The terminal blocks for SG integral control system Input/ Output connections from/to SWGR/MCC, shall be used with built in test and disconnect facilities complete with plug, slide clamp, test socket etc.

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2. All the terminal blocks shall be used complete with all required accessories including assembly rail, locking pin and section, end brackets, partitions, small partitions, test plug bolts and test plug (as specified above for SWGR connections), transparent covers, support brackets, distance sleeves, warning label, marking , etc.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams. At least 20% spare unused terminals shall be used everywhere including local junction boxes, instrument racks/enclosures, termination/marshalling cabinets, etc. All terminal blocks shall be numbered for identification and grouped according to the function. Engraved labels shall be used on the terminal blocks.
4. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
5. Internal wiring in factory pre-wired electronic equipment cabinets may be installed according to the applicable standards as to wire size and method of termination or internal equipment. Terminal blocks for connection of external circuits into factory pre-wired electronic equipment cabinets shall meet all the requirements as specified above.

16.5 Internal Panels, Cabinets, System Cabinet Wiring Philosophy

1. Internal panel/cabinet wiring shall be of multi-stranded copper conductor with FRLS PVC insulation without shield and outer sheath meeting the requirements of VDE 0815.
2. Wiring to door mounted devices shall be done by 19 strand copper wire provided with adequate loop lengths of hinge wire so that multiple door opening shall not cause fatigue breaking of the conductor.
3. All internal wires shall be used with Tag identification of printed type (partex labels) at both ends. All wire directly connected to trip devices shall be distinguished by one additional red color.
4. All external connection shall be made with one wire per termination point. Wires shall not be tapped or spliced between terminal points.
5. All floor slots of desk/Panels/cabinets used for cable entrance shall be used with removable gasketed gland plates and sealing material. Split type grommets shall be used for prefabricated cables.
6. All the special tools as may be required for solder less connection.
7. Tag identification for internal wires shall be printed (partex labels)
8. Wire sizes to be utilized for internal wiring shall be as per following table.

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Table 16.6
Wire Size for Internal Wiring

S.No.	Application	Wire Size
1	Current (4-20mA), low voltage signals (48 V)	0.5 Sq. mm
2	Ammeter/ Voltmeter circuit, control switches etc. for electrical system.	1.5 Sq. mm
3	Power supply and internal illumination.	2.5 Sq. mm minimum (shall be as per load requirement)

16.6 Cable Installation & Routing

1. All cable assigned to a particular duct/conduit shall be grouped and pulled in simultaneously using cable grips and suitable lubricants. Cables removed from one duct/conduit shall not be reused.
2. Cables shall be segregated as per IEEE Std. 422. In vertically stacked trays, the higher voltage cable shall not be in higher position and instrumentation cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other system shall be as follows:
 - a) From 11KV/6.6KV/3.3KV tray system - 900 mm
 - b) From 415KV tray system - 600 mm
 - c) From control cable tray system - 300 mm
3. Cables shall terminate in the enclosures through cables glands. All cable glands shall be properly gasketed. Fire proof sealing (to prevent ingress of dust entry and propagation of fire) shall be used for all floor slots used for cable entrance. Compression cable glands (double for armored and single for other cables) shall be used.
4. All cables shall be identified by Tag. Nos. provided in approved format at both the ends as well as at an interval of 5 meters.
5. Line voltage drop due to high resistance splices, terminal contacts, insulation resistance at terminal block, very long transmission line etc. shall be reduced as far as practicable.
6. The cables emanating from redundant equipment/devices shall be routed through different paths. The above segregation of cables & wiring for redundant equipment / devices shall be in accordance with IEEE-Std-422

16.7 Cable Laying

1. Cable shall be laid strictly in line with cable schedule. In general, the cable routing from the local instrument to JB shall be such that the cable go away from the hot zone.
2. Identification tags for cables.
Indelible tags to be provided at all terminations, on both sides of wall or floor crossing, on each conduit/duct/pipe entry/exit, and every 20 m in cable trench / tray.
3. Cable tray numbering and marking.

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To be provided at every 10m and at each end of cables way & branch connection.

4. Joints for less than 250 Meters runs of cable shall not be permitted.

5. Buried cable protection

With concrete slabs; Route markers at every 20 meters along the route & at every bend.

6. Road Crossings

Cables to pass through buried high density PE pipes encased in PCC. At least 300 mm clearance shall be used between.

- a) HT power & LT power cables,
- b) LT power & LT control cables,
- c) LT control & instrumentation cables,

Spacing between cables of same voltage grade shall be in accordance with the derating criteria adopted for cable sizing.

7. Segregation (physical isolation to prevent fire jumping)

- a) All cable associated with the unit shall be segregated from cables of other Units.
- b) Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire.

8. Cable clamping

All cables laid on trays shall be neatly dressed up & suitably clamped/tied to the tray. For cables in trefoil formation, trefoil clamps shall be used.

9. Optical fibre cables inside conduits shall be laid on cable trays wherever available and feasible. In areas where the same are required to be buried, the same shall be buried in separate trench approx. 1.6 meter depth, to be laid in 2" GI/rodent proof HDPE conduits covered with sand, brick and soil along the pipe line route.

10. While crossing roads- to be laid in GI/rodent proof HDPE conduits with sand filling at bottom and sand, soil filling at top with cement concrete;

While crossing canals/river- to be laid in GI/rodent proof HDPE conduits within Hume pipe.

16.8 Cable Accessories

1. Cables, which terminate in cabinets of draw out sections, shall have sufficient cable coils in the bottom of the cabinet to permit full withdrawal of draw out sections without disconnecting the cables. When prefabricated cables with factory connectors on both ends are longer than required, the excess cable shall be coiled in the bottom of one or both termination cabinets.
2. No splices shall be made in conductors for instrument and control circuits except where required at connections to devices equipped with factory installed pigtails.

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Such splices shall be made only in approved splicing boxes of fitting with removable cover. The splices shall be made with sufficient slack left in the wire to permit withdrawal of the splice from the splicing boxes for ease of future disconnection of the splices. All exposed conductor or connector surfaces shall be covered with a minimum of three half-lapped layers of all weather vinyl plastic electrical tape. Taping shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the other insulation or connections requiring insulation.

3. Proper grounding of all equipments shall be done. Further, proper termination of cable shield shall be verified and the grounding of the same shall be coordinated so as to achieve grounding of all instrumentation cable shields at same potential. This shall be completed prior to system tests.
4. Take full care while laying/installing cables as recommended by cable manufacturers regarding pulling tensions and cable bends.

16.9

Cable Conduits

1. Conduits shall be generally used for interconnecting cables from field instruments to Local JB's. All unarmoured cables shall be installed in conduit. All rigid conduits, couplings and elbows shall be hot dipped galvanized rigid mild steel in accordance with IS: 9537 Part-I and Part-II. The conduit interior and exterior surfaces shall have continuous zinc coating with an overcoat of transparent enamel lacquer or zinc chromate. Flexible metal conduit shall be heat resistant lead coated steel, water leak, fire and rust proof. The temperature rating of flexible conduit shall be suitable for actual applications. The flexible metal conduit shall be constructed with interlocked corrosion resistant steel & manufactured in accordance with UL1 & NEC Article 348.
2. All grounding bushings within all enclosures shall be wired together and connected internally to the enclosure grounding lug or grounding bus with 8 AWG bare copper conductors. Conduit runs to individually mounted equipment shall be grounded to the cable tray grounding conductor with 12 AWG bare copper conductors.
3. All rigid conduit fittings shall conform to the requirements of IS: 2667. Galvanized steel fitting shall be used with steel conduit. All flexible conduit fittings shall be liquid tight, galvanized steel. The end fittings shall be compatible with the flexible conduit supplied.
4. All individually mounted equipment and devices shall be connected to the supply conduit, using not more than one meter of flexible conduit adjacent to the equipment or device. Flexible conduit shall be installed in all conduit runs, which are supported by both building steel and structures subject to vibration or thermal expansion. This shall include locations where conduit supported by building steel or foundation becomes supported by steam generator framing.
5. Special areas, such as Control Rooms in which external noise is to be minimized, shall have flexible conduit in conduit runs where the runs cross from the main building framing to the Control Room framing.

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6. Conduit supports shall be furnished and installed in accordance with these specifications. Support material shall comply with the requirements.
 - a) Hanger rods shall be 12 mm diameter galvanized threaded steel rods.
 - b) Single conduit support shall be one-hole cast straps and clamp backs. Multiple conduit bank supports shall be constructed of special galvanized support channels with associated conduit clips.
7. Conduit sealing, explosion proof, dust proof and other types of special fittings shall be used as required by these specifications and shall be consistent with the area and equipment with which they are installed. Fittings installed outdoors and in damp locations shall be sealed and gasketed. Hazardous area fittings and conduits sealing shall conform to NEC requirements for the area classification.
8. Double locknuts on all conduit terminations shall be used. Water tight conduit unions and rain tight conduit hubs shall be utilized for all the application which shall be exposed to weather. Moistures pockets shall be eliminated from conduits.
9. Conduits shall be securely fastened to all boxes and cabinets.

16.10 Cable Sub Trays & Support

1. The cable sub-trays and the supporting system, to be generally used between Local/Group JB's and the main cable trays. It is the assembly of section and associated fitting forming a rigid structural system used to support the cable from the equipment or instruction enclosure up to the main cable trays (trunk route). The material of cable tray shall be GI.
2. The covers on the cable sub-trays shall be used for protection of cables in areas where damage may occur from falling objects, welding spark, corrosive environment, etc. & shall be electrically continuous and solidly grounded. The cable trays shall not have sharp edges, burrs or projections injurious to the insulation or outer sheath of the cables.
3. The supporting arrangement of cable tray system shall be able to withstand the weight of the cable and cable tray system. The supporting interval shall not be more than the recommended span for the above loading for the type of cable tray selected. The tray shall not overhang by more than one meter from the support at the dead end. As far as practicable the cable sub-tray system shall be supported from one side only, in order to facilitate installation and maintenance of cables.
4. Install the estimated quantities and size of sub trays / troughs including all required fittings and adaptors on as required basis.

Table 16.7
Specifications for Cable Tray

S.No.	Feature	Minimum Requirement
1	Material	Mild Steel as per IS-2062
2	Thickness	Not Less than 2 mm
3	Finish	Hot Dip galvanised as per IS-2629, 2633 & Zinc Coating as per IS-4579
4	Length	2.5 Mtr. +/- 10 mm

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S.No.	Feature	Minimum Requirement
5	Width	W +/- 3mm
6	Inward Bend	25 mm
7	Coupler Plate	Thickness 2 mm, length 100 mm, Width 50 mm
8	Coupler plate material	MS with Hot dip galvanised
9	Nuts, Bolts, washer etc.	As required/ Hot dip galvanised
10	Cover	Dome Fixed type, Thickness 1.2 mm (Minimum)
11	Cover Material	Hot dip galvanised MS sheet

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17. SYSTEM CABINETS, PANELS & JUNCTION BOX**17.1 General Requirements**

1. All control panels, system cabinets, local panels and local instrument enclosures, racks shall be furnished fully wired with necessary provision for convenience outlets, internal lighting, grounding, ventilation, space heating, anti-vibration pads and accessories as per IS:5039 as required for completeness of the system.
2. All panels & cabinets shall be free standing type and have bottom entry for cables unless otherwise specified. The bottom of panels, cabinets, enclosures shall be sealed with bottom plate, compression cable glands and fire proof sealing material to prevent ingress of dust and propagation of fire. The Cabinets shall be designed for front & back access to components, terminals and wiring.
3. The cabinets shall be used with bottom glanding plate which shall be removable from inside and shall be used with sufficient no. of knockouts. All knockouts shall be used with pluggable grommets.
4. The cabinets shall be of max. 2200mm height including base channel. The base channel shall be of 100 ISMC. All cabinets shall be of same height. Construction shall be modular.
5. System & non-system cabinets shall have "look alike" appearance.
6. All electronic system cabinets shall be designed for 50 deg C operating under maximum ambient temperature without air conditioning system in service. Further cabinets, panels shall be so designed that temperature rise due to heat load does not exceed 10 deg. C above ambient temperature under all operating conditions. Necessary louvers, fans, limited packing density, adequate spacing between instruments, devices etc. shall be used to maintain temperature rise within permissible limits.
7. Panels, cabinets enclosures wiring shall be arranged to enable the removal of modules/instruments and devices without unduly disturbing them.
8. All panels, cabinets, enclosures interiors shall be illuminated with rapid start fluorescent strip fixtures with door actuated switches. Door switch terminals shall be shrouded. All illuminated lights shall be used with isolation switch in addition to door switch for maintenance & switching off when not required. Illumination light shall be used on both front & back sides if both sides are provided with equipments/instruments/terminal blocks requiring maintenance.
9. Sufficient number of power receptacles with disconnect switches shall be installed within panels, enclosure and racks.
10. The local instrument enclosures/racks shall be used locally for mounting of electronic transmitters and switches, etc.
11. Exterior steel surface shall be sand blasted, ground smooth, filed, primed, sanded and smooth enamel painted to give a good finish subject to minimum paint thickness of 65-75 microns for sheet thickness of 3 mm and 50 microns for sheet thickness of 2mm. Minimum 2 coats of primer and two sprays of final finish colour shall be applied to all surfaces.

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12. The colour of the panel's interior shall be brilliant white. External colour of the panels shall be as RAL 7032 for LIE/ LIR and RAL 7035 for control room system cabinets.
13. All panels, enclosures, system cabinets, marshalling cabinets shall be used with a minimum of 20% spare terminations and system cabinets shall be used with spare space for 20% additional modules fully wired with connectors etc. in excess of the total requirement of the system design when the cabinets are delivered. The spare space capacity shall be distributed evenly throughout the cabinets.

17.2

System Cabinets

Table 17.1
Specifications for System Cabinets

S.No.	Features	Minimum Requirements
1	Application	For housing Signal conditioning cards, input/output cards, processor cards, power supply units etc.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Anti vibration pad	Required, 15mm
9	Painting	Interior- Brilliant White Exterior- RAL 7035
10	Cabinet Dimension	To be decided during detail engineering
11	Grounding	M6 earthing stud shall be used
12	Ventilation	Fans & louvers with brass mesh required
13	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
14	Lifting arrangement	Removable lifting eyebolts shall be used

1. Beacon Lamps shall be used in each cabinet to indicate panel having fault condition.
2. The racks in system cabinets shall have provision along with plug in sockets/back plane to house accommodate the spare slots/modules as specified elsewhere.

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3. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots & details of the card type/service shall be inscribed on this metal tag.
4. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
5. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
6. All cabinets shall have common key for locks.
7. Door shall have concealed type of hinges with 120 degree swing.
8. Door latches shall be of the three-point type to ensure tight closing.
9. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material.

17.3

Marshalling Cabinets

Table 17.2
Specifications for Marshalling Cabinets

S.No.	Features	Minimum Requirements
1	Application	For termination of all cables originating from field.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Terminal Blocks	Rail mounted cage-clamp suitable for conductor size up to 2.5 mm ² & fused type with LED indication for power supply (24 VDC, 230 V AC, 110 V AC etc.) for instruments & equipments.
9	Anti vibration pad	Required, 15mm
10	Painting	Interior- Brilliant White Exterior- RAL 7035
11	Cabinet Dimension	To be decided during detail engineering
12	Grounding	M6 earthing stud shall be used
13	Ventilation	Fans & louvers with brass mesh required

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S.No.	Features	Minimum Requirements
14	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
15	Lifting arrangement	Removable lifting eyebolts shall be used

1. Separate Marshalling cabinets for the system shall be supplied for terminating all cables originating from the field and for distributing the signals to different functional panels and cubicles.
2. The terminal blocks shall be cage clamp type. Fused terminal blocks hinged at one end to facilitate easy isolation shall be used wherever necessary. All cabinets shall be used with spare terminals for the spare inputs/outputs as specified elsewhere in the specification. The type of terminals for terminations from cabinets/panels shall match with the pre fabricated cables and pins supplied.
3. The terminals for field cables shall be arranged in a logical order of equipment/system wise.
4. The marshalling cabinets, the terminal blocks, the terminals and the electronic hardware if any, shall have identification numbers.
5. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
6. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
7. All cabinets shall have common key for locks.
8. Door shall have concealed type of hinges with 120 degree swing.
9. Door latches shall be of the three-point type to ensure tight closing.
10. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material.

17.4 Local Instrument Enclosure & Racks

1. Transmitters and switches, devices, etc. mounted in the field shall be suitably grouped together and mounted in local instruments enclosures in case of open areas of the plant and in local instrument racks in case of covered areas. These local instrument enclosures and racks shall be furnished as per the project requirements.
2. The local instrument enclosures shall be constructed of 2 mm sheet plate and shall be of modular construction with one or more modules and two end assemblies bolted together to form an enclosure. Vibration dampeners shall be installed for supporting each enclosure. The internal layout shall be such that the impulse piping/ blow down lines are accessible from back doors of the enclosure and the transmitters etc. are accessible from front side for easy maintenance. Gaskets shall be used between all mating sections to achieve protection class of IP-65.

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3. The local instrument racks shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be used with a canopy to protect the equipment mounted in racks from falling objects, water etc. The canopy shall not be less than 3 mm thick steel, and extended beyond the ends of the rack. Bulk heads, especially designed to provide isolation from process line vibration shall be used. Exact fabrication details shall be as finalized during detailed engineering stage. The junction box for racks also shall conform to IP 65 protection class.
4. Provision for continuous purging arrangement is to be made for all air and flue gas applications.
5. Each transmitter enclosure housing instruments i.e. for air and flue gas applications, requiring purge air for continuous air purging shall be used with common purge air header, air filter regulators of sufficient capacity, required pressure gauges, valves, fittings, SS tubing and individual purge meters for each purge line etc. as required.
6. The junction box of Local Instrument Enclosure & Racks shall be used with hinged type door, latch for locking & gland plates for cable entry. All terminals in junction box shall be of rail mounted cage clamp type suitable for conductor size up to 2.5 Sq. mm.

17.5

Local Junction Box

Table 17.3
Specifications for Junction Box

S.No.	Features	Minimum Requirements
1	No. of Ways	32 (2X16) with 20% spares terminals
2	Material & Thickness	3 mm thick Stainless steel
3	Protection class	IP-65 for outdoor/ IP 55 for Indoor
4	Cable entry	Bottom
5	Mounting	Suitable for Wall/column/structures mounting
6	Terminal Blocks	Rail mounted cage-clamp type suitable for conductor size up to 2.5 mm ²
7	Grounding	M6 earthing stud shall be used
8	Gland plate	Removable type
9	Door	Single Lockable door with gasket, able to open sideways, turnable hinge based, latch type lock without handle with common key.
10	Accessories	Tag plate, clamps, fixtures, bolts (SS), nuts (SS), Gasket (Neoprene), cable glands (SS), Lugs (Brass), Fire proof compound for sealing.

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1. All JB's for outdoor application shall be used with individual canopies to prevent ingress of water.
2. All JB' shall have provision to add 10% additional TB's.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams.
4. Separate Terminal blocks shall be used for Analog & Digital Signals & also for signals with different voltage levels.
5. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
6. Separate shield bus shall be used with screw connection for terminating cable shields.
7. All spare cable entries shall be used with plugs.
8. All wires in JB shall be neatly dressed & ferruled.
9. Double deck type terminal block shall not be used.

Table 17.4
Specifications for Cable Glands

S.No.	Features	Minimum Requirements
1	Type	Double compression
2	Entry Thread	½ " NPT
3	Material	Brass
4	Finish	Cadmium Plated
5	Protection	IP-54 or better
6	Accessories	Neoprene gasket, Locknut, Reducer etc.

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18. TIME SYNCHRONIZATION SYSTEM (MASTER CLOCK SYSTEM)*{TO BE DELETED, IF ALREADY PROCURED UNDER TG PACKAGE.}***18.1 General**

A Global Positioning Satellite (GPS) based Master Clock System shall be provided with the Plant DCS system. Necessary signal output for time synchronization from Master Clock System shall be made available to the SG control system to have common time reference.

1. The system shall be provided with a GPS based date insensitive master & slave clock system (common for the station) for time synchronization of all plant control systems & equipments.
2. The system shall be complete with receiving antennae (for receiving time from GPS), receiver and associated electronics, Redundant Master Clocks, Slave Clocks, interconnecting cables, cubicles, power supplies & any other accessories.
3. The master clock shall have adequate number of communication ports to provide independent time reference signals for the following applications:
 - a) All DCS system equipment including plant common systems.
 - b) SER systems.
 - c) All PLC based BOP & offsite plant control systems
 - d) Vibration monitoring system for Unit specific requirements and for plant utilities.
 - e) PADO system.
 - f) Computerised Maintenance Management system
 - g) Management Information system
 - h) Station LAN Server
 - i) SG Integral control systems.
 - j) TG Integral control systems.
 - k) SG Flame monitoring & analysis system.
 - l) Any other equipment requiring time synchronising.
4. The following spare ports shall be as a minimum:
 - a) Spares for Hour Pulse
 - b) Spares for Minute Pulse
 - c) Spares for Second pulse
 - d) Spares for BCD real time output with one (1) second frequency
 - e) Spares for serial time code in IRIG-B format with one (10 second frequency.
 - f) Spares for serial time code in RS 232 C with one (1) minute frequency.

18.2 Design Requirements

1. The offered master clock system shall be a fully wired panel consisting of the following minimum items & shall be located in Equipment Room in CCR :

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- a) GPS Antenna
 - b) GPS Receiver
 - c) Signal Processing Unit
 - d) Local display unit
 - e) Power supply
 - f) All required cables, mounting accessories, cabinet for the processing electronics etc.
2. The system shall be designed in a 100% redundant configuration and shall include two master clock systems.
 3. The Master Clock System shall receive the synchronizing pulses from the GPS system and form a common time reference for recording of any event, logs and reports, which may take place in any portion of the network distributed throughout the Plant. Global Positioning System, to which the Master Clock gets synchronised, shall be an absolute system to provide continuously 3 dimensional position fixing, velocity measurement and Time reference generation
 4. The master Clock shall be configured as Real Time Clock with display of time in 24 hrs format & it shall drive the slave display units. It shall be ensured that loss of any slave display unit does not affect the display of any other slave unit. The character size of slave display unit shall be minimum 100 mm LEDs (4''). Since the timing synchronization of many off-site facilities is being done through station LAN, the slave clocks may be alternatively driven by respective systems / sub-systems.
 5. Accuracy of the master clock system shall be as follows:
 - a) PPS output : +/- 500 nano second or better.
 - b) IRIG-B output : +/- 200 micro second of UTC or better
 6. All the cables for interconnection between Master Clock and Slave Clocks & other systems shall be provided. This shall include all signal cables, (minimum Type-G cable as per specification) as well as power supply cables.

Table 18.1
Specifications for Master clock system

S.No.	Features	Minimum Requirements
1	GPS Antenna type	Helical
2	Noise	Less than 6 dB
3	GPS Receiver	Micro processor based
4	Tracking method	Code/carrier tracking
5	Output data format	NEMA 0183 or equivalent
6	Communication speed	9600 BPS or better
7	Output rate	Every Second
8	Signal Processing unit	Micro processor based digital type
9	Reference	OCXO with stability of 1 PPM
10	Time accuracy	1 PPM

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19. UNINTERRUPTED POWER SUPPLY (UPS)*{TO BE DELETED, IF ALREADY PROCURED UNDER TG PACKAGE.}***19.1 General**

This specification is intended to cover the *[design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning]* of UPS system complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [.] of *[Name of the Power Plant]* at *[District], [State]* for *[Name of the Client]*.

19.2 Scope of Supply

Redundant, 230 VAC Uninterrupted Power Supply (UPS) System for various C&I packages including the plant control system (DCS) consisting of 2x 100% capacity static inverters, 2 x 100% capacity static switches, Manual by-pass switch, 2x 100% capacity float-cum-boost chargers, Battery with accessories, Step-down transformer, Voltage Stabilizer, 2x 100% AC Power Distribution Boards etc. shall be provided. UPS shall be provided with all interconnecting cable between UPS equipment and battery, UPS system cabinets and enclosures etc.

UPS shall be provided with all equipment and accessories required for completeness of the system including any feeder distribution as required for protecting UPS equipment and connected inputs and outputs shall be furnished in line with the specification.

19.3 Technical requirements

1. The equipment furnished under this subsection of the specification shall meet the requirements of all applicable codes and standards including ANSI, NEMA, IEEE, NEC and IS.
2. The UPS equipment and the complete system shall have Surge Withstanding Capability (SWC) to meet the requirements of ANSI C 37.90a - IEEE Standard 472-1974.
3. The UPS shall be provided to cater to all the loads for systems, equipment and instruments requiring UPS supply. Spare feeders of at least 10% of the total number of feeders shall be built in.
4. The selection and selective co ordination of all the protecting devices including fuse free circuit breakers/ fuses shall conform to the requirements of National Electric Code NEC –1984 and other applicable codes and standards. The selectivity ratios of the fuses shall be such that there is a sufficient margin between the total electric energy of the upstream fuse. The selectivity ratio shall be not be less than 2:1 in any case.
5. The following general requirements shall be met for ensuring proper branch and circuit protection-

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- a) The feeder fuse ampere rating and feeder conductor ampacity must be at least 100% of the non continuous load plus 125% of the continuous load as calculated per Article 220 (220-10 G) of NEC Code- 1984. The feeder conductor must be protected by a fuse not greater than the conductor ampacity.
 - b) Each ungrounded service entrance conductor shall have a fuse in series with a rating not higher than the ampacity of the conductor.
 - c) If secondary fuses are sized not greater than 125% of transformer secondary current, individual transformer fuses are not required in the primary, provided, the primary feeder fuses are not larger than 250% of the transformer rate primary current.
6. The UPS system shall be suitable for operation at ambient conditions indicated in the specification.

19.4 Functional requirements

1. The Uninterrupted Power Supply (UPS) system of continuous duty shall supply regulated, filtered and uninterrupted 230V, 50 Hz, single-phase power, within specified tolerances. Each of the UPS loads shall receive one feeder each from the AC Distribution Board of Inverter A& B. However, each inverter shall supply only 50% loads under normal conditions.
2. Each UPS System component shall be compatible for satisfactory and well coordinated operation with other related components as well as with the input and output systems.
3. The KVA rating of the UPS shall be guaranteed at 230VAC, 50 Hz, single phase output at 50 deg C ambient temperature and load factor of 0.8 lagging. In case, the standard UPS rating are applicable at an ambient temperature lower than 50 deg C, then derating factor of at least 1.5 % / deg C shall be considered. The Bidder shall demonstrate the above stated capacity at 50 Deg C during shop testing.

19.5 Normal Operation

1. During normal operation, UPS loads shall be supplied by both 100% capacity inverters each working at 50% load. The inverters shall receive power from DC source (Charger/Battery) and their static switches shall be in the respective "Inverter" position. In this mode the two inverters shall act as hot standby for each other.
2. Necessary paralleling networks shall be included to ensure equal load sharing by both inverters. The rating of the paralleling device / circuit shall be such that it does not act as a limiting factor on the fault clearing capability of the inverters individually and when working in parallel. Load sharing network details shall be provided to establish all functionalities including fuse clearance.
3. One inverter shall act as "Master", working on its internal oscillator and the other inverter shall follow by using the synchronising signal from master inverter for automatic control of its output frequency.

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19.6 Emergency operation

In case of failure of any inverter, the static switch shall automatically transfer the UPS loads of faulty inverter (say Inverter-"A") to the healthy Inverter-"B" which shall start working at 100% capacity. Thus the feeding of UPS power is continued automatically to all loads connected to both inverters despite the failure of one inverter and the quality power supply to all UPS loads connected to both inverters shall be maintained without interruption. Isolation of faulty inverter shall be automatic and achieved in less than 4 mille seconds.

On inverter failure, the plant AC source is automatically brought in as the standby source to healthy Inverter working at 100% capacity. In this mode, the healthy Inverter shall get the synchronizing signal from the standby AC source.

Operation on internal oscillator and transfer/retransfer to standby source shall be as follows:

1. The output frequency of the healthy inverter shall be automatically synchronised with the plant stand-by AC source supplied through step down transformer and voltage stabilizer using synchronizing signal from the standby source. If the frequency of the standby source is beyond these limits, the inverter frequency control shall be automatically disconnected from stand-by synchronizing signal and the inverter shall maintain the output frequency at 50 Hz within + 0.1 percent under all conditions of load and input voltage by working on its own internal oscillators.
2. During operation on its own internal oscillator, the inverters shall continuously monitor the frequency of standby source. Upon restoration of proper frequency conditions of stand-by source, the inverter shall automatically start using stand-by source frequency as the synchronizing signal for inverter output frequency control.
3. During the operation of any inverter on its internal oscillator due to synchronizing frequency being beyond the specified limits, the transfer of static switch from "Inverter" to "Standby source" shall be inhibited.
4. While one of the inverters (healthy) is feeding 100% load and the AC source is acting as standby, and in case this inverter also fails, the 100% load shall be automatically transferred from inverter to standby AC source through static switch, provided the standby source is synchronized to the inverter (synchronous transfer). However, such transfers shall be inhibited during operation of inverter on its internal oscillator due to standby AC source frequency being beyond the synchronization limits. Asynchronous transfer of inverter loads to standby AC source with a beak, on inverter failure shall be envisaged.
5. Retransfer of loads from standby AC source to inverter shall be automatic or manual as pre selected by the operator and shall be accomplished only after synchronism of the inverter output with the standby source has been automatically accomplished.
6. The manual bypass switch shall have the provision for fully by-passing the UPS system and connecting all UPS loads to the standby AC source.

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19.7 Static inverters and auxiliary equipment

The static inverters shall be solid state type employing silicon controlled rectifiers or power transistors and other solid state devices to convert direct current power to essentially sinusoidal alternating current power as per this specification. Ferro resonant type inverters shall not be acceptable. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, surge suppression network, automatic synchronisation etc. as specified herein. Inverter shall be of continuous duty. Natural convection or forced cooling using redundant fans shall be used. Equipment shall be designed for operation with full load even with cooling fans failure / non-availability.

19.7.1 Inverter Capacity

Each static inverter shall have the following minimum capabilities. Continuous full load rating: meeting specification stipulations Over load capacity: 125% of full load rating for 10 minutes and 200% for 10 seconds minimum and 300% for 4ms minimum for all specified input voltages.

The inverter shall have sufficient I²t capability to clear a slow acting HRC fuse having a continuous current rating equal to at least 20% of the continuous full load current rating of the inverter, while feeding 100% rated loads of the inverter.

Voltage regulation: $\pm 1\%$ for 0-100% load at all input voltage and all power factors.

Step load pick up: Upon transfer of full load, the inverter output voltage shall not drop below 85% of nominal voltage during the first half cycle after transfer and 90% of nominal voltage in the next half cycle. The recovery to within $\pm 1\%$ of voltage shall be in less than 50 milliseconds.

The Bidder shall indicate the maximum current rating (in Amps) of slow acting HRC fuse which can be cleared by the proposed inverters upon a branch circuit or bus fault. This shall also be accompanied by calculations and test data.

19.7.2 Input / Output Voltage

The inverters shall be fed from Battery and chargers which do not feed any other loads. Input voltage shall be nominal DC output voltage of battery and charger of range from final voltage after discharge of battery to maximum DC bus voltage during equalize charging of battery. The inverter shall also be capable of working satisfactorily meeting all specification requirements with only the chargers connected to its input without battery in circuit. Filtering on the input of the inverters shall be furnished as required to operate with the output ripple of the chargers. Each inverter shall include equipment necessary to protect itself from damage resulting from excursions, loss or restoration of DC input voltage and synchronizing voltage. The inverter output voltage shall be 230V AC, 50 hz, single phase. Total harmonic content shall be 4% (max) and harmonic content of any single harmonic shall not exceed 3%. The inverter efficiency at 100% load

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and 0.8 pf shall be minimum 85% and at 50% load and 0.8 pf shall be minimum 80%.

19.7.3 Over loads, Short Circuits and Load loss

1. The inverters shall be provided with suitable fuses at the input and output which shall permit proper co-ordination with other protective devices and at the same time protect the inverter against damage due to internal faults. All necessary equipment shall be provided to protect the inverters against over loads, short circuits and 100% loss of load. The inverter shall be self protecting against damage if energized with full load connected. All the fuses used in inverter power & control circuits shall be fast acting type, operating in less than 5 ms.
2. The inverter shall be provided with current limiting circuitry which shall limit the output current to a value which will not damage the inverter or blow its fuses.
3. The inverter shall have sufficient I_{2t} capability to prevent damage to itself until short circuit conditions on the output are cleared.
4. Each inverter shall be capable of operation with non linear loads. Bidder shall furnish details of non linearity for the loads. Output waveform of the inverters) shall remain within specified limits when operating with non linear loads at 100 percent rated load.
5. The inverters shall be self protecting against all AC and DC transients, voltage surges and steady state abnormal voltages and current likely to be encountered in utility power station.

19.7.4 Automatic Synchronization

1. Inverter equipment shall include stable solid state oscillator devices designed to automatically maintain the inverter output in phase and in synchronism with the standby AC source. The frequency regulation shall be automatic within +/- 0.1% for all conditions of inputs, loads and temperature occurring simultaneously or in any combination.
2. Facility shall be provided for automatic transfer to internal oscillator operation when the standby source frequency is not within the synchronization limits.
3. Provision shall be made for step less adjustment of synch disconnect frequency range from 50 Hz +/- 0.5 Hz to 50 Hz +/- 2 Hz.
4. Automatic adjustment of phase relationship between inverter output and standby AC source shall be gradual, at a controlled slew rate which shall not exceed one Hz per second.
5. The inverter shall normally work on the internal oscillator with either of the two inverters as master synchronizer and the other following it. Suitable selector facility shall be provided to select the master. When any one inverter fails the healthy inverter gets the synchronizing signal from the standby A.C. source.

The DC input current shall never exceed the full load current except for a short circuit within the inverter. This limitation applies to transient as well as steady state currents and includes in rush currents upon initial energisation of the UPS, load energisation, short circuits external to the inverter etc. For any value of the load and load power factor drawn by the equipment served, the inverter shall not

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impose on DC source any voltage oscillations in excess of 5 volts (RMS total, all frequencies) or any current oscillations in excess of 3 percent (RMS total, all frequencies) of the DC current at full load.

19.7.5 Static inverter auxiliary equipment

In addition to the inverter equipment specified above, auxiliary equipment shall be furnished with each static inverter as follows:

1. Output ammeter, Output voltmeter, Output KVA meter, Input voltmeter, Frequency meter, Power factor meter, Inverter ON-OFF switch, Alarm Reset Push Button etc. of one number each shall be provided on the front panel of the inverter enclosures.
2. Indicating lights shall be furnished on front of the UPS panels. For those abnormal conditions which could be of a momentary nature, the indicating lights shall remain energized and the contact remain closed until cleared by a reset push button on the panel.
3. The following indications shall be provided as a minimum i.e. DC voltage to the Inverter Low/ High, Loss of DC input to the inverter, Inverter output voltage High/ low, Inverter failure, Standby AC source failure, Inverter synchronized with standby AC source in case of failure of the other inverter, Inverter feeding 100% UPS load, Standby AC source feeding 100% UPS loads, Fan failure and temperature high etc.
4. In addition to the above indications, the Bidder shall furnish electrically independent, potential free contacts for each of the above conditions. These contacts shall be rated for 0.5 Amps, 220 Volts DC and shall be wired to the terminal blocks.
5. The 4-20 mA signals for Inverter A & B output voltages, output currents, output frequency etc shall be furnished.

19.8 Static transfer switches and auxiliary equipment

The static transfer switches shall be provided to perform the following functions

1. To transfer the load automatically between the Inverter to the standby inverter as described under automatic synchronization.
2. To transfer UPS load under manual control from standby AC source to inverter when placing the UPS System in service and from inverter to standby AC source when taking the UPS out of service.
3. The static transfer switches shall have two modes of operation namely automatic and manual.
4. The static transfer switches shall use silicon controlled rectifiers and other static devices required for automatic transfer of load from Inverter to Standby source and vice versa.
5. The static switches shall be provided with the requirements specified herein including the following:

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- | | | |
|----|-----------------------------|---|
| a) | Capacity(continuous) | Continuous full load capacity of the inverter. |
| b) | Capacity (overload) | As per overload capacity of inverter indicated in the specification |
| c) | Capacity (Peak) | 1000% of continuous rating for 5 cycles. |
| d) | Transfer Time | 1/4 cycle maximum. (The transition shall be "make before break". Voltage failure shall be sensed at the output of static switch |
| e) | Voltage Rating (Nominal) | 230 Volts, 50 Hz, single phase. |
| f) | Transient Voltage Tolerance | 340 Volts peak above the normal line voltage. |
| g) | Ambient temperature | 50 deg C max. |
| h) | Cooling | Natural or forced circulation, using redundant fans. |
| i) | Duty | Continuous |

6. The transfer of static switch from normal "Inverter" position to "Stand-by" position shall be initiated by Inverter failure and UPS system trouble, Static switch output voltage failure, over current or manual push button operation.

The UPS bus shall be monitored by two voltage detectors. One fast acting circuit shall be used for detecting a complete and instantaneous voltage loss while the other slower acting averaging circuit with adjustable trip level shall be employed to detect voltage deviation beyond selected limits. Both voltage detector circuits shall automatically initiate operation of static transfer switch.

UPS bus current shall be continuously monitored by a current monitoring detector. This detector shall operate the static transfer switch when the load current exceeds the overload rating of any inverter. The detector shall rest when the load current falls below the rated current of the inverter resulting in retransfer of static switch with inverter position.

The static switch shall automatically transfer the load from inverter to stand-by AC source when the maximum I_{2t} capability of the inverter is reached or when the inverter output voltage drops below 90%.

Over current transfer limit shall be continuously adjustable from inverter continuous rating to inverter current limit rating.

7. Transfer Inhibit of static switch shall be under the following conditions:

- Automatic or manual synchronous transfer of load from inverter to stand-by AC source or vice versa, shall be inhibited when the inverter frequency is not synchronized to the alternate source. However, asynchronous transfer facility under such condition shall be provided.
- Transfer resulting from overload shall be inhibited when the standby AC source is not available. In this case the load fed by the inverter shall be automatically disconnected.

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8. Static transfer switches shall be provided with necessary protective devices (circuit breakers) both in "Normal" as well as "Stand by" position.
9. The static switches shall be furnished with contacts to alarm failure of the alternate source or opening of any fuse protecting the static switches.
10. Auxiliary equipment for static transfer switch
11. Following auxiliary equipment shall be furnished with each static transfer switch a minimum:
 - a) Red indicating Light to indicate switch in "Normal" position, Green indicating Light to indicate switch in "Standby" position, White indicating Light to indicate "Normal" and "Standby", power sources in synchronism, Push-button to simulate normal AC UPS power failure (sensed at static switch output) to test the satisfactory working of static switch, transfer labeled "Transfer Test", Push-button for manual retransfer of static switch to "Normal" position, Push-button for manual transfer from normal to alternate source, Light to indicate standby AC source voltage deviation high, Light to indicate voltage transfer enabled, Light to indicate voltage transfer disabled etc shall be provided on the front of the enclosure.
 - b) Two (2) number each of NO contact for static switch transfer to "Standby" position and standby source voltage deviation $> \pm 2\%$ from normal shall be provided within the static transfer switch enclosure.

19.8.1 Manual by-pass switch

1. The manual by-pass switch shall be used to isolate any static switch from its load and stand-by power supply and to take the static switch out of service without power interruption to the load. In doing so, the manual by-pass switch shall connect both load buses to a single inverter. The manual bypass switch shall provide the facility for by passing the entire UPS system during the operation of the UPS in the option of the operator.
2. The manual bypass switch shall have "make before break" contacts to ensure continuous supply to UPS loads during the operation of the same.
3. The manual bypass switch shall be rated for 600 Volts, 50 Hz, single phase operation. It shall have continuous load carrying capacity equal to full load inverter current and necessary short term load carrying and interrupting capacity to meet the requirements of the UPS system.
4. Another bypass and disconnect devices shall be envisaged as required for orderly start up, shut down and maintenance of UPS system and system components.
5. The manual by-pass switch and required disconnect devices shall be furnished duly mounted and wired in enclosure.

19.8.2 Float-cum-boost chargers and auxiliary equipment

1. Two 100% capacity chargers shall be furnished for the UPS system. Each charger shall confirm to the following requirements.
2. Each charger furnished for UPS system shall be adequately rated to ensure that any one shall meet full DC load of UPS system operating at 100 % rating plus recharge the fully discharged UPS batteries.

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3. The chargers shall be served from a 415 volt, 50 Hz, 3 phase system. The chargers shall maintain the output voltage within plus and minus 0.5 % from no load to full load, with an input power supply deviation in voltage level of +/- 10 % and input power supply deviation in frequency of +/- 5 % and with both deviations present in any combination.
4. In addition to supplying DC power for inverters, the chargers shall be designed to charge a fully discharged battery without over loading or causing over voltage or without causing interrupting operation of AC or DC circuit breakers for the entire range of intended operating regimes. Suitable solid state electronic circuits shall be provided to ensure that the charging current is voltage regulated and current limited. After the battery is recharged the charger shall maintain the battery at full charge until the next emergency operation when the UPS battery is again required to provide DC power.
5. Float and equalizing controls shall have an adjustment range of +/- 5% continuous (without steps).
6. The chargers shall be self-regulating, solid state, silicon controlled, full-wave rectifier type designed for single and parallel operation with the battery specified. The chargers shall be designed for automatic load sharing during parallel operation.
7. The charger shall be current limited at 125% of full load to reduce output voltage for charger circuit protection and for protection of battery from overcharge. The current limit shall be continuously adjustable from 80% to 125%.
8. All necessary equipment and devices shall be provided to protect the charger from short circuits, transient voltages, surges, load and supply fluctuations including sudden loss of input or load.
9. The charger shall have a slow walk-in circuit which shall prevent application of full load DC current in less than 10 seconds after AC power is energized.
10. The minimum full load efficiency at nominal input and float output shall be 90% or better. The output regulation, ripple content and power factor shall meet the requirements of UPS system offered.

19.9 Battery Charger Auxiliary Equipment

Following auxiliary equipment shall be furnished for battery charger a minimum:

1. AC Voltmeter, DC Voltmeter, AC Ammeter, DC Ammeter, Charger On-Off push buttons, Potentiometers (one "Float Voltage Adjust" and one "Equalizing Voltage Adjust", both with manual adjustment knobs, the settings of these knobs, shall be independent of each other), Selector Switch for float charge / Equalizing charge, Charging rate setter, Selector switch and lights for ground fault detector, Indicating lights with proper actuating devices, Circuitry and legend etc shall be furnished on the front of the panel of the charger enclosure.
2. Indications such as Failure of input AC supply, Charger failure, System on battery operation, Battery equalize timer 'on', Low battery voltage, DC ground

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fault, Redundant fan failure and temperature high (if provided), Charger fuse failure, Low DC output voltage, High DC output voltage etc.

3. One set of independent potential free contacts rated for 0.5 amps, 220 volt DC shall be furnished for the alarms above and wired to terminal block for use of alarm annunciation system.

19.10 Ground Detector System

Each charger shall be furnished with a ground detector system consisting of a relay and a centre tapped resistor. The resistor shall be connected between the positive bus and the negative bus. The relay coil shall be connected to resistor and ground. The relay shall be furnished with one normally open and one normally closed contact wired to terminal blocks for connection to external circuits.

Two indicating lights and one three position spring return to centre selector switch mounted on front of charger cabinet shall be provided for each ground detector system.

19.11 UPS Battery

1. The battery shall be heavy duty Nickel-cadmium type and shall have sufficient Amp-hour capacity to supply 100% full load current of UPS for one hour. The Ni-cd battery shall conform to IS: 10918 and shall be sized according to IEEE Std. 1115.
2. The battery shall be high discharge performance type to withstand discharge/charge cycles throughout life without loss of capacity. In battery sizing calculation, Bidder shall also take into account a minimum voltage drop of 2.5 volts from battery room to the inverter input.
3. Battery sizing calculations, supporting curves/data etc. with the proposal to demonstrate that the proposed battery capacity meets the above specification shall be furnished. Various correction factors such as capacity factor, temperature derating factor (at a minimum electrolyte temperature of 4°C), design margin shall be take in to account as per data below:
 - a) Temperature derating factor (A_t : (T_d)
an electrolyte temperature of 40C)
 - b) Design margin : 20% = 1.2
 - c) Capacity factor (K_T) (For : AH capacity of chosen cell
discharge duration of 1 hr. & end : /(discharge current in amp for
cell voltage of 1.1 volts) chosen cell Corresponding to 1
hour) x Float correction factor.
 - d) The UPS battery shall be :
furnished as specified herein
and shall meet following
requirements.
 - i) Nominal Voltage : As per the requirement of

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- nominal DC voltage level at the input of the inverters.
- ii) Ambient temperature : 50 ° C max.
 - iii) Specific gravity, full charge : 1.19 ± 0.01
 - iv) Voltage per cell
 - Nominal : 1.2 V
 - Floating : 1.40 V to 1.42V
 - Boost : 1.53 V to 1.67V
 - End cell voltage : 1.1 Volts

19.12 Battery Accessories

2 nos. of Hydrometer along with syringes suitable for vent holes in different cells, Thermometers, Specific gravity correction chart, Wall mounted type holder made of teak wood for hydrometer & thermometer, Cell testing voltmeter (3-0-3V), Acid/Alkali mixing jar 2 nos. Rubber apron, Rubber gloves, Set of spanners, Goggles (industrial) Instruction Card, Variable metallic resistor & shunt, Inter cell connectors, Suitable terminal lugs for cables, Two tier teakwood battery rack, Jack for lifting the cells etc shall be provided as accessories and fittings of the Batteries and auxiliaries.

19.12.1 Step-down transformer & voltage stabilizer

One 415 Volt, 3 phase to 240 Volt, single phase transformer along with associated voltage stabilizer shall be furnished.

This transformer and stabilizer combination shall convert 415 Volt +/- 10% plant auxiliary AC supply to 230V, +/- 2% single phase standby AC Power, which shall serve as UPS system back up supply source.

The transformer and stabilizer shall be sized for 100 % UPS load and shall co-ordinate with the largest branch circuit protection device for feeder short circuit current without sacrificing voltage regulation. The voltage stabilizer shall employ silicon solid state circuitry and shall maintain a stabilized voltage for 0 -100% load with input voltage variations as indicated above.

The stabilizer shall meet the following characteristics as a minimum. Fast rate of correction - within 5 cycle; Output distortion - less than 5% under worst conditions; Efficiency shall be better than 94%; No load losses less than 5%.

19.12.2 AC Distribution Boards

Panel boards for distribution of continuous AC power to essential loads shall be dead-front type panel boards rated for 600 V, AC service. Sheet steel thickness shall be 3 mm for load bearing member and 1.6 mm for other members. The hinged panel board front shall cover the fuses and wiring gutter but not the switch handles. The hinged front and switch handles shall be covered by the enclosure-door.

Each panel board shall be constructed for 2 wire, single phase distribution with solid neutral bar. Phase and neutral bars shall be of copper. Rating of the main

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lugs shall be equal to the rated continuous full load current of each inverter. Type of enclosure shall be IP 42 as a minimum.

Each panel board shall have one fused disconnect switch of adequate rating for incoming feeder for AC Bus and requisite single pole, suitably rated disconnect switch branch circuit devices. Fused switches shall be equipped with arc quenchers, visible blades and quick-make quick-break operating mechanisms. The number of feeders and rating of each feeder shall be to suit the individual load requirements.

The AC distribution board and components thereof shall be from the latest proven product range of a qualified manufacture. However, 25% spare feeders with fuses of each rating shall be provided.

19.12.3 Wiring and interconnections

All interconnections required from input to output terminals or outgoing inverter, transfer switches and distribution board equipment shall be provided within the enclosures in accordance with the manufacturer's proven practice, applicable international standards and good engineering practice. Internal wiring in factory pre-wired electronic systems cabinets may be installed according to the standard practice as to wire size, insulation and method of termination on internal equipment. Wiring for external circuits including all alarm contacts shall be brought to grouped terminal blocks located for convenient connection for external circuits entering from top or bottom.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-D
DETAILED TECHNICAL SPECIFICATION-CIVIL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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1 CIVIL, STRUCTURAL, ARCHITECTURAL WORKS-DESIGN & EXECUTION CRITERIA

1.1 Introduction

This specification covers the design, preparation of general arrangement, construction as well as fabrication drawings, supply of all labour as well as materials and construction of all civil, structural as well as architectural work on EPC basis for Boiler and associated structures for the Renovation and Modernisation of existing [Name of project...] Thermal Power Project of [210/215/220/250] MW capacity. Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope shall be as per Volume-II, Section-I, Civil Scope of Work.

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2 BUILDINGS & STRUCTURES

Design and construction of new buildings, structures, foundations etc. as well as repairing / retrofitting of existing buildings, structures, foundations shall take into account requirement for operation and maintenance of all equipments and its users. The buildings will have good architectural features. The surrounding areas shall be properly micro levelled and graded. The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials fittings and finishes.

- Due consideration shall be given for adequate natural lighting and ventilation for both plant and non-plant buildings.
- Retrofitting / repair works / new constructions shall not cause damage to the existing structures. The temporary supports shall not be allowed on the existing structures for any of these works unless the loads are minor and may not cause any damage to any existing structure. However in such a case Bidder shall take approval from the Owner/Consultant prior to initiating the work.
- Internal finishes shall be provided with latest available materials approved by Owner/Consultant with due consideration of the functional aspect of the area.
- External finishes shall be provided with latest materials approved by Owner/Consultant for improving the aesthetics.
- The orientation of the important buildings shall be in line with the existing site condition and function as such.
- Each building shall have its own identity. However, a total homogeneity shall be maintained in the design of all buildings.
- Adequate frontage shall be provided to all important buildings to create a better visual impact.
- All other civil and structural buildings shall be developed in conjunction with the above aspects.

2.1 Brief description of Buildings, Structures and Facilities

a) Boiler Structure and Boiler Area

[The Boiler shall be suspended from a steel structure provided by the Boiler supplier, which shall be supported on reinforced concrete foundation considering isolated /strip foundation based on soil investigation report. Criteria for designing the steel structure are described in section-2. Roof of steam generator shall be of permanently colour coated galvanised M.S

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troughed metal sheet of approved profile conforming to IS 14246. Minimum base metal thickness shall be 0.8 mm. Proper drainage of the roof shall be provided by means of gutters and down take pipes. Down take pipes shall be GI pipes with threaded connections. Side cladding shall be of permanently colour coated sheet as above but minimum base metal thickness of 0.6 mm.

Provision of Air conditioned rooms for VFD panels shall also be suitably made in the steam generator area.

The reinforced concrete ground slab in the Steam Generator Areas shall include floor drainage for cleaning purpose. All the floor drains shall be connected to peripheral drains.

The RCC Transient pit for each unit (of suitable capacity as per technological requirement) for collecting & transferring the water from the Slag bath overflow water.

The RCC Underground sump with suitable compartments of adequate capacity for settling, cooling of the hot water upto the required temperature as per the system requirement along with suitable barricading system above Finished floor level.]

b) Mill and Bunker Building including Bunkers

[The framing shall be of structural steel. This shall be designed as a moment connection framing in the transverse direction and braced in the longitudinal direction. These structures primarily support coalbunkers, coal feeders and tripper arrangement to feed the coal into coalbunker.

The bunker shall be circular in plan and shall have the capacity as per the requirement stipulated elsewhere under Mechanical section. A comprehensive flow ability study shall be conducted by the CONTRACTOR for the coalbunker hopper to ensure smooth flow of coal in all seasons with different moisture contents and different percentage of fines. Geometric parameter of hopper and lining material shall be decided considering the findings of flow ability study. For the cylindrical portion of the bunker 50 mm concrete lining shall be provided using gunning technique, with nominal reinforcement unless the CONTRACTOR recommends use of other types of liners. Conical portion shall be provided with 5 mm thick liner of stainless steel of grade SS 409.

Mills are to be located on the ground floor. In addition to Mill foundations provision has to be made in the Mill bay ground floor for trenches accommodating Mill reject system conveyors.

A Mill maintenance platform shall be provided at appropriate elevation to attend to routine maintenance. This shall be a platform with chequered plate or gratings over steel framing with handrail all round. Above this floor a framing shall be provided to support under slung crane used for handling mill maintenance work. The crane runway girders shall extend to the full length of Mill bay to enable approach to the service bay also.

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Above this framing, feeder floor is provided. The extent of the feeder floor shall be decided by the CONTRACTOR based on his maintenance requirements. Feeder floor will be of RCC supported on structural steel framework. Handrails shall be provided on all the sides. A steel staircase shall be provided for access to feeder floor from ground floor. Access shall so be provided to feeder floor from boiler elevator.

Framework for supporting the circular bunker shall be provided above the feeder floor based on geometry of the hopper.

Bunker shall be provided with a top steel cover with slit openings for entry of coal. On sides of the bunker necessary openings shall have to be provided for bunker ventilation / dust extraction.

Tripper floor shall be immediately above the bunker. This floor shall be of RCC supported on structural steel framework.

Tripper roof shall be of RCC supported on structural steel framework. Tripper roof supports bunker ventilation / dust supporting structure. An RCC parapet or steel handrail shall be provided for the tripper roof. An access stair / ladder shall be provided from tripper floor to roof in each unit.

In addition to the above, framing arrangement for structural steel platform at various levels around the bunker shall be provided with proper access ladder, for poking, striking and attending to air cannons.

Tripper floor shall be given access through Boiler staircase / elevators.

Bunker supporting structure is normally left uncladded up to the bottom of tripper floor. For tripper floor up to 3000 mm above finished tripper floor level, brick wall shall be provided. Above this level permanent colour coated galvanised trough sheet cladding shall be provided. Fixed steel windows with 6 mm thick-wired glass shall be provided in the tripper house as per requirements for conveyor gallery.

As the roof is accessible and maintenance crew is likely to work on this floor, the entire floor shall be provided with cement / clay tiles set in CM 1:3, 25 thick and the tiles pointed with cement mixed with crude oil.

Rigid polyvinyl chloride pipes (PVC) of approved manufacturer conforming to IS: 13592 shall be provided as rainwater down comer (RWDC) pipe. These pipes shall be fixed and jointed strictly in accordance with the manufacturers' instruction. The minimum diameter of the pipe shall be 100 mm.

All structural steel work shall be given two coats of primer and minimum 2 coats of synthetic enamel paint of approved brand and shade. All exposed gratings and handrails shall be galvanised. Expansion joint shall be provided to the structure as required by IS: 800.]

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c) Equipment Foundations (PA Fan, FD Fan, ID Fan etc.)

[All foundations shall be designed and constructed with the input data from equipment manufacturer matching with the layout and levels of the relevant structures. The foundation systems for rotating equipment will be sized and proportioned not to exceed the bearing and settlement criteria and to assure satisfactory performance of the equipment. In addition to a static analysis, a dynamic analysis will be performed to determine the fundamental frequencies of the foundation system. To preclude resonance, the fundamental frequency of the foundation will be 20 percent away from the operational frequency of the equipment. Amplitudes shall be kept within the allowable limits specified by the manufacturer or in absence of manufacturer's specified value, as specified in the IS Codes/ DIN Codes. The dynamic behaviour of the foundation will meet the requirements of IS: 2974 (Part I to IV) – Code of Practice for Design and Construction of Machine Foundations. Foundations for rotating equipments like Boiler feed pumps, ID/FD/PA fans, Coal mills, etc. shall be designed to carry loads furnished by the equipment manufacturer.

All rotating equipment will be provided with vibration isolation system mounted on foundations. The vibration isolation system supplied will be of proven make, consisting of steel helical spring units and viscous dampers (providing damping resistance in all three planes). The vibration isolation foundation system will be provided for Boiler feed pumps, ID/FD/PA fans and Coal mills. Equipment foundation will be separated from adjoining part of building and other foundations joints at floor/slab will be suitably sealed

The vibration isolation system will be capable of vibration isolation not less than 95%.

Foundations for static equipment e.g. Boiler, ESP shall be designed to carry the loads furnished by the equipment Manufacturer.

If minor equipments with dynamic load are required to be supported on building structures, floors etc. suitable vibration isolation will be provided.

The boilers shall be suspended from a steel structure provided by the boiler supplier, which shall be supported on reinforced concrete foundation resting on isolated /strip foundation. The Coal Bunkers, FD fans, PA Fans and PF Mills sited adjacent to the Boilers shall similarly be supported on reinforced concrete bases.

The foundations to the I.D Fan, units shall include reinforced concrete blocks with anti-vibration mountings.

The reinforced concrete ground slab in the Boiler Areas shall include drainage channels with water-jets for removal of boiler ash.]

d) Electro Static Precipitator

[Electrostatic Precipitator shall be supported by steel structure designed & supplied by ESP manufacturer. ESP columns shall be supported by RCC

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pedestal resting on RCC strip/raft foundation based on soil investigation report. External platforms shall be provided at various levels as per operation and maintenance requirements. Access to the external platform shall be from the internal staircase. Platforms shall be provided with steel grating or chequered plate for access up to the roof of each ESP. Area below the ESP shall be paved.]

e) ESP Control Room

[This shall be two-storied RCC framed structure. The ground floor shall accommodate cable vault, toilet, and staircase. First floor shall accommodate switchgear room, control room etc. Side cladding shall be of brick wall.

Staircase area shall be protected from fire safety angle as per TAC regulations. Main door to switchgear room shall be steel sliding door having adequate area to admit switchgear. There shall be minimum two doors to the switchgear room of flush welded steel type. Control room should have one swing type aluminium glazed double panel door and one single panel door. Windows shall be steel glazed for switchgear room with wired glass. For control room if window is provided the same shall be fixed with 5.5 mm thick sheet glass. Main entrance of the building shall be provided with suitable door matching with the aesthetic and architectural features of the building. False ceiling of Aluminium type shall be provided in the Control room. Under deck insulation shall be provided above false ceiling and Air washer room.

Roof shall be given a slope of minimum 1 in 100 towards the side opposite to transformer yard. Adequate number of rainwater down take pipe shall be provided using rigid PVC pipe with a minimum dia. of 100 mm. Garland drain as well as plinth protection shall be given around the building.]

f) Cable & Pipe racks

[The cable and pipe rack shall be structural steel. All the structural steel shall be welded/ bolted. The foundations for the supports shall be of reinforced concrete. All the pipe/cable racks falling in the Steam Generator area shall be suitably connected to the pipe/cable racks of other areas as per the piping/electrical requirements.

All cable and pipe routing in and out lying area shall run over ground on structural steel pipe/cable racks at a height as per mechanical Volume II A. Where the pipes cross roads clear headroom shall be as per mechanical Volume II A. The racks can be multi tiered .Cable shall normally be laid above the pipes. Expansion provision shall be provided wherever there is a change in direction or where length of the racks exceeds 100 m. Access ladder shall be provided at suitable location. Pipe & cable racks shall be provided with walkways as per mechanical Volume II A throughout with GI gratings.]

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g) Duct Supports

[Supports for ESP inlet duct between air preheater and ESP, between ESP outlet flue duct and structure of Chimney shall be of structural steel supported on RCC foundation and also columns supporting ESP.]

3 DESIGN REQUIREMENTS

3.1 Location

Geographical location of the plant site is approximately between [...] N] to [...] N], Latitude and [...] E] to [...] E], Longitude.

3.2 Ground Condition

Subsurface condition: The natural ground surface level approximately varies from [60 m to 74.5 m] from MSL.

[The soil profile in the plant area can be broadly classified into 3 layers namely laterite, cemented sand and cemented silt in general as per detail soil investigation report. Top soil upto a depth ranging from 0.4 m to 0.75 m is entirely non-uniform. The underlying layer is laterite whose depth varies from 4.0 m to 5.5 m followed by deep layers of cemented silt and cemented sand].

The ground water table (GWT) at finished ground level shall be considered for foundation design purposes.

The detailed soil investigation report conducted for plant shall be made available to Bidder for required replacement / refurbishment / retrofitting of Foundations, if any.

Bidder is advised to carefully study the content of detailed Soil investigation report for the existing type of foundations and design of new ones.

The type, size, depth of the foundation shall be based on the detail soil investigation report provided by OWNER.

3.3 Climatic Condition

a) Temperature

Maximum : [...] °C

Minimum : [...] °C

For design purpose, maximum temperature to be considered: [...] °C

minimum temperature to be considered: [...] °C

b) Rain fall

Minimum : [...] mm in May]

Maximum : [...] mm in October]

Peak hourly rain fall: [183mm] (corresponding to 50 years return period)

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[Note: Maximum per day rainfall as per weather report has been considered conservatively as peak hourly rain fall which will be used for drainage system design etc.]

Annual average: [..... mm to mm & average mm]

3.4 Seismic Zone

The site is located in [Zone II] as per IS: 1893-2002. Zone factor shall be [0.10]. Importance factor shall be considered as [1.75].

3.5 Wind Zone

The site is located in wind speed zone [..... m/s] as per IS: 875 (Part 3)-1987.

3.6 Loads and Load Combinations

All new structures shall be designed and old structures requiring modification shall be checked for the most critical combinations of dead loads, imposed loads, equipment loads, wind loads, seismic loads, temperature loads, forces developed due to differential settlement and any other loading conditions which can occur during the design life of the facility.

(a) Dead Loads

Dead loads consist of the weights of the complete structure with finishes, fixtures, partitions, wall panels and all existing / modified / replaced equipments of semi-permanent nature including storage structures partitions, roofing, piping, cable trays, bus ducts etc. The content of storage structures etc. shall be measured at full capacity for this purpose.

The piping loads (for empty, operating and test conditions), cable tray loads and the contents of the storage structures shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing load for uplift.

The following unit weight of material shall be considered for computation of loads. Loads given in IS: 875 (part-I) shall be made use of for material not listed below.

Table 2.1
Weights of Material

Material	Unit weight (kN/m ³)
Plain cement concrete	24.0
Reinforced cement concrete	25.0
Structural steel	78.5
Brick work	19.0
Cement plaster	21.0
Floor Finish	24.0

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Material	Unit weight (kN/m ³)
lignite	12.6

(b) Superimposed Live Load (SILL)

Listed below is the minimum SILL for the areas involved. Floors and supporting members subjected to heavy equipment live loads shall be designed on the basis of the equipment loads specified by vendor or specifically defined SILL whichever is greater.

The specific minimum floor SILL is listed below:

**Table 2.2
Superimposed Live Load (SILL)**

S.No	Description	SILL Value
a)	Roof	
	Flat accessible roof	1.5 kN/m ²
	Flat accessible roof with HVAC equipments, etc.	5 kN/m ²
	Flat inaccessible roof	0.75 kN/m ²
	Sloped Roof	As per code IS: 875 (Part-2)
b)	All building floors & Stairs	5 kN/m ²
c)	Walkways of Conveyor Galleries	5 kN/m ² or Concentrated Load of 3 kN at centre which ever is critical
d)	M.C.C. Floor	10 kN/m ²
e)	Equipment Load	As applicable
f)	Tunnels under road, culverts & its allied structures including Concrete pipes	Class "A" / Class "70R" as per IRC standard whichever is higher / load due to bull dozers
g)	Underground basement, tunnel	Surcharge of 10 kN/m ²
h)	Vehicular traffic	Surcharge of 20 kN/m ²
i)	Covers for Channels	Surcharge of 10 kN/m ²
j)	Other areas:	
	• RCC floors (Offices, laboratories, conference rooms and general floors)	5 kN/m ²
	• Balconies	5 kN/m ²
	• Chequered plate / gratings	5 kN/m ²
	• Walkways	3 kN/m ²
	• Toilets	2 kN/m ²

- In addition to LL, Hung loads for electrical, ventilation & air conditioning minimum of 0.5 kN/m² shall be considered.

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- Load of 1 kN/m² shall be considered as hung load for piping unless otherwise mentioned. However, the actual loads will be as furnished by the supplier. The stringent most will be followed.
- For other areas LL shall be considered as per IS: 875 (Part-2).

(c) Seismic Load

The proposed plant is located in Seismic [Zone-I] as per IS: 1893, Seismic force on the structures will be considered accordingly.

(d) Wind Load

The proposed plant is located in Wind Speed Zone of [50 m/s] as per IS: 875 (Part 3). The wind force on the structures will be considered as follows:

Table 2.3
Wind Speeds

Description	Wind Speed
Basic Wind Speed Vb (at 10m above mean ground level)	[50 m/sec]
Risk coefficient K1 (for 100 years)	[1.07]
Category of terrain	[Category 1]
Factor K2	As per IS: 875
Topography factor K3	As per IS: 875

For the design of structures, wind force on Equipment, supported on frame including all fixtures, piping, staircase, ladder, etc, shall be considered.

Design of structures shall be checked for the condition of wind load with gust factor.

(e) Earth Pressure Loads

For earth pressure the worst condition with dry / submerged and active, passive or at rest shall be considered. The pressure coefficient shall be adopted as recommended in Soil Report or for the backfill material used.

(f) Temperature Loads

The total temperature variation shall be considered as 2/3rd of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the average between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50 % of the total considered temperature variation with temperature load applied with positive and negative sense.

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For design purpose average maximum annual variation shall be taken as $[+50^{\circ}\text{C}]$ to $+5^{\circ}\text{C}$.

Coefficient of thermal expansion of steel shall be taken as per IS: 800 where the value is given as $12 \times 10^{-6}/^{\circ}\text{C}$. Coefficient for thermal expansion for concrete shall be taken as per IS: 456.

(g) Thermal Loads (during operating condition)

When thermal loads (such as produced by temperature changes in piping, equipment and structures) results in friction between equipment and supports (exchangers) or piping and supports, the friction force will be taken as the operating load on the support multiplied by the applicable friction coefficient given below:

Table 2.4
Thermal Loads

Description	Value
Surfaces	Friction coefficient
Rolling supports	0.05
Steel to steel	0.30 (longitudinal) and 0.10 (lateral)
Concrete to steel	0.30

(h) Equipment Loads

Static and dynamic loads of major existing / modified / replaced equipments shall be based on the manufacturer's data of the specified equipments and shall be considered in design in addition to the live load.

Equipments to be tested for hydraulic test, tanks and piping design loading shall include hydraulic test loading. Weight of equipments, ducts, tanks, pipes, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads applicable.

(i) Cranes, Hoists, Monorail and Elevator loads

All lifting beams and monorails shall have their design loads increased for impact factor. Loads for overhead cranes, hoists, monorails and elevators shall be taken as per IS: 875.

100 % of the lifted load including elevator live load plus the cab weight shall be considered for the elevator support beam design. Pedestals in elevator pits shall be designed assuming impact factor as per IS codes.

(j) Vibration and Noise

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The design shall ensure that vibrations from any moving machinery transmitted from its immediate foundations to adjacent buildings or areas of the same building shall be suppressed in accordance with the recommendations of relevant codes of practice.

(k) Other Loads

- Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance loads, creep and shrinkage shall also be considered in design of all structures.

- Dust loads

All buildings / structures shall be designed for a dust load of 1 kN/m² for flat roof and 0.5 kN/m² for sloped roof.

- Construction/Erection/Maintenance Loads

The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing as far as possible. However, construction or access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

- Future Loads

Loads from future expansion shall be considered when so directed by the Owner/Consultant. Future loads may include any of the loads listed above.

- Surge Loads

Surge loads may occur in some vessels or equipment. In such cases, the magnitude and direction of the load shall be given by the equipment supplier.

(l) Basic Load Cases

Following basic loads shall be considered for analysis and design:

Dead load	: DL
Superimposed dead load	: SIDL
Self weight of permanent equipment	: EL
Steam piping (Static & Dynamic) & other piping loads	: PL
Cable loads	: CL
Live load on floor / walkway	: LL
Superimposed live load	: SILL
Live load on roof	: LLR
Seismic load	: SL

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Wind load	: WL
Load due to soil pressure	: SP
Load due to surcharge	: SCL
Load due to hydrostatic pressure	: HP
Load due to temperature	: TL
Hoist, monorail loads	: MR1
Crane loads	: CRL
Special loads	: SPL

(m) Load Combinations

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load combinations shall be taken as per IS: 456, IS: 800 & IS: 875 (all parts) and other relevant IS codes.

Wind and seismic forces shall not be considered to act simultaneously.

Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loading.

(n) Load Combinations for underground structures

- For the design of sub structure only liquid pressure from inside and no earth pressure and ground water Pressure and surcharge pressure from outside (applicable only to the Structures which are liable to be filled with water or any other liquid) shall be checked.
- For the design of sub structure combination of earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside shall be applied.

(o) [Coal] Bunkers

The following densities shall be considered for design of [Coal] bunkers:

For volume calculations	: [8 kN/cum]
For structural design	: [12.6 kN/cum]

4 EARTHWORK AND ROCKWORK

4.1 General

This section applies to all earth and rockwork required for the replacement / refurbishment / retrofitting of existing foundations or construction of new

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buildings foundations (if any), any types of structure and burying service lines in the ground.

The Bidder shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the detailed soil investigation and of the available information and instruction given in writing by the Owner/Consultant.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Owner/Consultant. All necessary precautions shall be taken to cause the minimum possible alteration or disturbance to the other existing foundations, material lying under and adjacent to the excavation final lines.

4.2 Fill Materials

The fill materials used and source are to be examined and approved. Excavation materials can be used if they fulfil the requirements.

a) Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials, which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas etc.

b) Ordinary fill shall have the following properties:

- Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.
- The intention is to use ordinary fill for non-built areas.

c) Special fill:

- Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks.

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4.3 Excavation

The works shall be excavated either by hand or by use of excavating plant and tools acceptable to the Owner/Consultant.

Last 300 mm shall be excavated by hand tools only to ensure that natural conditions of soil at foundation level should not be disturbed. In case if over excavation has been done, the depth of soil over excavated shall be filled with M10 Grade concrete and no earth filling shall be allowed to fill over excavated earth.

Also excavation by hand may be required close to existing installations, existing foundations and/or underground services, but subject to special instruction of the Owner/Consultant.

The Bidder shall carry out all kind of earth and rockwork for the following particular works as defined hereafter (where applicable):-

- i) Clearing and grubbing
- ii) Excavation of topsoil
- iii) Open cut excavation
- iv) Backfilling
- v) Safety precaution during earthwork
- vi) Mining or underground excavation (if required)
- vii) Grading
- viii) Replacement of material
- ix) Trench excavation for service lines
- x) Embankments
- xi) Archaeological findings

4.4 Safety Precautions

The Bidder shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc shall be to the Bidder's debit. The additional moving of soil resulting from such damages will not be paid for.

4.5 Over Excavation

Bidder shall ensure that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

4.6 Stockpiles and Disposal

Excavated material from the works selected by the Owner/Consultant for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on site as directed by the Owner/Consultant.

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Distance of stockpiling of excavated material from the pit edge shall be minimum 1.5 meters or half of the depth of the pit whichever is higher. The Bidder shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Owner and shall not be permanently deposited elsewhere. The Bidder shall trim and form the edges of spoil to profiles and levels as directed by the Owner/Consultant.

The placing of materials within the waste disposal areas shall be made in layers not exceeding 0.50 m in thickness in order to obtain an appreciable degree of compaction by means of transportation equipment and/or if required by appropriate compaction equipment.

All traffic to or from the waste disposal areas shall run over the surface of such areas in order to achieve compaction.

4.7 Preparation of Foundation

All earth surfaces, against which concrete is to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Owner/Consultant and then protected by means of a lean concrete layer, 7.5 cm or PCC thickness as shown in the design drawings, whichever is greater. No concrete is to be poured until formation is inspected and approved by the Owner/Consultant.

No structural concrete shall be poured against earth surface. Shuttering shall be used at sides and PCC shall be provided below foundations.

4.8 Backfilling

Foundations and structures shall be backfilled with approved material compacted in layers not exceeding 150 mm by suitable equipment upto the required designed levels. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Owner/Consultant.

Density requirements as per standard Proctor Test shall be in accordance with relevant parts of IS: 2720 and all tests shall be made by/on under the supervision of Owner/Consultant at Bidder's own expenses, at optimum moisture content:

- a) Backfilling of foundations and under grade slabs - 98%
- b) Under roadways and parking areas - 98%
- c) Embankment - 95%

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Owner/Consultant after compaction tests have been made.

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Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the sub-grade.

Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Owner/Consultant.

4.9 Soil Replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange. The suitability of soil for its use for filling shall be as per provisions of Indian Standards.

Prior to the commencement of work, three samples shall be taken from the anticipated borrow area and tested in respect of IS: 2720 or Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

These three samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of not more than 15 cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for watering of soils.

The fill material shall be compacted by vibratory roller (min. weight 20T.). However for small compaction works such as small patches etc., comparatively low weight compactors or other compaction methods may be used after taking approval from Owner / Consultant. The minimum required degree of compaction should be as defined under "Tests and Properties". One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Owner/Consultant. The Bidder shall either provide all required laboratory facilities and staff to perform the tests or he shall co-operate with an experienced soil testing laboratory, subject to the approval of the Owner/Consultant.

Filling work may be continued in case all tests performed show satisfactory results.

4.10 Protection of Existing Utilities and Services

During modification/rehabilitation of existing structures or construction of new structures, the Bidder shall provide all protection for existing utilities and services as may be required by his modification and construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Owner/Consultant.

In addition to the requirements as specified, herein the Bidder shall comply with the following requirements:

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- a) Use all necessary precautionary and protective measures required to maintain existing structures, utilities, services and appurtenances that must be kept in operation. In particular, the Bidder shall take adequate measures to prevent undermining of existing structures and utilities/services presently in service.
- b) Protect existing or new utilities and services where required by the Bidder's operations and/or as directed by the Owner/Consultant. The Bidder shall be responsible for bracing and supporting existing structures, utilities and services to prevent settlement, displacement or damage.

4.11 Dust Control

The Bidder shall use all means necessary to control dust on roads, dismantling/demolition and modification areas, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

4.12 Dewatering during Construction

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the detail soil investigation and/or information given in writing by the Owner/Consultant.

Ground water control for keeping the construction pits dry shall be included in the Bidder's scope of work.

The method and technique shall be based on the IS: 3764.

The scope of supply includes removal of all equipment, plants, pipes, machinery, etc for modification /rehabilitation of existing foundations and re-installation of all equipment, plants, pipes, machinery, etc and its removal after completion including operation & maintenance of the equipment during the construction period.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that alterations and extensions can be made at any time throughout the operating time, if necessary. Reserve units shall be kept ready for service when failure of any of the installed units occurs.

The Bidder has to consider the possibility of a temporary failure of any pump, diesel engine and/or the electric power service and shall install emergency power units with sufficient capacity to feed the necessary power to the installed unit at the moment of failure. The Bidder shall submit to the Owner/Consultant, the detailed method of the envisaged pumping system for dewatering, the pump

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capacity and the standby reserve units. The Bidder shall adjust the system if required by the Owner/Consultant.

The Bidder must ensure that any dewatering works will not cause any interference to his own work and to those of other Bidders working elsewhere on site. Any damage occurring during the above mentioned period should then be made good by the Bidder at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least *[0.50]* m below the foundation level.

4.13 Equipments

All equipments, instruments, machineries, tools, pipelines, etc required for execution of the water control shall be kept in good working condition throughout the operation period.

4.14 Execution

The Bidder shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to the Owner/Consultant for information and checking every working day. For that purpose, the lowering of the water table shall be controlled by piezometers. The numbers and position of them shall be submitted to the Owner/Consultant's approval. The Bidder shall provide and maintain these piezometers at his own expenses during the dewatering works or as long as the Owner/Consultant requires it.

Pump operations shall not be stopped nor pipes, channels and equipment for dewatering and water control removed or altered in any way, except with the express permission of the Owner/Consultant. The Owner/Consultant will stipulate the time of removal. Until then, the pumps and water drainage facilities shall be kept in proper working order without extra payment being granted.

Pump sumps and channels:

Provision of pump sumps and channels of the dimensions required for each particular case shall include all necessary excavation of any kind of soil above and under water, backfill and consolidation, sheeting, bracing, stiffening, sealing, scaffolding accesses, as well as the disposal of water and all auxiliary works.

Routing of channels or pipes for discharge water shall be such as not to impede or obstruct any of the other works and/or operations.

The same shall be applicable for pump sumps. Prior to the determination of any arrangement of pump sumps, the Owner/Consultant's approval shall be obtained.

Routing and location of water discharge lines shall be submitted to the relevant authorities and to the Owner/Consultant's approval.

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Difficulties during dewatering:

The Bidder shall consider all difficulties and additional work due to the presence of unexpected ground water during subsequent construction work. Where it is possible to keep off or divert such water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from Owner/Consultant has been obtained.

Ready for service condition:

The Bidder shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by the Owner/Consultant in this matter shall be carried out immediately.

Leakage:

Blockouts and pipe connections through structures and their closure, proper grouting of joints, etc or repairs in the event of leakage shall be the responsibility of the Bidder.

Piezometers:

The ground water lowering effect is to be checked by piezometers in unfavourable positions (e.g. in the middle of the building pit) before starting the excavation. The piezometers are to be installed at unfavourable positions or in more permeable layers (in stratified sub-soil) below the bottom of the excavation. They serve to check whether or not the water pressure (head) has been sufficiently reduced in those layers below the bottom of the excavation, which are more permeable. Security against hydrostatic uplift is to be demonstrated by calculation.

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5 REINFORCED CONCRETE STRUCTURES AND FOUNDATIONS

5.1 General

All structures, building foundations, machines / equipment foundation, water retaining structures, trenches, pits, etc. shall be designed as per latest relevant IS codes in general. Construction in general shall follow provisions of IS: 456 and IS: 3370 for normal and water retaining structures respectively.

5.2 Design Methodology

a) General

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456.

IS: 11384 shall be followed for design of steel concrete composite beam.

For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

b) Foundation and Underground Structures

Type of foundation system, i.e. isolated, strip, raft shall be decided based on the loading arrangement, load intensity and soil strata. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

Foundation system adopted shall ensure that settlement / relative settlement is as per provision of IS: 1904 and other Indian Standards. However, the settlement shall be restricted to a lower value, if necessary as per the system requirement.

All foundation including machine / equipment foundations shall be of RCC construction. All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian standards IS: 2974 and IS: 456. Raft foundations shall be designed as per IS: 2950.

All foundations shall be treated as per the guidelines prescribed in IS 456: 2000 against sulphate/other aggressive chemicals if found present in soil or as per the requirements of detail Geotechnical Investigation Report.

For design of underground structures, subsoil water level shall be assumed at Finished Ground level. All underground pits, tunnels, basements, cable and pipe trenches, etc. shall be designed as leak proof RCC structure, where depth of ground water table so warrants. In case of leakage in the above structures injection grouting method shall be applied to repair the structure according to

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the requirement of IS: 6494. Effects of uplift and reduction in bearing capacity due to underground water table shall also be considered.

For Subsoil conditions, Average ground water table, Foundation system, Earth Pressure Coefficient, refer to detail geo-technical investigation report of the site.

The soil conditions met during the foundation works especially in the foundation level are to be checked by the Bidder's soil Engineer, recorded and compared with previous known or investigated results. If essential differences occur, which could be detrimental to the structures, the Bidder has to inform the Owner/Consultant and to propose further measures. Foundation works in such areas are to be continued only after approval of such measures by the Owner/Consultant

If there is any doubt about the soil quality or if discrepancies appear with regard to the previous decisions or investigations stated by the Owner/Consultant, then additional measures are to be taken after consulting the Owner/Consultant (e.g. additional excavation and lean concrete fill)

Allowable settlements, elastic plus consolidation, shall be limited as follows: -

- i) Total settlement : 38 mm
- ii) Differential settlement : 6 mm

Foundations for equipment shall be designed to meet the total and differential settlement established by the equipment manufacturer if they are more stringent than the allowable settlements listed above. Foundations for buildings shall be designed to meet the total and differential settlement as required for the building function if they are more stringent than the allowable settlements listed above.

c) Settlement and Expansion Joints

Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS: 8009 – "Code of Practice for calculation of settlement of foundation".

d) Foundations at Different Depths

Foundations at different levels should be based beyond a load-spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure) of the higher-level structures on the lower ones must be taken into consideration.

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e) Replacement

If unsuitable soils are encountered below the grade slabs or basement floor, they are to be replaced by suitable layer wise compacted material down to the good bearing soil.

Materials and compaction method as well as quality control are described in clause 'Earth and Rockworks' of this section. Selected fill is to be employed below all grade paving and basement floors.

f) [Liquid Retaining Structures]

[RCC water retaining structure like storage tanks shall be leak proof and designed as un-cracked section in accordance with IS: 3370 (Part 1 to IV) by working stress method. However the parts of such structures not coming in contact with liquid may be designed according to IS: 456.]

Water channels and substructure of pump houses shall be designed as cracked section with steel stresses as per IS: 3370 (Part 1 to IV) by working stress method and limiting crack width to 0.2 mm.

All water retaining / storage structures shall be designed assuming liquid upto the height of wall irrespective of provision of any over flow arrangement. No pressure relieving devices shall be permitted in underground structures.

In all liquid retaining structures, PVC water bar shall be provided at each construction / expansion joint. The sequence of construction shall also be specified on drawings showing construction joints.

The walls shall be designed for a surcharge load of 2000 Kg/m² or actual whichever is higher.

Liquid Retaining Structure shall be checked for two loading conditions. With water inside up to operating level and no earth fill outside or water in one compartment and no water in the other compartment (where two compartments are provided).

Base slab / raft of all liquid retaining structure shall be designed to withstand the uplift pressure.]

g) Modification of the existing foundation (as required) for the new equipment supplied

The new equipment shall be supported on an RCC deck which in turn shall be supported over steel helical springs and viscous dampers. The steel helical springs and viscous dampers shall be supported over structural steel beams which in turn shall rest over columns. The columns shall be supported over foundation. The modification of existing foundation may involve partial to full dismantling and reconstruction of new foundation as per design & constraints of space.

Precautions shall be taken not to disturb the basic building structure & other foundation and it shall be ensured that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to

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adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

The contractor shall be responsible for maintaining all safety norms including the stability of existing structures. Any propping, shoring and under pinning required to this effect shall be put in place before the dismantling work is undertaken.

Wherever any existing concrete member is required to be partially dismantled, a coat of epoxy paint shall be applied to the exposed reinforcement and the cut surface of concrete shall be built up by providing 40 mm thick concrete with wire mesh.

h) Machine Foundations

General

Design of equipment foundation for block type machine foundation (if any) shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in mind the existing structural arrangement and space limitation.

Block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times the mass of machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes and/or machine manufacturer's recommendations whichever is more stringent shall be satisfied. Minimum reinforcement for all machine foundations shall be governed by 18:2974 and 18:456.

The following geotechnical data shall be worked out from the soil investigation:

Bearing capacity

Total permissible settlement

Bulk Density

Poisson's Ratio of founding strata

Shear Modulus (G) (average)

The design of machine / equipment foundation shall be as per IS: 456 and IS: 2974. The provisions of DIN 4024 shall also be followed for machine foundations. All machine / equipment foundations and structures subject to vibrations shall be suitably proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

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For the foundations supporting minor equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining part of building and other foundations. Joints at floor/ slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitable to ensure integral action.

The frequency criteria and amplitude criteria shall be satisfied for all values of shear modulus (G) ranging from 0.5 times the average value to 1.5 times the average value.

The extent of foundation shall be based on the general arrangement of the equipment and the design requirement. However minimum width of any foundation shall not be less than one meter. Water table has to be considered at finished ground level for design of all foundations.

Suitable arrangement shall be made for prevention of transmission of vibration from the proposed foundation to the nearby structure/ foundation/ paving slab.

All design calculations and drawings shall be submitted to Owner for approval.

In case any modification to any existing nearby structural steel bracing/support system/ concrete work is required, the contractor shall check the adequacy of the design of the existing structures for the new loads. Suitable modification to the existing structure as required shall be carried out by the contractor.

Loose pockets if any found below the foundation shall be removed and filled up with PCC of grade M10.

Loads

All static and dynamic forces / loads which equipment supplier considers applicable shall be considered for analysis and design of machine foundations.

Foundation Sizing

The outline plan dimensions of foundations as given by the machine supplier will be adopted. The height of foundation will be selected after taking into consideration soil strata and operating level of the machine. The eccentricity of common CG of machine and foundation with respect to the centroid of base area should not exceed 5 % of the corresponding base dimensions of foundation. Partial contact between the foundation and soil strata shall be considered wherever applicable. The footing will be checked for minimum contact area of 80 % and maximum bearing pressure will be calculated for the actual contact area only.

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Analysis and Design

The minimum grade of reinforced cement concrete shall be M25, unless specified otherwise.

The analysis and design of machine foundations will be carried out to ensure the following:

- Compliance with the manufacturer's requirements and relevant standards
- No resonance phenomenon of a disturbing nature to machine operation should exist at the normal running speed
- Calculations to be performed for dynamic as well as static cases for reinforced concrete block type pedestal
- Soil bearing capacities
- Deep foundation capacities
- Lateral earth pressures
- Allowable settlements
- Structure, equipment and environmental loadings
- Equipment performance criteria
- Access and maintenance requirements
- Temporary construction loadings

The foundation will be designed for the most critical combinations of forces and moments, resulting from all possible combinations of the various loading from the equipment system. The foundation sections will be sized and reinforced adequately for bending moments and shear stresses and uplift.

The foundation shall be checked for overturning, sliding and uplift as per relevant IS Codes. The foundation will be checked for overturning with minimum and maximum vertical loads.

For analysis of machine foundation following data will be furnished by the equipment manufacturer:

- Loading diagram showing static and dynamic loads and points of application of loads
- Operating speed of machine
- Weight of rotating parts, maximum eccentricity of rotating mass from the geometric axis of rotation
- Location of C.G. of machines in all three axis
- Mass moment of inertia
- Allowable amplitude / velocity of vibration at machine bearing points
- Temperatures at various areas during operation

While designing following aspects shall also be taken care of:

- All dynamic foundations shall be isolated from building foundations. The isolation gap shall be of minimum 25 mm.

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- Natural frequencies of structures and components shall be away from running speed of equipment by at least 20 % generally but for important ones it shall be away by at least 30 %.
- For design of foundation of large fans etc., provision shall be kept in the foundation for addition of mass / area for retaining of the foundations if required at a later date

However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral loads shall be 1.5
- Factor of safety against sliding shall be 1.5
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5. Uplift check shall be carried out during construction stage also.

For miscellaneous machines, most suitable type of foundation shall be provided. Foundation for pumps, and minor rotating equipment etc., are usually in the form of solid block foundations, resting on the ground or on a floor of the building. At such machine supports, floor may be thickened and extra reinforcement may be provided. Also the machines, which are almost vibration free, light to moderately heavy, may be supported in the above manner. Rubber or neoprene pads under some of these machines to reduce transmission of vibrations to the supporting floor will be provided if required.

All block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456. Suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining foundations.

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25°C when placed. For maintaining the temperature of 25°C in the top decks of machine foundations, crushed ice shall be used in mixing water.

Non-Shrink Grout for Equipment Foundations

Special non-shrinking grout of approved make shall be provided in strict accordance with the manufacturer's instructions / specifications. Ready mix non-shrink grout of GP2 brand or equivalent, of approved make shall be used for base grouting of major rotating equipments.

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(a) Increase in Stresses

Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

Bearing capacity of the soil shall be allowed to be increased by 25 % under seismic/ wind load condition.

(b) Elevated Foundations

Design of all equipment foundations shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in view the existing structural arrangement and space limitation. Adequacy of the design of the existing structures, for the new loads shall be, checked by the contractor. Suitable modification as required shall be carried out by the Contractor and complete design for the same shall be furnished to owner for approval. Where ever new columns/foundation is required the same shall be designed and constructed by the contractor as per relevant Indian Standard Code.

For the foundations of the all equipments details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic forces as per IS:1893. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Design of RCC foundations/as well as structures, checking of design of existing structure shall be carried out by working stress method. A fatigue factor of 2.0 shall be considered for dynamic forces.

The foundation general arrangement shall be such that the spring units are placed over the structural steel beams. The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The vibration amplitudes at the bearing locations shall not exceed the limits as per VDI 2060 or limits specified by the machine supplier whichever is more stringent. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

The grade of concrete for the top deck shall be M35.

(c) Steel Helical Springs and Viscous Dampers

The supporting structural beam and columns shall be designed for the loads transferred through springs and all other loads such as piping loads, seismic loads as per IS:1893. The stiffness of the beams supporting the springs shall be at least 10 times the stiffness of the springs supported over it along both vertical and horizontal direction.

The scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implied for the

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successful completion of the work for which these specifications are intended.

Scope of work of the bidder shall include manufacturing, testing, supply, transport to site, pre-stressing, erection, supervision of erection, release of pre-stress, alignment, commissioning etc of Steel helical springs and viscous dampers:

- Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
- Frames for pre-stressing of spring elements.
- Suitable hydraulic jack system including electric pumps, high-pressure tubes etc. required for the installation, alignment etc, of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.
- Any other items which may be required for the complete installation and satisfactory commissioning of the spring system.

Supervision of complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

The steel helical springs and viscous dampers supplied should be of proven make. The bidder or his sub-contractor should have designed spring supported machine foundations, manufactured, supplied and installed steel helical springs and viscous dampers (conforming to DIN 2096 & DIN2089) and viscous dampers (providing damping resistance in all three planes) for not less than 2 (two) machine foundations of heavy rotating machine systems such as ID/FD/PA fans and coal mills.

The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of units.

All design calculations and drawings shall be submitted to Owner for approval.

5.3 Stability of Structures

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like underground storage tanks, pits, trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For the purpose of calculating downward load due to any

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overburden, only the mass located vertically above the projected area of the base slab shall be taken in to consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS: 456 and other latest relevant IS codes. However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum
- Factor of safety against sliding shall be 1.5 minimum
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In cases where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

5.4 Minimum Thickness of Concrete Structural Elements

The following minimum thickness shall be followed:

Table 2.5
Minimum Thickness of Concrete

S.No	Description	Thickness, mm
a)	Suspended floor / slab / walkways /canopy slabs, etc.	125
b)	Ground floor slab (non-suspended)	150
c)	Water Retaining slabs / walls	200
d)	Cable/pipe trenches/underground pits/Laundry walls and base slab	125
e)	All footings (including raft foundations)	300
f)	Parapets	125
g)	Sunshades	75 at edge
h)	Precast louvers / fins	50
i)	Precast trench cover slabs / floor slabs / louvers	75
j)	Paving	100
k)	Basement walls and base slab	200
l)	Underground tank: Below ground water table	200

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S.No	Description	Thickness, mm
	Above ground water table	150

From fire resistance point of view minimum cover to reinforced concrete members shall be as per Table 16A of IS: 456.

5.5 Minimum Heights for Pedestal of Steel Columns

Pedestals to Steel Columns for building structures:

Top of RCC foundations (pedestals) shall normally be kept at a minimum [250 mm] above finished floor level (FFL) unless specified otherwise. Foundation levels for columns shall be decided to accommodate underground services, pits, trenches, etc.

Stair and ladder pedestal shall be kept [200 mm] above the finished floor level.

Pedestals to Steel Columns for Equipment structures:

- a) Equipment in open area : as required [(300 mm min)]
- b) Equipment in covered area : as required [(150 mm min)]
- c) Structures and equipment
- Supplied by vendor : as per vendor's data subject to minimum as specified above.

5.6 Minimum heights for encasement of steel columns

In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following:

- a) Open area : [300 mm] above paved level
- b) Covered area : [150 mm] above FFL

5.7 Concrete Works

i) General Description, Proportions and Mixing Mix Design

At the commencement of the contract the Bidder shall make preliminary tests to determine the proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling and placing and when concrete hardens, it shall have the required strength, durability and surface finish. The Bidder shall get approval of Owner/Consultant to such proportions before he starts concreting. However, such approval shall not relieve the Bidder of his responsibility to produce concrete having compressive strengths as laid down in the foregoing Table.

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No departure from the approved proportions will be permitted during the works unless and until the Owner/Consultant gives written authorisation for any change in proportion. The Owner/Consultant shall have authority at any time to check whether the mixing of concrete is being carried out according to the approved proportions.

For the all major and important R.C. works and for all special works, the design of mixes shall be made by the Bidder at his own cost, for each grade of concrete as well as for various workability. The design of mixes shall be made according to I.S. 10262 or any other approved standard methods.

The concrete made by designing the mix is termed hereinafter as "Design Mix Concrete".

The cement content for various grades of concrete shall be based on design mix. However, irrespective of requirement of cement found out from design mix, cement content of concrete shall not be reduced below the quantities specified as under.

Grade of concrete	Minimum cement content per Cu.m finished concrete
M-15	290 kg
M-20	320 kg
M-25	380 kg
M-30	not less than 400 kg
M-35	not less than 400 kg

ii) Water Cement Ratio

Where a particular water cement ratio is stipulated in the design or drawing along with the characteristic grade of concrete the design of mix shall be carried out by adjusting the other variable factors to obtain the characteristic strength of concrete with stipulated water cement ratio.

In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, such as water retaining structures, basements, underground premises, tunnels, pump houses, pre-stressed structure, thin precast members etc. the water cement ratio shall be kept low and preferably not exceeding 0.45.

The water cement ratio, as achieved in the Mix Design, or as specified in the drawings shall be adhered to strictly and shall not be varied without the permission of the Owner/Consultant.

iii) Workability

The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling & placing so that after compaction it becomes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

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The workability of fresh concrete at the place of batching/mixing shall be measured by compacting factor test and at the place of disposition by means of slump test. During the finalisation of Trial Mixes, the relationship between compacting factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS:1199.

Normally, in the condition of low water cement ratio as well as for medium/high workability, the workability shall be achieved by increasing the cement content, in consistent with added water.

In cases where the cement content is to be limited to reduce the heat of hydration, and the water/cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of plasticiser or air entraining agent. In such cases the method of mixing and dosage of the plasticiser/air entraining agent shall be according to the manufacturer's specification and with the approval of the Owner/Consultant.

The usual limits of consistency for various types of structures are given below:

iv) Limits of consistency

Degree of Workability	Slump in mm with Standard - Cone		Use for which concrete is suitable as per IS : 1199
	Minimum	Maximum	
Very low	0.0	25.0	Large mass concrete structure with heavy compaction equipment, roads and the like.
Low	25.0	50.0	Uncongested wide and shallow R.C.C structures
Medium	25.0	75.0	Deep but wide R.C.C structures with congestion of reinforcement and inserts
High	75.0	125.0	Very narrow and deep R.C.C structures with congestion due to reinforcement and Inserts

v) Durability

The durability of concrete, depending on the exposure condition, is to be taken into account while designing the mix. For given aggregates, the cement content should be sufficient to make sufficiently low water cement ratio and Appendix A of IS: 456 shall be taken as guideline for durability considerations.

Minimum fire rating of 2 hours shall be considered where fire hazard is expected and accordingly minimum cover shall be taken as per Table 16 A of

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IS: 456. For structures below ground level which are exposed to sulphate attack, requirement of cement shall be as per Table 5 of IS: 456. Intermixing of different grades of concrete in the same structure shall not be allowed in a particular element.

Mix design concrete shall be used for all areas other than plain concrete work used for lean concrete, screeds and backfill.

The following minimum grades of concrete as per IS: 456 shall generally be used for the type of structures noted against each grade.

Table 2.6
Grades of Concrete

Concrete mix/Grade	Type of structure
1:5:10	Fill concrete
1:4:8	Blinding layer below foundations, trenches and underground structures, foundation below brick wall, etc. Minimum thickness of layer shall be 75 mm
M15	Plinth protection work around buildings
M25	Base plate encasement, encasement of structural steel work, all RCC paving work, ground floor slabs, cable and pipe trenches, precast concrete work etc.
M30	All RCC structures and equipment foundations, super structure, grade beams, columns, roof slabs and all underground RCC structures, cable and pipe rack foundation, pedestals, etc. water retaining structures below and above ground, boiler foundations, mill foundations, etc.

Inter mixing of different grade of concrete in the same structure shall not be allowed normally.

vi) Trial Mixes

- Before concreting commences, the Bidder shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation. Only materials which the Bidder intends to use for concreting (including all admixtures) shall be used in the trial mixes.
- Test cubes from trial mixes shall be made and tested in accordance with IS: 516.
- As per IS: 456 and IS: 516, three separate batches of concrete should be made, workability of each batch determined and three test cubes shall be made from each batch for each age (e.g. for 7 and 28 days) at which tests are required. The strength shall conform to target mean strength as per IS: 456 – Requirements for design mixes.

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- The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength and if the average strength of the nine cubes is not less than recommended by IS: 456 and IS: 516, trial mixes.

vii) Quality and Testing

Not more than 5% of the test results may fall below the 28 days specified strength. Making and curing of test specimens shall be in accordance with relevant IS: 456, IS: 516 and IS: 1199.

All mixes can only be placed following approval by the Owner/Consultant. The mean strength shall exceed the characteristic strength by a margin of 1.65 times the standard deviation expected from the batching plant. However, no standard deviation less than 3.5 N/mm² shall be used as a basis for designing a mix.

viii) Trial Mixes and Field Tests

Sufficient laboratory trial mixes shall be prepared to show that concrete complies fully with the specified performance criteria. The following tests are to be included:

- Air content < 1%
- Slump: Piles 170 + 25 mm, regular work 80 + 20 mm as per IS: 1199
- Fresh and hardened concrete densities
- Field trial mixes shall be carried out under full-scale site conditions as per IS: 4925 (for structural concrete only).
- Where directed by the Owner/Consultant, concrete incorporating reinforcement details shall be cored to assess stratification of mixes. Cores of 150 x 200 mm (diameter and length) shall be used.
- Each trial mix shall have 9 x (150 x 150 x 150 mm) cubes taken to measure 24 hours/7 days and 28 day compressive strengths. These trials shall be run for three consecutive days (for structural concrete only).
- At least 3 x sets of field trials shall be tested according to the provisions laid down in laboratory testing.
- The average 28 day characteristic strength for trial mixes shall be as per IS 456. Failure to comply shall result in the mix having to be re-designed.
- All test results shall have to be complied before approval can be given.

ix) Consistency of Concrete

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete

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before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests measured in accordance with IS: 1199 and shall not exceed the values given in clause 7.1 of IS: 456-2000.

x) Mixing of Concrete

- The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way and shall comply with the requirements of IS: 456, IS: 1791 and IS: 12119.
- The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than 2 (two) minutes after all the materials and water are in the drum.
- Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

xi) Laboratory

The Bidder shall establish and maintain a field laboratory on the site and this laboratory shall be available at all time to the owner.

The laboratory must have qualified technicians to carry out all tests and must be adequately equipped to ensure that all necessary testing work can be carried out in compliance with the standards.

5.8 Strength of Concrete

i) Testing of fresh concrete by means of test cubes

- a) All test cubes shall be made and tested for compressive strength in accordance with IS: 456, IS: 516 and IS: 1199.
- b) The minimum required strength for different classes of concrete shall be as shown in clause "General description and proportions and mixing" here above.
- c) The grade of concrete required will depend partly on the particular use and the characteristic strength needed to provide the structure with adequate ultimate strength and partly on the exposure conditions and the cover provided to any reinforcement.
- d) A minimum of four test samples (of six test cubes each) shall be taken on each concreting day (from the same mix) and for at least each 40 m³ of concrete mixed. At least one sample shall be taken for each shift.
- e) For columns, beams and cantilevers seven (7) cubes for every 15 m³ of concrete poured shall be taken. The concrete for test samples shall be taken directly from the concrete mixer and shall be handled (vibrated etc) under similar conditions to those prevailing during the construction.

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The moulds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.

- f) The strength level of each type and each strength concrete will be evaluated separately and the concrete strength will be considered satisfactory if:
- Compressive strength: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-
 - The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column 2 of table 11 of IS: 456.
 - Any individual test result complies with the appropriate limits in column 3 of table 11 of IS: 456.
 - Flexural strength: When both the following conditions are met, the concrete complies with the specified flexural strength:-
 - The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2 .
 - The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2 .
- g) If the results are less than those specified, the Owner must suspend all concreting work and order further tests. Any concrete found not to comply with the specification shall be broken out and replaced to the satisfaction of the owner.
- h) The Bidder shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

ii) Testing of concrete in structures

- a) The types of tests described hereinafter are applicable to the finished parts of the structures. They may be used in routine inspection and for quality control.
- b) Type of tests:
- Cutting cores: The procedure used shall comply with the requirements of IS: 516 or an approved equivalent standard.
 - Gamma radiography: The testing shall be carried out in accordance with the requirement of IS: 13311, part 1 or equivalent.
 - Ultrasonic test: Such tests may be used to obtain approximate indications of the strength of the concrete in the structures (IS: 13311, part 1).
 - Electromagnetic cover measuring devices: Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design (IS: 13311, part 1).

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- Rebound hammer test: Such tests may be used to obtain approximate indications of the strength of the concrete (Ref. IS: 13311, part 2).
 - Load tests of structures or parts of structures: If the results of the above mentioned check tests show that the quality of the materials is inadequate or if other defects are revealed, the owner may require a loading test to be made.
- c) For the purpose of testing floors, roofs and similar structures and their supports, the test load shall be equivalent to the sum of the characteristic dead load and one-and-a quarter times (1.25 times) the characteristic imposed load for a period of 24 hours which the works or part thereof to be tested have been designed.
- d) Wherever certain procedures for testing of parts in structures are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Owner/Consultant.
- e) If within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under superimposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.
- f) If the result of the test is not satisfactory, the Owner/Consultant shall instruct that the part of the works concerned be taken down or cut and reconstructed to comply with this specification. The Bidder shall at his own cost take down or cut out and reconstruct the defective work.
- g) The Owner/Consultant may require other tests to be made. Number of samples, tests and types will be as per Owner requirements.
- h) All the costs for the above mentioned tests shall be borne by the Bidder.

5.9 Materials

a. Storage of materials

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Storage of materials shall conform to IS-4082 "Recommendation on stacking and storage of construction materials and components at site". Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Bidder.

b. Cement

OPC / PPC Cement of reputed make conforming to relevant codes, shall be used for all Concreting works and the certificate of manufacturer shall be furnished with each batch. Cement used shall be ordinary Portland cement

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unless the chemical nature of the soil warrants special cement for structures below ground level.

Sampling and Testing of Cement

- All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties as required by relevant IS: 8112 for grade 43 and IS-12330 for sulphate resistant cement.
- The manufacturer's test certificate will normally be accepted as proof of compliance with the specification, but the Owner may order further tests of a character specified in the appropriate Indian standards. The confirmatory tests are to be conducted by a recognized quality control organization. The Bidder shall bear all expenses required for the preparation, dispatch, and tests of the samples. In case the results of such tests show any sample to be inferior to specifications, the whole consignment from which the sample was taken shall not be used and shall be immediately removed from the site.

Delivery and Storage of Cement

- The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture, date of original loading, destinations en-route, date of unloading, intended date of delivery to site.
- The Bidder shall obtain and provide to the owner the manufacturer's average test certificate for each consignment of cement to the works.
- The certificates shall be provided before the consignments are required for use and shall show the chemical composition and physical properties determined in accordance with the relevant standard.
- Samples shall be taken from each consignment of cement and tested as directed by the owner in an approved independent laboratory.
- Consignments shall be used in the order in which they were delivered.
- Bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the owner before any cement is delivered to site.
- Each consignment of cement shall be separately stored for ease of access, identification, inspection and sampling. Sufficient stocks shall be maintained on site to ensure the proper progress of the works and the stock holdings shall be to the approval of the owner.
- No cement from any consignment shall be used in permanent works without the approval of the owner.

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- Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter or which has been contaminated or is otherwise unsatisfactory in the opinion of the Owner/Consultant will be rejected and shall be removed from site without delay.
- The Bidder shall be responsible for satisfying himself that the performance characteristics of cement are not such as to necessitate excessive cement content or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete notwithstanding apparent compliance with this specification.

c. Reinforcing steel

General

Reinforcing steel used in reinforced concrete shall comply with the following standards:-

Deformed bars shall be of grade Fe500 and conform to IS: 1786.

Mild steel shall conform to IS: 432.

Mesh reinforcement shall conform to IS: 1566.

Binding wire

Binding wire for general use shall be annealed wire 16/18/20 BWG conforming to IS 280. The number of strands shall be as per IS specification.

Reinforcement supports

- Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing; supporting, and fastening the reinforcement.
- Spacers shall be cast from concrete of the same quality as that in which they will be embedded.
- Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.
- Binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the Bidder shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

Certificates

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analyzed and the date of such tests and analyses and that such tests

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and analyses comply in all respects with the standards. The following tests shall be carried out on reinforcement:-

- Cast analysis
- Carbon equivalent value
- Tensile strength, yield stress, elongation
- Bend test
- Bond classification
- Chemical analysis

Stock of reinforcing steel

In order to ensure due progress of the works, the Bidder shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted as satisfactory by the Owner/Consultant.

Rejection

The owner at his discretion may order random testing of the reinforcement steel and in the event of any failed test reject the entire lot notwithstanding the manufacturer's or coating applicator's certificates.

The Bidder shall remove all rejected reinforcing steel from the site without delay at his own expense.

Storage

All bars for reinforcement and steel fabric reinforcement shall be stored on the site under cover on timber or concrete supports suitably spaced and of sufficient height to keep the steel not less than 150 mm clear of the ground.

Bar-bending Schedules

The Bidder shall prepare bar bending schedules based on the detailed reinforcement drawings. These shall be presented to the Owner/Consultant for review. The Bidder is fully responsible for their completeness and correctness in every way nor shall any claim for extra cost or time be allowed on the grounds of errors or discrepancies which may arise between drawings and schedules.

d. Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. pH value of water shall not be less than 6.

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Only potable water shall be used. Tests and quality of water shall be in accordance with IS: 456 or equivalent.

e. Aggregates

General

The aggregates for concrete shall be crushed natural rock subject to Owner's approval.

The aggregate to be used in the work shall be supplied from an established pit or quarry.

The concrete supplier shall obtain from the aggregate producer, or otherwise provide current test, examination, and inspection reports performed and certified by an approved laboratory for submittal to the Owner/Consultant.

As a minimum, this information shall include the following items:-

• **Item 1**

A comprehensive description, with current photographs of the pit or quarry, including but not limited to, identification by name and location, type of deposit, age, potential reserves, primary products by size including average gradation based on previous six (6) months production and the range for each sieve size; mining methods, process equipment, quality control organization and laboratory; the primary and alternate means of product transportation; listing of primary and secondary users of the product.

• **Item 2**

Petrographic examination in accordance with IS: 2386 (Part-8) and ASTM C-295 performed by a qualified concrete aggregate petrographer. This report shall be based on material produced and examined within the previous six (6) months and must be representative of the current production.

• **Item 3**

Coarse aggregate shall be sampled from current production in accordance with IS: 2386 (Part 1 to 8). Three [20 mm, 10 mm & 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:

IS 2386(Part 1): Methods of test for aggregates for cement: Part 1
Particle size and shape (Amendments 3)

IS 2386(Part 2): Methods of test for aggregates for concrete: Part 2
Estimation of deleterious materials and organic impurities (Amendment 1)

IS 2386(Part 3): Methods of test for aggregates for concrete: Part 3
Specific gravity, density, voids, absorption and bulking

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IS 2386(Part 4):	Methods of test for aggregates for concrete: Part 4 Mechanical properties (Amendments 3)
IS 2386(Part 5):	Methods of test for aggregates for concrete: Part 5 Soundness
IS 2386(Part 6):	Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregates (Amendments 2)
IS 2386(Part 7):	Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity
IS 2386(Part 8):	Methods of test for aggregates for concrete: Part 8 Petrographic examination
ASTM C-295	Standard guide for petrographic examination of aggregates for concrete

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the Owner/Consultant shall meet the requirements of IS: 383 and IS: 456.

Testing is to be carried out at the following intervals:

Table 2.7
Grades of Concrete

Type	Coarse Agg.	Fine Agg.
Grading	Daily	Daily
Specific Gravity	7 days	7 days
Magn Sulphate soundness	30 days	-
Clay, Silt and dust content	Daily	Daily
Shape (elongation and flakiness)	3.5 days	-
Los Angeles Abrasion	Initial stage only	Initial stage only
Moisture content	2 days	Daily
Drying shrinkage	Initial only	Initial only
Organic impurities	30 days	30 days
10% fines value for concrete	7 days	-

Combined grading shall also be done on a daily basis.

Storage and handling of aggregates

- Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent wind blown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.

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- Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect against wind blown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.
- Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.
- Rescreening Coarse Aggregate: Rescreening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If rescreening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.
- Natural or manufactured sand shall be allowed to drain until it has reached somewhat uniform moisture content before it is used.

Fine Aggregate

Fine aggregate source shall be manufactured crushed stone or river sand, excluding fines, which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone nor 4% for natural sand.

The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

Crushed Stone Sand

- i) Concrete subject to abrasion 1% by weight
- ii) All other concrete 3% by weight

There shall be no clay or fine silt present.

The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on an IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS: 383.

The grading of the aggregates should be such as to produce a concrete of the specified proportions, which will work readily into position without

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segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of silt adhering to the aggregate is found to be unacceptably high.

Coarse Aggregate

Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The unit weight of the coarse aggregate shall not be less than 2.5 t/m³. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm² when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

Samples of aggregates shall be submitted to the Owner/Consultant, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the Owner/Consultant have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

f. Concrete additives

Use of Concrete Additives

Concrete additives approved by the Owner/Consultant shall be used to improve consistency, workability, quality and strength of the concrete.

Chemical admixtures manufacturer shall provide certified test reports from qualified independent laboratories showing actual test results indicating material that complies in all respects with the applicable specification.

Admixtures used in concrete shall conform to the appropriate specification and requirements as indicated below:-

- Air entraining admixtures shall conform to IS: 9103.
 - Water reducing and retarding admixtures shall conform to IS: 9103.
- Accelerating admixtures shall not be used.

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- High range water reducers shall be naphthalene-sulfonated polymer based material. No admixtures containing chlorides shall be used.
- Chemical admixture suppliers shall provide certified test reports with each shipment indicating compliance with the appropriate specification. The test reports shall include the chloride content of the admixture, specific gravity and solids content.
- Fibers: Polypropylene fibers shall be collated, fibrillated polypropylene fiber of approved manufacture.
- Admixtures used in production of concrete shall be the same as used in establishing the required concrete mix and shall be used in accordance with the manufacturer's directions.
- Liquid admixtures shall be stored in such a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations.

Accelerating and Retarding Additives

Such additives shall only be used in case of necessity and after obtaining the written approval of the Owner/Consultant.

Plasticizers and Air entraining Additives

Plasticizers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Owner/Consultant and in accordance with the manufacturer's instructions.

5.10 Dismantling/Demolishing and Modification in PCC&RCC

- The dismantling implies, carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of a structure. This includes chipping work, cutting of reinforcement, making holes/opening etc. in concrete members, according to the required shape, size and profile at all elevations.
- The term demolition implies, taking up or down or breaking up of a structure/member, in part or full, as specified or shown in the drawings or as directed by Engineer.
- In a structural member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as directed by the Engineer.
- All material obtained from the demolition/dismantling work shall be property of the Owner, unless otherwise specified.
- All serviceable materials obtained, shall be separated out and stacked properly up to a lead of [500 meter] or shall be returned to OWNER's stores and all unserviceable materials, rubbish etc., shall be disposed off as directed by the Engineer, up to a lead of [2kms].

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- The dismantling / demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process or work.
- Necessary propping, shoring and under pinning shall be provided for safety of adjoining work or property which is to be left intact, before dismantling/demolishing work.
- All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall be taken to keep the dust nuisance down. Safety requirements stipulated in IS: 4130 shall also be followed.
- As and where necessary, the dismantled/demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Engineer. Wherever required, temporary enclosures shall be erected to minimize the dust or moisture infiltration.
- Wherever fresh concrete is laid over old concrete, to ensure proper bond between old concrete and fresh concrete, the surface of old concrete shall be thoroughly cleared by removing all loose particles and coat of epoxy paint shall be applied.

5.11 Minimum Cover to Foundation Bolts

Minimum distance from the centre line of foundation / anchor bolt to edge of pedestal shall be the maximum of the following:

Clear distance from the edge of base plate / base frames to the outer edge of the pedestal shall be minimum 50 mm

Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm

Clear distance from the edge of sleeve or anchor plate to the edge of pedestal shall be 75 mm

5.12 Miscellaneous Requirements

Fillets at the junction of roof and vertical walls shall be provided with cast in-situ cement concrete 1:2:4 (nominal mix) followed by 12 mm thick 1:4 cement mortar.

A screed layer not less than 100 mm thick of cast in-situ concrete of nominal mix 1:3:6 shall be provided below all water retaining structures. A sliding layer of craft paper or bitumen paper shall be provided over the screed layer to destroy the bond between screed and base slab.

Plywood formwork shall be used for all water retaining / conveying structures and for all over ground concrete works. For other areas steel/ plywood formwork shall be used.

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Unless specified 20 mm and down graded aggregates shall be used for all structural concrete works. However 40 mm and down graded aggregates may also be used under special conditions for foundation.

Tolerance for formed and concrete dimension shall be as per IS: 456.

5.13 Major Equipment Foundation

Special requirements for concreting of major equipment foundations shall be as given below:

Coarse Aggregates

Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali aggregate reaction. Materials, which contain high percentage of reactive silica, shall not be used. In exceptional cases of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations, which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundations).

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25° C when placed. For maintaining the temperature of 25° C in the top deck of machine foundations, crushed ice shall be used in mixing water.

Admixture

Plasticizer cum retarder/accelerating type admixture shall generally be added to the concrete for promoting workability in addition to retarding / accelerating setting time for mass concreting work. The Bidder shall submit the mixing proportion/report after conducting the design mix as per the relevant codes and standards. The slump of concrete shall generally be in the range given below:

Fan and Mill deck	: 100mm to 150mm
Block foundation	: 100mm to 150mm
Column	: 100mm to 150mm

Formwork

Plywood formwork shall be used for the top deck of all machine foundations. Any other type of formwork required to be used may be permitted subject to prior approval of the OWNER/CONSULTANT after submission of the required data.

Scheme for Concreting

Batching plants shall be mobilized for all RCC works. Concrete pump shall be mobilized for fans and mill foundations. Arrangements for stand-by Plant and Equipments shall also be made.

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Placing of Concrete

Base mat as well as top deck of machine Foundations shall be cast in a single pour. However the BIDDER shall submit method statements for various structures and shall get the prior approval from the OWNER/CONSULTANT before placing the concrete.

Ultrasonic Testing

Ultrasonic pulse velocity test shall be carried out for the top deck of all machine foundations to ascertain the homogeneity and integrity of concrete. In addition, additional cubes (at the rate of one cube per 150 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values. Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the BIDDER shall rectify the defects suitably using cement / epoxy grout etc.

5.14 Transport of Concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods, which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The Concrete shall be transported by transit mixers of adequate capacity. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Owner/Consultant.

The Bidder shall obtain permission well in advance of any concrete pour.

5.15 Concreting Operations

Inspection prior to Concreting

All concreting methods shall be subject to the approval of the Owner/Consultant.

Concrete placing shall not be started until the Owner/Consultant has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

Placing of Concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The Bidder shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

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The temperature of concrete shall not exceed 40°C measured at discharge into the works.

The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable differential temperature between any two points in the same element is 15°C. Additional temperature control measures during construction (such as the use of insulated formwork) will be required. Bidder to prepare a process control chart and method statement verifying measures to achieve these requirements.

Temperature monitoring of concrete work is required where:

The minimum dimension of any casting is 0.8 metres or more, or otherwise instructed by the Owner/Consultant.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours time shall be subject to the same treatment as the construction joints.

Concrete shall not be dropped into place from a height exceeding 1.5 metres. Trunking and chutes to Owner/Consultant's approval shall be used for any concrete to be deposited from a height exceeding 1.5 m.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

5.16 Compaction and mechanical vibration of concrete

As concrete is being placed it shall be compacted by mechanical vibrators complying with IS: 2505, IS: 2506, IS: 2514 & IS: 4656, to obtain a dense material free from honeycombing, free from water and air holes.

The Bidder shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation/bleeding caused, but complete compaction of the concrete is achieved.

5.17 Finish of concrete

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

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5.18 Construction, expansion and contraction joints

Construction joints

The number of construction joints should be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subject to agreement between the Owner/Consultant and the Bidder before any work commences. Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Concrete should not be allowed to run to a featheredge and vertical joints should be formed against a stop board.

The top surface of a layer of concrete should be level and reasonably flat unless design considerations make this undesirable. Joint lines should be so arranged that they coincide with features of the finished work.

If a kicker (i.e. a starter stub) is used it should be at least 70 mm high and carefully constructed. The kicker must be incorporated with the previous concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

The maximum horizontal length of wall to be poured in one operation in any one direction is 7.5 metres. A period of 7 days to be allowed between adjacent pours except where water stops are provided when this can be reduced with Owner/Consultant's approval. Alternatively a gap of 600 mm width shall be left between adjacent pours and filled after 7 days from the date of formation subject to Owner/Consultant's approval.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible a vibrator should be used.

Where the Owner/Consultant considers that special preparation is necessary, i.e. for an in-situ structural connection, preparation should be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush, which is sufficient to remove the outer mortar skin and expose the larger aggregate. Where this treatment is

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impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking of hardened surfaces should be avoided.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.

Joints shall be straight and vertical, except where otherwise specified, and concrete surfaces on both sides of the joint shall be flush. Where necessary, water stoppers of a type approved by the Owner/Consultant shall be embedded in the concrete. The water stopper should be made of high quality material, which must obtain its resilience through the service life of the structure for the double function of movement and sealing. The surface of water stoppers should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints the water stopper should be provided with anchor parts. The cross-section of the water stoppers should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

All joints between structural steel and concrete parts shall be sealed by a suitable permanent flexible compound.

5.19 Concreting at night

When approval is given to carry out concreting operations (under control of the Owner/Consultant) at night or in places where daylight is excluded, the Bidder has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

5.20 Protective measures for concrete

In general, the cover of rebars shall be as per IS: 456 taking into account the site conditions. However, the minimum concrete cover shall not be less than:

Concrete parts above ground (external surface)	: 40 mm
Concrete exposed to underground & groundwater	: 50 mm
Isolated footings	: 50 mm
Raft	: 75 mm
Slabs	: 25 mm
Beams	: 25 mm
Columns	: 40 mm

Immediately after the compaction of the concrete has been finished, the Bidder shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be

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covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constant moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Owner/Consultant. Where formwork cannot be removed within 24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Owner/Consultant's approval to the use of a particular curing compound and to the method of application will only be given after the Bidder has completed satisfactory site trials and a sample panel has stood for at least 28 days.

Where large sections of concrete are poured, special precautions to the approval of the Owner/Consultant shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete.

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind, however light, shall be allowed on concrete which has not properly set and the Bidder shall prevent any load to be imposed on the concrete structures until it has been declared by the Owner/Consultant to be ready to carry loads.

5.21 Concrete with Special Properties

General requirements

The pre-condition for obtaining concrete with special properties is that it should be made with the appropriate composition, that it is placed in such a way that segregation does not occur and further that it is fully compacted and given appropriate curing.

Waterproof concrete

This concrete must meet the provisions of IS: 3370. Waterproof concrete must be sufficiently dense (impermeable).

Waterproofing and protection of underground concrete structures

Water aggressive to concrete should be kept away from the fresh concrete.

Concrete, which is exposed for a prolonged period to "very severe" chemical attack, must be protected against direct access of the aggressive substances.

The protection, which is to be laid as protection to all concrete surfaces in contact with the ground, shall consist of an approved waterproofing membrane. The membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane.

Such membranes shall be PVC sheets of minimum 0.35 mm thickness with knobs of Maxlock.

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The waterproof membranes shall be installed in strict accordance with manufacturer's instructions.

The membranes shall extend 15 cm above ground level.

When setting forms and reinforcing steel caution shall be exercised to avoid damage to the impervious membrane. The surface of the impervious membrane extending outside the forms shall be protected during subsequent operations.

Any puncture or damaged areas shall be cleaned and patched according to manufacturer's instructions.

Concrete with high wearing resistance

Concrete which is exposed to severe mechanical action, e.g., due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, should possess high wearing resistance and correspond at least to grade M30.

The aggregate upto 4 mm size should consist predominantly of quartz or materials of at least equal hardness; the coarser particles should consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action, it will be necessary to use special hard materials. The particles of all types of aggregate should have a moderately rough surface and be of compact shape. The combined aggregate should be as coarsely graded as possible.

Furthermore, the concrete should be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete should be kept moist for at least 7 days after placing.

Finishing of formed surfaces

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that shall be covered with earth backfill. Exterior surfaces that shall be exposed above grade and all interior surfaces, except those not usually exposed to view shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed. The resulting recesses shall be cleaned, wetted, and filled with patching mortar. Patches on rubbed surfaces shall match the texture of the adjacent concrete.

Finishing of unformed surfaces

No surface treatment shall be required for buried or permanently submerged concrete. As a minimum, unformed surfaces shall be finished by screeding and floating. Surfaces requiring a trowelled finish shall be finished by screeding, floating, and trowelling.

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Float finished and screeded surfaces shall be finished to provide a flat profile within a 6 mm deviation as measured from a 3 m straightedge. Trowel finished surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 3 mm when measured from a 3 m straightedge.

Screeding

Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

Floating

The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and colour.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

Trowelling

The exposed portions of the tops of equipment bases, tops of interior curbs, and the surfaces of interior slabs not receiving a separate finish shall receive a steel trowel finish. Trowelling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Trowelling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

Surfaces to be covered with neoprene-hypalon coatings shall be lightly trowelled but not burnished.

Brooming

Brooming shall follow the float finish for exterior surfaces where a nonslip surface is required. Brooming shall be done with an acceptable steel or fiber broom not less than 450 mm wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1.5 mm and 3 mm deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

Aggregate Exposure

Surface mortar shall be removed and the aggregate exposed from surfaces that shall be covered with mortar, concrete, or grout at a later time.

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Edging

Unless specified otherwise, exposed edges of floated or troweled surfaces shall be edged with a tool having a 6 mm corner radius.

Finishing mortar

Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 102 kilograms of concrete sand to one sack of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 50 mm.

Separate finishes

Certain slabs surfaces shall be finished with a separate concrete finish or floor covering.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances. Low areas shall be filled. High spots shall be ground slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 3 mm from a 3 m straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the drawings or a float finished surface set 3 mm low and levelled with trowel finished fill material.

Surfaces that receive a mortar set quarry tile, ceramic tile, or vitrified finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 6 mm as measured from a 3 m straightedge.

5.22 Formwork

Design and construction

For stability and type of formwork and support framing used, IS: 14687 is to be observed.

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section) "Dimensional Tolerances".

The Bidder shall submit in sufficient time in advance for the approval of the Owner/Consultant the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Particular attention must be paid to the formwork supports and braces to avoid any slip when the concrete is poured.

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Materials for formwork

Forms shall be constructed from steel or from sound timber well seasoned and free from shakes. Plywood lining for forms shall be of timber, which is resin-bonded and water repellent.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete. Where a slope exceeds 1 V: 2 ½ H, formwork shall be provided for the top of the concrete faces and anchored to prevent flotation.

The details of fair-faced concrete facades have to be to the satisfaction of the Owner/Consultant. The concrete surface for facades has to be absolutely stainless and all efforts have to be taken to achieve this. All the proposed formwork shall be properly designed before its usage.

Grading of formwork and of finished concrete surfaces

Quality of formwork, materials to be used and treatments of surface are graded according to the finish of the concrete surface as given in IS: 14687.

The type and treatment of the formwork lining (plywood, metal, plastics, etc) should be appropriate to the grade of concrete finish required.

Preparation and inspection of formwork

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces, which are not oiled, shall be wetted thoroughly to prevent warping.

Erection and placing of formwork

All formwork shall be erected and placed in accordance with the construction drawings approved by the Owner/Consultant. Shuttering shall be true to line and braced and struttred to prevent deformation under weight and pressure of the wet concrete, live loads, wind and other forces. The deflections shall not exceed 3 mm.

The formwork for beams and slabs shall be erected so that the form on the sides of the beams and of the soffits of slabs can be removed without disturbing the beam soffit.

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If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Wherever necessary, panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc shall be fixed to the formwork carefully.

Panels shall be put together to ensure a perfect fit at the joint and fixed in both directions.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on the drawings as "Fair-faced Formwork".

Where concrete surfaces are covered (non-exposed surfaces), the formwork shall be referred to and marked as "Sawn Formwork".

Internal spacers and ties, if any, shall be so arranged that after removing of the forms no holes shall extend through the concrete, in the case of watertight concrete or to be closed by plastic plugs and epoxy mortar in all other cases.

All formwork will be inspected and approved by the Owner/Consultant before concrete placing commences but this shall not relieve the Bidder of any of his responsibilities under the contract.

Striking of formwork

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

In accordance with IS: 456 clause 11.3.1, the striking period for cast in-situ concrete under certain conditions may be taken as follows: -

Table 2.8
Formwork

Type of Formwork	Minimum period before striking formwork
Vertical formwork to columns, walls, beams	16 to 24 hours
Soffit formwork to slabs (props to be refixed)	3 days

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Type of Formwork	Minimum period before striking formwork
immediately after removal of formwork)	
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs:	
1) Spanning upto 4.5 m	7 days
2) Spanning over 4.5 m	14 days
Props to beams and arches:	
1) Spanning upto 6 m	14 days
2) Spanning over 6 m	21 days

Special care is necessary in the case of components, which have to carry nearly the full-calculated load as soon as the formwork is struck.

Columns, piers and walls are to be struck before the beams and slabs supported by them. Scaffolds, formwork supports and self-supporting floor formwork are to be carefully lowered by releasing the devices.

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

To keep deflections through creep and shrinkage to a small amount, auxiliary supports should be left in place or immediately repositioned after striking.

5.23 Water stoppers

Water stoppers shall be of PVC or equivalent and shall be eye-letted with a minimum 25 cm width. Type and manufacturer shall be submitted to the Owner/Consultant's approval.

All intersection pieces shall be prefabricated by the manufacturer and only welding of butt-joints in running lengths will be allowed to be carried out on the site.

The site welding of butt-joints shall be executed by using the manufacturer's purpose-made electrically heated jig and work shall be done by competent and trained personnel only. The manufacturer's instructions shall be carefully observed.

The wings of the water stoppers shall be formed with corrugations or bulbs to achieve a good bond. Moreover, the water stoppers shall conform to the following requirements:-

- The tensile strength not less than 10 N/sq.mm when tested.
- The ultimate elongation shall not be less than 22% when tested.
- The tear resistance shall not be less than 2 N/sq.mm when tested.
- The material shall not crack when tested.

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- Under accelerated elongation, the tensile strength shall not be less than 8 N/sq.mm and the ultimate elongation shall not be less than 200%.

The water stoppers shall be installed so that they are securely held in position during the placing of concrete, which shall be fully and properly compacted around the water stoppers to prevent voids or porous areas. Adequate clearance between the reinforcement and all the water stoppers shall be kept to permit proper compaction of concrete.

No holes or nailing shall be made through any water stopper for fixing purposes. Jointing by lapping two pieces of water stoppers shall not be permitted.

The free edges of water stoppers shall at all times be protected from direct sunlight.

5.24 Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed and if required the concrete may be protected for few more days as per the design mix / approved methodology.

Trowelled surfaces except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane-curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

Water curing

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water may be interrupted for surface rubbing. The concrete surface shall not be permitted to dry.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap and kept saturated for the remainder of the curing period.

Membrane curing

Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at coverage of not more than 7.4 sqm/litre. Membrane curing shall not be used on surfaces that shall be covered at a later date with mortar, concrete, damp proofing, tile, or any coating. Membrane curing shall not be used on cast-in-place concrete bases for field-erected tanks. Membrane curing will be permitted only after prior approval of the OWNER/CONSULTANT.

Floor sealer

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All concrete floors shall be given two coats of clear floor sealer in addition to that applied as membrane curing compound. The first coat shall be applied at the end of the curing period before any traffic is permitted on the floor. The second coat shall be applied after the floor has been cleaned in preparation for the final inspection. Floor sealer shall be applied in strict accordance with the manufacturer's recommendations.

5.25 Waterproofing/Damp proofing

A waterproofing seal shall be provided for all below grade structures where applicable by external tanking with PVC sheets of 1.0 mm thickness with knobs for membrane type waterproofing. In addition, joints in deep underground structures shall be provided with structural waterproofing.

Damp-proof course 40 mm thick, consisting of cement concrete 1:2:4, with admixture of approved water-proofing compound shall be laid at plinth level for walls of all buildings for protection of super-structure against moisture and dampness.

5.26 Repair of damaged and defective concrete

Concrete after its final setting shall be inspected by the Owner/Consultant and any cracks, honeycomb areas, segregations, etc shall be marked. No repairs shall be carried out until directed by the Owner/Consultant.

Surface defects in formed concrete shall be repaired to the satisfaction of the Construction Manager within 24 hours. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 25 mm shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the concrete is placed.

Defective concrete shall be replaced within 48 hours after the forms have been removed.

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6 PRESSURE GROUTING

The work shall consist of drilling grout holes, exploratory holes and check holes, pressure testing, pressure washing, and injecting suspension grout under pressure, and shall include furnishing of all materials, labor, and equipment as described and specified.

6.1 Materials

a) Cement

Portland cement shall be ASTM C150 Type II or Type V, containing less than 0.6 percent alkali.

b) Aggregate

Aggregate shall be non reactive and shall be washed before use. When sources of aggregate are changed, test reports shall be provided for the material from the new source prior to commencing grout work. Fine aggregate shall be sand or crushed stone.

c) Admixtures

Admixtures shall be compatible with the grout and shall comply with the manufacturer's recommendations. Admixtures shall be added to the grout mix separately.

Water Reducing Retarder: Water reducing retarder shall comply with relevant Indian standard or as approved by Owner.

Lubricant: Lubricant additive for cement pressure grouting shall be Intrusion Prepakt Intrusion Aid, Sika Intraplast N, or as approved by Owner.

d) Water

Water for washing aggregate, for mixing and for curing shall be potable, shall not contain more than 1000 mg/l of chlorides as Cl, nor more than 1300 mg/l of sulfates as SO₄, and shall not contain impurities which may change the setting time by more than 25 percent or a reduction of more than 5 percent of the compressive strength of the grout at 14 days when compared to the results for grout made with distilled water.

e) Grout

Drypack Grout

Drypack grout shall be a mixture of approximately one part cement, 1.5 parts sand, water reducing retarder and sufficient water to make a stiff workable mix, branded Dry Pack or approved equal.

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Cement Grout

Cement grout shall be a mixture of one part cement, two parts sand proportioned by volume admixtures for pressure grouting and sufficient water to form a workable mix.

Nonshrink Grout:

- Non-shrink expansive flowable grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticiser admixture shall be added in the grout. For grouting of base of machine foundation high strength ready mixed non-shrink flowable grout shall be used.
- Type and grade of grouting for structural columns and equipment bases shall be as indicated. Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M 30.
- Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipment. For secondary posts, stair and ladder base, etc. grouting shall not be less than 25 mm thick.

Special grout, where specified on the drawings, shall be provided in strict accordance with the manufacturer's instructions/specifications. Pre-mixed Grout Conbextra GP-2 of 'FOSROC' make or equivalent of crushing strength 650 kg/cm² for major equipment foundations and Conbextra GP-1 or equivalent having crushing strength of 450 kg/cm² for other foundations where concrete grade M30 or higher is provided

- Forms and shims used to obtain adequate clearance shall not be removed and the anchor bolts shall not be tightened for at least three days after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and edge of the foundation shall be finished smooth to allow drainage away from the base. Attachment of interconnecting piping of machinery and complete load transfer of machinery shall not be done before the bolts are tightened. During this period, grouting work shall be properly cured using rags/gunny bags.

In view of extremely small proportion (about 0.01% by weight of cement) of the aluminium powder required, it is necessary to take all precautions to ensure thorough mixing. It is advisable to mix the blend of aluminium powder thoroughly with sand and cement before water is added because aluminium powder has a tendency to float on water.

- Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement: 1 admixture: 1 sand), or as per manufacturer's instructions.

Pre-mixed non-shrinking grout shall be used as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

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Epoxy Grout for Crack Repair and Dowel Anchorage

Except for applications involving pressure grouting or crack injection, epoxy shall be a high modulus, moisture insensitive, two components, 100 percent solids, thermosetting modified polyamid epoxy compound. The material shall equal which is capable of not sagging in horizontal or overhead anchoring applications.

Epoxy for applications involving pressure grouting or crack injection, shall be a high modulus, moisture insensitive, two components, injection grade, 100 percent solids blend of epoxy resin compounds. The material shall equal which is capable of achieving complete penetration of hairline and larger cracks.

Polymer Concrete for Resurfacing and Patching

Polymer concrete shall consist of a liquid binder and dry aggregate mixed together to make a flowable mortar. The liquid binder shall be a chemical and oil resistant, stress relieved, low modulus, moisture insensitive, two component epoxy resin compound. The binder material shall equal with a consistency similar to light weight oil for proper mixing with the aggregate. The aggregate shall be oven dry, kept in sealed packages until the time of mixing and be of size and consistency compatible with recommendations of the manufacturer of the liquid binder for the intended application.

Adhesive Resin for Dowel Anchorage:

Pneumatically operated caulk gun and automatically mixed at nozzle. Subject to compliance with one of the following: HIT RE500-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-2322), HIT-HY 150 MAX-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-3013), SET-XP Adhesive Anchoring Systems, Simpson Strong-Tie Co. (ICC ESR-2508).

6.2 Pressure Grouting Equipment

Pressure grouting equipment shall include a mixer and holdover agitator tanks designed to place grout at pressures up to 0.345N/mm² (50 psi). Gauges indicating grouting pressure shall be provided and the mixer shall be equipped with a meter capable of indicating to within 0.003 m³ the volume of grout placed.

6.3 Execution

Bonding compounds for use with grout is to be provided and installed per the manufacturer's recommendations.

a) Drypack Grout

Drypack grout is to be used for built-up surfaces, setting miscellaneous metal items and minor repairs.

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Surfaces required to be built-up with drypack grout are to be roughened by brushing, cleaned and coated with the bonding compound before application of grout. The grout is to be applied to the required thickness.

b) Cement Grout

Cement grout is to be used for filling nonbearing portions of equipment pads and pressure grouting.

Except for the specialized requirements for pressure grouting, grout is to be mixed and placed in the same manner as cast-in-place concrete. Grout is to be mixed for at least one minute and diluted grout is to be agitated until placed.

c) Non-shrink Grout

Nonshrink, nonmetallic aggregate grout is to be used under equipment, bearing plates and column base plates. Nonshrink, metallic aggregate grout is to be used under rotating equipment where high strength and fatigue are of concern, to grout anchor bolts and to grout reinforcing steel. Grout is to be placed and cured in accordance with the manufacturer's recommendations.

Holes required for grouting shall be blown clean with compressed air and are to be free of dust or standing water. Horizontal holes for grouting are to be drilled at a slight downward angle and with the inserted dowel or bolt bent to match.

d) Epoxy Grout

Epoxy grout shall be used for repairing cracks by pressure grouting or gravity, repairing structural concrete and may be used for setting dowels or bolts in holes. Concrete is to be primed in accordance with the grout manufacturer's recommendations.

The use of epoxy grout must comply with the following restrictions:

- Limited to areas where exposure, on an intermittent or continuous basis, to acid, chlorine gas or to machine or diesel oils, is extremely unlikely.
- Limited to applications where exposure to fire or to concrete temperatures above the product heat deflection temperature or 120 deg F (40 deg C)(whichever is less) is extremely unlikely. Overhead applications are not allowed.
- Holes for the anchors shall be drilled (not cored), shall be blown clean with compressed air and shall be free of dust or standing water.
- The anchor type, size and embedment depth shall be as shown on the drawings and the anchor must be installed in accordance with the manufacturer's recommendations.
- The anchor must not be loaded until after the full curing period has elapsed.

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e) Pressure Grouting

Prior to grouting, cracks and holes to be grouted shall be washed clean. Washing is not required for grouting soil voids. Once started, grouting shall be continuous until completed. In case of a mechanical failure or other stoppage of the work, the grout equipment shall be washed out sufficiently to ensure that fresh only grout is pumped when the work is restarted.

After grouting is completed, the Contractor shall remove the grouting plant and all related parts, equipment, and supplies from the site, including unused materials and waste.

6.4 Field Quality Control

- The Testing Laboratory will Develop and utilize an effective method of field marking anchor and dowel test locations and results.
- Testing of grout mixes for conformance to manufacturer's specified strength: The independent testing laboratory shall take four test samples of each day's grout mix and test grout mix samples at 7 and 28 days. Test reports shall be submitted to the Owner for review.
- Test 25 % of reinforcing steel dowels installed with adhesive resin on a given day in tension using pullout procedure. Test to 80% of specified yield strength of the dowel with special inspection. Dowels specifically noted on the drawings as "No test required" do not require tension testing.
- If the failure rate of dowels exceeds 10 percent, testing will be increased to 100 percent of that day's installation of similar anchors or dowels. Testing will be reduced to 25 % of that day's installation when the failure rate is reduced to 10 percent or less. Failed dowels will be replaced at no additional cost to the Owner. The Contractor will produce daily reports of all testing activities; copies of daily reports will be submitted to the Owner in a timely manner.

6.5 Submittal

- Manufacturer's data shall be provided for bonding compounds, dry pack, non-shrink, pressure grout, retardants, epoxy grout, polymer concrete.
- Test reports, accompanied by a manufacturer's statement that previously tested material is of similar type, quality, and manufacture as that which is proposed for use on this projects, shall be submitted for Cement, Aggregates, Retardants, Bonding compounds and Epoxy resin
- The Contractor's testing laboratory shall provide evidence of correction of deficiencies noted in the inspection report before materials specified in this section are delivered to the job site.

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7 RETROFITTING WORKS

7.1 General

- a) The Work shall, in general, conform to other works/items specified in this Specification.
 - If the specifications for any item are not available in in this Specification cited above, relevant BIS Specifications should be followed.
 - In case BIS Specifications are also not available, the decision of Engineer-in-Charge given in writing based on acceptable sound engineering practice and local usage shall be final and binding on the contractor.
- b) The work will be carried out in accordance with the architectural and structural drawings to be approved by Owner. The structural and architectural drawings shall have to be properly correlated before executing the work.
- c) For items where so desired, samples shall be prepared before starting the particular items of work for prior approval of the Owner and nothing extra shall be payable on this account.
- d) Materials brought at site of work shall not be used in the work before getting satisfactory Mandatory test results.
 - Equivalents for the various materials and the materials of approved make shall be got approved from the Owner in writing before using them on the work.
- e) The contractor shall submit the required documents regarding the genuineness of materials used such as manufacturer's certification that the firm has manufactured the supplied materials.
- f) The contractor shall get approved from the Owner the storage space for epoxy/polymer/patented/other manufacture of materials to ensure that the storage temperature is maintained between 5° C and 38° C unless recommended otherwise by the manufacturer.
- g) Contractor shall comply with manufacturer recommendations so as to comply with environmental conditions under which the repair materials may be applied.
- h) The contractor shall employ Principal Technical Representative & skilled site workers who shall have adequate qualifications and experience for the proper execution of such works and already performed works of this kind with success.
- i) Contractor shall advise all workers working with epoxies to avoid contact with eyes and skin, inhalation of vapours, and ingestion. Necessary protective and safety equipments in the form of hand gloves, welders' goggles, shall be provided by the contractor and used on site.

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- j) Care shall be taken to ensure that vibrations are well within acceptable limits for structural safety and users of the building.
- k) For the execution of protection and repair works, properly maintained plant and equipment permitting adequate treatment of the concrete substrate, proper execution of the work and determination of the required properties of the construction materials and construction measures must be present on the construction site.
- l) To ensure efficient and effective functioning, all plant and equipment must be checked on-site and at field material testing laboratory prior to first use and at appropriate intervals thereafter.

7.2 Chipping of Unsound/Weak Concrete Material

a) Purpose

To remove weak, loose or carbonated concrete over an area from its surface with pneumatically operated or power driven tools by chiselling, chipping etc.

b) Materials and T&P

Power or pneumatically driven chisel, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator (0.2% phenolphthalein solution) with pH range at least up to 10.5 and clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support to relieve the structural member of stress and strains.

Step-2: Scaffolding, if necessary for the exterior members, shall be done for working upon the area.

Step-3: Working Platforms for interior members, if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if necessary.

Step-5: Mark off the area to be repaired using straight lines between corners. The marked area shall have 90° corners with the sides parallel or normal to the direction of the reinforcement. The marked boundaries for the repair area should be a minimum of 50 mm outside the perimeter of the spall. For a single spall, the repair area should have a minimum width of 100mm in any direction. If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair.

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Step-6: Cut shall be made along the marked boundary, normal-to-the surface. It should be made with a diamond cutter blade. However, when diamond cutting is not practical, the normal cut can be made with a power driven chisel. Minimum depth of cut shall be 10 mm. In situations where the diamond saw could cut into the reinforcing steel due to inadequate concrete cover, the boundary edge should be formed manually by means of chisel and impact hammers. A cover meter could be used to estimate the depth of cover.

Step-7: Chipping to remove all the unsound and weak concrete material shall be done carefully from the damaged portions of structural members by adopting mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

e) **Tolerance**

The chipping tolerances shall be ± 5 mm.

f) **Chiselling**

Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer. Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm Mechanical Milling (single drum, rotary cutter head with Tungsten-carbide bits) is applicable for large areas where the concrete cover is to be removed. Care must be taken to avoid contact with the reinforcing steel as both the reinforcement and the cutter drum could be damaged. Rounded And Feathered Edges should be hand cut to form normal-to-the-surface boundaries. All the edges and cavities shall be square shouldered.

Step-8: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on concrete in contact and in the immediate vicinity of reinforcement soon after its chipping. As otherwise, chipped concrete surface in contact with air is likely to get carbonated soon after its coming in contact with atmospheric carbon dioxide.

Step-9: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, in case the concrete in contact and in immediate vicinity of the reinforcement is carbonated.

Step-10: Inspection and soundness testing, after concrete removal & cleaning, for weaknesses and delamination of exposed surfaces shall be visually carried out. If required, additional removal will be done.

Step-11: Cleaning of debris and dust shall be carried out from within the chiselled/ chipped area and its disposal as per direction of the Engineer-in-Charge.

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7.3 Removing concrete all around reinforcement including from its behind

a) Purpose

To create an average clear air gap equal to nominal size of coarse aggregate plus 5 mm all around embedded reinforcement, in contact with carbonated concrete for rust removal & passivating its surface with fresh alkaline passivating coat and concrete/ mortar.

b) Materials and T&P

Power or pneumatically driven chiselling, abrading, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator i.e. 0.2% solution of phenolphthalein indicator for pH range preferably up to 11.5 or at least up to 10.5, clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support, if not done already, to relieve the structural member of stress and strains.

Step-2: Scaffolding & working platforms for the exterior members, if not already done and if necessary, shall be erected for working upon the area.

Step-3: Working Platforms for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if not already done and if necessary.

Step-5: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on freshly chipped concrete in contact and in the immediate vicinity of reinforcement.

Step-6: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, if the concrete in contact and in immediate vicinity of the reinforcement is carbonated. The concrete around reinforcement shall be removed so as to have a near uniform air gap of about 5 mm plus the nominal size of coarse aggregate to be used in repair concrete/mortar. However, the air gap shall not be less than 15 mm in any case. Power/pneumatic driven tools/chisels shall be used for such portions of carbonated concrete around reinforcement, which could not be removed manually, to achieve a near uniform required air gap all around including behind the reinforcement. Power Driven Chisels/Hammers are normally applicable for chiselling smaller depths up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger depth in excess of 50 mm.

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Step-7: Cleaning of debris and dust shall be carried out from within the chiselled /chipped area and its disposal as per direction of the Engineer-in-Charge.

7.4 Cleaning reinforcement of total rust including from behind reinforcement

a) Materials and T&P

Chiselling, abrading, chipping, hammering, wire brushes, paint brush, abrading cloth, etc hand tools complete with accessories, tested and approved chemical rust remover.

b) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

c) Procedure

Step-1: Cleaning by manual method-

Remove the rust manually from all round the surface along the length of reinforcement, using hand tools like chisels, hammers, wire brushes, abrading cloth/paper, etc. This shall be continued manually along the length of the rusted reinforcement till such time that the steel surface is cleared of all rust that could be removed manually.

Step-2: Cleaning by chemicals –

Remove the Rust by using tested chemicals, if directed by Engineer-in-Charge, due to unsatisfactory results of manual rust removal. Chemical rust remover shall be brush applied over the reinforcement surface thoroughly all around the circumference and along the full length of rusted reinforcement. After 24 hours (or as prescribed by manufacturer) of its application, the surface shall be cleaned with wire brush and all loose particles removed. It shall be washed with water thoroughly and allowed to dry.

7.5 Cleaning Reinforcement and exposed concrete surface

a) Purpose

Clean the prepared concrete surface of all-loose, lightly sticking materials including the foreign materials, loose concrete, aggregates etc to provide a good bond with the applied repair material and clean the reinforcement surface of any minor rust remaining after manual and chemical cleaning to achieve shining bright metal.

b) Materials and T&P

Coarse sand conforming to Zone I or II as per IS: 383, Air compressor of a minimum 35 Kilowatt capacity, spray gun for sand, all related accessories for sand blasting, hand tools like wire brushes, chisels, etc

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c) **Testing of Materials and T&P**

The sand shall be tested to conform to the specification.

The air compressor shall be tested to perform to the required standards as laid down in specifications of shotcreting.

d) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

e) **Procedure**

Step-1: Specified tested coarse sand shall be collected at site in required quantity for sand blasting.

Step-2: Make available mechanical power driven air compressor in working condition at site with all required accessories for carrying out sand blasting as well as air blasting operations.

Step-3: Coarse sand shall be sprayed under pressure over the exposed surface so as remove all loose and foreign material and to cause an intense abrading of the reinforcement and removal of rust from entire surface of reinforcement to achieve shining bright surface. The sand blasted surface shall be subsequently cleaned with oil free air blast.

7.6 Providing drilling and inserting nipples along crack lines

a) **Purpose**

To fix injection nipples and seal the remaining portion of honey combed or cracked concrete /masonry for grout injection.

b) **Materials and T&P**

12 mm diameter approved PVC/aluminium /Galvanised Iron nipples, Chisel, hammer, power driven tool for chase cutting & drilling, hand operated blow out pump, sealing putty of polyester/epoxy/polymer modified mortar etc. and all related accessories and materials.

c) **Testing**

The sealing putty and the nipples shall be tested to conform to the manufacturers specifications. The power driven tools shall be test driven and their drill/cutting bits shall be tested for effectiveness before taking up the repair operation.

d) **Procedure**

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Personnel, Supervision, Product delivery, Storage and Handling etc.

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Step-2: Identify the Cracks and mark the area for injection grouting.

Step-3: Prop & support the structural member, if required, to relieve it of stress and strains.

Step-4: Open up cracked surface by making 'V' notch or groove of size 12 mm x 12mm.

Step-5: Remove plaster, if required, to identify and mark the honey combed area.

Step-6: Drill holes at least 25 mm diameter and 40mm deep along crack lines at spacing of 300 mm or thickness of the structural member, whichever is less. In honey combed area @ 9 nos per sqm. as directed by Engineer-in-Charge and up to 30 mm to 40 mm depth.

Step-7: Remove coarse debris and dust in opened up cracks and drilled holes by blowing oil free compressed air, if available with air compressor, otherwise with hand operated blow out pump. Concrete surfaces required to be grouted shall be free from all loose and unsound materials by means of mechanical abrasion using stiff wire brushes, after removing all loose areas with chisel and hammer. Area shall be made free from any deleterious materials, such as oil dust dirt etc. by means of oil free jet of compressed air. All prepared concrete surfaces shall be thoroughly inspected and got approved by the contractor.

Step-8: Insert 12mm dia specified injection nipples in holes drilled along crack lines and fix them by sealing only its sides with epoxy or polymer modified mortar.

Step-9: Seal the crack or the honey combed surface between the nipples by polymer modified mortar as may be approved by Engineer-in charge. The polymer used shall be of approved grade and applied as per specifications mentioned separately elsewhere. The polymer-modified mortar shall be moist cured for 1-3 days and allowed to gain strength before actual grouting commences.

7.7 Sealing of cracks by injection of advance grout

a) Purpose

To inject the specified grout into honeycombed or cracked concrete/masonry

b) Materials and T&P:

Cement, sand. Water and admixture for cementitious grout shall be as per clause 5 of this specification.

Polymer: It shall be as specified and shall conform to ASTM-C-1059.

Hand/power operated grouting pressure pump/gun with pressure gauge. The grouting equipment shall be capable of supplying, mixing, stirring and pumping grout to the satisfaction of the Owner. The equipment shall have

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the capacity to inject grout at a pressure upto 7 kg per square centimeter measured at the grout connections. It shall be capable of mixing and pumping of cement sand grout 1:2 with water cement ratio ranging from 0.5 to 1.

Air compressor with all related accessories for carrying compressed air to the required location. Hand operated blow out pump may be allowed by Owner for small crack depths/areas.

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing, Spray equipment/brush for application of polymer modified/ bonding cement slurry

c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured material (e.g. specified resin, hardener, polymer, cement, etc as may be required) shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: If directed by Owner, collect random samples of materials for test and send to approved laboratories so as to ensure that they satisfy the physical and mechanical properties. The grout pump and the pressure gauge shall be tested before taking up the repair operation.

Step-4: Identify the Cracks and mark the area for injection grouting.

Step-5: Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

- Prop & support the structural member to relieve it of stress and strains.
- Provide grouting nipples.

Step-6: Blow the compressed air followed by washing with water through nipples located at the highest level and downwards to ensure removal of even fine dust particles from the cracked surface, which could obstruct the free flow of grout material and impede its bonding with cracked surface (and drying with air blast wherever epoxy injection grout is to be used).

Step-7: Saturate the cracked surface in the vicinity of crack/honeycombed concrete/ masonry with water (but without excess water), only if the cementitious grout is to be injected. Otherwise, this step may be skipped.

Step-8: Prepare the injection grout as specified under clause 5 of this specification.

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Step-9: Inject the approved & specified grout into the cracks by means of suitable gun or pump at a pressure of 1- 2 kg./cm² for epoxy grout and 4-7 kg./cm² for cementitious grout. In case of vertical cracks injection shall be started at the lowest nipple and continued until the injected grout begins to flow out at the next higher nipple. Whereas in other cases of horizontal locations, the injection shall be started from one nipple and continued until the injected grout begins to flow out at the other nipple.

The first nipple shall then be closed off and injection continued at the second until the grout flows out at the third. The process shall be repeated until the whole of the crack has been sealed. As soon as the system is cured, the nipples shall be cut.

In case of Honeycombed Area, each grout hole shall be grouted individually. Grouting pressures to be used in the work will vary with the conditions encountered and different areas and the pressure used shall be between 1 to 4 kg/cm². The sequence of injection shall be as per the direction of Engineer-in-Charge.

7.8 Providing and inserting shear key bars

a) Purpose

Shear key bars are used for providing a structural connection of the applied repair material with the substrate/parent surface for transfer of forces occurring at the interface.

b) Materials and T&P:

Epoxy cartridges and specified lengths and diameter of steel reinforcement.

Standard Power driven drilling/hammering equipment, Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

c) Procedure

Step 1: Mark the locations of shear keys and get the same approved for structural connection from the Owner.

Step 2: Drill holes to specified depth and diameter in concrete at marked locations for the specified dia of shear key bars.

Step 3: The drilled hole in dry state shall be cleaned with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump.

Step 4: Inject epoxy from the foil pack with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards.

Step 5: Insert the reinforcing bar and allow the epoxy adhesive to cure.

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7.9 Reinforcement for RCC works etc.

a) Purpose

To provide reinforcement in repair concrete for structural purposes, controlling effects of thermal variation or holding shotcrete/gunite material in position. The reinforcement material may comprise specified grade and quality with or without zinc coating.

b) Material & T&P:

Specified reinforcing material, necessary hand or power driven tools for cutting, bending, binding, transportation, handling and placement etc. Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

c) Procedure

The general requirements, placing in position, measurement etc. shall be generally followed as in clause 4 of this specifications excepting those specifications provided in the following clauses.

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Testing of Material: The requisite number of test specimens of specified reinforcing material shall be collected from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements before use on the work.

Step-3: Execution:

The required reinforcement as per approved detailed drawings in the form of round bars or welded wire fabric in such a way so as to cause the least interference with placement of repair material.

d) Overlaps:

Lapped reinforcing bars shall not be tied together. They shall be separated by at least 50 mm wherever possible. Wire mesh shall be lapped by 1-1/2 squares in all direction. Minimum requirement of lap length of bars shall be as specified in I.S. 456.

e) Clearance around reinforcement:

Sufficient clearance shall be provided around the existing exposed and additional reinforcement to permit complete encasement with sound repair material.

f) Cover:

Minimum cover to reinforcement shall be as specified under clause 4 or as per I.S. 456. As far as possible the bars shall be arranged so as to permit shooting from opposite side.

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g) **Fixing:**

Reinforcement shall be fixed to existing shear key bars and depth gauges driven into the concrete with wires and secured rigidly so that the vibration resulting from the deposition of repair material shall not impair or displace them.

h) **Where Guniting /shotcrete to be done in more than one layer**

In such cases, the additional reinforcement should be so fixed that it is encased in succeeding layer. No additional reinforcement is required to be fixed in first layer of guniting.

Mesh reinforcement shall be fixed in the manner so that it is firmly held at least 12 mm away from the parent concrete surface as well as from the final finished surface. It shall be ensured that it is stiffened enough and cannot belly out during the guniting / jacketing / concrete overlays with consequent lack of cover. It shall be done by tying with parent concrete surface through shear key bars or depth gauges. GI-wire mesh fabric will add sacrificial "Zinc" coating & shall reduce corrosion process in the reinforcement. The wire mesh spacing shall be as specified in the drawings.

7.10 Alkaline Passivating bond coat over Reinforcement

a) **Purpose**

To protect steel reinforcement with a passivating alkaline layer provided all around its circumference along the length with strong adhesive to bond with applied repair concrete or mortar.

b) **Materials and T&P:**

Specified alkaline passivating & bonding materials e.g. CPCC material, epoxy, epoxy phenolic IPN-RB or specified polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, mechanical mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882.

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

Patented materials e.g. CPCC or epoxy-phenolic IPN-RB as per licensee's specifications

c) **Execution:**

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life

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so permits. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: Prepare the surface for treatment.

Step-4: Thoroughly inspect all the concrete surfaces prior to applications of passivating/ bond coat and get approved from the Engineer-in-Charge.

Step-5: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-6: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),

Mechanical blender for mixing

Brush for application of specified and approved passivating/bond coat.

Step-7: Material Mixing: Components of the passivating/ bond coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-8: Material Application: The alkaline passivating & bonding material shall be applied to prepared reinforcement substrate after tying in new reinforcement wherever specified in the form of bars or welded wire fabric. It shall be applied to reinforcement surfaces by stiff nylon bristle brush. The coating material shall be worked well all round the periphery and along its exposed length using a stiff brush ensuring that no pinholes are remaining. The second coat, if required, the same shall be applied as per manufacturer's recommendation after the first coat is touch dry.

7.11 Bonding coat for hardened concrete with repair concrete/ cement mortar

a) Purpose

To provide adequately strong adhesion of parent concrete with applied repair concrete or mortar.

b) Materials and T&P

Specified bonding materials e.g. epoxy or polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, spray gun, mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

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c) Execution

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer- in-Charge Full quantity shall be worked out as theoretically required for consumption in the whole work

Step-3: Prepare the surface for treatment.

Step-4: Saturate the surface with water but shall be free of excess surface water, debris and dust, where cementitious bond coat is to be applied. Otherwise, surface to remain dry and clean of debris and dust.

Step-5: Thoroughly inspect all the concrete surfaces prior to applications of adhesive and get approved from the Engineer-in-Charge.

Step-6: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-7: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing Spray equipment, brush for application of epoxy, polymer modified, bonding cement slurry.

Step-8 Bond Coat Mixing: Components of the bonding coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-9 Bond coat application for jacket concrete/ shotcrete/ Mortar placement: The specified adhesive shall be applied to concrete surface at atmospheric temperatures below 40°C for epoxy adhesive and below 30°C for polymer modified cement or cement-sand slurry adhesive. Bonding coat shall be applied by spray equipment or stiff nylon bristle brush as approved by Engineer-in-Charge. The bonding material shall be worked well into the surface of the parent body ensuring that no pinholes are visible.

Polymer modified bonding cement slurry shall be applied to a thickness not in excess of 2 mm.

If necessary, a second coat shall be applied at right angles to the first to ensure complete coverage and absence of pin holes.

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All concrete surface shall be well protected beyond limits of surface receiving adhesive against spillage.

Step-10 Repair Material Application: Fresh plastic concrete/ shotcrete/ mortar shall be applied while adhesive is still tacky and well within the pot-life/ setting period. If adhesive cures to the extent of losing its tack or has set before plastic concrete/shotcrete/mortar is placed, the same shall be removed or slightly abraded and second coat of adhesive applied. Freshly placed plastic concrete shall be thoroughly consolidated to ensure full bonding of new concrete with the substrate.

d) **Bond of repair with parent concrete:**

Evaluate bonding of fresh concrete/ shotcrete/ mortar to existing concrete after the fresh material has cured for not less than 7 days by sounding and tapping fresh concrete with a blunt metal instrument to the satisfaction of Engineer-in-charge. Suspect inadequate bonding, if a hollow sound is detected in any area. In case of conflicted location contractor shall extract one core from the repaired surface area at the end of 28 days.

Conduct one core test at random for checking the bond, for every 100 square metre or part thereof. The contractor shall core each area after 28 days of application of concreting/ shotcreting/ repair mortar application for determination of bonding adequacy.

Core drilling shall be done through applied repair material and into the existing concrete. Core diameter shall be not less than three times the nominal size of the coarse aggregate used in repair material or as required by the Engineer-in-Charge. Length of cylindrical cores shall preferably be twice the core diameter or twice the thickness of applied repair material or as instructed by Engineer-in-Charge but in any case not less than the dia of the core.

Cores shall be visually inspected by Engineer-in-Charge for evidence of poor workmanship.

Cores shall be tested in tension to evaluate the quality of bond between new concrete/shotcrete/mortar and the parent concrete. If the failure is in the parent concrete the bond of new repair material shall be deemed to be satisfactory.

Failure at the bond line or in the repair material shall be concluded as lack of proper bond or inadequate strength of repair mortar

Dismantle such areas of work failed in bond or repair material and re-prepare the surface after chipping off new concrete/mortar work and abrading the epoxy/ polymer/cement slurry interface. Nothing for testing concrete for bond between old and new concrete shall be paid separately.

7.12 Curing of RCC Surfaces etc

a) **Purpose**

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To ensure satisfactory hydration of cement by retaining or replenishing the mixing water lost due to natural drying and evaporation process for a specified period through exposed cementitious surfaces of the freshly placed cement mortar/ concrete.

b) General

Importance of wet curing to all items of work involving use of cement can not be over emphasised. Any surface experiencing discontinuity of dampness of surface with any patch having dried out during the specified period of curing, it shall be prominently marked with lime or other suitable prominent colour.

c) Materials and T&P:

Curing compound, brush or hand operated spraying gun and all other related accessories for application on Concrete/Plastered Surface.

d) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified manufactured material shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out theoretically for consumption in the whole work.

Step-3

• **Moist Curing:**

Cover all exposed surface of concrete, when the concrete begins to harden i.e. two to three hours after compaction with moist gunny bags or any other material approved by the Owner.

Keep the exposed surfaces continuously damp after its final setting (i.e. after a maximum of 8 hours of concreting) by ponding with a sheet of water or by covering with a layer of sacks, canvass, hessian or similar water absorbent materials constantly kept wet by water sprinkling for at least 7 days, where ordinary portland cement is used and 10 days, where portland pozzolana cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as per manufacturer's recommendations or as directed by the Owner.

• **Using Curing compound:**

Testing of Materials:

It must be ensured that curing compound should neither affect the strength nor the surface of concrete. It shall not leave any undesirable stains on

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surface to affect the bond of plaster or other finishes to be applied later. It should be soluble in water, so that it can be removed by splashing or washing with water without scrubbing the surface.

Test for Efficacy:

The testing of curing compounds shall be done from each lot of curing compound received at site by casting two sets of 15 cm cubes with each set having 6 cubes. One set shall be moist cured by covering with damp gunny bags and subsequently by immersing under water and the other set by applying curing compound on top after 2 to 3 hours of casting and subsequently on de-moulding apply on the remaining faces all around. The cubes shall be kept in an environment similar to which the actual structure is exposed for a period of 7 days after its casting. Three concrete cubes each from both sets shall be tested after 7 days for their crushing strength as per standard test procedure. The average crushing strength of cubes cured with curing compound shall be not less than 95% of the crushing strength of cubes cured under damp or immersion curing.

Test for Staining:

The set of three sample cubes applied with curing compound, remaining after 7-day cube crushing strength test, shall be washed with water with soft brush scrubbing with nylon bristles and allowed to dry for a period of seven days in an atmosphere with relative humidity not exceeding 40% at ambient temperature. The other set of three cubes cured for seven days under damp or immersion conditions shall also be kept for another seven days under identical humidity and temperature conditions. The surface of the two sets of such cubes shall be compared by closely observing for any visible stain and texture that may detrimentally affect its bond with subsequently applied plain plaster or aesthetic appearance. Such observations shall be recorded in three categories as no effect, slight effect and moderate effect. The curing compound shall be considered as acceptable in the 'no effect' category and unacceptable in the 'moderate' category. The decision of Engineer-in-Charge, which shall be final and binding, based on the likely use of finished surface of concrete/plaster shall determine the acceptability of the 'slight effect' category.

Concrete curing compounds, after testing satisfactorily for efficacy, may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing within two to three hours of casting and well within an hour of removal of formwork.

7.13 Engineered Steel Tubular double Scaffolding System

Purpose

To provide a scaffolding system with adjustable working platforms on the exterior of the building for the workmen to work upon any part of the area to be

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accessed safely and with ease for surface preparation, application of repairs and construction activity.

Materials

The standard proprietary tubular double scaffolding system of repute with all accessories, working platforms etc.

Design

It shall be designed for all the incidental dead, live and wind loads as per IS: 875 in steel tubular sections as per general design considerations governed by IS:800. The design of the scaffolding system shall cater to the safety features for the workmen.

Fabrication and Erection

Fabrication and erection shall be done as per the design brief and installation instructions of the proprietary firm. It shall be maintained in functional condition for the work duration.

7.14 Temporary barricading using angle iron verticals and sheet panels

Purpose

To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work.

Materials

Available Corrugated G.I. Sheet minimum 24 G thick; Framing structural material at least MS Angle iron of size [40x40x5mm] or equivalent.

Fabrication & Erection

Size of framing panel shall be decided depending upon site conditions and these could be approximately 2.0 metres long with height as 1.8 metre.

It shall be made up at least of two verticals, each with additional length of about 600 mm for fixing in to ground firmly and two horizontals equal to the length of panel.

It shall be made up by cutting the structural sections to size, shear punching holes in verticals and horizontals for nuts and bolts or making other suitable provision for receiving CGI sheet or other specified panelling material and connection of panel with adjoining panels.

Fabrication of frame of an individual panel shall be by welding at corners, welding MS plate at base of verticals or any other acceptable practice approved by Engineer-in-charge.

G. I sheet or other specified panelling material shall be suitably fixed. It shall preferably be done by means of nuts and bolts at its ends spaced at about 300

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mm c/c transversely and at about 600 c/c longitudinally along corrugations. The corrugations of CGI sheet shall run along the shorter span of the panel.

In case of newly fabricated panels, these shall be painted with red oxide zinc chromate primer on steel work and approved primer on other material and at least one coat of paint of approved shade. In case of used panels, one coat of paint of approved shade shall be applied over the existing paint. The portion of verticals to be embedded in ground shall be suitably protected against rusting by painting it with bitumen or other suitable paint.

The fabricated panels shall be suitably fixed vertically and firmly in to the ground to the satisfaction of Engineer-in charge by maintaining a uniform height of about 1.8 metres above GL and connecting each panel with the adjoining panels with nut and bolts or other suitable means.

Suitable provision of frame/posts in the openings provided in barricading shall be made for receiving door shutter at locations as approved by Engineer-in-Charge.

7.15 Temporary protective fabric screens

Purpose

To protect passersby from falling debris and also to protect the workmen and structure being repaired against direct exposure to sun.

Materials:

For screening purpose jute cloth, woven PVC cloth, geo-textile or wire-mesh as specified and approved by Engineer-in-Charge shall be used, which shall conform to their relevant BIS Code. Screen materials shall be fixed by suitable means comprising of M.S.Flats/ J-bolts /nails/clamps, etc with washer or any other suitable means on frames of existing scaffolding etc.

Procedure

Scaffolding, if required, comprising of verticals, horizontals and diagonal bracings of steel tubes shall be fixed over ground which is payable separately.

One end of the screening material, brought to site in looms/rolls, shall be properly fixed over top horizontal member with suitable means and suspended so as to cover the required area.

The vertical fall of screen shall be suitably fixed/firmed up at intermediate levels so as to keep it in position during the work duration.

Next strip of the screening material shall be fixed with its sides stitched or suitably jointed or lapped with the previous ones as approved by Engineer-in-charge.

Spacing of frame member of scaffolding shall be so selected that the sagging of screen shall not hinder the repair process.

The contractor shall maintain the protective screens in acceptable conditions for the entire work duration as required by the Owner.

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8 CONCRETE RETROFITTING METHODS

In selecting the retrofitting method, the current status of the existing concrete structure as determined through inspection, the performance of the structure, the performance required of the structure after retrofitting, the conditions for retrofitting construction work, the ease of maintenance, economy and other factors shall be considered.

At the stage of selecting the retrofitting method, the current status of the existing structure and its performance shall be obtained, and the performance required for the structure after retrofitting and the conditions for retrofitting work shall be determined. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors.

Various retrofitting methods listed below shall be used for retrofitting objective:

8.1 Retrofitting of concrete members

Continuous fiber reinforced plate bonding construction method:

Bonding continuous fiber reinforced plates to the surface of the existing structure to restore or improve load-carrying capacity

Continuous fiber reinforced plate jacketing construction method:

Jacketing with continuous fiber reinforced plates around the periphery of the existing structure to restore or improve load-carrying capacity and deformation characteristics

Prestressed concrete jacketing construction method:

Placing pre-stressing wires and pre-stressing stranded steel wires in place of lateral ties around the periphery of existing member sections and using mortar and concrete to bond them in order to reinforce the structure. To increase the restraining effect of the inner concrete, the pre-stressing steel is generally stressed during placement.

Pre-stressing introduction (internal cable) construction method:

Using internal cables for the existing concrete members to provide pre-stressing and restore or improve the load-carrying capacity of the members.

Repaving method:

Replacing some or all of the existing concrete members with new members through the use of precast members or concreting on site to restore or improve load-carrying capacity.

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8.2 Retrofitting as a structural body

Beam (girder) addition method:

Adding beams between the main girders of the existing reinforced concrete deck to reduce the deck span and restore or improve the load-carrying capacity of the reinforced concrete deck.

Seismic wall addition method:

Placing new reinforced concrete walls between existing reinforced concrete rigid-frame bridge piers and bonding them to form a continuous unit in order to restore or improve the load-carrying capacity as a structural body.

Support point addition method:

Supporting the intermediate sections of the beams and other existing concrete members with new members to reduce the span of the members in order to restore or improve the load-carrying capacity as a structure.

Seismic isolation method:

Using seismic isolation bearings and the like to reduce the seismic energy applied to the structure in order to improve its various performance values during an earthquake.

8.3 Foundation retrofitting

Underground wall (beam) addition method:

Connecting the foundations with cast-in-site diaphragm walls and underground connecting beams to distribute stress and ensure the stability of the entire system.

Pile/footing addition construction method:

When pile foundations are damaged or there is residual displacement, adding piles or footings to increase the load-carrying capacity of the foundation.

Foundation improvement method:

Improving the ground around the foundation with cement improvement materials to improve the ground bearing capacity and horizontal foundation resistance. Also prevents excessive pore water pressure and liquefaction.

Steel sheet-pile coffering construction method:

Placing sheet-piles around the periphery of the footings and bonding them to the footings to improve bearing capacity and horizontal resistance.

Foundation compacting method:

When insufficient foundation bearing capacity is a concern due to scouring or the like, using concrete or the like to compact the ground around the foundation in order to restore bearing capacity.

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8.4 Repair of cracks and missing sections

Cracks fill method:

Forcing low viscosity resin and ultra-fine cement into the cracks in existing concrete members to seal the cracks.

Fill method:

Filling cracks, rock pockets, cavities, peeling and other small-scale missing sections in existing concrete members with resin and mortar to repair sections.

Section repair method:

Removing deteriorated or damaged portions of existing concrete members and then restoring these members to their original sectional status using materials with excellent bonding to existing concrete.

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9 SHORING AND UNDERPINNING

9.1 Material and Equipment

- a) The contractor shall furnish all materials, tools, equipment, facilities and services as required for providing the necessary shoring and underpinning work and facilities. Jack and jacking equipment shall be more than adequate for the imposed loads and shall be provided with calibrated gauges.
- b) Shoring and bracing materials
Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles, and accessories as required.
- c) Lagging and sheeting material
Provide heavy timber boards, planking or sheeting as required. Lagging board shall be secured in place by steel H-piles, with boards inserted between the H-flanges.
- d) Underpinning Pier
An excavation pit, provided generally by manual excavation, which is carried to a pre-selected bearing surface and then filled with concrete to provide supplementary foundation support for the underpinning structure.
- e) Concrete
Refer clause 4 of this specification for concrete requirements.
- f) Grout
Refer to Clause 5 of this specification for Non-Shrink Grout requirements.
- g) Structural Steel
Refer to Clause 9 of this specification for Structural steel requirements

9.2 Execution

- a) Detection of Movement
 - For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding improvements to be monitored. Settlement markers shall be capable of being read to an accuracy of 1.52mm.
 - Take and record readings not less than once per week during performance of the work until the permanent structures is complete to the ground level.
 - Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.

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- Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks, or longer if movement persists, and report the results to the Engineer.
- The detection of movement shall be performed by a qualified licensed land surveyor or civil engineer.

9.3 Shoring and Underpinning

- Existing footings, foundations, pile caps, grade beams, retaining walls, or pavement which may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement.
- Provide soldier piling, lagging and sheeting, tie-backs, slurry diaphragm wall, and cementitious grouting, as required, to hold back earth at excavations and as required to prevent cave-ins and earth sloughs.
- Footings, foundations, pile caps, grade beams, retaining walls, or pavements which have been undermined by earthwork and pile-driving operations shall be filled and supported with concrete extended to undisturbed bearing earth or bedrock.
- Concrete may be placed as a stiff mix of minimum slump (dry pack), or concrete may be pneumatically placed (shotcrete), or concrete may be placed by conventional methods with concrete formed to hold it in proper position.

9.4 Concrete Piers, Walls and Pile caps

- Install concrete underpinning piers, walls, and pile caps as indicated, with the bottom at the indicated or bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed.
- Where earth forms are indicated, install waterproof building paper or board between the earth and concrete to prevent water loss from the fresh concrete.
- Do not remove support of existing structure until concrete piers, walls, or pile caps have attained design strength.

9.5 Piles and Caissons

- Install pipe pile shells or drilled shafts at locations indicated, and extend from underside of existing footings to indicated elevations, plus additional penetration if required to develop the design working load of the pile or caisson.

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- Distribute jacking reactions over the existing structure in a manner that will not overstress or deflect the existing structure.
- Weld splices where indicated. Provide watertight welds capable of developing the full strength of the pile or caisson. Align splices to ensure the straightness of the pile from top to tip. Use outside sleeves and backup rings as necessary.
- Where the pile tip is below the ground-water table, maintain the elevation of the water inside the shell at approximately the elevation of the ground-water table during installation of the shell.
- After installation of the shell, apply the full design-working load to the empty pile shell and maintain until there is no measurable settlement over a one hour period.
- Maintain the excavation within the pile shell approximately 12 inches above the tip during driving, and dewater pile shells prior to filling with concrete in a manner which will prevent loss of earth or soil at the tip. An earth plug may be left in the pile tip or a concrete plug may be placed and cured prior to dewatering pile shells.
- After load testing to the design load, dewatering, and inspection of the shell by the Engineer, fill accepted pile shells with concrete in the presence of the Engineer. Keep an accurate record of the volume of concrete deposited in each pile. Deficiencies revealed by comparing the volume of the inside of the pile with the volume of placed concrete will be cause for rejection of the pile or correction of the deficiency.
- Securely wedge in place with steel wedges those piles that have satisfied the load-testing requirements. Weld and encase in concrete all wedges, plates, wedging struts and piles, as indicated or required.
- Following completion of load transfer of underpinned structures, fill the underpinning pits with concrete as indicated. Provide reinforcement, shear keys, dowels, and water stops as indicated or required. Place concrete to within 3 inches of the underside of the existing foundation. After three days, dry pack the space between the foundation and concrete.

9.6 Load testing of piles and acceptance criteria

- After the concrete within the pile or shaft has set for at least 24 hours, test each pile or pier by jacking to a load equal to 150 percent of the design-working load of the pile. Maintain the load until there is no measurable settlement of the pile over a one-hour period.
- Load-test piles in sequences and groupings that will minimize or eliminate eccentric loadings on the existing foundation and piles.
- Piles will be rejected and shall be retested if, in the opinion of the Engineer, there is a danger of unequal loading.

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- Should the existing structure fail to furnish sufficient reaction to installed underpinning piles to the test loads specified, provide additional reaction to prevent damage to, and movement of, the structure during installation of piles, and to obtain specified underpinning test loads. The additional reaction shall not detrimentally affect the structure.
- Maximum out-of-plumb tolerance for installed piles: two percent.
- Maximum offset of top of pile from the design center: 3 inches.

9.7 Fill and backfill

Provide engineered fill and backfill in accordance with Clause 3 of this specification, after acceptance of the underpinning by the Owner.

9.8 Temporary Supports

Install temporary supports where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work.

9.9 Restoration

Restore existing structures to conditions equivalent to those existing prior to the start of shoring and underpinning work, including repair of any settlement-related damage.

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10 STRUCTURAL STEEL WORK

Design of structural steel work shall include generally but not be limited to the steel constructions listed below:

- Steel building structure and open structures including beams, columns, bracings, supporting structures for floors, roof slabs, cladding etc.
- Hoist & monorail supporting beams etc.
- Platforms and walkways
- Ladders, staircases, handrails, etc.

10.1 Design

(a) General

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However where large cut outs are to be provided in the floor slabs horizontal floor bracing shall be provided. Grating / Chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support and horizontal bracing shall be provided as required in such cases.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimize vibration, avoid resonance and maintain alignment and level.

(b) Design of structure

The Design of steel structures shall be done by Working stress or Limit state method, in accordance with the provisions of IS: 800 and other relevant IS codes as applicable to specific structures. Basic consideration for structural framing shall be stability, rigidity, building usage, ease of fabrication / erection and overall economy. Additional bracings / moment connections shall be used to assure stability of structures. Structure shall be designed such that the surfaces of all parts shall be accessible for inspection, cleaning, painting and maintenance. Most of steel superstructure shall be designed as simple space frame structures. Simple space frame design utilizes single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Large span built-up girders shall be single web plate girders of welded construction with bearing and intermediate stiffeners. For lifting / monorails beams ISMB sections shall be preferred and the bottom flange of all beams shall be checked separately for distortion and reinforced suitably if required.

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Columns shall be designed to support the load combination which results in maximum interaction ratio. Exterior columns shall be designed to resist moments due to wind & seismic. Columns shall also be designed to resist moments caused by discontinuous vertical bracing or non-concentric bracing work points. Column base can be fixed or pinned. Lateral forces shall be resisted by rigid jointed moment connections in rigid frame design. For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension, etc.) use 90 % of the column dead load and no live load. Uplift forces from vertical bracing and Wind uplift on the roof shall be included where applicable.

Permissible stresses for different members shall not be allowed to exceed by 33.33 % under wind and seismic conditions. However, members who shall be designed primarily to resist wind load such as bracing members, no increase in permissible stresses will be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. All anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself. No anchor pockets in foundation shall be allowed. Design of base plates shall be based on design pressure on foundation which shall not exceed the following:

Pedestal in concrete grade M30 7.50 N/mm²

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A coefficient of friction of 0.30 shall be used in conjunction with the minimum column load. If the horizontal shear force exceeds the frictional resistance force or if the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Anchor bolts are not assumed to resist any horizontal shear force. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Static analysis of overhead conveyor galleries upto a span of 24 m is allowed. However dynamic analysis shall be carried out for overhead conveyor galleries exceeding 24 m span.

For equipments, the bolt shall be either embedded or placed inside the pedestal and grouted with non-shrink grout.

The following criteria shall be followed for posting loads on the design drawings. For vertical beam reactions, the load shall be posted whenever the value exceeds the maximum allowable uniform distributed load. For axial loads in floor beams, the actual horizontal load which the beam end connection must resist shall be posted for each end of the beam. Note that this value may be different for opposite end of the same beam. For truss members, only one member force shall be noted for each member.

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(c) Permissible deflections

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

- Vertical deflection**

a)	For beams supporting dynamic equipment	Span / 500
b)	For beams supporting floors / masonry	Span / 325
c)	For beams supporting pipes (pipe racks)	Span / 400
d)	For roofing and cladding components	Span / 250
e)	For gratings and chequered plates	Span / 200 subject to a maximum of 6 mm

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

For manually operated cranes and monorails	: Span / 500
For electric overhead cranes	
i) Up to 50 t capacity	: Span / 750
ii) Over 50 t capacity	: Span / 1000

- Horizontal deflections**

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	Height / 325
b)	Multistoried building (without crane load)	Height / 500
c)	Pipe rack columns	Height / 200
d)	Open Structures	Height / 200
e)	Crane gantry girder due to surge	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail due to action of crane surge load only	Height / 2500 limited to level maximum of 10 mm
g)	Open gantry columns at crane rail level due to action of crane surge load only	Height / 4000 limited to maximum of 10 mm

Provisions of IS: 800 and relevant latest IS Codes shall be followed for limiting deflections of structural elements not listed above.

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(d) Minimum thickness and size of steel elements

- Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgement in each instance.

Trusses, purlins, girts and bracing	6 mm
Columns and beams	8 mm
Gussets	8 mm
Stiffeners	8 mm
Base plate	10 mm
Chequered plates	6 mm o/p
Grating flats	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc shall be 6 mm.

- Minimum Sizes**

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

(e) Slenderness and depth ratios

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

Truss	1 / 10
Rolled beams and girders for Ordinary floors and rafters	1 / 24
Supporting floor beams for vibrating Machines / equipments	1 / 15
Roof purlins and girts	1 / 45
Gable columns	1 / 30

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(f) Design of Connections

Welding will be done in accordance with the recommendations of IS: 816 and IS: 9595.

Shear connections will be designed for 75 % of section strength for rolled sections and 80 % of section strength for built up section or rolled section with cover plates. Designed shear force shall be more than actual shear. Moment connections between beam and column will be designed for 100 % of moment capacity of the beam section.

All butt welds will be full penetration butt welds.

Size of fillet weld for flange to web connection for built up section will be as follows:

- i) Able to take full shear capacity or actual shear whichever is more for box section
- ii) Able to take 80 % of full shear capacity or actual shear (if indicated in drawings) or shall be 0.5 times of the web thickness whichever is more. For I-section Weld will be double fillet
- iii) All welds will be continuous. The minimum size of the fillet weld will be 6 mm as per relevant IS code

Connection of vertical bracings with connecting members will be designed for full tensile capacity of the bracings. The connection between top flange & web of built-up girder will be full penetration butt weld & for bottom flange, connection may be fillet weld.

Connection of base plate & gusset members with the columns will be done considering that total load gets transferred through weld.

Splicing

All splicing work will be full strength. Field splicing will be done with web / flange cover plates. For, exceptional cases the field splicing will be designed for 50 % of load carried by the cover plates and remaining 50 % load through full penetration butt weld. Shop splicing for all sections other than rolled will be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections will be carried out using web and flange cover plate. For design efficiency of site weld shall be considered as 80 %.

Insert plates

Insert plates shall be designed / checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall also be checked. Lugs using steel bars shall preferably be fillet welded to the plate to transfer full strength of the lug.

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10.2 Fabrication

(a) General

Fabrication drawings shall be prepared according to the provision of IS: 800, IS: 813, IS: 816, IS: 9595, IS: 1367 and IS: 9178.

The work to be provided by the Bidder, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following:

- i) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on design drawings submitted by the Bidder and approved by the Owner/Consultant.
- ii) To submit revised design with calculations and detailed fabrication (drawings in case any substitution of the designed sections are to be made.
- iii) To submit design calculations for joints and connections developed by the Bidder along with detailed fabrication drawings.
- iv) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding \ electrodes for field connections. The field connection materials supplied by the Bidder shall be to the extent of actual requirement plus 10 % (ten percent).
- v) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- vi) Suitably mark, bundle and pack for transport all fabricated materials.
- vii) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

(b) Conformity with Design

Except where the standard connection details are furnished, the Bidder shall design all connections, supply and fabricate all steelwork and furnish all connection materials, Shear connectors / shear lugs on the beams in accordance with the approved drawings and / or as instructed by the Owner/Consultant Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and / or as approved by the Owner/Consultant. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

(c) Quality control

The Bidder shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work shall be performed in accordance with this specification. In addition to the

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Bidder's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Owner/Consultant. As far as possible, all inspection by the Owner/Consultant shall be made at the Bidder's fabrication shop whether located at Site or elsewhere. The Bidder shall co-operate with the Owner/Consultant in permitting access for inspection to all places where work shall be done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Bidder.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

- a) Steel Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
- b) Bolts, Nuts Manufacturer's certificate, dimension & Washers checks, material testing.
- c) Electrodes Manufacturer's certificate, thickness and quality of flux coating.
- d) Welders .Qualifying Tests
- e) Welding sets Performance Tests
- f) Welds Inspection, X-ray, Ultrasonic tests
- g) Paints Manufacturer's certificate, physical Inspection reports
- h) Galvanizing Tests in accordance with IS: 2633 and IS: 4759.

(d) Materials

If desired by the Owner/Consultant, Test Certificates of materials supplied by the Bidder in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Owner/Consultant, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

Materials for main and secondary members shall be selected in line with good engineering practice and shall be arranged within any structure with due regard for maintenance of the structure and Plant and Equipment supported or sheltered by the Structure and also with regard to corrosion.

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pitting, rusts, etc. that may impair their strength, durability and appearance.

All rolled steel shall conform to the requirements of the Indian Standards.

- i) Structural Steel will conform to IS: 2062 Grade-A for rolled steel members or plates up to 20 mm thickness.

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- ii) For plates above 20 mm thickness and welded construction, steel conforming to IS: 2062 Grade-B will be used.

(e) Workmanship

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of IS: 800 and other relevant Indian Standards or equivalent.

Straightening Material

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed as per IS:1852. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

Cutting

Cutting shall be affected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Owner/Consultant.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

Planning of Edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Owner/Consultant.

Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end,

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but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

Bolted construction

All bolts and nuts shall conform to the requirements of IS: 1367.

Field connections shall preferably be bolted connections unless specified otherwise. Weld connections at site shall be avoided.

High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter unless designated otherwise. High strength bolts shall be installed as bearing type joint except where loads are reversible. Bearing Type connection (H.T. bolts Grade 8.8) shall be used for all removable type connections. Bolts will be tightened to develop the required pre-tension during their installation.

All erection bolts shall be of minimum 16 mm diameter of property class 4.6 conforming to IS: 1367 unless specified otherwise.

Holes for bolts shall not be more than 1.5 mm for bolt of diameter equal or lesser than 25 mm and shall not be more than 2 mm for bolt of diameter greater than 25 mm.

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

Assembly

Drifting to enlarge un-matching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted nor damaged and shall be so prepared that the specified cambers, if any, are maintained.

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Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Owner/Consultant.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or locknut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

Welded Construction

Welding shall be in accordance with relevant Indian Standards. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817. All shop connections shall be welded type.

Preparation of Material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears, Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than 20C.

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

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When required by the Owner/Consultant, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Consultant.

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding shall be started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

No welding shall normally be done on parent material at a temperature below (-) 50C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 50C and 00C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 200C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

Submerged arc welding process shall be used for welding longitudinal fillet welds (connecting flanges with web) and longitudinal / transverse butt joints for fabrication of columns, framing beams and all other built up members unless manual arc welding is specifically required. All electrodes, flux, bare wire etc will be procured from approved manufacturers. All butt welds in beams, girders & columns will be of full penetration. All butt welds will be radio-graphically or ultrasonically tested as per relevant IS codes and standard practice. The base wire electrodes for submerged arc welding will conform to IS: 7280. The combination of wire and flux will satisfy requirements of IS: 3613.

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Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the Owner/Consultant.

Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-buttressed over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2 mm.

Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

Miscellaneous

- Lacing bars

The ends of lacing bars shall be neat and free from burrs.

- Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

- Bearing Plates

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

- Architectural Clearances

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Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

- Shop Connections
 - i) All shop connections shall be welded as specified on the Drawings.
 - ii) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Owner/Consultant for convenience of erection and the Bidder will have to make the desired changes at no extra cost to the Owner.
- Shop Erection

The steelwork shall be temporarily shop-erected complete or as directed by the Owner/Consultant so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

(f) Shop Painting

All fabricated steel material, except those galvanized or to be embedded in concrete, shall receive paint coatings as specified below. All paints shall be of approved brand and shade as per the Owner's requirement.

Steel surface, which is to paint, shall thoroughly be cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by wire brush & if required by sand blasting prior to actual surface preparation. The surface shall be cleaned to grade ST-2.5 as per SIS05-5900 or as per IS: 1477 (Part -I).

All steel structures shall receive two primer coats and two finish coats of painting. After fabrication the first coat of primer shall be immediately given over the prepared steel surface. The second coat of primer shall be applied over the dried first primer coat. Two finish coats shall be applied over the primer coats before dispatch of structure at site.

Primer paint shall be red oxide zinc chromate conforming to IS: 2074. Dry film thickness of each coat shall be 50 microns. Adequate care should be taken such that the surface does not possess a slick finish to which paint may not adhere properly. Top coat shall consist of two coats of HB Synthetic enamel of approved shade and colour with glossy finish and DFT as 75 microns (total). Thus the total DFT of painting including that of primer coats shall not be less than 175 microns.

Following care shall be taken while painting:

- i) Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.

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- ii) Surfaces inaccessible after assembly shall receive two coats of primer prior to assembling.
- iii) Surfaces inaccessible after erection, including top surfaces of floor beams supporting gratings or chequered plate, shall receive one additional coat of finish paint over and above number of coats specified above before erection.
- iv) Portion of steel member embedded / to be encased in concrete shall not be painted.
- v) Areas / Surfaces subjected to chemical attacks shall be painted with acid resistant paint.
- vi) Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

(g) Inspection, testing and acceptance criteria

Unless specified otherwise, inspection to all work shall be made by the Owner/Consultant at the place of manufacture prior to delivery. The Owner / Consultant shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification. The Bidder shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Owner/Consultant to carry out inspection and / or tests in accordance with the Contract.

The Bidder shall guarantee compliance with the provisions of this Specification.

The Bidder shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Bidder shall get the specimens tested in a laboratory approved by the Owner/Consultant and submit to the Owner/Consultant the test results in triplicate within 3 (three) days after completion of the test.

Steel

All steel supplied by the Bidder shall conform to the relevant Indian Standards, except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Owner/Consultant, random samples of materials will be taken from each unidentified lot of 50 ton or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be borne by the Bidder.

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All material shall be free from all imperfections like mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

All raw steel plate of thickness more than 20 mm supplied by the Bidder shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Owner/Consultant:

- i) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.
- ii) If the results of the tests in (i) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (i) or as directed by the Owner/Consultant.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Owner/Consultant requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Bidder. If the plates in the fabricated item are found to be laminated, the component will be rejected.

Welding

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Owner may ask for at least one test-destructive or non-destructive including X-ray, ultrasonic test or similar, the cost of which shall be borne by the Bidder. In the event of further tests as may be desired by the Owner. The cost of such test shall be borne by the Bidder if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Owner / Consultant shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

Bolts, nuts and washers

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Owner/Consultant and shall conform to the relevant Indian Standards. If desired by the Owner/Consultant, representative samples of these materials may have

- i) Name of the Bidder
- ii) Number and date of the Contract
- iii) Name of the office placing the contract

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- iv) Nomenclature of stores
- v) A schedule of parts or pieces, giving the parts or piece number with
- vi) Tolerance

The tolerance on the dimension of the individual rolled steel components shall be as specified in IS: 1852. The tolerances on straightness, length etc. of various fabricated components (such as beams, girders, columns, etc) of the steel structures (other than steel railway and road bridges structure) subjected to dynamic loading (like wind, seismic etc.) and thin walled constructions (like box girders) shall be as specified in IS: 7215.

10.3 Erection

(a) General

The work to be provided for by the Bidder, unless otherwise specified in the Bid, shall include but not be limited to the following:

- i) The Bidder shall provide all transport equipment, lifting equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- ii) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Bidder shall pay all demurrage and / or wharfage charges etc. on account of default on his part.
- iii) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the Owner/Consultant. If necessary, suitable temporary approach roads to be built for transportation of fabricated steel structures.
- iv) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Owner/Consultant. The Bidder shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- v) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Owner/Consultant.
- vi) Touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Bidder free of cost to the Owner.
- vii) All minor modifications of the fabricated steel structures as directed by the Owner/Consultant including but not limited to the following:

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- Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
- Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
- Reaming of holes for use of higher size bolt if required.
- Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Owner/Consultant.
- Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
- Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
- Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
- Carry out tests in accordance with this Specification if directed.

(b) Conformity with design

The Bidder will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and / or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and / or the instructions of the Owner/Consultant. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and / or the instructions of the Owner/Consultant.

(c) Storage of materials

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site.

(d) Yard

The Bidder will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access, trailers and other heavy equipments. The yard shall be fenced all round with security / arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access, trailers and

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other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

The Bidder should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. All of which shall be carried out by the Bidder at his own cost as directed by the Owner.

(e) Covered Store

All field connection materials, paints, etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Bidder.

(f) Workmanship

Erection Plant and equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Owner/Consultant.

Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Owner/Consultant. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

Temporary bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure Installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Bidder in respect of temporary bracings and guys shall cease when the structural steel is once located plumbed levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Owner/Consultant.

The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Bidder to take out the materials from 'the

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project site. The Owner may remove and return the materials in good condition to the Bidder without any charge if they have been left in place under other agreed arrangement.

Temporary floors for buildings

It shall be the responsibility of the Bidder to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and / or by-laws of state, Municipal or other local authorities.

Setting out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Owner/Consultant. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Bidder shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations.

He shall remain responsible for correct positioning. For heavy columns, etc. the Bidder shall set proper screed bars if desired by the Owner/Consultant, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

Drifting

Correction of minor misfits of bolts will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

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11 ARCHITECTURAL WORKS

The architectural design concept of buildings shall be evolved considering the functional, technical and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes. To achieve above objective Bidder shall employ a qualified architect / architectural firm to carry out all designs and hold all other architectural responsibilities for the project.

The Bidder shall obtain and be conversant with all laws, by-laws and regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The Bidder shall provide the drawings and documents for such statutory approvals.

11.1 General

The architectural services shall cover finishing work of new buildings and modernised existing buildings/structures, included under the specification starting from masonry work, partition walls, cladding walls, roof protection, finishing of walls, floors and ceilings, false ceiling as required potable water system, sanitation etc.

During execution of the contract, the Bidder shall take approval from the Owner, for all building materials and finish items (e.g. floor tiles, doors, and windows, paints etc.) to be used for the contract by submitting samples and/or product literature as appropriate.

Finishing works including material used for renovation/modernisation work shall be matched with the finishing of existing structures to make similarity in architectural view of new and existing structures.

11.2 Finishes

All exposed surfaces shall be clean and smooth and members shall be sized to give a pleasing appearance. The Finishes for all Structures and Buildings shall meet the functional requirements and shall be as per the approved Finishing Schedule. However, the finishing schedule shall be pre-approved by the Owner/Consultant.

11.3 Design Requirements

(a) Architectural Concepts

- All buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to

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all buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

- Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipments, exposed structural elements, piping, trestles, bus ducts and other service elements.
- Overall emphasis shall be on developing an eco-friendly architecture, merging with the nature with its own sustainable energy management systems.
- The scheme shall be conceptually finalized in totality including that of equipments so that the proper co-ordination with other agencies can be taken up at appropriate time.

(b) Architectural Design

- Natural light shall be used to the maximum extent. For adequate light and ventilation, National Building Code recommendation shall be followed.
- Entrance canopies, chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.
- All the buildings shall be architecturally designed to meet the National Building Code.
- Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect Statutory requirement and any clearances from local authority may be required to be met with, wherever essential. The Architect Consultant shall be of national - International repute having experience in similar kind of works. The consultant shall evolve the design philosophy and shall present it in the form of presentation drawings, prospective views, 3-D Models & detail drawings.
- A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving plant technology and architectural & civil engineering for a smooth control hierarchy and man machine interface.

The Bidder shall develop the architectural layout of all the buildings listed in this document as per the final approved equipment disposition and other layout considerations indicated elsewhere in this specification. These drawings shall need the approval of the Owner/Consultant before construction. The Bidder shall also have to submit perspective views if so desired by the Owner/Consultant at

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no expenditure to the Owner. Approval from statutory authorities, e.g. Factories Inspector, Explosives Inspector, Loss Prevention Association of India / Tariff Advisory Committee etc. shall be the responsibility of the Bidder without any obligation of the Owner.

The entire complex shall have an architectural character and style of its own and shall be visually and functionally integrated with the existing landscape. The Bidder must visit the site and have a feel of the overall environment, so that a harmonious as well as integrated architectural concept of the proposed phase of development is achieved. Special care must be taken to enhance the visual and technological quality of development by adopting updated technology, materials, finish etc.

11.4 Guideline for Architectural Works

11.4.1 Roof Insulation and Ventilation

Wherever required the roof of buildings shall be insulated with foam concrete. For ventilation requirements relevant section of the specification shall be referred.

11.4.2 Roof Waterproofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size 230x230x18 mm laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

11.4.3 Brick/stone masonry and parapet wall

All masonry works shall be designed in accordance with IS: 1597, IS: 1905, IS: 2212, IS: 4326 and other relevant IS codes as applicable. Structural design of load bearing and non-load bearing walls constructed with solid or perforated burnt clay bricks or concrete blocks shall be in accordance with criteria specified by National Building Code of India.

All walls shall be non-load bearing infill panel walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change rooms, first aid rooms and toilets, which may be half brick thick.

Minimum 50 kg/sq.cm compressive strength brick shall be used for non-load bearing super structure brickwork. Cement sand mortar 1:6 for one brick thick

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wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided to reinforce the wall where required.

All brickwork shall be plastered as per specification.

Even where metal cladding is specified, for initial [3 m] height from the ground level, minimum one brick thick masonry wall shall be provided.

All up stands and parapet walls on roof shall be of RCC construction, minimum height of parapet walls shall be [1050 mm] and a minimum thickness of [125 mm].

11.4.4 Cement based polymer modified mortar

a) Purpose

To carry out structural repairs to prepared patches of spalled concrete with an alkaline impervious repair material comprised of polymer admixed cement-sand mortar.

b) Materials and T&P

Polymers in emulsion or powder forms as may be specified conforming to ASTM C1059, Ordinary Portland Cement of 43 grade conforming to relevant BIS code, Sand conforming to Zone-II or Zone-III grade of IS: 383, Mixing water conforming to IS: 456-2000, mortar mixer with mechanical water dozer, spatulas, trowels, etc.

c) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified polymers shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 Testing of Material: The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less). These are to be tested for conformance to the specified requirements before use on the work. Polymer modified cement mortar with cement: sand proportion by weight as (1:3) shall have the following properties

Minimum compressive strength -20N/sq.mm after 28 days at 27oC

Step-4: Identify and mark the area for Polymer modified mortar repair.

Step-5 Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

Prop & support the structural member to relieve it of stress and strains.

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Removal of existing surface plaster/treatment shall be done.

Chipping unsound/weak concrete material shall be done.

Removing concrete all around embedded rusted reinforcement shall be done.

Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done.

Sealing the cracked or honeycombed concrete with injection grouting shall be done.

Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate, which may also be used as depth measuring gauge.

Additional fresh reinforcement, if required, shall be tied with required overlaps or welded.

The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically.

Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done.

Step-6: Clean the dust and saturate the prepared surface of concrete and reinforcement with a clean oil free air blast and water fit for construction.

Step-7: Inspection of concrete surface prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-8: Alignment & thickness Control- Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-9: Apply Passivating & bonding coat over the cleaned existing and new reinforcement.

Step-10: Apply bond coat on the cleaned concrete substrate.

Step-11: Mix and Prepare Polymer Modified Mortar to have a uniform consistency and texture by adding cement sand and polymer as weigh batched ingredients of the design mix, a specified proportion of water through water dozer.

Use of prepacked ready to use components supplied by manufacturers in containers may be allowed subject to approval of Owner. In case where prepacked ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as

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specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

Plastering with cement based polymer modified mortar shall be done immediately after applying the bonding slurry to the prepared surfaces, preferably in coats of approximately 10mm thickness as greater thickness may lead to delamination/collapse. However, coats shall be applied in fairly rapid successions within 15 to 30 minutes. After applications of mortar the surface shall be finished using a wooden float.

Step-12: Moist cure the polymer modified mortar surface for 1-3 days followed by air curing at ambient temperature or as per manufacturer's specification, if specified otherwise. Use of flowing water or ponding of water shall not be done for curing. Steam curing shall not be permitted.

Step-13: Test the Surface of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

d) Inspection & Quality control

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing stoppage of work during low temperatures (minimum working temperature being 8°C in most of the polymer modified mortar or as per manufacturer direction) and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 28 days of mortar application. The cores shall be examined for evidence of poor workmanship by the Owner, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall dismantle such areas of work as required by the Owner and re-do the same after re-preparing the surface by chipping off mortar work and abrading the bonding slurry interface.

11.4.5 Partition Wall

All intermediate walls shall be full brick thick wall in 1:6 cement sand mortar. Half brick thick wall in 1:4 cement: sand mortar with [2 nos. 6 mm] diameter rod in every fourth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area.

11.4.6 Metal cladding

a) Permanent colour coated sandwiched insulated metal cladding system

Trough zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system.

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Weight of coating shall not be less than 180 gm / sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanised M.S. sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanising shall not be less than 180 gm / sq. m.

The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanised steel sheet of grade 375 as per IS: 277. Inner sheet shall be fixed at the rate not more than 0.75 m centre to centre to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS: 8183, having a density of 32 kg / cu. m for glass wool & 48 kg / cu. m for rock wool.

b) Permanent colour coated (non-insulated) metal cladding system

Trough zinc-aluminium alloy coated not less than 180 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability.

c) Flashings, Cap, Trim Closures etc.

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

11.4.7 Plastering

On the exterior wall & rough side of interior brick wall [18 mm] thick minimum with cement-sand mortar in two layers shall be applied. Where external finish will require rich plastering for special finish plaster shall be of 1:4/1:3.

Interior wall: [12 mm] thick with 1:4 cement-sand mortars

Ceiling: [6 mm] thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

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11.4.8 Removal of plaster manually from masonry or concrete surface using chisel and hammer and disposal of debris etc

a) Purpose

For removal of all type of loose /delaminated /damaged/weak cement plaster from surface of masonry or concrete.

b) Procedure

Step-1: Safety shall be ensured in accordance with contract conditions and specifications.

Step-2: Provide double scaffolding, protective screens etc.

Step-3: Existing plaster to be identified for removal by tapping all areas and its boundary shall be marked with a colour marking (in an optimal rectangular shape), which shall be approved by Engineer-in-Charge.

Step-4: Make a cut normal to the surface all along the boundaries with power driven cutters. The depth of cut shall not exceed the thickness of plaster.

Step-5: Remove the plaster manually with the help of chisel and hammers to completely expose the parent masonry or concrete surface, so as not to have any traces of such plaster left behind.

11.4.9 False ceiling and under deck insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the under side of the roof / floor slab of the air-conditioned areas based on the functional requirement. Aluminium false ceiling system shall comprise of [84 mm] wide [12.5 mm] deep closed type plain panels of approved colour, roll formed out of [0.5 mm] thick corrosion resistant aluminium alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, AC ducts etc. Suitable M.S channel (minimum ISMC100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc.

Bidder shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire detectors, fire protection sprinklers etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the Owner approves the layout. Under deck insulation shall comprise of [50 mm] thick resin bonded mineral wool insulation mat conforming to IS:8183. This mat shall be backed with [0.05 mm] thick aluminium foil and [24 Gx25 mm] wire mesh netting. These shall be fixed to ceiling or wall as the case may be with [100x50x6 mm] slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at [600 mm c/c and 14 G] steel wire drawn through slots and fixed to wire netting.

11.4.10 Doors

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- Generally hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas.
- Solid core factory made wooden flush doors in hard wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.
- Special areas like control rooms and other special area shall be provided with minimum 15 micron pre-coated Le. colour anodised aluminium glazed partitions with air lock facilities having two sets of doors.
- Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard and also to all fire exists as per TAC requirement.
- Doors shall be provided at appropriate location to prevent dust ingress from outside.
- FRP Doors with FRP Frames shall be provided for all the toilet doors.
- Weather stripping shall be provided to all outside doors as well as air-conditioned areas and all other doors where dust-free environment is required.

11.4.11 Rolling shutters

Rolling steel shutters conforming to IS: 6248 will be used for large openings where frequent use is not envisaged. Unless noted otherwise, main entry doors of width and height to suit the requirements. Rolling shutters with area up to 8 m² shall be pull and push type hand operated, while above 8 m² shall be pull and push type with ball bearings (Electrically operated) as per IS specification.

11.4.12 Windows & Ventilators

In all buildings, full glazed windows and ventilators in minimum [15 micron] colour anodized aluminium window frame shall be provided with [4 to 6 mm] thick (depending on the size of panel) clear float glass and [6 mm] thick clear wired/laminated glass where required from safety point of view. Structural glazing may be considered as an important facade element.

The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Glass thickness and member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Bidder before execution.

11.4.13 Plywood Covering Panels to Cover Windows etc. During repairs

a) Purpose

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To protect the finished items against their spoiling/damage to finishes during the process of carrying out repairs in a building. The items could include finished windows, doors, glass curtain wall or other such items.

b) Materials:

Wooden Battens of size 50mm X 50mm (approximately) or as approved by Engineer-in-charge, free from warping, cracks etc. made from locally available timber.

Plywood of suitable thickness, preferably 6 mm thick, as approved by Engineer-in-Charge.

Nails, screws etc. as per requirement.

c) Fabrication:

Size of covering panels shall be more than the size of windows etc. to be shielded/ protected, enough to be fixed to the walls without damaging the windows etc.

Wooden battens shall be cut approximately to the size of panels of windows etc. to be protected. The joints of the wooden framework shall be lap joint or as approved by Engineer-in-Charge.

Where the panel size is more than 2 square metres or as specified by the Engineer-in-Charge, the stiffening shall be done with batten backing to impart stiffness enough to provide rigidity against undue deflection due to impact of falling debris, self load, etc.

Plywood shall be fixed with nails/screws over the batten frames. The spacing of nails/screws shall be about 300mm c/c or as may be required at site.

d) Fixing:

The plywood covering panel shall be suitably fixed without damaging the windows etc. being protected by such panels with nails/screws fixed in walls strong enough to resist the forces likely to be imparted during repair work. It shall be done in such a manner that it can be removed with ease without damaging the covered windows etc. after completion of repairs.

e) Removal:

After completion of work, the covering panels shall be removed carefully, so as not to cause any damage to windows etc. covered. The damages, if any, shall be made good.

11.4.14 Facilities in Buildings

Adequate toilet and drinking water facilities shall be provided for personnel working in each building. Each building shall have toilet facilities both for Gents and Ladies. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.

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However minimum 1 Water Closet, 1 washbasin, 1 urinal shall be provided in each toilet.

Each floor shall have drinking water facility connected through water purification system like Aquaguard or similar approved make.

11.4.15 Glazing & Glazed Partition

- Glazing in Control room between AC. and non-AC. areas shall be insulating glass consisting of [two 6 mm] thick toughened float glass sheet hermetically sealed and separated by [12 mm] gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.
- [4 mm] thick ground glass shall be provided for toilets.
- Glazing between two AC. areas shall be with 6 mm thick clear float glass.
- All glazing shall be in aluminium frame.
- [6mm] thick Wired / laminated glass shall be used for windows / ventilators at higher level for safety.
- [24mm] thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with [12mm] air gap & hermetically sealed shall be mounted on [15 micron] coloured anodised aluminium frame suitable for structural glazing system.

11.4.16 Sealant

Silicon sealant or polyurethane sealant shall be used in all expansion joints exposed to weather. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water-lightness.

11.4.17 Damp Proof Course

[40 mm thick 1:1.5:3] concrete with waterproofing admixture. Water proofing compound shall be of Zydex, SIKA, or similar approved.

11.4.18 Plinth Protection

Minimum [1000 mm] wide and minimum [100 mm] thick M 15-grade concrete plinth protection along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be provided. The plinth protection shall be laid over prepared sub-grade and base formed with locally available broken laterite stone to thickness of [150 mm].

11.4.19 Painting

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- Exterior Masonry Surface : Buildings shall be finished with [Acrylic Emulsion pain] as per IS specification with approved colour and scheme.
- Exterior Steel Work : Anti-corrosive synthetic enamel paint over [anti corrosive primer].
- All Woodwork: [Synthetic paint over a coat of primer].
- All Internal Steel Work : [Synthetic enamel over a coat of primer].
- Interior Office Spaces Rooms, All AC Areas : Acrylic emulsion paint over [2 mm] control thick plaster of paris punning.
- Balance areas: As indicated in finish schedule in this document.
- Fire Door: Post Office red shade shall be provided.

11.4.20 Flooring

Unless and otherwise specified, the nominal total thickness of floor finish shall be [50 mm] including under bed and topping. The flooring shall be laid on already matured concrete base. The under bed for floors shall consist of minimum grade of M 15 with stone chips [12.5 mm] downgraded as coarse aggregates. The under bed shall be provided appropriate slope towards catch pit for floor drainage.

- **False Flooring System**

Removable type false flooring system shall be provided wherever required (computer rooms etc.). RCC floor slab will be sunk to a depth [800 mm], which shall be height of the false floor system. The flooring shall consist of fire resistant phenol formaldehyde bonded particle board panels [600x600x35 mm] size, mounted on steel pedestals of adjustable height and supporting steel grid system to provide under floor space. [2 mm] thick flexible anti-static PVC topping on top and PVC strip edging on sides of each panel shall be provided.

- **PVC Floor Finish**

Two mm thick PVC as per IS: 3462 and laid as per IS: 5318 over concrete under bed of [48 mm] shall be provided in electronic cubicle rooms, conference room, etc. PVC tiles shall ensure anti static surface.

- **Vitrified ceramic Tiles**

Heavy duty vitrified ceramic tiles of appropriate thickness and of minimum size [600 mm x 600 mm] of approved shade & colour shall be provided for control room as per relevant code and manufacturer's specification over concrete bedding to result in an overall thickness of [50 mm].

- **IPS Flooring**

IPS (cement concrete flooring) with metallic floor hardener topping [12 mm] thick with a total thickness of [50 mm] shall be provided in maintenance and

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unloading area of Mill and bunker bay, operating floor of pump house, permanent stores and other plant building areas where heavy duty flooring is required.

IPS flooring with non-metallic floor hardener shall be provided in all MCC and switchgear rooms, which are not air-conditioned.

IPS flooring shall also be provided in areas, which are not provided with any special finish. Areas which are likely to be subjected to oil spillage shall be provided with two coats of oil resistant painting over IPS floor finish. If required, Bidder has to use floor hardeners at appropriate locations.

- **Heavy Duty Ceramic Tiles**

Heavy duty vitrified ceramic tiles with suitable finish shall be used in toilets, pantry, dining hall of canteen, locker rooms etc. The tiles shall be minimum of [300 x 300 x 7 mm] of approved shade, brand and colour.

- **Acid / Alkali Resisting Tiles**

Battery rooms and other areas coming into contact with acid / alkali vapours or fumes shall be given acid / alkali resistant tiles [25 mm] thick, jointed with acid / alkali resistant cement slurry. Bedding shall comprise of potassium silicate mortar conforming to IS: 4832 (Part-I) and resin based mortar like epoxy for jointing. Total thickness of flooring shall be [50 mm].

- **Integral Floor Finish**

For cable vaults floor finish integral to the concrete base shall be provided as per IS: 2571.

11.4.21 Miscellaneous

PVC nosing shall be provided for edge protection of R.C.C. stair treads.

Angles [50x50x6 mm] (minimum) with lugs shall be provided for edge protection of cutouts / openings in floor slabs, edge of drains covering gratings, edge of R.C.C cable / pipe trenches of any other place where breakage of edges / corners is expected.

Floors of switchgear rooms shall have embedded steel channel suitable for easy movement of breaker panel.

11.4.22 Skirting/DADO

- [150 mm] skirting matching with floor finish shall be provided in all areas unless specified otherwise elsewhere.
- Toilets and locker rooms shall be provided with dado of [2100 mm] high with glazed tiles of minimum 5 mm thickness generally as per IS: 777.
- For battery room and other areas coming in contact with acid / alkali spillage / fume, dado of acid / alkali resistant tiling as per IS: 4457 shall be provided to a height of [2100 mm] set in potassium silicate mortar and joints pointed with resin bonded mortar

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- Staircase wall shall be given dado of vitrified tiles of approved colour and shade to a height of [2100 mm] or as per approved drawings.

11.4.23 Roof access

All roofs shall be provided with access thorough a staircase / cage ladder. Minimum [1000 mm] wide access path shall be provided with suitable tiles to approach equipment on roof.

11.4.24 Roof Drains

(a) Roof drains design criteria

Minimum diameter of the pipe shall be [150 mm]. The roof drains shall be sized for the roof area runoff for a maximum rainfall per hour at site.

Detailed specification is mentioned elsewhere in this specification.

(b) Roof Drainage and Water Proofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size [230x230x18 mm] laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

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12 GENERAL REQUIREMENTS

12.1 Roof

Roof of conveyor galleries and Boiler shall be of permanently colour coated galvanised M.S troughed metal sheet of approved profile. Minimum base metal thickness shall be 0.8 mm. The rate of zinc consumption for galvanising shall be 275 gm/sq. m. The external face shall have permanent colour coating of PVF 2 paint of minimum DFT of 20 microns and inner surface shall be coated with silicon modified polyester paint with DFT of 20 microns.

12.2 Waterproofing of underground structures

All underground structures like basements, pump houses, water retaining structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sq.m (minimum) for water/ damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that waterproofing grouting can be injected later in case of leakage.

12.3 Anti-termite treatment/Anti-weed treatment

Pre-constructional anti termite treatment shall be given to all buildings as per IS: 6313 and other relevant Indian Standards.

Reservoirs shall be given an anti-weed treatment of approved quality and quantity as per the manufacturer's specification. Anti weed treatment shall be carried out before carrying out the lining work.

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13 GENERAL CIVIL WORKS AND CONSTRUCTION TOLERANCES

13.1 Basic requirements for all civil works

Design requirements

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Owner/Consultant.

- Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers (whichever is less).
- The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable nor troublesome to personnel and will not cause damage to the machine or structure.
- The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating plant.
- The differences between frequencies and the dynamic analysis of the superstructures and foundations shall be in accordance with the relevant design standard.
- The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.
- Throughout the works all floor slabs above rooms containing electrical equipment shall be watertight. No drainpipes or water pipes are permitted to pass through these rooms.
- All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Owner/Consultant and shall comply strictly with the tests prescribed hereinafter or, where tests are not laid down in this specification, with the requirements of the latest issue of the relevant Indian, American, British, German Standards or other Standards approved by the Owner/Consultant.
- Samples of all materials proposed to be used in the works may be called for at any time by the Owner/Consultant.

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- The work shall be carried out by competent personnel skilled in their various trades.
- Before commencing the works, the Bidder shall ascertain the locations and nature of all existing underground services and shall take every possible precaution against any damage occurring to them or interference therewith, during the execution of the works.
- Suitable access to the roofs of the buildings by means of steel stairs shall be provided for maintenance and repair of any installation.
- All rooms with fire hazard shall be provided with suitable emergency exists.
- Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles, which will be used (cars, forklifts, trucks/trailers etc) to reach up to the point of unloading of the equipment.
- Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms, at all levels using suitable stair wells and suitable electric hoists. The dimensions of rooms, stairwells, doors, etc shall be designed to suit the a.m. transport concept.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.

13.2 Basic requirements during construction

Basic Cleaning

Basic cleaning includes all floors, walls, ceilings, built-in fittings and equipment, including the furnishings. The basic cleaning operation must result in a degree of cleanness, which permits the fully equipped buildings and rooms and associated outdoor installations and secured surfaces to be taken over without complaint.

Advertising boards and stickers, temporary protective coatings and claddings, remains and splashes of paint, must be removed with water or suitable solvents. Dust and other dirt must be completely removed from all wall and floor surfaces, as well as from all furniture.

Windows and mirrors must be cleaned so that they are completely clear and without streaks.

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Perlator gauges, showerheads, odour traps and floor drains of the sanitary installations must be cleaned and the fittings and bright pipe work must be spotlessly polished.

Petrol and oil separators must be emptied, cleaned and refilled if necessary during basic cleaning.

Lamps, including dishes, lighting units and tubes, switches and sockets as well as bases and skirting boards, doors with frames and glazing, windows, window seats and other furniture and fittings must be included in the basic cleaning operation.

Initial Equipment

The specification is drawn up on the assumption that the scope of the initial equipment and consumption materials is to be provided complete in every respect; everything required for the use and care of the installations must be supplied, even if this is not expressly specified in the documentation.

Bidder shall ensure that during excavation ground water level shall be lowered by at least 0.50 m below the founding level adopting appropriate method of dewatering. Lean concrete below foundation shall be laid soon after excavation with minimum loss of time.

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14 STANDARDS, CODES AND REFERENCES

14.1 General

The Design of the Steel Structural Works shall be prepared and presented in accordance with IS codes. In absence of guidelines of specific items in the IS codes, International codes viz., American, BS, DIN or Australian code shall be used. All the Indian Standards referred to shall be the latest revision (including all amendments issued thereto) on the date of opening of the price bid. The Standards adopted shall be clearly stated in the calculations.

The Design shall comply with the current Local Authority Building Regulations (National Building Code) where appropriate. Subject to the agreement of the Owner, other International / Foreign National Standards, and, International / Foreign National Standard Codes of Practice, may be used.

To the extent that the Design shall include materials, methods or workmanship to be incorporated into the works, they shall be selected and incorporated into the design in accordance with the recommendations and requirements of the following (as appropriate in order of precedence but not mutually exclusive):

Statutory requirements

The Contract provisions

Bureau of Indian Standard Codes of Practice

International / Foreign National Standards

Agreement Certification for Materials

Manufacturer's recommendations for materials

Competent Trade Association recommendation

Engineering judgment

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

Where British / American / DIN or other codes and standards are referred to in this document, equivalent Indian Standards may be substituted if available.

Materials supplied from India shall follow the Indian Standard Specifications.

Field and laboratory testing procedures for materials follow Indian Standard Specifications.

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14.2 Codes for Loads

- IS: 875 : Code of Practice for design loads (other than earthquake) for Buildings and structures (All parts)
- IS: 1911 : Schedule of unit weights of building materials
- IS: 1893 (Part 1) : Criteria for earthquake resistant design of structure – General provisions and buildings
- IS: 1893 (Part 4) : Criteria for earthquake resistant design of structure – Industrial structures including stack-like structures

14.3 Codes for RCC

- IS: 456 : Plain and reinforced concrete - Code of Practice
- IS: 2974 : Code of Practice for design and construction of machine foundations
- IS: 2911 : Code of Practice for design and construction of pile foundation
- IS: 4326 : Code of Practice for earthquake resistant design and construction of buildings
- IS: 5525 : Recommendation for detailing of reinforced concrete works
- IS: 1786 : Specification for high strength deformed steel bars and wires for concrete reinforcement

14.4 Codes for Structural Steel

- IS: 800 : Code of Practice for general construction in steel
- IS: 801 : Code of practice for use of cold-formed light gauge steel structural members in general building construction
- IS: 806 : Code of Practice for use of steel tubes in general building construction
- IS: 808 : Dimensions for hot rolled steel beam, column channel and angle section
- IS: 812 : Glossary of terms relating to welding & cutting of metals
- IS: 813 : Scheme of symbols for welding
- IS: 814 : Covered electrodes for manual metal arc welding of carbon and carbon manganese steel - Specification
- IS: 815 : Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel
- IS: 816 : Code of Practice for use of metal arc welding for general construction in mild steel
- IS: 817 : Training of welders - Code of practice (Part 1 & 2)
- IS: 818 : Code of practice for safety and health requirements in electric and gas welding and cutting operation.

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- IS: 819 : Code of practice for resistance spot welding for light assemblies in mild welding
- IS: 822 : Code of practice for inspection of welds.
- IS: 1182 : Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
- IS: 1200 : Method of measurement of building and civil engineering works
- IS: 1161 : Steel tubes for structural purpose
- IS: 1363 : Indian standard- Hexagonal head bolts, screws and nuts of product grade C
- IS: 1367 : Technical supply condition for threaded fasteners
- IS: 1477 : Code of practice for painting of ferrous metal in building
- IS: 1852 : Specification for rolling and cutting tolerance for hot-rolled steel products
- IS: 2062 : Structural steel (fusion welding quality)
- IS: 2074 : Ready mixed paint, air drying, red oxide zinc-chrome, priming
- IS: 2645 : Specification for integral cement waterproofing compound
- IS: 2932 : Specification for enamel, synthetic exterior type –I
- IS: 3613 : Acceptance tests for Wire flux combination of submerged arc welding
- IS: 3757 : Specification for high strength structural bolts
- IS: 4000 : Code of practice for High Strength bolts in steel structures
- IS: 7205 : Safety code for erection of structural steel work
- IS: 7215 : Specification for Tolerances for fabrication of steel structures
- IS: 7280 : Specification for Bare wire electrodes for submerged arc welding of structural steel
- IS: 8640 : Recommendations for dimensional parameters for industrial building
- IS: 9178 : Criteria for design of steel bins for storage of bulk material (All parts)
- IS: 9595 : For Metal arc welding of carbon and carbon manganese steel - Recommendation
- IS: 11592 : Conveyor galleries
- IS: 12843 : Tolerances for erection of steel structures

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14.5 Miscellaneous Codes

IS: 919	:	ISO system of limits and fits
IS: 1038	:	Specification for steel doors, windows and ventilators
IS: 1172	:	Code of basic requirements for water supply, drainage and sanitation
IS: 1346	:	Code of Practice for water proofing of roofs with bitumen felts
IS: 1742	:	Code of Practice for building drainage
IS: 1905	:	Code of Practice for structural use of unreinforced masonry
IS: 2210	:	Criteria for design of reinforced concrete shell structures and folded plates
IS: 2633	:	Method for testing uniformity of coating on Zinc Coated Articles
IS: 3067	:	Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
IS: 4759	:	Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products
IS: 10440	:	Code of Practice for construction of reinforced brick and reinforced brick concrete floors and roofs
IS: 13592	:	Un-plasticized polyvinyl chloride (UPVC) Injection molded fittings for soil & waste discharge system for inside and outside buildings including ventilation and rail water system specification
IS: 15658	:	Precast concrete blocks for paving
SP: 6	:	Handbook for structural engineers - All parts
SP: 7	:	National Building Code of India
SP: 16	:	Design Aids for reinforced concrete to IS: 456-1978
SP: 20	:	Handbook on masonry design and construction
SP: 22	:	Explanatory handbooks on codes for earthquake engineering (IS: 1893-1975 and IS: 4326-1976)
SP: 24	:	Explanatory handbooks on Indian Standard code of Practice for plain and reinforced concrete
SP: 25	:	Handbook on causes and prevention of cracks in buildings
SP: 32	:	Handbook on functional requirements of industrial buildings
SP: 34	:	Handbook of concrete reinforcement and detailing (SCIP)
TAC	:	Traffic Advisory Committee
-	:	Indian Explosive Act
-	:	Indian Factory Act and State Factory Act

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- : Indian Electricity Act

Any statutory codes / standards / regulations other than listed above, as may be applicable, shall be followed.

Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in this document, the latest editions of the codes and standards given below shall also apply:

- a) Japanese Industrial Standards (JIS).
- b) American National Standards Institute (ANSI).
- c) American Society of Testing and Materials (ASTM).
- d) American Society of Mechanical Engineers (ASME).
- e) International Organization for Standardization (ISO).
- f) American Welding Society (AWS).
- g) National Electrical Manufacturers Association (NEMA).
- h) National Fire Protection Association (NFPA).
- i) International Electro-Technical Commission (IEC).
- j) German national codes (DIN)
- k) Expansion Joint Manufacturers Association (EJMA)

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-II
SECTION-II, PART-A
ANNEXURE-M1
SPECIFICATION OF CFBC BOILER**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURE - M1

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GENERAL

[The CFBC boiler shall be outdoor type, top supported with natural circulation, balanced draft , two pass circulating fluidized bed combustion using crushed limestone as the sulfur absorbent with all necessary auxiliaries, integral piping, elevator etc. The Boiler shall produce [.....] ton/hour steam to drive a steam turbine and its associated electric generator with the capacity of approximately [.....] MW Gross of each Unit. All components of the Boiler shall be designed to burn the coal with the analysis furnished. CFBC Boiler complete with all the accessories shall be covered under this section of specification.

The proposed boiler will be provided with all supporting structure, platforms, galleries and stairways for access to maintenance of each unit. All boiler platforms will be accessible by suitably located stairways. Monorails and hoists, as required, will be provided for handling of heavy pieces of equipment. The boiler design will focus on efficient & reliable operation, optimized capital & operating cost and environment protection.]

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2 SPECIFIC DESIGN CRITERIA OF BOILER & AUXILIARIES

- 2.1 Each Boiler shall be of the top supported with natural circulation, balanced draft, two pass circulating fluidized bed combustion using crushed limestone as the sulfur absorbent suitable for outdoor installation. The Boiler Maximum continuous Rating (BMCR) shall correspond to 102% of the steam flow at turbine inlet under VVO conditions plus the steam requirement for auxiliary systems of the unit. Preliminary steam turbine throttle conditions shall be [130 kg/cm² (a)], 537°C main steam and [537°C] reheat temperature respectively.
- 2.2 Boiler shall be an outdoor boiler with canopy at top. All electrical and C&I equipment shall be designed for outdoor operations. Where necessary, outdoor equipment such as pumps etc shall be protected by suitable enclosures or rain canopies to facilitate maintenance.
- 2.3 The Boiler will be operated continuously. The Boiler shall be capable of maintaining stable operation at 30% BMCR while firing worst coal without oil support. The step load change shall be minimum ±10%/min and the ramp rate shall be minimum ±2% per minute for 30-50% BMCR load and minimum ±3% per minute for 50-100% BMCR load.
- 2.4 Design life of the Boiler equipment shall be 25 years minimum. However, the unit shall also be capable of operation for two shifting cycles. The design duty for [20/25] years shall be as follows:
- Hot start : [4000]
- Warm start : [1000]
- Cold start : [150]
- 2.5 The Boiler unit shall be primarily designed for sliding pressure/ modified sliding pressure mode of operation. However flexibility to operate with constant pressure at lower loads shall also be provided.
- 2.6 Design pressure of the furnace walls shall be sufficient for the specified pressure at the superheater outlet, plus drop through superheater at the specified full load, plus not less than 6% margin. All gas side design pressures shall be in accordance with NFPA 85 or equivalent. Boiler vendor shall be responsible for determining the actual pressures based on its calculations. A furnace implosion study shall be completed to verify adequate design pressure. The minimum furnace and convection pass flue gas transient pressure shall be ±660 mmwcl at 67% of yield stress. The bidder shall consider furnace explosion vents if required.
- 2.7 The furnace shall be of the balanced draft type.

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2.8 In line with automatic run back capability of the unit load on loss of critical auxiliary equipments, the Boiler equipments and systems shall ensure smooth and stable runback operation.

2.9 Minimum 100% TMCR load under H.P. Heaters out Condition.

The Boiler shall be designed for continuous operation with all the High Pressure Feed Water Heaters out of service, when the feed water temperature at economiser is low. The economiser shall be suitably designed to take a thermal shock of sudden change in feed water temperature, under such conditions. The superheater and reheater temperature control system shall be designed to maintain the rated steam temperature with the HP heaters out of service from 60% to 100% TMCR.

2.10 Low Frequency Operation

The Unit shall operate the interconnected electrical net work for which the frequency may go as low as 47.5 Hz. These criteria should be considered while sizing the Boiler and its all auxiliaries.

2.11 The Boiler and auxiliaries shall perform continuously within the specified noise limit mentioned in General Technical specification.

2.12 All major auxiliaries shall be sourced from such reputed manufacturer(s) who would have supplied equipments of similar type, design for at least one (1) other power station of similar size, which are as on date of NIT, in successful commercial operation for a period of at least one year.

2.13 Limits of NOx Emission

To reduce the NOx emission from Boiler, the Bidder shall make all provisions in the Boiler design and fuel firing system.

The Bidder shall bring out the special measures incorporated in the Boiler design to keep the NOx emission within the specified limit value in the proposal.

2.14 Boiler shall be capable to undertake forced cooling under emergency.

The furnace and superheater, when cleaned by operation of soot blowers supplied with the Boiler, shall have sufficient surface to provide the BMCR Guarantee performance.

2.15 The Boiler shall be capable of 100 % BMCR load with 100% worst coal as specified.

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- 2.16 The Boiler shall be capable of 100% BMCR load with worst ambient air conditions.
- 2.17 1x100% boiler fill pump shall be adequately sized to fill each boiler in not more than 2 hrs time of continuous operation, taking suction from condensate storage tank (CST). The pump shall also supply water for filling of the deaerator. *[Provision shall be kept for interconnecting the discharge of boiler fill pumps of the 2 units for flexibility and transferring condensate].*
- 2.18 The quality parameters of steam shall be as per the requirement of the turbine manufacturer. However, the same shall not be inferior to the following under all operating conditions:
- a) *[Silica as SiO₂ :<20ppb]*
 - b) *[Sodium + Potassium as Na + K :<10ppb]*
 - c) *[Copper as Cu :<3ppb]*
 - d) *[Iron as Fe :<20ppb]*
 - e) *[Conductivity at 25 deg C :<0.3 μS/cm]*
- 2.19 The quality parameters of the boiler water shall not be inferior to the following limits:
- a) *[Phosphate ions : 0.5 to 3 ppm]*
 - b) *[Silica_ : ≤ 0.25 ppm]*
 - c) *[TDS_ : ≤ 0.20 ppm]*
 - d) *[Conductivity at 25 deg C: ≤50 μS/cm]*
 - e) *[pH at 25 deg C : 9.2 to 9.4]*

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3 DESIGN AND CONSTRUCTION

The Boiler shall be designed and fabricated in accordance with ASME Boiler and Pressure Vessel (B & PV) Code, Section I, or International equivalent. Piping not falling within the jurisdiction of ASME B & PV Code, Section I, shall be designed and fabricated in accordance with ANSI B31.1.

3.1 Steam Drum

The steam drum will be provided with:

- Fully welded drum with hemispherical dished ends in both sides.
- Manholes with hinged manhole doors on both sides.
- Steam drums internals comprising cyclones, scrubbers, demisters, vortex breakers etc (Demister is of SS construction).
- All nozzle connections for steam, feed water, down comers, safety valves, level gauges, mountings, CBD & IBD lines, chemical dosing lines, sampling connections etc as per approved P&IDs.
- Necessary supports like sling support/ U-rod for supporting the steam drum and disc springs (total supporting assembly).
- N₂ gas system design, N₂ nozzles and connecting piping from one point near the boiler operating floor.
- Local drum level gauges.
- Remote level gauge (Electronic drum level indicator -EDLI).
- Pressure gauges at drum floor & operating floor.
- Level transmitters and pressure transmitters.
- Temperature elements/ indicators for skin metal temperature.
- Supply of necessary piping & fittings, valves etc as per approved P&IDs.
- Supply of instruments as per approved P&IDs.
- Rust preventive painting at shop floor.
- Steam drum will be manufactured and supplied as per approved QAP.

3.2 Safety Valves & Silencers

The following safety valves and silencers shall be provided:

Steam Drum

- a) Spring loaded mechanical safety valves as per ASME requirements.
- b) Drain piping.

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Main Stream (FSH Outlet) Line

- a) Spring loaded mechanical safety valves (as per ASME) along with silencers and necessary piping.
- b) Drain piping
- c) EMRV (as per ASME) with hand operated isolation valves, silencers and necessary piping up to silencer.
- d) Motor operated start up vent valve (as per ASME) with manual operated isolation valve, silencer and necessary piping.

Reheater

- a) Spring loaded mechanical safety valves on inlet header (as per ASME) along with silencer and necessary piping.
- b) Spring loaded mechanical safety valves on outlet header (as per ASME) along with silencer and necessary piping.
- c) Motor operated start up vent valve on outlet header (as per ASME) with manual operated isolation valve, silencer and necessary piping.
- d) Drain piping.

3.3 Superheater and Reheater

The boiler shall be equipped with suitable superheaters and reheater of sufficient capacity and surface to superheat the steam to the required condition.

Standard and proven design shall be offered with full details for customer's review and acceptance.

3.4 Economizer

The economizer shall be of non-steaming type. The economiser shall be designed for counter flow design with the water flow upwards, through the elements and the gas flow from top to bottom. Tubes shall be arranged in parallel in-line rows. Tubes shall be welded to nipples on headers. Plain tubes or extended heating surface are acceptable, spiral fins are not acceptable. Feed stop and check valves shall be located in the feedwater piping upstream of the economizer. Double drain valves shall be provided. Economiser filling line and sampling lines shall be provided at the inlet of economiser. The sub-cooling of the economizer shall be minimum 40 deg C. The sub-cooling is defined as saturation temperature at 30% MCR load minus economizer outlet water temperature at 30% MCR load.

Maximum gas velocity through economizer section should not exceed maximum average 10 m/sec.

Boiler vendor shall furnish retractable economizer soot blowers as required to limit the buildup of fly ash between banks, tubes, and headers.

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Handholes shall be provided with welded covers. Where required for access and inspection, doors shall be provided with tight gasketed joints.

A pyramidal watertight hopper shall be constructed to include the entire active area of the economizer. Hopper sides shall be inclined to provide a valley angle of at least 65 degrees. Flanged connections shall be provided to connect to ash removal equipment.

The economizer shall be arranged for external water washing and an access platform shall be provided at the hopper outlet.

Space provision shall be kept for augmenting line coils/ bank in economiser sealing if required.

3.5 Furnace

The furnace may have vertical tubing configuration. Front, rear and sides of the furnace shall have fin-welded or fusion welded walls with fully welded tube walls. The roof shall be fin-welded or fusion welded where possible. Location of the wall tube field welds shall be easily accessible for testing, inspection and maintenance. The rear wall shall be accessible from the outside from the bottom elevation of the furnace to an elevation above the nose cone for operation and maintenance of soot blowers, instrumentation and other accessories. The furnace shall be designed with sufficient volume to provide complete and efficient combustion of fuel.

All furnace casing penetrations shall be gas tight.

Openings i.e. peepholes shall be provided in the furnace walls for observation of furnace conditions. There shall be an opening in each sidewall at the level of the hopper restriction.

Tubing material shall be selected for the most severe conditions imposed by operation in this application. The wall tubing material and wall thickness shall be conservatively selected to withstand all anticipated transient and steady state operating conditions expected including the erosion characteristics of the coal. However, material diagram shall also be provided from the bidder as part of the boiler specification requirement.

The tube thickness calculation shall use the maximum tube mean temperature as the design metal temperature. However, the maximum outer wall surface temperature shall be checked to make sure the selected tube thickness is adequate for the maximum outer wall surface temperature.

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Sleeves shall be provided in the furnace roof to permit installation of hanging scaffolds for maintenance and repair purposes. Sleeves shall extend through the penthouse roof.

The minimum distance between tubes forming the throat and discharge opening of the hopper bottom (centerline to centerline) shall be no less than 1 meter, and shall extend the full width of the furnace.

A carbon steel skirt plate of sufficient depth to accommodate furnace expansion plus 150 mm shall be securely attached to the furnace tubes and sealed to prevent air leakage. The plate shall be dimensioned in accordance with the bottom supported flooded ash hopper. The skirt plates shall be shielded from furnace radiation. The minimum height of bottom ring header shall be 10.0 meters from the ground level.

At all loads there shall be no flame impingement on any part of the furnace walls and no accumulation of slag on the walls or hoppers that will interfere with continuous satisfactory operation of the plant.

The gas velocities shall be low bearing in mind the high ash content of the fuel. The gas passages shall be designed to ensure a smooth flow without any abrupt change in direction. Erosion problems in tubes shall be taken care of by providing least nos. of baffles, screens etc. The erosion allowances considered in tube design shall be clearly indicated. Allowance of 1.0 mm to furnace tube thickness and 0.5 mm allowance to FSH and final RH tube thickness shall be considered.

The gas temperature at furnace exit shall be minimum 60 Deg.C less than ash initial deformation temperature so as to minimize possible surface fouling consistent with the requirements of superheat temperature.

Furnace shall be designed in such a way that it will provide sufficient tolerance against Departure from Nucleate Boiling (DNB) for all furnace upset conditions while operating in subcritical regime.

Provision shall be made for installation of additional soot blowers in the furnace after the unit is commissioned, if the operational requirements warrant the same.

Furnace/evaporator/waterwalls shall comply requirements at 100% BMCR and HP Heaters out conditions for the range of specified coals, under most stringent combination of conditions.

3.6 Combustion Chamber

A balanced draft, water-cooled combustor, of fusion welded membrane wall type construction complete with water wall tubes and headers and drains etc shall be provided to make it gas and pressure tight envelope.

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This shall be as per bidder's standard practice but the details will be furnished along with the offer for customers review and acceptance.

3.7 Hot Plate Cyclone

The entire cyclone and loop seal assembly shall be designed as top supported to expand downwards with the furnace and the back pass. The tube metal temperatures in both furnace and cyclone / loop seal assembly would be same to avoid any differential thermal expansion between the components.

This shall be as per bidders' standard practice but the details shall be furnished along with the offer for customers review and acceptance.

3.8 Fuel Feeding System

The fuel feeding system shall consist of fuel (coal/Lignite) bunkers, outlet gate valves, coal feeders, outlet chutes etc. The system shall be provided with the necessary arrangements to continue feeding within design range of fuel size and within design range of moisture content.

Crushed fuel (coal / Lignite) matching the design size requirement will be supplied by the owner through the belt conveyors and trippers (covered in a separate package) to the steel bunkers included in the scope of this package. The storage capacity of the bunkers shall be designed for 14 hrs capacity corresponding to worst fuel quality. The bunker supporting structures shall be designed considering the optimum bulk density of the worst fuel. The conical hopper portions of the bunker shall be lined with stainless steel including an optimum height from the bottom. The bunker valley angle shall be maintained not to exceed 65 degrees and the bottom openings shall be liberally sized to ensure a smooth flow of fuel from the bunkers by preventing any hang up or plugging.

Fuel feeders of drag chain type shall be provided to receive fuel from each bunker. The fuel feeders shall be provided with variable frequency drives (VFDs) so that fuel feed rate can be controlled by varying the speed of the feeders. The feeders shall be designed in such a way that even when one feeder goes out of operation, the full steam capacity of the boiler can be met with the required fuel feeding through other feeders. The fuel feeders shall be designed to deliver the maximum specified output when the boiler is in operation either with the design fuel or the worst fuel.

The fuel feeders shall be entirely enclosed with casing. The complete feeder shall be kept at a slightly positive pressure with the provision of seal air connection to prevent any back flow of fuel and air from the high pressure furnace bottom. The

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outlet of the feeders shall be fitted with an air bustle to supply the necessary assistance air to augment smooth fuel feeding apart from the gravity fed provision.

Inclined coal chutes of stainless steel shall be provided at the outlet of the air bustle of each feeder. The inclination of the chutes shall be selected to ensure smooth flow of fuel at all operating conditions.

3.9 Limestone (Sorbent) Feeding System

Limestone feeding system shall be provided to reduce SOx emissions. The capacity of the system shall be designed on the basis of sulfur content in the fuel. The system shall consist of limestone milling plant, limestone powder handling system for conveying the pulverized limestone pneumatically up to limestone storage bunkers in the boiler area and limestone injection system from the storage bunkers up to the furnace inlet. Airlock feeders of gravimetric type shall be provided for injecting the limestone powder from the storage bunkers to the furnace inlet.

3.10 Loop Seal

A loop seal consisting of a bubbling fluidized bed shall be provided between the cyclone separator and the furnace. The loop seal shall be complete with distribution grid, air nozzles, fuel injection arrangement, sorbent injection arrangement and dedicated air blowers with accessories shall be provided. The pressure in the Loop seal shall be higher than the furnace pressure so as to prevent combustion gases to back flow into the cyclone. The details of loop seal shall be furnished along with the offer for customers review and acceptance.

3.11 External Fluidized Bed Heat Exchanger (EFBHE)

EFBHE consisting of a bubbling fluidized bed complete with distribution grid, air nozzles, heat exchanger tube bundles and dedicated air blowers with accessories shall be provided as per the bidder's standard practice. The details of EFBHE shall be furnished along with the offer for customers review and acceptance.

3.12 Bottom Ash Removal System

Bottom ash removal system shall be designed to remove bed ash by continuous overflow to maintain bed height and also by intermittent flow from the bottom through ash drains to remove oversize particles, maintain bed pressure drop, avoid accumulation and consequent de-fluidization. The system shall be designed as the bidder's standard practice. The details of Bottom ash removal

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system shall be furnished along with the offer for customers review and acceptance.

3.13 Bottom Ash Cooling System

Bottom ash cooling system shall be provided to cool the bottom ash to 120 to 150 deg C before entering the bottom ash conveying system. For this purpose, suitable ash coolers either of air cooled or water cooled type shall be provided as the bidder's standard practice. The details of Bottom ash cooling system shall be furnished along with the offer for customers review and acceptance.

3.14 Enclosures

The Boiler shall be constructed to form an air and gas tight chamber from air inlet to flue gas outlet for preventing leakage.

Adequate number of access and observation openings/doors shall be provided at various levels and positions in the furnace, superheaters, reheater and other enclosed parts. Doors shall be hinged and air tight and shall meet all safety requirements by law or special regulations.

Access shall be adequate for taking power operated maintenance cradle within the furnace, either in assembled or dismantled condition. Adequate openings on roof and fixing arrangements as required shall also be provided.

Enclosure shall include a fin-welded or fusion-welded wall or a welded steel plate casing fastened directly to furnace tubes, necessary insulation and an outer lagging or ribbed type clad aluminum alloy 3004 with stucco embossed finish, not less than 1 millimeter (0.040 inch).

Furnace and rear pass enclosure walls shall be suitable for water washing.

Hinged access doors, arranged to permit convenient and safe access for maintenance, shall be provided at floor and platform levels. Access and observation doors shall be also provided to permit access to all compartments and the easy removal of slag accumulation. Access doors shall be not less than 400 millimeters (16 inch) in diameter. All doors shall be provided with seals.

3.15 Air Heaters

Tubular type air heaters shall be provided for heating the primary air and secondary air and shall be designed for 60% BMCR condition.

Gas velocity through air heater should not exceed 10 m/sec.

Access doors shall be air and gas tight when closed and be of adequate size for inspection, cleaning and replacement of parts.

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Isolating gates/ dampers (flap type with sealing efficiency > 99.5%) shall be provided for both APH at inlet & outlet of the APH and carrying out maintenance.

The Steam Coil Air Preheater (SCAPH) shall be adequate to maintain cold end mean metal temperature 10 deg.C above acid dew point. SCAPH shall be complete with necessary valves, remote operated control valve, motor operated isolating valve, steam piping, steam traps etc.

Suitable water wash hopper(s) shall be furnished with flanged connection(s). Hoppers shall be water tight for water washing. The air heaters shall be arranged for external water washing. An access platform shall be provided at each hopper outlet flange.

A complete air heater soot blowing system shall be provided with each air heater.

The Steam Coil Air Preheater (SCAPH) shall be adequate to maintain cold end mean metal temperature 10 deg.C above acid dew point. SCAPH shall be complete with necessary valves, remote operated control valve, motor operated isolating valve, steam piping, steam traps etc.

Bidder may propose alternate arrangement for the SCAPH for the back end corrosion protection (viz hot air recirculation or gas bypass etc). However, for such alternative bidder shall clearly explain their proposed arrangement in the bid document for Owner's review.

Design of air and gas ducts to and from the air heater shall be of suitable design for even distribution of gas and air across the air heater at all loads. Design of air heater shall permit off-load water washing with suitable hoppers.

3.16 Air and Flue Gas System

The air and flue gas system shall be designed to meet the requirements of 100% SG MCR conditions and with the fuels specified.

The air and flue gas system shall consist of 2x 60% capacity centrifugal backward curved fans of each type, tubular air preheater (APH), Air heater bypass system, cold air, hot air, and flue gas ducting, dampers and expansion joints etc.

The air and flue gas system for each of the Boiler unit shall be balanced draft system and shall consist of 2 x 60% capacity PA fans, 2 x 60% capacity SA Fans, 2 x 60% capacity centrifugal type ID fans with variable speed hydraulic coupling, 1 x 100% tubular air preheater shall be provided for preheating the

- (a)Primary Air and
- (b)Secondary Air

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High pressure blowers (2 x100 % capacity) shall be provided for supplying the fluidizing air for the ash coolers and ash classifier [if applicable] with 100 % isolation and handling arrangement for individual streams with associated cold air, hot air and flue gas ducting and dampers to handle the Boiler requirements.

All the dampers and shafts shall be bearing supported.

The sizing criteria for the fans shall be as follows:

Sl no	Particulars	Primary fan	air Secondary air (SA) Fan	Seal blowers for sealing air requirement	Wall for fluidising air Blower for ash coolers	ID Fan
a.	No of fans per unit	2 x 60 %	2 x 60 %	2 x 100 %	2 x 100 %	2 x 60 %
b.	Test block margins					
i)	Flow, Mass Rate	+ 20 %	+ 20 %	+ 20 %	+ 20 %	+ 20 %
ii)	Variable pressure *	+ 30 %	+ 30 %	+ 30 %	+ 20 %	+30 %
iii)	Temperature , OC	+ 5	+ 5	+14	Max Ambient	+15
c.	Maximum rotating speed, rpm	< 1500	<1500	<1500	<3000	<750
d)	Type of motor	Induction	Induction	Induction	Induction	Induction

*Variable pressure is defined as pressure loss associated with ducts, dampers and valves.

Fans shall be sized to provide adequate air flow for the range of fuels specified at BMCR load. Owner reserves the right to review all fan and blower calculations, including supporting calculations.

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The rotor shall be overspeed tested to at least 10% above the maximum operating speed and shall be dynamically balanced. The fan shaft is to be supported in bearings on either side independent of the casings. Overhung impellers will not be acceptable.

All fans shall be designed for under frequency operation up to 47.5 Hz without any reduction in its performance. The first critical speed of the rotor shall be well above the operating speeds (by at least 15%).

Forced oil lubrication system (if offered) for the fans and motors shall consist of 2 x 100% oil pumps each with motor, 2 x 100% oil coolers and filters; one (1) oil tank associated valves, piping, one number nitrogen filled pressure vessel etc.

The flow induced pulsation should be avoided by suitable design of fan and connecting duct work.

Suitable design of shaft sealing shall be provided to prevent ingress of atmospheric air.

Each bearing pedestal of all the fans and blowers shall be provided with vibration sensors to facilitate on line monitoring from the control room.

Each bearing housing of all the fans and blowers shall be provided with adequate number of duplex RTD's and temperature indicators for remote and local monitoring.

Each bearing is to be provided with oil level indicator and a screwed drain plug. Adequate sealing arrangement shall be provided at each end of the bearing housing to prevent leakage of lubricating oil.

Silencer shall be provided at the inlet of fans sucking atmospheric air with weather hood and inlet screen. The suction shall be taken at least 10m above the ground. The silencer shall be adequately designed with GI sheets of 2 mm thickness.

Each bearing shall be provided with an oil bath to prevent bearing damage in case of complete loss of plant auxiliary power when the fans must coast down without power.

An adequate number of interconnecting, isolating and control dampers with drives shall be provided on all cold air, hot air, seal air and flue gas ducting before and after equipment on these systems to permit proper operations. The control dampers shall be pneumatically operated and isolation dampers shall be electrically operated along with manual operation provision.

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The gas and air ducts shall be designed for wind loads as loads as specified for the steam generating unit proper and their own weight including fly ash load which may get deposited at the duct bottom, insulation and lining. The top of the ducts shall be crowned to ensure proper drainage. The bottom portion of the flue gas duct between air heater outlet and ESP inlet shall have wall thickness of minimum 10mm to counter erosion. However the thickness of the other three sides of this duct shall be of minimum 6 mm thick.

The duct work shall be free to expand, but it shall be rigid against wind and seismic disturbances. Adequate provision shall be made for all expected expansion or contraction. Metallic expansion joints shall be used in air and flue gas systems. MEJ shall be provided with internal sleeve to protect against ash, bed material etc. If Non metallic Expansion joints are used, same shall be with bolster arrangement.

All gas and air ducts shall be designed to ensure uniform distribution of gas and air flow to the various portions of the unit. These ducts shall consist of turning vanes / baffle plates, stiffening devices, metallic expansion joints, interior bracings, access doors and brackets, support structures and hangers as necessary. Compensator protection plates shall be provided in all the metallic expansion joints.

The maximum air and flue gas velocity to be considered for sizing of duct system considering 25 % excess air requirement shall be as follows:

- a) Maximum air velocity : 13 meter /sec for cold air
: 20 meter /sec for hot air
- b) Maximum flue gas velocity : 12 meter /sec for ducting up to ESP inlet
: 16 meter /sec for ducting from ESP outlet to chimney inlet

Access Doors shall be provided in all air and flue gas ducts particularly near all dampers for maintenance purposes. Each ID fan shall be provided with an access door before discharge damper.

Aerofoils shall be provided in the air ducts for the measurement of air flow of PA & SA fans at individual limbs and total air flow after air pre-heaters.

Individual continuous purging shall be provided for all Air and Flue gas transmitters. The tap points for these services shall be "Y" shaped.

The purging line shall be connected near the root valve only and not at the Transmitter end.

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Locking devices shall be provided to dampers to permit locking in both open and shut positions. All damper bearing shafts shall be bearing supported.

Electrical operated guillotine type isolation dampers along with drives shall be provided at locations required for carrying out internal repairs and maintenance of the equipments /fans when the Boiler is on load. The inlet dampers for ID fans shall be located in horizontal duct of main inlet duct to avoid fly ash build up when in closed position. All other regulation dampers shall be pneumatically operated and isolation dampers shall be motor operated. As a minimum guillotine type isolation dampers shall be provided before and after each ID fan.

The flue gas duct layout shall be designed considering the following aspects:

- The change of direction of flue gas duct shall be gradual to avoid ash collection at the bottom of the duct and also to prevent erosion by local concentration of fly ash.
- The number of direction changes of the flue gas duct shall be minimal to minimise the ash collection points. Adequate number of baffles to be provided at all direction changing locations.
- However, the air preheater, economiser and duct hoppers shall have provision for removal of fly ash during maintenance period when the steam generation is out of operation. To facilitate such fly ash removal, a 100% gas tight isolation gate near the hopper bottom shall be provided. The hopper bottom shall be blanked with a blind chute suitable for unloading fly ash from all the above mentioned hoppers.

All the fans and blowers shall be provided with electrically operated hoists both on fan and motor side. The primary air discharge ducts of left and right shall be interconnected with isolation dampers. The similar interconnection shall be carried out in secondary air system.

3.17

Soot Blowing System

A complete set of automatic, programmable, selective sequential-type electric motor operated and driven soot blowing equipment shall be furnished for the furnace walls, superheater, reheater, economizer and air heaters. The soot blowing system shall include all necessary blowers, electric drive motors, DCS based sequence control, all piping including drain system piping (to grade floor level), valves, safety valves, switches, hoses, electrical accessories, relays, support frames and hangers complete including all components for operation. Soot blowers shall be provided with a means of locally de-energizing both power and control circuitry for maintenance.

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The soot blower elements shall be as automatic sequentially operated. Adequate wall blowers have been considered for dislodging of the ash on coils and tubes.

Necessary valves for PRDS station have been considered for steam soot blowing system. LT Switchgear, control panel, complete power, control & inst. Cable of soot blower system.

The soot blower piping includes the following

- a) Supply piping through pressure reducing station.
- b) Drain piping
- c) Vent piping
- d) The complete soot blower piping shall have warm up and automatic draining features.
- e) All necessary valves, relief valves and mountings and fittings have been considered.

Electrically operated long retractable/ rotary soot blowers complete with PRV and other accessories & fittings should be supplied as per design requirement.

Sequential operation of the soot blowers will be realized in soot blower PLC panel.

3.18 Boiler Coal feeding system

The coal burning system shall be designed to meet the requirement of Boiler at 100% SG MCR condition.

To transport the solid fuel (coal) from the bunker outlets to the boiler, the system shall be complete with isolation valves /gates, chutes, feeders, with all supports / hangers, instrumentation etc for a complete system.

3.19 Blow Down System

Systems indicated below shall be as per Bidder's standard practice but details of which shall be furnished along with the offer for customer's review and acceptance.

Other specific requirements are indicated below. These are, however, minimum required.

A Blow down Tanks

One (1) no. continuous & One (1) intermittent blow down tanks (as applicable) including level gauges, redundant level transmitters for remote level control through SG C&I system, control valves, safety valves with silencer, vents, drains.

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All other local instruments like gauge glass, level switch, high/low level alarms and pressure/temperature instrumentation shall also be provided.

B Valves

All necessary isolating, control, regulating, check and relief valves and/or pneumatic valves, motorized valves including main steam stop valves, vent valves, drain valves, root valves, safety valves with silencer, mountings etc., as required for the boiler integral piping system. All Pneumatic operated valves shall be complete with actuator assemblies and accessories like limit switch assemblies, position transmitters, air locks etc. Integral bypass valves with actuators and accessories, for all high pressure isolating valves as specified. Any valve/mounting not specifically indicated but required for safe/efficient/reliable operation of the boiler shall be included.

The valves and accessories shall comply with the following requirements and shall include:

- a) Drain, vent, air release, instrument root drains and sampling lines shall be provided with two valves in series. However, single isolating valve shall be provided in case pressure is less than 40 Kg/ sq cm (a).
- b) Main stream stop valves with motor drives along with motorized bypass valves and piping.
- c) One non-return valve and a motor operated isolating valve with integral bypass valve on feed line(s) at inlet and as close as possible to the economizer.
- d) Steam drum safety valves with silencer and drain pans.
- e) Superheater and reheater safety valves with silencer and the drain pans for these.
- f) Electromatic relief valves, on SH outlet and RH outlet and the drain pans for these. Each of these electromatic relief valves at SH/RH outlet(s) shall be composite unit including solenoid valve assembly, pressure sensing device, impulse piping, accessories etc. The control of ERV shall be performed in DDCMIS with CRT/KBD operation. A motorised remote operated isolation valve shall be provided on upstream side of each relief valve.
- g) Start-up drain and vent isolating valves with motor drives.
- h) All start-up vents, lowest set pressure spring loaded safety valve and electromatic safety valves at superheater outlet, lowest set pressure spring loaded safety valves on steam drum and reheater outlet and impulse safety valve on reheater outlet shall be provided with separate

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and independent silencers for each. The silencers shall meet specified noise levels and the safety/ relief valve floats.

- i) All instrument tapping points with root valves. Two root valves in series shall be provided for lines above 40 kg/cm² (a) pressure.
- j) Isolating and drain valves for each of gauge glasses.
- k) Necessary drain system including low noise drain valve to ensure draining of the Boilers in one hour without any assistance.
- l) A non return valve and isolation valve on boiler fill line.
- m) Any other valves not mentioned specifically but needed to complete the system with drives, wherever required.
- n) The start-up, load maneuvering and shut down of Boiler is proposed from the unit control room. The Contractor shall provide all required valves with their actuators and remote operation facilities to achieve this.
- o) Emergency drum drain valves, two (2) in series with motor drives.
- p) Power operated, regulating type valve on continuous blow down line with motorized isolation valve on either side.
- q) An identical bypass arrangement to the valves on continuous blow down line, as indicated above, shall also be provided.
- r) All other operational requirements specified elsewhere shall also be complied with. The Bidder shall provide all required valves with specified type of actuator to meet such operational requirements.

3.20 Chemical Dosing System & SWAS

- a) Skid mounted HP dosing system comprising of mixing cum storage tank (MSRL/ SS304) with motorized agitator and variable stroke, positive displacement type pumps. The plunger of the pump will be of SS304.
- b) Associated piping from pump outlet to steam drum inlet, valves, mountings, fittings, safety valves within system as per approved P&IDs.
- c) Base frame, foundation bolts & nuts, coupling set, safeguard, mating flanges etc.
- d) Necessary supports & supporting structure.
- e) Complete SWAS system.

3.21 Pressure parts design criteria

The design of all pressure parts (tubes, headers, vessels etc.) shall be as per ASME or other international codes with the approval of the purchasers. It is however, the responsibility of the Contractor to get various calculations and other

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technical documentations approved by the statutory authorities in the State and country of location of the plant.

Design pressure of the boiler pressure parts shall be atleast 1.05 times the maximum operating pressure, or as required by ASME/ other international codes, whichever is higher.

For boiler drum, the design pressure shall be higher of the value as per above or highest set safety valve pressure for full discharge.

The thickness of the pressure parts (steam and water tubes/ headers, pressure vessels etc.) shall be calculated using ASME formulae/factor of safety etc. Additional erosion allowance on the calculated tube thickness shall be provided at specified locations as specified by the purchasers in these specifications.

3.22 Pressure part materials

Materials used for boiler tubing, headers, piping, vessels and other pressure parts shall comply with maximum permissible temperature limits for various materials as specified below:

- a) Up to and including 400 deg C : Carbon steel to ASTM 106 Gr C. or SA 210C or approved equivalent
- b) Above 400 deg C but below 550 deg C : Alloy steel to ASTM A335, P-11/T-11, 22/T22, P91/T91 or approved equivalent.
- c) For SH/RH outlet leg (High temperature zone) : T-91/P-91
- d) Above 550 deg C : P-91/T-91* Austenitic Steel Grade to owner's approval.

*Note: P91/ T91 material could be used only up to 590 deg C.

Water walls shall be of membrane type and water wall tubes shall be of seamless design.

3.23 Thermal Insulation

The furnace, fans, air heaters, flues, ducts, hoppers, and piping, shall be thermally insulated so that the outside surface temperature will not exceed 60 deg C. In areas where surface temperature exceeds 60 deg C, personnel protection shall be provided within 1 meters (3 feet) of platforms, walkways and general access areas, and up to 2meters (7 feet) from grade or

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platforms/walkways, or where personnel may inadvertently make contact with those surfaces.

Thermal insulation on flues, ducts, and the wind box shall be mineral fiber block or mineral fiber blanket type insulation complete with outer lagging. Lagging of the ribbed type clad aluminum alloy 3004 with stucco embossed finish, not less than 1 millimeter (0.040 inch) thick shall be provided. All surfaces shall be self-draining.

Thermal insulation on the furnace casing shall be non-corrosive, non-asbestos material, readily removable and designed to prevent hot spots due to passage of hot gasses past butted joints. Insulation shall be thoroughly dried prior to installation of the casing.

Thermal insulation on pipe and equipment shall be calcium silicate or mineral fiber block type insulation complete with aluminum outer lagging. Aluminum lagging shall be of alloy 3003 or 3005, with a minimum thickness of 0.5 millimeters (0.016 inch) and fastened with stainless steel bands. Multi-layer insulation shall be applied where the inner surface of the insulation is 316°C (600°F) and above. The maximum thickness of the insulation per layer shall not exceed 75 millimeters (3 inches).

Procedure qualification and welder performance qualification shall be in accordance with either ASME B&PV Code, Section IX or ANSI B31.1 as applicable.

3.24 Welding and Repair welding

Post-weld Heat Treatment (PWHT) along with careful attention to welding procedures is required for welded joints to ensure minimal stress and optimum ductility. Boiler design shall maximize shop-welding and minimize field connections to reduce field heat treatment as much as possible. In the weldment of dissimilar alloys, material selection must be based on consideration of PWHT temperature. All boiler field welds will be on similar tubes. All welds between transition stub tubes and austenitic stainless steel tubes should be shop-welded.

All boiler field welds shall be on similar tubes. Welds between transition stub tubes and austenitic stainless steel tubes shall be shop-welded.

All pressure parts welding and repair welding, including non-destructive examinations, shall comply with ASME B&PV Code, Section I and ANSI B 31.1, as applicable or Equivalent International Standards.

Procedure qualification and welder performance qualification shall be in accordance with ASME B&PV Code, Section IX or ANSI B31.1 as applicable.

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3.25 Start Up Light Diesel Oil System

LDO system shall comprise of pressurizing pump sets of adequate capacity to meet startup requirement of Boiler, filters, strainers, burners, control valves, control and instrumentation etc with equipment redundancy and flexibility of operation, complete piping, valves, and fittings commencing from pump suction inlet from tanks right up to the burners in combustor, and re-circulating system, high energy arc igniters, scanners, and scanner cooling air system.

The startup firing system shall not require adjustment to increase capacity. The burners shall be furnished complete with all piping, manual valves, strainers, instruments, pressure regulators, solenoid valves, safety valves, and all necessary equipment and controls in accordance with NFPA 85C as applicable. Flexible stainless steel hoses to connect the burners to the LDO piping shall be provided. The system shall provide stability to solid fuel firing system. The contractor shall supply all piping and hangers for piping between each burner valve rack and the main shutoff rack.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-III
PART-A
TECHNICAL SCHEDULES-MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

{Guidelines for Using the Document}

{This document of Technical Schedules covers the data applicable both to the PF as well as CFBC Boilers. Since the Construction Features of CFBC Boilers vary widely from Manufacturer to Manufacturer, the Utilities are advised to ensure that the data to be sought for the R&M of CFBC Boilers is in line with the design of existing CFBC Boilers.}

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BOILER & AUXILIARIES

S.No	Detail	Description			
1.0	PERFORMANCE DATA	100% BMCR	100% TMCR	60% BMCR	HP Heater out of service
1.1	Load Data				
1.1.1	Steam flow from Super-heater, T/hr				
1.1.2	Steam flow through Re-heater T/hr				
1.1.3	Super-heater De-superheating Spray water flow, kg/hr				
1.1.4	Re-heater De-super heating Spray water flow kg/hr				
1.1.5	Auxiliary steam flow for soot blowing, oil burner atomization etc., kg/hr				
1.2	Calculated Flow quantity kg/hr.	100% BMCR	100% TMCR	60% BMCR	HP Heater out of service
1.2.1	Total air to Regenerative Air Pre-heater (RAPH) / Tubular Air Pre-heater inlet (Tubular APH) {As the case may be}				
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1.2.3	Total secondary air at Wind boxes.				
1.2.4	Flue gas at RAPH inlet / Tubular APH				
1.2.5	Flue gas at RAPH outlet / Tubular APH				
1.2.7	Coal firing				
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	b) With Worst Coal				
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1.2.9	Cold Air fan outlet air				
1.2.10	ID fan inlet flue gas				

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S.No	Detail	Description			
1.2.11	Tempering air for each pulverizer(Not Applicable for CFBC Boiler)				
1.2.12	Total air to each pulverizer (Not Applicable for CFBC Boiler)				
1.3	Steam/Water Pressure & Pressure Drops, Kg/cm²g	100% BMCR	100% TMCR	60% BMCR	HP Heater out of service
1.3.1	Steam at Super-heater outlet				
1.3.2	Pressure drop in Super-heater(s)				
1.3.3	Steam in Boiler Drum				
1.3.4	Pressure drop in Economizer*				
1.3.5	Water at Economizer inlet **				
1.3.6	Steam at Re-heater inlet				
1.3.7	Pressure drop thru' Re-heater(s)				
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1.3.9	Steam at Aux. Steam tap-off				
	* Less static head				
	** Including static head				
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1.7.8	Total loss through the system				
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1.9	Flue Gas Pressure & Pressure Drops, mm WG	100% BMCR	100% TMCR	60% BMCR	HP Heater out of service
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S.No	Detail	Description			
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1.9.7	Drop thru' Ducts & Dampers from	100% BMCR	100% TMCR	60% BMCR	HP Heater out of service
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1.11.1	Total number offered				
1.11.2	Number required for operation with -				
	a) Design Coal				
	b) Worst Coal				
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	b) Worst Coal				

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S.No	Detail	Description			
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	a) Design Coal				
	b) Worst Coal				
1.18.3	In Superheater with -				
	a) Design Coal				
	b) Worst Coal				
1.18.4	In Reheater with -				
	a) Design Coal				
	b) Worst Coal				
1.18.5	In Water Walls with –				
	a) Design Coal				
	b) Worst Coal				
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	a) Design Coal				
	b) Worst Coal				
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S.No	Detail	Description			
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	b) Worst Coal firing				
1.19.5	Unburnt Combustible Loss for				
	a) Design Coal firing				
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	a) Design Coal firing				
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	b)				
	c)				
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	a) Design Coal firing				
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	(Total loss- Heat credits)				

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S.No	Detail	Description			
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		100% BMCR	100% TMCR	60% BMCR	HP Heater out of service
1.20.3	Heat output of unit				
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1.20.6	Maximum net heat input per m ² of furnace plan area, Kcal/hr/m ²				
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1.20.8	Maximum heat liberation rate Kcal/m ²				
1.20.9	Maximum hot input/ burner, Kcal/hr.				
1.20.10	Cooling factor Kcal/hr./m ²				
1.21	Particulate matter concentration	100% BMCR	100% TMCR	60% BMCR	HP Heater out of service
1.21.1	Particulate concentration at ESP inlet -				
	a) Design Coal firing, g/Nm ³				
	b) Worst Coal firing, g/Nm ³				
1.21.2	ESP Efficiency				
	a) Design Coal				
	b) Worst Coal				
1.21.3	Particulate concentration at ESP				

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S.No	Detail	Description			
	Outlet				
1.22	Distribution of Ash (kg/hr.)				
1.22.1	Furnace bottom hoppers with				
	a) Design Coal				
	b) Worst Coal				
1.22.2	Economiser hoppers with				
	a) Design Coal				
	b) Worst Coal				
1.22.3	RAPH/ Tubular APH hoppers with				
	a) Design Coal				
	b) Worst Coal				
1.22.4	ESP hoppers with				
	a) Design Coal				
	b) Worst Coal				
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	a) Design Coal				
	b) Worst Coal				
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1.23.2	PA Fans				
1.23.3	FD fans				
1.23.4	ID fans				
1.23.5	Air Heater				
1.23.6	Coal Feeders				
1.23.7	Boiler Start up drain Recirculation Pump (If applicable)				
1.23.8	Seal Air Fan				

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S.No	Detail	Description			
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1.25	Control range of Boiler (% MCR)				
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	a) NOx Emission				
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S.No	Detail	Description
2.0	STEAM GENERATOR AND PRESSURE PARTS	
2.1	General Data	
2.1.1	Manufacturer	
2.1.2	Operation (fixed pressure/sliding pressure) from 100% TMCR to 40% BMCR	
2.1.3	Design code	
2.1.4	Type of firing	
2.1.5	Type of circulation for steam generator	
2.1.6	Minimum load at which steam generator can be operated continuously with complete flame stability without oil support (%MCR)	
2.1.7	Minimum load at which the steam generator can be operated continuously with complete flame stability with oil support (%MCR)	
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2.1.10	Details of permanent thermocouples giving the number and their location	
2.1.11	Write up on Burner management system furnished?	
2.1.12	Submitted evidence to support adequacy of design proposed considering furnace slagging, Coal ash corrosion & erosion, Superheater and Reheater fouling?	
2.2	Furnace (Applicable to PF Boilers)	
2.2.1	Type	
2.2.2	Wall Cooling Arrangement	
2.2.3	Bottom (Whether dry)	

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S.No	Detail	Description
2.2.4	Draft (Whether balanced)	
2.2.5	Tube Arrangement (Whether Membrane type)	
2.2.6	i) Explosion/Implosion withstand capacity (mmwg) at 67% yield point	
	ii) Protective measures provided to prevent implosion/explosion	
2.2.7	Residence time for fuel particles in the furnace (supported with calculations), hrs.	
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2.2.9	Height from top of furnace bottom ash hopper to furnace roof, M	
2.2.10	Depth (M)	
2.2.11	Width (M)	
2.2.12	Furnace projected area M ²	
2.2.13	Furnace volume M ³	
2.2.14	Furnace temperature probe	
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	b) Manufacturer	
	c) Quantity	
	d) Size	
	e) Location	
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S.No	Detail	Description			
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2.2.20	Elevation of Sorbent Injection,m				
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2.2.23	Superficial velocity,m/s				
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2.2.25	Coal / Lignite Feed Particle Size[...] to [...]mm				
2.2.26	Type of Sorbent Used				
2.2.27	Sorbent Feed Particle Size, microns				
2.2.28	Calcium/Sulfur Ratio				
2.2.29	Sulfur Removal Efficiency,%				
2.2.30	NOx emission, ppm				
2.2.31	Combustion Efficiency,%				
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2.2.33	Water Walls, m ²				
2.2.34	Superheaters, m ²				
2.2.35	Reheaters, m ²				
2.2.36	Economiser, m ²				
2.2.37	Air Heater, m ²				
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2.2.39	Temperature Measurement of Super-heater tubes, whether provided.				
2.2.40	Temperature Measurement of Re-heater tubes, whether provided.				
2.3	Water Walls	Front	Side	Rear	Roof
	a) Number/Type				
	b) Outside diameter (mm)				

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S.No	Detail	Description			
	c) Design thickness (mm)				
	d) Pitch				
	e) Actual thickness used (mm)				
	f) Design standard				
	g) Material				
	h) Total projected surface area of tubes, M2				
	i) Method of joining long tubes				
	j) Method of attachment to drum				
	k) Method of joining to headers				
	l) Total weight of tubes, Kg				
	m) Design pressure of tubes kg/cm ²				
	n) Maximum pressure of tubes Kg/cm ² abs				
	o) Design metal temperature deg.C				
2.4	Water Wall Headers	Front	Side	Rear	Roof
2.4.1	Number of headers				
2.4.2	Height of the lowest header above the ground level, M				
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2.4.4	Design thickness, mm				
2.4.5	Actual thickness provided, mm				
2.4.6	Length of each header, M				
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2.4.9	Design pressure of headers, kg/cm ² g				
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2.5	Boiler Drum				

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S.No	Detail	Description
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2.5.3	Material specification and composition	
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2.5.5	Composition	
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S.No	Detail	Description
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	a. During normal operation	
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	c. During sliding pressure operation from 100% TMCR to 40% TMCR	
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2.6.1	Total dissolved solids	
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2.6.3	Sodium	
2.6.4	Chlorides	
2.6.5	Copper	
2.6.6	Iron	
2.6.7	Moisture	
2.7	Superheaters	
2.7.1	Type (Radiant/convection)	
2.7.2	Platent (drainable/non-drainable)	
2.7.3	Pendant (drainable/non-drainable)	
2.7.4	Horizontal headers (drainable/non-drainable)	
2.7.5	Material specification and composition	
2.7.6	Effective heating surface area M2	
2.7.7	Total circumferential heating surface area,M2	
2.7.8	Gas flow path area, M2	

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S.No	Detail	Description
2.7.9	Depth of each bank in the direction of the gas flow, mm	
2.7.10	Clear space between the two banks in the direction of gas flow, mm	
2.7.11	Maximum steam side metal temperature °C	
2.7.12	Maximum gas side metal temperature °C	
2.7.13	Type of flow (counter or parallel)	
2.7.14	Material of tube support (composition)	
2.7.15	Design standard	
2.7.16	Design tube thickness, mm	
2.7.17	Outside diameter, mm	
2.7.18	Actual thickness used, mm	
2.7.19	Margin on tube thickness over and above pressure requirement, mm	
2.7.20	Number of elements/section	
2.7.21	Total number of tubes	
2.7.22	Tube Pitch	
	a. Parallel to gas flow	
	b. Across gas flow	
2.7.23	Number and type of thermocouples fitted to Superheater tubes	
2.8	Reheater	
2.8.1	Platen (drainable/non-drainable)	
2.8.2	Pendant(drainable/non-drainable)	
2.8.3	Horizontal headers (drainable/non-drainable)	
2.8.4	Material composition	
2.8.5	Total effective heating surface. m ²	
2.8.6	Total circumferential heating surface, m ²	
2.8.7	Gas flow path area, m ²	

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S.No	Detail	Description
2.8.8	Depth of each bank in the direction of gas flow, mm	
2.8.9	Clear space between the two banks in the direction of gas flow, mm	
2.8.10	Maximum operating pressure Kg/cm ² g	
2.8.11	Design pressure, Kg/cm ² g	
2.8.12	Maximum steam side metal temperature, deg.C	
2.8.13	Maximum gas side metal temperature, deg.C	
2.8.14	Maximum steam side metal temperature with IP turbine out of operation deg.C	
2.8.15	Design standard	
2.8.16	Outside diameter, mm	
2.8.17	Design tube thickness, mm	
2.8.18	Actual thickness used, mm	
2.8.19	Margin on tube thickness over and above pressure requirement, mm	
2.8.20	Total number of tubes	
2.8.21	Tube pitch, mm	
	a. Parallel to gas flow	
	b. Across gas flow	
2.9	Headers of Superheater & Reheater	
2.9.1	Material specification	
2.9.2	Location (outside/inside gas path)	
2.9.3	Maximum operating pressure, Kg/cm ² (g)	
2.9.4	Design pressure, Kg/cm ² (g)	
2.9.5	Design standard	

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S.No	Detail	Description
2.9.6	Outside diameter, mm	
2.9.7	Thickness, mm	
2.9.8	Whether any diaphragm is used in any header and if so give details	
2.9.9	Details of final outlet header connection	
2.9.10	Method of internal inspection	
2.9.11	Total volume, m ³	
2.9.12	Maximum header unbalance	
2.10	Superheater & Reheater Temperature Control	
2.10.1	Attemperator	Superheater Reheater
	a. Type	
	b. Number of stages of attemperation	
	c. Position in steam circuit	
	d. Specification of material	
	e. Superheater steam temperature range that can be maintained between 60% to 100% of Boiler MCR, deg.C	
	f. Spray nozzle material	
	g. Maximum spray water flow rate and corresponding steam output, T/hr	
	h. Minimum spray water rate and corresponding steam output T/hr	
2.10.2	Tilting burners (if applicable)	
	a. Maximum angle of tilt upwards	
	b. Maximum angle of tilt downwards	
	c. Type of tilt mechanism	
	d. Reheat steam temperature range that can be maintained between 60% to 100% of boiler MCR, deg.C	
2.11	Piping, Valves and Specialties for Critical (external) Piping	
2.11.1.0	Pipes & Fittings	

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S.No	Detail	Description
2.11.1.1	Basic codes and standards for	
	a) Design fabrication and erection	
	b) Testing and inspection	
2.11.1.2	Indicate the following for each pipe class	
	a. Design pressure, Kg/cm ²	
	b. Design temperature, deg.C	
	c. Design flow T/hr	
	d. Design velocity M/sec	
	e. Primary rating, lbs	
	f. Pipe manufacturing process and construction	
	g. Material of construction for	
	i) Pipes	
	ii) Fittings	
	h. Pipe sizes, mm (outside dia x thickness) and/or (Max inside dia x min thickness)	
	i. Tolerance for dia x min. thickness	
	j. Pipe wall thickness for bends, mm (corresponding to each pipe size)	
	k. Design metal temp deg.C	
	l. Friction factor	
	m. Pressure drop in Boiler MCR condition Kg/cm ²	
	n. Temp drop at 92.2% BMCR (deg.C)	
	o. Butt weld and socket weld and preparation standard	
	p. Welding process	
	q. Hydrostatic test pressure, at shop & after erection (for piping	

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S.No	Detail	Description
	systems under purview of IBR shall also be indicated) Kg/cm ² g	
	r. Minimum duration of hydrostatic test, (indicate for shop test as well as after erection) minute	
	s. Reference standard for ultrasonic examination of pipe bend for thickness conformance	
	t. Type of rust inhibitor given before shipment	
	u. Valve specification code	
2.11.1.3	Procedure and acceptance standard of non-destructive examination on weld joints	
2.11.2.0	Gate/Globe/Check/Stop Check Valves	
	For each type (construction, pressure class & body/bonnet material wise) of valve, indicate the following	
2.11.2.1	Reference valve specification code as designated in Section–2.09	
2.11.2.2	Basic specification	
2.11.2.3	Manufacturer	
2.11.2.4	Pressure class, lbs	
2.11.2.5	Nominal size	
2.11.2.6	Construction	
	a. Bonnet/cover	
	b. Disc	
	c. Ends	
	d. Seat	
	e. Others	
2.11.2.7	Materials	
	a. Body & bonnet/cover	

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S.No	Detail	Description
	b. Stem/hinge pin	
	c. Disc and seat ring	
	d. Back seat stem guide bushing	
	e. Gland packing	
	f. Bolts and nuts	
2.11.2.8	Hardness, BHN	
	a. Stem	
	b. Disc	
	c. Seat	
	d. Backseat/stem guide bushing	
2.11.2.9	Type and details of end connections	
2.11.2.10	Hydrostatic tests	
	a. Shell test pressure, Kg/cm ² g	
	b. Seat test pressure, Kg/cm ² g	
	c. Acceptable seat leakage rate in ml of water per hour per 25 mm of nominal valve size	
	d. Duration of shell and seat tests minutes	
2.11.2.11	Valve weight, Kg	
2.11.2.12	Gear operator provided?	
	If so for what size of valves?	
2.11.2.13	Integral bypass valves provided?	
	If so for what size of valves?	
2.11.3.0	Electric Actuator for Valves	
	Furnish the following for each type of valve	

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S.No	Detail	Description
2.11.3.1	Manufacturer	
2.11.3.2	Model No. and Type	
2.11.3.3	kW rating and power factor	
2.11.3.4	Rated voltage	
2.11.3.5	Enclosure type	
2.11.3.6	Insulation type	
2.11.3.7	Space heater provided? Indicate rated voltage	
2.11.3.8	Valve operating speed, mm of stem travel/minute	
2.11.3.9	Limit Switches	
	a. Manufacturer	
	b. Model No. & Type	
	c. No. of position limit switch for-	
	i) Opening	
	ii) Closing	
	d. No. of torque limit switch for	
	i) Opening	
	ii) Closing	
	e. No. of normal closed and normally open contacts for each limit switch	
	f. Contact rating (at 240V AC)	
	g. Enclosure type	
	h. Space heater provided	
2.11.3.10	Weight of actuator, kg	
2.11.4.0	Steam Traps	
2.11.4.1	Manufacturer	
2.11.4.2	Model No. & type	
2.11.4.3	Rated differential pressure(kg/cm ²) and discharge capacities (T/hr)	

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S.No	Detail	Description
2.11.4.4	Material	
	a. Body	
	b. Internals	
2.11.4.5	Whether provided with integral or separate strainer	
2.11.5.0	Strainers	
2.11.5.1	Manufacturer	
2.11.5.2	Type	
2.11.5.3	Material	
	a. Body	
	b. Internals	
2.11.5.4	Screen mesh size	
2.11.5.5	Ratio of screen open area and pipe internal cross sectional area	
2.11.6.0	Welding of piping	
2.11.6.1	Type of weld	
2.11.6.2	Special electrode details (type, quantity)	
2.11.6.3	Number of welds envisaged for each piping covered in this spec	
2.12.0	Economiser	
2.12.1	Type (plain, drainable, non-steaming)	
2.12.2	Material specification and composition	
2.12.3	Manufacturer	
2.12.4	Water side effective heating surface area, m ²	
2.12.5	Gas side effective heating surface area m ²	
2.12.6	Gas flow path area, m ²	

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S.No	Detail	Description	
2.12.7	Heat transfer co-efficient (gas to water) at 100% BMCR Kcal/M2/hr		
2.12.8	Provisions made for economizer on load cleaning?		
2.12.9	Details of re-circulating system		
2.12.10	Design pressure of tubes, kg/cm2 (g)		
2.12.11	Outside diameter of tubes, mm		
2.12.12	Design tube thickness, mm		
2.12.13	Actual thickness used, mm		
2.12.14	Length of tubes, mm		
2.12.15	Pitch, mm		
2.12.16	Pitch across gas flow, mm		
2.12.17	Design standard		
2.12.18	Total volume of tubes m ³		
2.12.19	Tube supports		
	a. Type		
	b. Material		
2.12.20	Maximum gas side metal temperature deg.C		
2.12.21	Maximum steam side metal temperature deg.C		
2.12.22	Minimum allowable inlet feed water temperature the economizer can handle safely deg.C		
2.12.23	Headers	Inlet header	Outlet header
	a. Material specification		
	b. Outside diameter, mm		
	c. Design thickness, mm		
	d. Actual thickness used, mm		
	e. Design standard		

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S.No	Detail	Description	
	f. Type of construction		
	g. Method of internal inspection		
	h. Maximum header unbalance		
	i. Design pressure, kg/cm ² g		
	j. Maximum working pressure, Kg/cm ² g		
2.13	Boiler Mountings and Fittings		
2.13.1	Drum safety valves		
	a. Manufacturer		
	b. Type and rating		
	c. Number		
	d. Specification of material for -		
	i) Body		
	ii) Trim/spring		
	iii) Seat		
	e. Set pressures, kg/cm ² g		
	f. Flow capacities, T/hr		
	g. Type of end connections		
2.13.2	Safety Valves	Superheater	Reheater
	(for each safety valve)		
	a. Manufacturer		
	b. Type and rating		
	c. Number		
	d. Specification of material for -		
	i) Body		
	ii) Trim/spring		
	iii) Seat		
	e. Set pressures, Kg/cm ² g		
	f. Flow capacity, T/hr		
	g. Type of end connections		
2.13.3	Power operated Impulse/ Electromatic safety valve at SH		

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S.No	Detail	Description			
	outlet				
	a. Manufacturer				
	b. Type of actuator				
	c. Number				
	d. Capacity of valve T/hr				
	e. Set pressure, Kg/cm ² g				
2.13.4	Drum Level Gauges				
	a. Manufacturer				
	b. Type				
	c. Number				
	d. Location				
	e. Size				
2.13.5	Reheater isolating device				
	a. No provided				
	b. Manufacturer and Model				
	c. Design Pressure and temperature				
	d. Material of construction				
2.14	Flow Meters	Desuper heating Feed Water flow	HFO Flow	Return HFO Flow	LDO Flow
2.14.1	Service				
2.14.2	Pressure drop Kg/cm ²				
2.14.3	Material				
2.14.4	Nozzle/orifice plate				
2.14.5	Maximum flow T/hr				
2.14.6	Type of end connections (Welded/flanged)				
3.0	REGENERATIVE AIR PREHEATER (RAPH) (Not applicable for CFBC Boiler)				
3.1	Manufacturer				
3.2	Type				
3.3	Number offered per boiler				
3.4	Mounting (vertical/horizontal)				

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S.No	Detail	Description
3.5	Maximum handling capacity, NM3/hr	
	a. Flue gas	
	b. Air	
3.6	Handling capacity at 100% BMCR, NM3/hr	
	a. Flue gas	
	b. Air	
3.7	Flue gas temperature at air heater outlet deg.C	
3.8	Specification and composition	
	a. Cold and elements	
	b. Intermediate elements	
	c. Upper hot element	
	d. Shaft	
	e. Seals	
3.9	Recommended average cold end temperature at 100% BMCR to minimise corrosion °C	
3.10	Total effective heating surface m ²	
	a. Gas side	
	b. Air side	
3.11	Casing material	
3.12	Casing thickness, mm	
3.13	Pressure drop at 100% BMCR, Min. wg	
	a. Air side	
	b. Gas side	
3.14	Type of radial seals	
	a. Hot end	
	b. Cold end	
3.15	Type of circumferential seals	

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S.No	Detail	Description
3.16	Type of axial seal	
3.17	Gas velocity at 100% Boiler BMCR, M/sec	
3.18	Air velocity at 100% boiler BMCR, M/sec	
3.19	Net free area for air and gas flow m ²	
3.20	Electric motor drives	
	a. No. of motors	
	b. Motor speed, RPM	
	c. Motor name plate rating	
3.21	Speed reducer	
	a. Type	
	b. Speed ratio	
	c. Manufacturer	
3.22	Emergency drive	
	a. Type	
	b. Speed, rpm	
	c. Pressure, (kg/cm ² g) and flow requirements of air M ³ /sec)	
3.23	Bearings -	
	a. Manufacturer	
	b. Type	
	c. Type of lubrication	
3.24	Bearing cooling water requirement	
	a. Quantity, M ³ /hr	
	b. Inlet pressure, Kg/cm ² g	
	c. Pressure drop, kg/cm ²	
	d. Temperature rise, deg.C	
3.25	On load cleaning	
	a. Type of blower (single/ multiple nozzle)	
	b. Type of drive (sweep action/retractable)	
	c. Pressure of steam jet, Kg/cm ² g	

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S.No	Detail	Description
	d. No. of blowers	
3.26	Off load cleaning	
	a. Provision made for off load cleaning	
	b. Type of drive	
	c. Medium used (water/air)	
	d. Pressure of water/air required, Kg/cm ²	
	e. Quantity of water/air required M ³ /hr	
3.27	Accessories (provided/ not provided) and Number provided	
	a. Lube oil pumps	
	b. Oil coolers	
	c. Oil filters	
	d. Oil tanks	
	e. Oil pump	
	f. Support legs & foundation bolts	
	g. Coupling guards	
	h. Solenoid valve (air motor)	
	i. Air pressure adjusting device	
	j. Relief valve	
	k. Pressure gauges	
	l. Temperature indicator	
	m. Differential pressure gauges	
	n. Sight flow fittings	
	o. Main drive motor	
	p. Duplicate (emergency) drive motor	
3.28	Air heater fire preventive measure envisaged and details	
4.0	Tubular Air Preheater	
4.1	Number per Boiler	
4.2	Details of each Air heater	
4.3	Type	

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S.No	Detail	Description
4.4	No. of gas passes	
4.5	No. of air passes	
4.6	Whether of Counter Flow Type	
4.7	Number of bank in the main section	
4.8	Number of bank in the cold end section	
4.9	Details of Each Bank:	
4.10	Tube outside diameter, mm	
4.11	Tube thickness, mm	
4.12	Tube material	
4.13	Tube arrangement	
4.14	Tube length, m	
4.15	No. of tubes across air flow	
4.16	No. of tubes with air flow	
4.17	Tube pitch with air flow,mm	
4.18	No. of tubes	
4.19	Heating surface , m ²	
4.20	Total heating surface per Air heater, m ²	
4.21	Total Air-heater heating surface per boiler , m ²	
5.0	SCAPH	
5.1	No. offered per boiler	
5.2	Manufacturer	
5.3	Steam pressure KSC	
5.4	Steam Temperature °C	
5.5	Design air flow Nm ³ /hr	
5.6	BMCR air flow Nm ³ /hr	
5.7	Air velocity m/s	
5.8	Design air inlet temperature °C	
5.9	Design air outlet temperature °C	
5.10	Quantity of steam corresponding to	

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S.No	Detail	Description	
	i) Design air flow, kg/hr		
	ii) Normal air flow, kg/hr		
5.11	Drain		
	i) Drain Temperature °C		
	ii) Drain Enthalphy , kcal/kg		
5.12	Total Surface area m ²		
5.13	Accessories (State whether provided or not & numbers provided)		
	i) Local instrument		
	ii) Isolating valves		
	iii) Regulating valves		
	iv) Condensate collection tank		
	v) Inter connecting piping		
	vi) Instrument tapping points		
5.31	Flue and Air duct		
	1. Thickness and material of flue gas duct		
	2. Thickness and material of air duct		
	3. Velocity of flue gas max/min		
	4. Velocity of air max/min		
6.0	DRAFT PLANT	Forced draft fans	Induced draft fans
6.1	Manufacturer		
6.2	Type		
6.3	Number of fans per boiler		
6.4	Capacity (flow rate for each		
	a. At 100% Boiler BMCR		
	b. At design (test block) conditions		
	c. Max flow rate the fan handle		
	d. Min flow rate the fan can handle		
6.5	Static Pressure, mmWC		
	a. At 100% Boiler BMCR		
	i) For fan inlet		
	ii) For fan outlet		
	b. At design (test block) condition		

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S.No	Detail	Description	
	i) For fan inlet		
	ii) For fan outlet		
	c. At shut off condition		
	d. Min safe pressure		
6.6	Design margin provided		
	a. Flow rate %		
	b. Static pressure %		
6.7	Density of air/gas at working temperature, Kg/Cm3		
6.8	Synchronous speed of connected electric motor, Rpm		
6.9	Normal fan speed, Rpm		
6.10	Critical speeds of fan		
	a. First critical speed, Rpm		
	b. Second critical speed, Rpm		
6.11	Design tip speed of blades, M/sec.		
6.12	Fan efficiency at		
	a. Design (Test block) condition		
	b. 100% BMCR		
	c. 100% T MCR Turbine rated output)		
	d. 60% Boiler MCR		
6.13	Direction of rotation facing fan coupling (clockwise or anti-clockwise)		
6.14	Impeller details		
	a. Impeller diameter, mm		
	b. Shaft diameter, mm		
	c. Moment of inertia of shaft and impeller, kg/m2		
6.15	Overall dimensions of fan& motor		
6.16	Size of motor provided, KW		

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S.No	Detail	Description	
6.17	Power Consumption, KW		
	a. At 100% Boiler MCR		
	b. At 100% T MCR (Turbine rated output)		
	c. At 60% Boiler MCR		
	d. Shaft HP at 100% Boiler MCR		
6.18	Moment of inertia of fan and motor, Kg/M2		
6.19	Type of coupling		
6.20	Lubrication System (forced/ring-lubrication)		
	a. For fans		
	b. For motors		
6.21	Features of Construction		
	a. Blades provided with renewable wearing noses? Yes/No		
	b. Mode of adjustment of gas/air flow control		
	c. Range of above flow control		
	d. Type of casing		
	e. Type of diffuser		
6.22	Material of construction and thickness		
	a. Casing		
	b. Casing side plates		
	c. Casing liner		
	d. Impeller blade		
	e. Inlet cone		
	f. Outlet diffuser		
	g. Impeller hub/shroud		
	h. Impeller wear plate (if any)		
	i. Shaft sleeve		

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S.No	Detail	Description	
	j. Coupling		
	k. Base plate and foundation bolts		
	l. Inlet guide vane/Inlet damper		
6.23	Bearings		
	a. No. and make		
	b. Type of bearings		
	c. Bearing liner material		
	d. Method of lubrication		
	e. Grade of lub oil		
	f. Thermometers provided ?		
	g. Thermocouples provided?		
	h. Method of cooling the bearings (if not forced lubrication)		
6.24	Shaft sealing arrangement		
6.25	Hydraulic servo drive		
6.26	Lube Oil System		
	a. Number of pumps per fan		
	b. Number of pumps in stand-by/service		
	c. Type of pump		
	d. Number of oil cooler fan		
	e. Number of oil coolers in standby/service		
	f. Relief valves provided?	Yes/No	Yes/No
	g. Pressure switches provided?	Yes/No	Yes/No
	h. Thermometers provided?	Yes/No	Yes/No
	i. Electric heaters with oil tanks provided?	Yes/No	Yes/No
6.27	Accessories		
	a. Coupling guards provided?	Yes/No	Yes/No
	b. Base plate and foundation bolts	Yes/No	Yes/No

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S.No	Detail	Description			
	provided?				
	c. Forced lubrication unit with pumps, filters, coolers, connected piping etc. provided?	Yes/No		Yes/No	
	d. Local instruments provided?	Yes/No		Yes/No	
	e. Provision for vibration sensors made?	Yes/No		Yes/No	
	f. RTDs for fan and motor bearings provided?	Yes/No		Yes/No	
6.28	Minimum load of fan at which it can operate in parallel without any knocking and bumping				
7.0	SOOT BLOWERS				
7.1	Manufacturer of				
	a. Blowers				
	b. Control Equipment				
7.2	Location & Mounting				
7.3	Cleaning Medium				
	a. Pressure, Kg/cm ² g				
	b. Temperature, deg.C				
	c. Source of cleaning medium				
7.4	Number of groups of soot blowers				
7.5	Total operating time per group min				
7.6	Number, voltage and capacity of power supply feeder to soot blower MCC				
7.7	Blowers	Furnace Blower	Reheater Blower	Economiser Blower	Superheater
	a. Type and make				
	b. Number of soot blowers				
	c. Number of blowers in operation at a time				

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S.No	Detail	Description			
	d. Duration of operation per operating group, min.				
	e. Operating pressure, Kg/cm ² g				
	f. Steam consumption rate, T/hr				
	g. Rate of steam consumption per blower, T/hr				
	h. Total time required for one complete cycle of soot blowing operation. min				
	i. Length of travel, mm				
	j. Blowing radius/angle				
7.8	<u>Materials of Construction</u>				
	a. Lance/swivel tube in high temperature area				
	b. Lance/swivel tube in intermediate temperature area				
	c. Lance/swivel tube in low temperature area				
	d. Nozzles				
	e. Travelling carriage				
	f. Gland packing				
	g. Bearings in high temperature area				
	h. Bearings in intermediate temperature area				
	i. Bearings in low temperature area				
	j. Feed tube				
	k. Blowing head				
	l. Chain				
	m. Compression hangers				
	n. Bolts				
7.9	<u>MOTOR particulars</u>				

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S.No	Detail	Description			
	a. Type				
	b. Capacity				
	c. Volt-ampere				
	d. RPM				
7.10	<u>Accessories provided</u>				
	a. Blowing head				
	b. Pressure reducing valve				
	c. Relief valve				
	d. Orifices				
	e. Travelling carriage				
	f. Clamps of required sizes				
	g. Limit switches				
	h. Gear boxes				
	i. Speed reducer				
	j. Supporting frame				
8.0	<u>BLOW DOWN VESSELS</u>	Continuous Blowdown Tank	Intermittent Blowdown Tank		
8.1	Whether separate vessels offered for Continuous & Intermittent blow down?				
8.2	Numbers				
8.3	Design code followed				
8.4	<u>Operating conditions</u>				
	a. Pressure, Kg/cm ² g				
	b. Temperature, deg.C				
	c. Approx. Flow, m ³ /hr				
8.5	<u>Design conditions</u>				
	a. Pressure, Kg/cm ² g				
	b. Temperature deg.C				
8.6	Weld joint efficiency				
8.7	Radiography (spot or full)				
8.8	Stress relieving				

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S.No	Detail	Description
8.9	Hydraulic test pressure, Kg/cm ² g	
8.10	Hammer test pressure, Kg/cm ² g	
8.11	Shell thickness, mm	
8.12	Corrosion allowance, mm	
8.13	Shell diameter, M	
8.14	Shell height, M	
8.15	Capacity adequate to receive drains from Deaerator, main steam and hot reheat lines?	
8.16	Drain & overflow arrangement	
8.17	<u>Materials of Construction</u>	
	a. Shell and head	
	b. Nozzle necks	
	c. Nozzle flanges	
	d. Manhole nozzle	
	e. Manhole flanges & name-	
	f. Supports & structures	
9.0	<u>COAL PREPARATION & FIRING EQUIPMENT (APPLICABLE TO PF BOILERS)</u>	
9.1	<u>Coal bunkers</u>	
	a) Number per boiler	
	b) Storage capacity at 100% MCR	
	c) Specific weight of material considered for bunker design	
	d) Max moisture content considered for bunker design	
	e) Min valley angle	
	f) Construction material	
	g) Lining material thickness	
	h) Type of isolation gate provided	
9.2	<u>Raw Coal Feeding Equipment</u>	
9.2.1	Raw Coal bunker shut off gates	
	a. Manufacturer	

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S.No	Detail	Description
	b. Type & Number	
	c. Material of the gate	
	d. Motor rating	
9.2.2	Down spout from Coal bunker to feeder	
	a. Manufacturer	
	b. Inside diameter x thickness, mm	
	c. Height, m	
	d. Material	
	e. Offset between feeder outlet and centre line of Coal bunker, mm	
9.2.3	Raw Coal feeders	
	a. Manufacturer	
	b. Numbers	
	c. Type	
	d. Feeder size	
	e. Normal capacity each, T/hr	
	f. Maximum capacity each T/hr	
	g. Method of output control	
	h. Speed pulser allowable VA burden	
	e. Power consumption, KW	
	i) At 100% Boiler MCR	
	ii) At 100% T MCR (ie. turbine 100% MCR)	
	iii) At 60% Boiler MCR	
	j. Type of drive	
9.2.4	Raw Coal Weighters	
	a. Manufacturer	
	b. Model number	
	c. Number	
	d. Method of measurement	

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S.No	Detail	Description			
	e. Range of measurement, T/hr				
9.2.5	Downspout from feeder outlet to Pulveriser				
	a. Manufacturer				
	b. Inside diameter x thickness, mm				
	c. Material				
	d. Height, m				
	e. Offset between feeder outlet & pulveriser				
9.3	<u>Coal Pulverisers</u> (APPLICABLE TO PF BOILERS)				
9.3.1	Manufacturer				
9.3.2	Type				
9.3.3	Number				
9.3.4	Performance of Pulverisers with Design Coal Operation (Turbine rated output)	100% BMCR	100% TMCR	60% BMCR	40% BMCR
	a. Fuel heat input required, Kcal/hr.				
	b. Coal required, T/hr				
	c. Percentage through 0.3 mm and 0.09 mm mesh				
	d. Number of pulverizers in service				
	e. Coal throughput per Pulverizers T/hr				
	f. Maximum capacity of each Pulveriser, T/hr				
	g. Percentage of operating Pulveriser capacity				
	h. Power consumption for all the operating Pulverisers, KW				
9.3.5	Performance of Pulverisers with Worst Coal Operation	100% BMCR	100% TMCR	60% BMCR	40% BMCR
	a. Fuel heat input required Kcal/hr.				
	b. Coal required, T/hr				
	c. Percentage through 0.3 mm and				

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S.No	Detail	Description			
	0.09 mm mesh				
	d. Number of Pulverisers in service				
	e. Coal throughput per Pulveriser T/hr				
	f. Maximum capacity of each Pulveriser, T/hr				
	g. Percentage of operating pulveriser capacity				
	h. Power consumption for all the operating Pulveriser, KW				
9.3.6	Maximum crushed Coal size the Pulveriser can accept, mm {				
9.3.7	Speed of pulveriser, Rpm {				
9.3.8	Maximum flue gas flow, NM3/hr				
9.3.9	Minimum flue gas flow, NM3/hr				
9.3.10	Flue gas inlet temperature °C				
	i) Before tempering				
	ii) After tempering				
	iii) After Mill temperature				
9.3.11	Pressure inside the pulveriser mmwc				
9.3.12	Design pressure of housing, mmWC				
9.3.13	Overall dimensions				
9.3.14	Construction features				
	a. Describe the provisions made in preventing fire in the pulveriser				
	b. Method of detections of fire in the pulveriser				
9.3.15	Type of drive transmission)				
9.3.16	Type of coupling				
9.3.17	Classifiers				
	a) Whether classifiers are provided				
	b) Adjustment of classifier vanes provided				
9.3.18	Materials of construction				
	a. Beater wheels				

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S.No	Detail	Description			
	b. Liners				
	c. Housing				
	d. Classifier				
	e. Base plate and foundation bolts				
	f. Bearing housing				
	g. Pulveriser base				
9.3.19	Estimated life of beater wheels in hours				
9.3.20	Estimated life of liners				
9.3.21	Estimated labour for replacement of the above wear parts in man-hours_				
9.3.22	Whether the following accessories are provided				
	a. Coupling guards				
	b. Air seal arrangement for Pulveriser				
	c. Oil cooler				
	d. Coal fineness sampling devices				
	e. Local instruments				
	f. RTD's for motor bearings				
9.3.23	Pulveriser lube oil system				
	a. No. of lub oil pumps per pulveriser				
	b. No. of lub oil pumps working				
	c. No. of oil coolers per pulveriser				
	d. No. of oil coolers working				
	e. Power consumption of lub oil unit, KW				
	i) At 100% BMCR				
	ii) At 100% TMCR(Turbine rated output)				
	iii) At 60% BMCR				
9.4	<u>Pulverised Coal Piping (APPLICABLE TO PF BOILERS)</u>	<u>Straight Portion</u>		<u>Bend Portion</u>	
9.4.1	a. Inside diameter x thickness mm				
	b. Material (indicate liner material				

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S.No	Detail	Description
	also)	
	c. BHN	
9.4.2	Estimated length of pulverized Coal piping, M	
9.4.3	Provisions made for equalizing the Coal/air mixture flow in the Pulverised Coal piping	
9.4.4	Elaborate the arrangement for preventing fire in the pulverized Coal piping when corresponding pulveriser is not in operation	
9.4.5	Method of detection of fire in the Coal pipes	
9.4.6	Estimated life of pulverized Coal pipes in hours	
9.5	<u>Seal Air Fans</u>	
9.5.1	Manufacturer	
9.5.2	Type	
9.5.3	Number of fans	
9.5.4	Mounting & Arrangement	
9.5.5	Capacity (flow rate for each fan) NM ³ /hr	
9.5.6	Source of air supply	
9.5.7	Normal speed rpm	
9.5.8	Auxiliary power consumption	
9.5.9	Overall dimensions of fan and motor	
9.5.10	Size of motor provided, KW	
9.5.11	Method of lubrication	
	a. For fans	
	b. For motors	
9.5.12	Mode of air flow control adjustment and range of control	
9.5.13	Materials of construction	

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S.No	Detail	Description
9.5.14	Bearings	
	a. Make	
	b. Number and type	
	c. Bearing liner material	
	d. Type of cooling	
	e. Type of lubrication	
	f. Grade of lube oil	
	g. Thermometers provided ?	Yes/No
	h. Thermocouples provided ?	Yes/No
9.6	<u>PULVERISED COAL BURNERS</u> <u>(APPLICABLE TO PF BOILERS)</u>	
9.6.1	Type	
9.6.2	Make	
9.6.3	Number of Coal burners fed by each pulveriser	
9.6.4	Number of burners per elevation	
9.6.5	Number of elevations of burners	
9.6.6	Total number of Coal burners	
9.6.7	Number of Coal burners in operation from 20% to 100% Boiler MCR, their locations and tilt (if applicable)	
9.6.8	Design data	
	a. Temperature of Coal air mixture, deg.C	
	b. Maximum allowable temperature of burners deg.C	
	c. Turn down ratio	
	d. Temperature of hot secondary combustion air, deg.C	
	e. Capacity of each burner at	
	i) 100% Boiler MCR	
	ii) 92.2% Boiler MCR	
	iii) Maximum	

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S.No	Detail	Description
	f. Type of combustion air entry	
	g. Pressure drop in the Coal burner, mmWC	
	h. Velocity of Coal air mixture at entry to burner m/s	
	i. Log mean density of Coal air mixture	
	j. Critical Coal air fall outvelocity and corresponding load	
	k. Velocity of secondary air at entry to burner, m/se	
	l. If burner tilt offered in degrees	
	m. Number & type of burner tilt drives (if applicable)	
	n. Percentage of excess air at the burner	
9.6.9	Construction features	
	a. Angle of fuel entry (fixed/ variable)	
	b. Cooling device (while in operation/idle)	
	c. Provision of measurement of burner metal tip temperature	
	d. Mode of adjustment of combustion air	
9.6.10	Materials of construction	
	a. Coal burner nozzle	
	b. Guide plates	
	c. Drive liner	
	d. Connecting liner	
	e. Air damper	
	f. Support bearing inside wind box	
	g. Connecting bar	
	h. Level	

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S.No	Detail	Description
9.6.11	Whether the following accessories provided	
	a. Drive for tilting Coal burners?	Yes/No
	b. Flexible connection between Coal pipe and burner?	Yes/No
	c. Position indicator for all dampers?	Yes/No
	d. Limit switches?	Yes/No
	e. Drive for air damper?	Yes/No
9.6.12	Codes and Standards applicable?	Yes/No
9.7	<u>Fuel Bunkers</u> <u>(Applicable for CFBC Boiler)</u>	
	a) Number per boiler	
	b) Storage capacity at 100% MCR	
	c) Specific weight of material considered for bunker design	
	d) Max moisture content considered for bunker design	
	e) Min valley angle	
	f) Construction material	
	g) Lining material thickness	
	h) Type of isolation gate provided	
	<u>Fuel Feeding Equipment</u>	
	Raw Coal bunker shut off gates	
	a. Manufacturer	
	b. Type & Number	
	c. Material of the gate	
	d. Motor rating	
	e. Power consumption, KW	
	i) At 100% Boiler MCR	
	ii) At 100% T MCR (ie. turbine 100% MCR)	
	iii) At 60% Boiler MCR	
	j. Type of drive	

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S.No	Detail	Description
9.8	<u>Sorbent Bunkers</u> <u>(Applicable for CFBC Boiler)</u>	
	a) Number per boiler	
	b) Storage capacity at 100% MCR	
	c) Specific weight of material considered for bunker design	
	d) Max moisture content considered for bunker design	
	e) Min valley angle	
	f) Construction material	
	g) Lining material thickness	
	h) Type of isolation gate provided	
	<u>Sorbent Feeding Equipment</u>	
	Sorbent unker shut off gates	
	a. Manufacturer	
	b. Type & Number	
	c. Material of the gate	
	d. Motor rating	
	e. Power consumption, KW	
	i) At 100% Boiler MCR	
	ii) At 100% T MCR (ie. turbine 100% MCR)	
	iii) At 60% Boiler MCR	
	j. Type of drive	
10.0	<u>CYCLONES (Applicable to CFBC Boiler)</u>	
	i) Number of Cyclones	
	ii) Type of Cyclones	
	iii) Method of Cooling(Water Cooled / Steam Cooled)	
	iv) Inlet gas velocity, m/s	
	v) Concentration of solids at the inlet, kg/m ³	

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S.No	Detail	Description
	vi) Particle Size Range [...to ...] μm	
	vii) Pressure drop, mmwc	
11.0	Loop Seal (Applicable to CFBC Boiler)	
	i) Type of Loop Seal	
	ii) Arrangement of fuel feeding	
	iii) Arrangement of sorbent feeding	
	iv) Number of Blowers	
	v) Capacity of Blowers, m ³ /s	
	vi) Discharge Pressure of Blowers, mmwc	
12.0	External Fluidized Bed Heat Exchanger (EFBHE) (Applicable to CFBC Boiler)	
	i) Material of Heat Exchanger tubes	
	ii) Surface Area of Heat Exchanger tubes; m ²	
	iii) Arrangement of fuel feeding	
	iv) Arrangement of sorbent feeding	
	v) Number of Blowers	
	vi) Capacity of Blowers; m/s	
	vii) Discharge Pressure of Blowers; mmwc	
13.0	Bottom Ash Removal System	

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S.No	Detail	Description
	i) Type of Bottom Ash Removal System	
	ii) Method of removal of oversized particles	
	iii) Combustor Bed height as per design	
	iv) Combustor Bed Pressure drop as per design	
13.1	Bottom Ash Cooling System (Applicable to CFBC Boiler)	
	i) Type of Cooling System Provided	
	ii) Method of Cooling (Water Cooled/Air Cooled)	
	iii) Temperature of Cooled Ash	
14.0	<u>ELECTROSTATIC PRECIPITATOR WITH AUXILIARIES</u>	
14.1	ESP Equipment Data	
14.1.1	Manufacturer	
14.1.2	Type	
14.1.3	No. of ESPs per Boiler	
14.1.4	Dimensions (associated with one ESP)	
	a) Width (across gas flow) (mm)	
	b) Flange to Flange length (In direction of gas flow) (m)	
	c) Height between bottom of hoppers to support level (m)	
	d) Gap between two ESP casings	
14.1.5	Number of ESP casing per boiler	
14.1.6	Number of gas path per ESP	
14.1.7	Number of electrical fields in series in each gas path	
14.1.8	Maximum bus voltage (KV)	

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S.No	Detail	Description	
14.1.9	Average bus voltage (KV)		
14.1.10	Maximum available corons power per 100 Sq.m. surface, watts		
14.1.11	Installed Power, kW		
14.1.12	Proposal Standard for conducting the performance tests		
14.1.13	Aspect ratio		
14.2	Coal fired	Design	Worst
14.2.1	Inlet dust concentration (g/NCu.m)		
	a) at 100% BMCR		
	b) at 60% BMCR		
14.2.3	Outlet dust concentration with one series field out of operation (mg/NCu. m)		
	a) at 100% BMCR		
	b) at 60% BMCR		
14.2.4	Outlet dust concentration with two series field out of operation (mg/NCu. m)		
	a) at 100% BMCR		
	b) at 60% BMCR		
14.2.5	Collection efficiency with one field out of service (%)		
14.2.6	Collection efficiency with two series fields out of service (%)		
14.2.7	Collection efficiency with three series fields out of service (%)		
14.2.8	Total Design gas flow rate, Cu.m/Sec.		
	a) at 100% BMCR		
	b) at 60% BMCR		

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S.No	Detail	Description	
14.2.9	Design gas flow rate through each ESP casing at 100% BMCR, cu.m/sec.		
14.2.10	Gas temperature drop across ESP		
14.2.11	Pressure drop across the ESP, mmwc		
14.2.12	Specific collecting area, Sq. m/NCu.m /Sec. of flue gas		
14.2.13	Total effective collection area, Sq.m		
	a) With n fields		
	b) With n – 1 fields		
	Where n is the total no. of fields		
14.2.14	Gas velocity inside ESP, m/sec		
	a) at 100% BMCR		
	b) At 60% BMCR		
14.2.15	Treatment time, seconds		
14.2.16	Design flue gas temperature, Deg.C		
14.2.17	Ash collection rate		
	a) First row		
	b) Second row		
	c) Third row		
	d) Fourth row		
	e) Fifth row		
	f) Sixth row		
	g)		

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S.No	Detail	Description
14.3	Precipitator casing	
14.3.1	Material	
14.3.2	Plate thickness	
14.3.3	Design pressure (mm WC)	
14.3.4	Design temperature (°C)	
14.3.5	Maximum temperature withstanding capacity and duration	
14.3.6	Number of inspection doors per precipitator casing	
14.3.7	Dimensions of access opening of inspection doors (mm x mm)	
14.4	Gas Distribution System	
14.4.1	Method of ensuring gas distribution	
	i) Inlet	
	a. Type	
	b. Quantity per ESP pass	
	c. Total for ESPs of one boiler	
	d. Location	
	e. Material used and thickness (mm)	
	ii) Outlet	
	a. Type	
	b. Quantity per ESP pass	
	c. Total for ESPs of one boiler	
	d. Location	
	e. Material used and thickness (mm)	
14.4.2	Free area per gas screen m ²	
14.4.3	Details of rapping gear for distribution plates	

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S.No	Detail	Description
14.4.4	Motor for rapping gas distribution system	
	a) Nos. provided per ESP pass	
	b) Type	
	c) Rating, kW	
	d) Location	
14.5	Discharge (Emitting) Electrodes	
14.5.1	Type	
14.5.2	Material of the electrode	
14.5.3	Material of the frame	
14.5.4	Configuration	
14.5.5	Diameter	
14.5.6	Spacing of electrodes in the direction of gas flow	
14.5.7	No. of electrodes in each field	
14.5.8	No. of electrodes per ESP pass	
14.5.9	No. of electrodes in ESPs of one boiler	
14.5.10	Height in contact with the gas	
14.5.11	Total assembled electrode frame height	
14.5.12	Maximum available corona power per Linear meter of electrodes, watts	
	a) First field	
	b) Second Field	
	c) Third field	

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S.No	Detail	Description
	d) Fourth field	
	e) Fifth field	
	f) Sixth field	
	g)	
	h)	
14.6	Collecting Electrodes	
14.6.1	Material & Type	
14.6.2	Size of electrodes	
	a) Width	
	b) Height	
	c) Thickness	
14.6.3	Type of construction	
14.6.4	Distance between collecting electrodes across gas path, mm	
14.6.5	Number of collecting electrodes per ESP casing	
14.6.6	No. of electrodes in each field	
14.6.7	No. of electrodes per ESP pass	
14.6.8	No. of electrodes in ESPs of one boiler	
14.6.9	Effective collection surface area per electrode (Sq.m)	
14.6.10	Method of interconnection of plates	

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S.No	Detail	Description	
14.6.11	Method of suspension		
14.6.12	Maximum available corona power per Sq.m. of effective collecting surface, watts		
	a) First field		
	b) Second Field		
	c) Third field		
	d) Fourth field		
	e) Fifth field		
	f) Sixth field		
	g)		
	h)		
14.7	Rapping Mechanism	Discharge Electrode	Collecting Electrode
14.7.1	Type of rappers, whether PLC Operated?		
14.7.2	Rapper size		
14.7.3	Frequency of rapping		
14.7.4	Drive		
14.7.5	Location		
14.7.6	Number of rappers		
14.7.7	Location of drive (top/side)		
14.7.8	Number of hammers per shaft		
14.7.9	Location of rapping points		

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S.No	Detail	Description	
14.7.10	a) Maximum effective electrode length and its percentage rapped at any time (m,%)		
	b) Number of plates rapped per rapper		
14.7.11	Rapper controller		
	a) Type		
	b) Method of frequency control		
	c) Method of intensity control		
14.7.12	Nominal time interval between raps (minutes)		
14.7.13	Time of single rapping cycle		
14.7.14	Accessibility/Location		
14.7.15	Motors for rappers		
	a) Nos. provided per ESP pass		
	b) Type		
	c) Rating, kW		
	d) Location		
14.7.16	Nominal time intervals between raps, minutes		
	a) First field		
	b) Second Field		
	c) Third field		
	d) Fourth field		
	e) Fifth field		
	f) Sixth field		
	g)		

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S.No	Detail	Description
	h)	
14.8	Insulators	
14.8.1	Type	
14.8.2	Material	
14.8.3	Creepage distance	
14.8.4	Number of insulators per T/R set	
14.8.5	Minimum flashover voltage (Kv)	
14.8.6	Heating arrangement for Insulators provided?	
14.8.7	Reference drawing number	
14.9	Transformer Rectifier Sets	
14.9.1	General	
	a) Type	
	b) Manufacturer	
	c) Rating (KVA)	
	d) Number per field per gas stream	
	e) Number per ESP	
	f) Number of bus sections per field per gas stream	
	g) Total number provided per boiler	
	h) T/R control panel dimension (mm)	
	i) Method of cooling and type of cooling	
	j) Overall size (maximum)	
	k) Average amperes per set (mA)	
	l) Peak voltage available (KV)	
	m) Output current (mA)	
	n) Expected power required per	

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S.No	Detail	Description
	stream (KW)	
	o) Efficiency of T/R set	
14.9.2	Transformers	
	a) Type	
	b) Rating of each set	
	i) Output voltage (KV)	
	ii) Output current (mA)	
	iii) Number of primary taps supplied	
	iv) Tap voltage (volts)	
	c) Transformation ratio	
	d) Class of insulation	
	e) Volume of oil (litres)	
	f) Temperature rise over ambient	
14.9.3	Rectifiers	
	a) Type & Rating, kW	
	b) Number per T/R set	
	c) Number per boiler	
	d) Half wave/full wave rectification	
	e) Rated current output of each rectifier set, mA	
	f) Rated voltage output of each rectifier set, kV	
14.9.4	Type of voltage control device	
	a) Type of current limiting device	
	b) Type of voltage limiting device	
	c) Power supply	
	d) No. of control cabinets per boiler	
	e) Rating of each unit	
14.10	ESP Dust Hoppers	
1410.1	No. of hoppers per ESP	
14.10.2	No. of hoppers per boiler	

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S.No	Detail	Description
14.10.3	Type and Material	
14.10.4	Plate thickness (mm)	
14.10.5	Valley angle (degrees)	
14.10.6	Storage capacity of each hopper (hrs)	
14.10.7	Volumetric storage capacity of each hopper (Cu.M)	
14.10.8	No. of access doors per hopper, dimension	
14.10.9	Height of the hopper bottom flange above the ground level (metres)	
14.10.10	Size of hopper outlet flanges	
14.10.11	Hopper heating	
	a) Type	
	b) Control temperature, (°C)	
	c) Rating (kW / hopper)	
	d) No. of heating element per boiler	
	e) Location	
	f) Thermostat setting for tripping	
	g) Name of manufacturer	
14.10.12	Hopper vibrating arrangement provided?	
14.11	ESP INSULATION AND CLADDING	
14.11.1	List of areas to be insulated per casings of precipitators, (Sq.m)	
14.11.2	Insulating Material	
14.11.3	Insulating material standard	
14.11.4	Thickness (mm)	

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S.No	Detail	Description
14.11.5	Density (Kg/Cu.m)	
14.11.6	Cladding material	
14.11.7	Cladding thickness, mm	
15.0	FUEL OIL UNLOADING, PREPARATION & FIRING EQUIPMENT	
15.1	Storage tank	HFO System LDO System
	a) Type of tank	
	b) Capacity of each tank	
	c) Quantity	
	d) Applicable code for design	
	e) MOC	
	f) Dimension, dia and height	
	g) Shell plate thickness,	
	h) Roof plate thickness	
	i) Details of accessories Pipes and fittings	
	a) Size	
	b) Standard Valves	
	Valve	
	a) Types of valves	
	b) Make	
	c) Type of end connection	
	d) MOC	
	e) Material for gasket	
	f) Motor operated valves	
	Flexible hoses	
	a) Type of hose	
	b) Make of hose	
	c) Std/Code	
	d) Size	
	- nominal bore	
	- length	

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S.No	Detail	Description
	e) material	
	f) Type of end fittings	
	g) Pressure rating	
	h) material specification	
	Oil filter	
	a) Type and make	
	b) Mesh size	
	c) End connections	
	d) Flow rate max	
	e) Pressure drop	
	f) Hydraulic test pressure	
	g) Design code	
	h) Area of filtration gross/net i) m2	
	i) Material specification	
	- filter housing	
	- filter media	
	- sealing material	
	Unloading and delivery of oil pumps	
	a) Type and make	
	b) Capacity	
	c) Head	
	d) KW rating of motor	
	e) Suction and discharge connection	
	f) Bearing external/internal	
	g) Material of major parts	
	Weight of various equipments	
	a) Bulk oil storage tank	
	b) Unloading and discharge pump	
	c) Piping /valves etc.	
	d) Ladders/Platforms etc.	
15.2	<u>Oil Firing pumps</u>	
15.2.1	Manufacturer	

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S.No	Detail	Description	
15.2.2	Type		
15.2.3	Number of pumps		
15.2.4	Number of pumps in standby/ service		
15.2.5	Liquid data		
	a. Liquid handled		
	b. Minimum temperature of oil the pumps can handle, °C		
	c. Specific gravity at above temperature		
	d. Maximum viscosity of the oil pump can handle, centistokes		
	e) Oil temperature and viscosity considered for selection of pump capacity, °C and centistokes		
	f) Oil temperature and viscosity considered for selection of motor rating °C & centistokes		
15.2.6	Rated capacity per pump, M3/hr		
15.2.7	Discharge pressure at rated capacity, Kg/cm2g		
15.2.8	Rated speed of the pump, rpm		
15.2.9	Efficiency at rated capacity, %		
15.2.10	Rated temperature and viscosity considered for selection of motor rating, deg.C & centistokes		
15.2.11	Relief valve set pressure, Kg/cm2g		
15.2.12	Maximum pressure pumps can develop, Kg/cm2g		
15.2.13	Pump BHP/KW at rated capacity and total head		
15.2.14	Pump BHP/KW at relief valve setting		
15.2.15	Drive motor rating and speed, KW & RPM		
15.2.16	Type of coupling		

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S.No	Detail	Description	
15.2.17	Construction features		
	a. Electric tracing jackets		
	b. Stuffing box		
	c. Mechanical seal		
	d. Built in relief valve	Yes/No	Yes/No
	e. Relief valve set pressure adjustable?	Yes/No	Yes/No
	f. Common base plate for pump & motor	Yes/No	Yes/No
	g. Drain rim	Yes/No	Yes/No
	h. Foundation bolts	Yes/No	Yes/No
	i. Coupling guard	Yes/No	Yes/No
15.2.18	Materials of construction		
	a. Casing		
	b. Rotor		
	c. Shaft		
	d. Shaft sleeves		
	e. Base plate		
	f. Wearing rings (if reqd.)		
	g. Bearing		
	h. Type of gland seal provided		
15.2.19	Codes and Standards applicable		
15.3	<u>Heavy Fuel Oil Heaters</u>		
15.3.1	Manufacturer		
15.3.2	Type		

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S.No	Detail	Description
15.3.3	Total number	
15.3.4	Numbers standby	
15.3.5	Fluid on	
	a. Tube side	
	b. Shell side	
15.3.6	Design data	
	a. Capacity of each heater, T/hr	
	b. Normal steam consumption per heater, T/hr	
	c. Inlet temperature deg.C	
	d. Outlet temperature, deg.C	
	e. Operating pressure, Kg/cm ² g	
	f. Design pressure, Kg/cm ² g	
	g. Hydraulic test pressure, Kg/cm ² g	
	h. Fluid velocity, M/sec	
	i. Maximum allowable pressure drop, Kg/cm ²	
	j. Heat transfer surface area (M2)	
	k. Fouling resistance	
15.3.7	Construction Features	
	a. Number of tubes	
	b. Number of passes per heater	
	c. Tube outside diameter, mm	
	d. Tube thickness, mm	
	e. Tube length, mm	

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S.No	Detail	Description
	f. Tube pitch, mm	
	g. Inner diameter of shell, mm	
	h. Outer diameter of shell, mm	
15.3.8	Materials of construction	
	a. Shell/shell cover	
	b. Flanges for shell & shell cover; channel & channel cover	
	c. Nozzles on shell & channel	
	d. Flanges for above nozzles	
	e. Tubes	
	f. Tube sheets-stationary/ floating	
	g. Floating head (cover/ cover flange/backing ring/ gland & packing)	
	h. Baffles	
	i. Support plates	
	j. Pass partition plates	
	k. Impingement plate	
	l. Tie rods	
	m. Spacers	
	n. Bolting for fixed and floating tube sheet joints	
	o. Bolting for all other shell and tube side joints	
	p. Gaskets for shell & channel covers	
	q. Gaskets in between tube sheet and shell/channel	

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S.No	Detail	Description			
	r. Saddle supports/brackets				
15.3.9	Codes and standards applicable				
15.4	Oil Strainers	HFO/ Pumps suction	HFO/ Pumps discharge	LDO Pump suction	Others (if any)
15.4.1	Manufacturer				
15.4.2	Type				
15.4.3	Number provided				
15.4.4	Number in standby service				
15.4.5	Mesh size				
15.4.6	Ratio of straining area to inlet area				
15.4.7	Maximum pressure drop at rated flow in Kg/Cm2 with				
	a. 100% cleanliness				
	b. 75% cleanliness				
15.4.8	Whether Steam/ Electric tracing of jackets provided or not?				
15.4.9	Materials of construction				
	a. Body				
	b. Basket				
15.4.10	End connection (flanged/ welded /screwed)				
15.4.11	Codes and standards applicable				
15.5	<u>Oil-Burners</u>	<u>HFO/ Burners</u>	<u>LDO Burners</u>		
15.5.1	Manufacturer				
15.5.2	Type				
15.5.3	Design data				
	a. Number of oil burners per boiler				
	b. Elevation of boiler burners (if applicable)				

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S.No	Detail	Description	
	c. Number of burners per elevation (if applicable)		
	d. Atomising medium		
	e. Scavenging medium		
	f. Duration of scavenging		
	g. Parameters of scavenging medium		
	h. Temperature of oil at burner inlet, deg.C		
	i. Atomising steam parameters		
	- Maximum flow rate, Kg/hr		
	- Maximum / minimum steam pressure range required for atomising, Kg/cm2g		
	j. Atomising air parameters		
	- Maximum flow rate, NM3/hr		
	- Maximum / minimum pressure range required for atomization, Kg/cm2g		
	k. Maximum / minimum oil pressure range required at burners, Kg/cm2g		
	l. Turndown ratio		
	m. Oil viscosity before the burners, centistokes		
	n. Combustion air temperature deg.C		
	o. Capacity of each burner Kg/hr		
	p. Percent Boiler MCR capacity that can be carried by		
	i. All the burners		
	ii. One single burner		
15.5.4	Construction features		
	a. Angle of fuel oil entry (fixed/variable)		
	b. Mode of adjustment of combustion air		

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S.No	Detail	Description	
	c. Type of diffuser		
	d. Type of cooling/sealing device		
	e. Type of drive for each oil burner for inser		
15.5.5	Materials of construction		
	a. Oil burner mixing plate/ spray plate		
	b. Guard pipe		
	c. Diffuser		
	d. Concentric tubes		
	e. Clamp		
	f. Gaskets		
	g. Flexible tubing		
	h. Burner body		
	i. Burner tip		
15.5.6	Whether the following accessories provided		
	a. Limit switches	Yes/No	Yes/No
	b. Clamps	Yes/No	Yes/No
	c. Gaskets	Yes/No	Yes/No
	d. Flexible hose	Yes/No	Yes/No
	e. Insertion, retract facility	Yes/No	Yes/No
	f. Position indicators	Yes/No	Yes/No

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S.No	Detail	Description
15.5.7	Codes and Standards applicable	
15.6	<u>Oil Ignition System</u>	
15.6.1	Manufacturer	
15.6.2	Type (high energy arc igniters)	
15.6.3	Number of igniters	
15.6.4	Number of spare igniters	
15.6.5	Heat input per igniter, Kcal/hr	
15.6.6	Retractable or stationary?	
15.6.7	If high energy arc igniters are offered then following data shall be furnished	
	a) Whether suitable for firing both HFO/ and LDO?	Yes/No
	b) Electrode material	
	c) Expected life of electrodes	
	d) Experience list of bidder for similar igniters furnished?	Yes/No
16.0	INSTRUMENTATION & CONTROL	
16.1	Whether following systems provided?	
	a) Burner Management System	Yes/No
	b) Furnace Protection System including Master Fuel Trip	Yes/No
	c) Safety Shut down System	Yes/No
17.0	AC MOTORS	
17.1	Provide the following Details	
	a) Number of HT Motors and their locations	
	b) Number of LT Motors and their locations	
18.0	DC MOTORS	

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S.No	Detail	Description
18.1	Provide the details of DC Motors and their locations	
19.0	Bottom Ash Removal System	
19.1	Bottom ash hopper	
	a) No. provided per boiler	
	b) Storage capacity up to operating level, tonne of dry ash	
	c) Type and make of refractory	
	d) Thickness of refractory	
	e) Material & thickness of hopper plate	
	f) No. of outlets per hopper	
	g) Quenching nozzles, seal trough make up, overflow, etc. provided?	
	h) Type of hopper gate	
	i) Material of construction of hopper gate	
	j) Method of actuation of gate (manual / hydraulic / motor operated)?	
	k) Necessary access doors, platforms, walkways, ladders/ stairs provided or not?	
19.2	Scraper Chain Conveyor	
	a) No. provided per boiler	
	b) Make & Model Number	
	c) Guaranteed capacity, t/hr of dry bottom ash	
	d) Capacity of slag Bath, Cu.m	
	e) Rating of drive motor	
	f) Material of construction	
	- Slag Bath	
	- Slag bath liner	
	- Scraper Bars	
	- Scraper chains	
	- Scraper sprockets	

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S.No	Detail	Description
	g) Quantity of cooling water per boiler	
	h) Rails, rails for clamp fixing, etc. provided for each conveyor?	
20.0	Insulation	
20.1	Insulating materials	
20.1.1	Type of insulating material(s)	
20.1.2	Manufacturer's name	
20.1.3	Maximum temp(deg.C) the insulating materials can withstand	
20.1.4	Insulating materials standard	
20.1.5	Density of insulating materials (Kg/M3)	
20.1.6	Thermal conductivity (Kcal/M/hr °C) at mean temperature of	
	a. 50°C	
	b. 100°C	
	c. 150°C	
	d. 200°C	
	e. 250°C	
	f. 300°C	
	g. 350°C	
	h. 400°C	
20.1.7	Resistance to micro-organism	Yes/No
20.1.8	Incombustibility	Yes/No
20.2	Provide the following Details	
	- Block mineral fiber mattresses, mm/Qty	
	- Pourable insulation, mm/Qty	
	- Segmented Blocked calcium	

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S.No	Detail	Description
	silicate, mm/Qty	
	- Cement, mm/Qty	
	- GI sheet jacket, mm/Qty	
	- Others(specify details), mm/Qty	
20.2.1	Furnace extended side backpass walls	
20.2.2	<u>Enclosure</u>	
	a. Roof	
	i) Horizontal	
	ii) Vertical	
	b. Extended side	
	i) Horizontal	
	ii) Vertical	
	c. Bottom	
	i) Horizontal	
	ii) Vertical	
20.2.3	Any other (give details) area including auxiliaries and ducting etc.	
21.0	<u>EQUIPMENT DIMENSIONS AND WEIGHTS</u>	
		<div><u>Dimensions</u></div> <div><u>Weight (Tonnes)</u></div>
21.1	Supporting structure	
21.2	Galleries and stairways	
21.3	Interconnecting platforms	
21.4	Steam drum	
21.5	Manholes/Peepholes, inspection windows etc.	
21.6	Water walls	
21.7	Superheater	
21.8	Reheater	
21.9	Desuperheaters	

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S.No	Detail	Description	
21.10	Economiser, Downcomers, supplies and raisers etc.		
21.11	Valves & fittings		
21.12	Air Preheater		
21.12.1	Air heater with drive		
21.12.2	SCAPH		
21.13	Fabricated components for Main steam generator under sheet casing		
21.14	Firing & insulation material for steam generator & other equipment		
21.15	Steam generator casing		
21.16	Fabricated components for insulation of Steam Generator equipment		
21.17	Skin casing		
21.18	Integral HFO & LDO lines		
21.19	Fuel oil preheating unit		
21.20	HFO & LDO pumps with drives with decanting pumps		
21.21	HFO & LDO burners		
21.22	Ignitor/scanner air system		
21.23	Coal burners		
21.24	Coal piping		
21.25	Cold air ducts		
21.26	Hot air ducts		
21.27	Flue ducts		
21.28	Other ducting		
21.29	Soot blowers with drives		
21.30	Soot blowing equipment		
21.31	Pulverisers with drives		
21.32	Pulveriser group piping		

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S.No	Detail	Description	
21.33	Fabricated components for insulation of milling system		
21.34	Insulation of milling system		
21.35	FD Fans with drives		
21.36	ID fans with drives		
21.37	Other fans with drives		
21.39	Coal feeders with drives		
21.40	Fan duct		
21.41	Platforms and rails		
21.42	Supporting structure for fuel gas system		
21.43	Dampers/vanes with actuators		
21.44	Fabricated components for insulation of flue gas system		
21.45	High pressure piping, valves & fittings, auxiliaries & accessories e.g. main steam, CRH, HRH lines, etc.)		
21.46	Insulation and cladding for high pressure piping		
21.47	ESPs with electrics		
21.48	Support structures for ESPs including platforms, interconnecting galleries, walkways, etc.		
21.49	Insulation and cladding for ESPs		
21.50	Auxiliary boiler with accessories and auxiliaries		
21.51	Compressors with drives		
21.52	Air receivers, Air drying units for compressed air		
21.53	Compressed air piping, headers, supports, etc.		
21.54	AC and ventilation system		

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S.No	Detail	Description
21.55	HP Dosing System	
21.56	Bottom ash handling system including ABG, scraper chain conveyor	
21.57	Other (list down items)	
21.58	Total weight of the package	
22.0	Furnishing of Additional Data	
22.1	Performance Data (No. of Reference Drg./ Leaflet/Write-up)	
22.1.1	Boiler efficiency Vs load	
22.1.2	Characteristic curves showing the variation of superheated and reheated steam temperature with load clearly indicating the regime of attemperation.	
22.1.3	Characteristic curves of Steam Generating unit showing variations in efficiency, steam temperature and pressure with loads, for Coal firing	
22.1.4	Correction curves for Steam Generator efficiency for variation in parameters such as	
	a) Load	
	b) Superheater outlet pressure	
	c) Superheater outlet temperature	
	d) Feed water inlet temperature	
	e) Excess air	
	f) Humidity	
	g) With variation in Coal quality parameters from those stated in Annexure-I	
	h) Flue gas temperature at air heater outlet	
	i) Ambient air temperature	
22.1.5	FD fan blade angle lines; stall lines; equal efficiency lines; and system resistance lines with all fans in service & with one FD fan out, both	

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S.No	Detail	Description
	at 50 Hz. and 47.5 hz respectively showing BMCR and test block points for both one fan and two fan operation	
22.1.6	ID fan blade angle lines; stall lines equal efficiency lines; and system resistance lines for all ID fans and Electrostatic Precipitator sections in service and also with one ID fan and one Electrostatic Precipitator section out of service both at 50 Hz and 47.5 respectively showing the BMCR and test block points, for both one fan and two fan operation.	
22.1.7	Characteristic Curves for the mill plant	
	a. Variation of Pulveriser capacity with moisture content in raw Coal	
	b. Variation in fineness of Pulverised Coal with moisture content in raw Coal	
	c. Variation in quantity and temperature of Flue required with moisture content in raw Coal	
	d. Relation between Pulveriser output and hard grove grindability index of Coal	
	e. Energy consumption per tonne of through put of Pulveriser for varying Pulveriser output	
22.1.8	Characteristic curves of the HFO & LDO pressuring pumps	
22.1.9	HFO & LDO burners output characteristics	
22.1.10	For ESPs	
	a) Gas flow rate vs. efficiency	
	b) Gas temperature vs. efficiency	
	c) Inlet dust concentration vs. efficiency	
	d) Gas flow rate Vs pressure drop	

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S.No	Detail	Description
22.1.11	Characteristic curves showing the acid & dew point temperature Vs. sulphur content, moisture content in the Coal and percentage of excess air	
22.1.12	Characteristic curves of the SH Spray attemperator	
22.2	<u>Supplementary Data</u>	
22.2.1	Complete list of all the equipment requiring the following shall be furnished indicating parameters, continuous requirement and the maximum requirement	
	a) Auxiliary steam	
	b) Cooling water	
	c) Service air	
	d) Instrument air	
	e) Number and electrical rating of AC and DC power supply feeders at available voltage for control instrumentation system	
22.2.2	Detailed list of Main Steam Generator auxiliaries with the respective continuous power consumption (in KW) of each auxiliary	
22.2.3	Complete schedule of motors giving voltage, phase, KW rating (calculated and installed capacity) service factor etc.	
22.2.4	Complete valve schedule giving design conditions, normal working conditions, pressure drop across valves, type, body/trim material pressure and temperature rating, make, size etc	
22.2.5	<u>Pressure Parts</u>	
	a. Details of Furnace construction	
	b. Details of Steam Drum	
	c. Details of Economiser, superheater and reheater	

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S.No	Detail	Description
	d. Details of Pressure vessels	
	e. Details of Safety valves	
	f. Items, a,b,c shall also include tube sizes, materials, quantities and spacing	
22.2.6	Recommended mode of erection, erection sequence and other relevant particulars in respect of installation of	
	a. Structural steel	
	b. Pressure parts	
	c. Rotating and static equipment	
	d. Ducting	
	e. Steam drum	
	f. Others, as applicable	
22.2.7	Detailed recommended procedures for welding and erection	
22.2.8	Complete Fuel firing equipment description	
22.2.9	Complete description and functional writeup of the Burner Management system / FSSS including Pulveriser automation and combustion air control and general arrangement and cutout details of console inserts with bill of materials.	
22.2.10	General Arrangement and writeup on Rotary Air heaters giving details of lubrication system and instrumentation	
22.2.11	Soot blowing system description complete with Control system write-up, console Mimic diagram ,logic panel general arrangement and cut out drawings	
22.2.12	Write-up on general description of Flue ducts and dampers	

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S.No	Detail	Description
22.2.13	Recommended Functional block diagrams with write-ups for each Control loop required for safe and efficient Steam Generator operation	
22.2.14	A complete list of local instruments, sensing devices and control equipment covered in the proposal with type, make, accuracy, range, connection sizes, contact details, dial size etc. in the Bidder's scope.	
22.2.15	Write-up on interlocks and protection other than BMS/FSSS with logic diagrams	
22.2.16	Startup and shut down procedures	
22.2.17	Startup diagrams showing the following plotted vs. time from ignition of first ignitor to BMCR	
	a. Ignitor fuel input	
	b. Main fuel input	
	c. Drum pressure	
	d. Feed water flow	
	e. Steam flow through Super-heater	
	f. Primary Superheater outlet temperature	
	g. Superheater attemperator spray water flow	
	h. Final Superheater outlet temperature	
	i. Steam flow through Reheater	
	j. Reheater outlet temperature	
	k. If burner tilt offered	
22.2.18	Limiting conditions if any for Quick starting and loading	
	a) Write up on the boiler variable and constant pressure operations	

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S.No	Detail	Description
	b) Detailed write-up with supporting technical literature on the method proposed to limit NOx emission	
	c) Complete list of mill wear parts with materials and anticipated life of each part	
	d) For ESP	
	i) Schedule of power consumption for all gas streams connected to one boiler	
	ii) List of annunciations giving suggested set values of parameters	
	iii) Write up on ESP internals	
	iv) Description of T/R sets	
	v) Write up on interlocks and protections	
	vi) Detailed hopper sizing calculations	
	vii) Write up on rapping mechanism	
	e) Write up on control philosophy of F.O.system along with a list of annunciation	
	f) Write up on tracing	
	g) Write up on control philosophy of compressed air system	
	h) Write up on control philosophy of auxiliary boiler	
22.2.19	a. Schedule of valves with full particulars of valves with actuators (for powered valves) such as type, make motor rating, pneumatic consumption, limit & torque switch details, time for full opening/closing etc.	
	b. Schedule of control valves giving type and make of valves and actuators, size body & trim material etc. stroking time and full technical particulars of valves and their actuators and associated	

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S.No	Detail	Description
	accessories	
	c. Schedule of Dampers and vanes with full particulars of dampers and their actuators (for powered dampers) such as type of Damper & actuator, make, torque rating, stroke and stroking time, electrical rating/pneumatic consumption, limit and torque switch, position transmitter details etc. including details of associated accessories.	
22.2.20	List of insert panels, control cabinets and local control panels included in the proposal with GA drawings, mounting and cutout details	
22.2.21	List of flow elements covered in the proposal with full particulars such as design details, data sheets, make and dimensions	
22.2.22	List of Field mounted junction boxes included in the proposal	
22.2.23	List & details of Instruments and Control items mounted on control panels, including details like type, make, cutout and dimensional drawings etc.	
22.2.24	Instrument and control equipment to be made available for Light up & Steam blowing	
22.2.25	List of Measuring signals to be fed to DAS	
22.2.26	List of Annunciations giving suggested set values of parameters	
22.2.27	Boiler GA drawings for making instrument tapping points	
22.2.28	Particulars of prefabricated & other special cables included in the steam generator scope	
22.2.29	Electromatic impulse safety valve functional write-up, type, make & cut out details of the remote control station	
22.2.30	Boiler tube metal thermocouples	

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S.No	Detail	Description
	details, number, type, make etc.	
23.0	DRAWINGS AND EQUIPMENT LOADING DATA	
23.1	<u>Steam Generator</u>	
	a. Plan of Steam Generator and its auxiliaries at ground floor level; at lowest burner level; drum level; and at an intermediate level (preferably at the long retractable soot blower level), indicating the galleries, platforms and stairways.	
	b. Front elevation; side elevation and cross section of the Steam Generating unit showing location of headers and drums, manholes etc.	
	c. Layout of Steam Generator structural steel columns upto Stack. These shall indicate the size of members and main dimensions, with design loadings and all lifting facilities for purposes of maintenance	
	d. Layout of interconnecting platforms	
	e. Preliminary layout of air and gas ducts showing damper location, manholes, expansion joints, supports etc.	
	f. Drawing for fully gas tight dampers clearly indicating how sealing is effected and the gas tightness efficiency (on flow)	
	g. General arrangement drawings of the pulverised Coal preparation and firing equipment including locations of various dampers	
	h. Schematic drawings of the fuel/oil preparation and firing equipment	
	i. General arrangement drawings showing arrangement of FD, ID fans, air heaters, Coal pulverisers, ducting	

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S.No	Detail	Description
	arrangement between the Boiler and the Electrostatic Precipitator inlet cone and Precipitator outlet cone to stack with dimensions and weight	
	j. Schematic diagram indicating terminal points and Instrumentation and Controls included in Bidder's scope and suggested for following circuits clearly indicating pipe duct size (OD's and ID's) operating parameters; maximum fluid velocities; insulation thickness; and material specifications of MS, CRH, HRH, Steam Generator feed and fuel oil piping, type of actuators	
	i) Steam flow	
	ii) Feed water flow	
	iii) Blow down	
	iv) Vents and drains	
	v) Air, fuel and flue gas	
	vi) Pulveriser system	
	vii) HFO/ & LDO system in the boiler area and burner system.	
	viii) HFO heating and HFO/ & LDO pressurising system	
	ix) lubrication systems of fans/ fan motors and any other equipment	
	x) Rotary air heaters	
	xi) Soot blower piping arrangement	
	xii) Auxiliary steam system	
	xiii) Cooling water	
	xiv) Service Air	
	xv) Instrument air	
	k. Drawings of Drum with preliminary dimensions and indicating stubs, locations and details for local and remote	

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S.No	Detail	Description
	instruments and controls.	
	l. Scheme drawing of Chemical Dosing	
	m. Necessary erection drawings for all equipment, piping, systems, sub systems etc.	
23.2	Boiler Duct Supporting Columns	
	a. Location plan Details of location and arrangement scheme of columns, embedments and fixing details, sizes of pedestals, levels, blockouts and anchor bolts and channels indicating scope of supply by equipment supplier.	
	b. Loading on foundations Axial load, bending moments and shear forces transmitted to foundations	
	c. Complete bracing arrangement for Boiler supporting structure and combinations of (+ve) and (-ve) forces for the seismic or wind (whichever is governing).	
23.3	*Foundation and loading details of ID, & FD Fans and their drives Including Lube Oil system	
	a. Location plan, dimensions and levels of foundation, pedestal, giving details of blockouts, inserts & embedments etc.	
	b. Fixing details of motor & fan	
	c. Details of fan giving weight of fan, weight of rotating parts, GD2 max. unbalanced force, speed of fan etc.	
	d. Complete loading data at various points of fan foundation	
	e. Loading details of the Motors giving total weight of motor; weight of stator ; weight of rotor; GD2 of rotating parts; short circuit Torque; motor speed and its rating etc.	

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S.No	Detail	Description
23.4	*Foundation and Loading Details of Pulveriser including lube oil system	
	a. Location plan dimensions and levels of foundation pedestal giving details of blockouts, inserts & embedments etc.	
	b. Fixing details of Pulveriser & motor	
	c. Details of Pulveriser giving total weight and its speed	
	d. Details of Pulveriser motor giving total weight of motor, weight of stator, weight of rotor, GD2, short circuit torque, speed and rating.	
	e. Pulveriser handling arrangement drawings	
	f. Details and loading of monorail in Pulveriser bay, if any	
	g. Loading, level & arrangement details for Pulveriser maintenance platform.	
23.5	<u>Coal Feeder</u>	
	Location, size, loading (static+dynamic) and fixing arrangement with floor and floor cutouts.	
23.6	<u>Fuel Piping</u>	
	Layout and location of supports, loading at support points.	
23.7	<u>Miscellaneous</u>	
	a). Arrangement of interconnecting platforms between Steam Generator with Power house and Mill bunker indicating location in plan, levels, loads transmitted from these platforms to Power house structure in the vertical & horizontal direction due to dead load & seismic effects	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-III
PART-B
TECHNICAL SCHEDULES-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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MASTER INDEX (ALL VOLUMES)

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	Section-II	Part-A	Detailed Technical Specifications - Mechanical
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		Part-D	Detailed Technical Specifications - Civil
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LII-GETS12021-G-00129-001	02	TECHNICAL DATASHEET FOR R&M WORKS OF BOILER & AUXILIARIES VOLUME-III, PART-B	[i]	25.09.2014

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

* * * * *

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1. Detailed Technical Specification-Mechanical
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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)**

**VOLUME-III, PART-B
TECHNICAL SCHEDULES-ELECTRICAL
(TO BE FILLED BY BIDDER)**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

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1 MOTOR

SL. NO.	DESCRIPTION	UNIT	DATA
1.	Manufacturer		
2.	Type and frame size		
3.	Nos. required		
4.	Application		
5.	Specification & Codes		
6.	Capacity for specified climatic conditions [50°C]		
7.	Location for installation		
8.	Type of enclosure & ventilation		
9.	Degree of protection		
10.	Type of duty		
11.	No. of phases, frequency & voltage		
12.	Permissible variations in		
a)	Voltage		
b)	Frequency		
c)	Combined		
13.	At rated voltage & frequency		
a)	Full load current		
b)	Full load speed		
c)	No load current		
14.	Minimum permissible voltage during starting :		
15.	Maximum permissible time at minimum permissible voltage during running at full load.		
16.	Maximum permissible time at 75% of rated voltage during running at full load.		
17.	Whether motor stalls at 70% of rated voltage Efficiency & power factor.		
18.	Stator winding		
	Type & nos. of terminals Brought out		
	Resistance between terminals at 20°C		
	Resistance per phase at 20°C		
	Inductance per phase		
	Capacitance per phase		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
	Starting current as % of full load current		
19.	Torque at full load in Kgm.		
a)	Break away torque in % of full load torque		
b)	Pull up torque in % of full load torque		
c)	Pull out torque in % of full load torque		
20.	Starting time in sec.		
a)	Without mechanism coupled		
b)	Mechanism coupled through hydraulic coupling when it may be presumed that load is transferred to motor shaft only after attaining almost full speed.		
	i. with rated voltage		
	ii. with 80% of rated voltage		
	iii. with 110% of rated voltage		
21.	Starting time in sec. With mechanism coupled through flexible coupling		
a)	with rated voltage		
b)	with 80% of rated voltage		
c)	with 110% of rated voltage		
22.	Safe stall time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
23.	Safe stall time (Cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
24.	Limiting motor temperature to determine safe stall time		
25.	Permissible maximum accelerating time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
26.	Permissible maximum accelerating time (cold motor)		
	i. At rated voltage		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
27.	Class of Insulation And Material		
28.	Whether insulation is suitable for 415 V, 6.6kV system		
29.	Temperature rise under normal conditions over 50°C ambient temperature		
30.	By resistance method --- °C over cooling water temp. for CACW motors.		
31.	Degree centigrade over cooling air temp. for CACA motor.		
32.	By Thermometer method ---- Degree centigrade over cooling water temp. for CACW motor.		
33.	Degree centigrade over cooling air temp. for CACA motor.		
34.	Method of starting :		
35.	Permissible starting duty cycles :		
36.	Stator thermal time constant :		
37.	Method of cooling (If applicable)		
	Details of water cooling system		
a)	No. of cooler		
b)	Water requirement per cooler		
c)	Losses removed by cooler		
d)	Max. permissible temperature of cooling water at inlet		
e)	Max. permissible temperature of cooling water at outlet		
f)	Maximum permissible pressure at water outlet		
g)	Water pressure drop through the cooler		
h)	Temp. of cold air coming out & entering the machine For permissible cooling water temperature of [31°C]		
i)	Temp. rise of air passing through machine at full load.		
j)	Air pressure drop through The cooler		
k)	Temp. rise of water through cooler		
l)	Protection against leakage of water :		
m)	Arrangement to ensure the water flow		
38.	Bearings		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
a)	Number :		
b)	Type :		
c)	Lubrication system :		
d)	Quantity of lubricant reqd. For both the bearings. Life in hours at rated speed :		
e)	Recommended lubricant :		
f)	Bearing end play :		
g)	Inlet oil pressure :		
h)	Temp. rise of oil :		
i)	Max. permissible temp. of bearing :		
j)	Max. Permissible temp. of Oil		
k)	Permissible running time without forced oil at full load & full speed :		
39.	Whether bearings are provided with 4 wire, platinum RTD having 100-ohm resistance at 0°C for remote temp. Indication.		
a)	Whether bearings are provided with local temperature indicator having two adjustable contacts rated for 5A at 240V AC or 0.5A at 220V DC. : Yes/No		
b)	If forced lube oil system provided : Yes / No		
c)	Qty of lubricant required for initial filling.		
d)	Recommended period after which lubricant should be replaced		
e)	Bearing cooling water requirement		
f)	Max. Permissible bearing cooling water inlet temp. (permissible)		
g)	Max. Permissible bearing cooling water outlet temp.		
h)	Terminal designation corresponds to direction of rotation (Facing driving end).		
i)	Terminal boxes with accessories separate terminal boxes provided.		
40.	Winding temp. detectors		
41.	Bearing temp. detectors		
42.	Moisture detectors		
43.	Neutral terminals		
44.	Main terminal box details		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
a)	Type & Nos.		
b)	Fault level permissible for 0.25 sec.		
c)	Location		
d)	Cable gland size & no.		
e)	Direction of cable entry.		
45.	Space Heater		
a)	Number		
b)	Location		
c)	Capacity of each		
d)	Total power requirement		
e)	Voltage.		
46.	Details of 4 wire platinum RTD having 100 ohm resistance at 0°C for winding temp. detector.		
a)	Nos. provided		
b)	Location		
47.	Whether CTs for differential protection are provided : Yes / No		
a)	If Yes, no. of CTs supplied along with motors C.T. details		
	i. C.T. ratio		
	ii. Knee point voltage		
b)	S.C. withstand capacity		
c)	Type of mounting		
48.	Shaft orientation		
49.	Shaft extension		
50.	Grounding pads size nos. & location		
51.	Method of coupling to driven mechanism		
52.	Motor GD ² :		
53.	Lifting device		
54.	Weight		
a)	Weight of stator (wound)		
b)	Weight of rotor (wound)		
c)	Weight of base plate		

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SL. NO.	DESCRIPTION	UNIT	DATA
d)	Weight of cooler		
e)	Net weight of motor		
f)	Shipping dimensions & weight		
55.	Thermometer provided		
a)	In cold air path		
b)	In hot air path		
c)	For measurement of oil temp.		
56.	Characteristic curves furnished		
a)	Speed vs. current at rated voltage	Yes / No	
b)	Speed vs. torque at 110%, 100%, 90% and 80% of rated voltage:	Yes / No	
c)	Thermal withstand curve for hot & cold conditions.	Yes / No	
d)	Efficiency vs. load:	Yes / No	
e)	P.F. Vs. load:	Yes / No	
f)	Current vs. time:	Yes / No	
g)	Negative phase sequence curve:	Yes / No	
57.	Drawings furnished		
a)	General arrangement of motor	Yes / No	
b)	Main terminal box showing the method of terminating the incoming cables Yes/No	Yes / No	
c)	Instruction manuals	Yes / No	
	MOTOR (DC)		
1.	GENERAL		
a)	Manufacturer :		
b)	Equipment driven by Motor :		
c)	Motor type :		
d)	Country of origin :		
2.	DESIGN & PERFORMANCE		
a)	Frame Size :		
b)	Type of duty :		
c)	Type of enclosure & type of cooling :		
d)	Applicable standard to which motor generally confirms:		
e)	Type of mounting :		

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SL. NO.	DESCRIPTION	UNIT	DATA
f)	Direction of rotation :		
g)	KW rating at amb. Temp. 50 °C :		
h)	Rated power supply voltage		
	i. Armature circuit (V) :	V	
	ii. Field circuit (V) :	V	
i)	Permissible voltage variation :		
j)	Minimum permissible starting voltage :		
k)	Rated speed at rated voltage (RPM) :	RPM	
l)	At rated voltage		
	i. Full load current (A) :	A	
	ii. NO load current (A) :	A	
m)	Starting current (A) :		
	i. 100% voltage :		
	ii. 85% voltage :		
n)	Starting time (with pump coupled) :		
	i. 100% voltage (Sec) :		
	ii. 85 % voltage :		
	iii. 80 % voltage :		
o)	Efficiency at rated voltage at :		
	i. 100% load :		
	ii. 75% load:		
	iii. 50% load:		
p)	Safe stall time (sec) at 110% :		
	i. Hot condition :		
	ii. Cold condition :		
q)	Torque (Kg-m) :		
	i. Starting at min. permissible voltage:		
	ii. Rated:		
r)	Fly wheel moment (GD2) motor (Kg-m)		
3.	CONSTRUCTIONAL FEATURES		
a)	Winding insulation :		
	i. Class & type :		

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SL. NO.	DESCRIPTION	UNIT	DATA
	ii. Tropicalised (Yes/No) :		
	iii. Temp. rise over specified ambient of 50 °C. :		
	iv. Method of temp. measurement :		
b)	Degree of protection of terminal box for :		
	i. Main terminal box :		
	ii. Space heaters (AUX. TB) :		
c)	For main terminal box :		
	i. No. and type of cable gland :		
	ii. Recommended cable size (Armature/field) :		
d)	Fault level (KA, sec) :		
e)	Bearings :		
	i. Type (at DE/NDE):		
	ii. Make :		
	iii. Recommended lubricant :		
	iv. Life :		
f)	Weight of motor (Kg.) :		
g)	Field current at rated speed (A)		
h)	Field resistance (Ohm) at rated speed at 30 °C		
i)	Field trimmer rating (Ohm) for getting basic speed at 30 °C.		
j)	Resistance (Ohm) between terminals at 30°C.		
	i. Armature :		
	ii. Series winding :		
	iii. Inter pole winding :		
	iv. Shunt winding resistance:		
k)	1 st and 2 nd critical speed :		
l)	Overload that can be carried by motor without changing overall performance and period for which it is applicable		
m)	Grounding device :		
n)	Space heater :		
	i. No. & location :		
	ii. Volt & KW rating :		
4.	RESISTORS		

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SL. NO.	DESCRIPTION	UNIT	DATA
a)	Starting (external) resistance :		
	i. Type of resistor :		
	ii. Ohmic, current & power rating of resistor elements		
	iii. Max. permissible temp. of resistor elements :		
	iv. Connection diag. Of resistor elements		
	v. No. of startup stages/steps :		
	vi. Resistance values of stages :		
	-at 30 deg. C (Ohm) :		
	-at running condition (Ohm) :		
	vii. Expected temp of resistor at running condition		
	viii. Expected temp of box at running condition		
	ix. Mounting/stacking of resistor elements and G.A. of resistor box		
b)	Schematic connection diag. Of motor with starting resistor and field trimmer resistor.		
5.	CHARACTERISTIC CURVES		
a)	Starting current/times :		
b)	Thermal withstand curve for hot and cold condition		
c)	Torque/speed		
d)	Load/Efficiency		
e)	Speed/Time		

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2 MOTOR ACTUATORS

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		
2.	Application		
3.	Motor type		
	Supply voltage	V	
4.	Phase, frequency	Hz	
5.	Motor rated voltage	V	
6.	Control Voltage	V	
7.	Voltage and its variation	V	
8.	Frequency and its variation	Hz	
9.	Combined V & f variation	%	
10.	Degree of Protection		
11.	Winding Insulation		
12.	Temperature Rise (over ambient temperature)	°C	
13.	Painting		
14.	Motor Starting		
a)	Method		
b)	Starting Current		

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3 LT TRANSFORMER (OIL TYPE/DRY TYPE)

6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Make		
2.	Application		
3.	Location		
4.	Type		
5.	Reference standard		
6.	Rated power (indicative)		
7.	Rated winding voltage ratio (line to line)		
8.	Number of phases		
9.	Winding		
10.	Rated frequency		
11.	Type of cooling		
12.	Insulation Class		
13.	Temperature rise Over ambient temperature of 50°C		
a	For Winding by resistance method		
b	For Oil by Thermometer method		
14.	Insulation level (LI/AC)		
a	HV- (LI/AC)		
b	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
15.	Vector group		

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16.	Short-circuit impedance on principal tap				
17.	Parallel operation of transformer				
18.	Type of taps provided				
19.	Taps provided on				
20.	Range of taps				
21.	Method of Tap charge control-				
a	Manual local				
b	Electrical local				
c	Electrical remote				
d	Automatic				
22.	System earthing				
a	H.V.				
b	L.V.				
23.	Terminal arrangement				
a	H.V.				
b	L.V.				
24.	Neutral for earthing				
25.	Transformer bushing	HV	LV	LV - N	
26.	Voltage class KV(r.m.s.)				
27.	Creepage distance mm				
28.	Min. Ph-Ph/ Ph-E clearance mm				
29.	System fault Level				
a	HV Side				
b	LV Side				
30.	Max. Noise level				

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31.	Auxiliary supply		
32.	LV neutral side current transformer for standby earth fault protection		
33.	Guaranteed no load loss (kW)		
34.	Guaranteed load loss (kW)		
35.	Efficiency		
a	At full load		
b	At 75% load		
c	At 50% load		
36.	Accessories		
	Each transformer furnished With fittings and accessories as per specification.		
37.	Approximate overall dimensions		
a	Length		
b	Breadth		
c	Height		
38.	Crane lift for un taking core and coil assembly Approximate Weights		
a	Core and coil		
b	Enclosure and fittings		
c	Oil		
d	Total weight		
39.	Shipping Details:		
a	Weight of the heaviest package		
b	Dimension of the largest package : (LxBxH)		
40.	Tests		
	Routine test as per IS and other tests as per specification		

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4 LT PCC/MCC/DISTRIBUTION BOARD

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material	Cu/Al	
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Colour finish shade	Interior exterior	

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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Starters		
3.1	Type	DOL Rev / Star-Delta	
3.2	Contactor rated duty		
3.3	Single phasing preventer required.	Yes / no	
3.4	Thermal overload relay reset	Manual / Auto	
4.0	Circuit breakers		
4.1	Maker's name		
4.2	Voltage, frequency & no.of phases , poles		
4.3	Rated operating duty		
4.4	Circuit breakers type		
4.5	Short circuit withstand current for 1 sec. Duration	kA	
4.6	Rated making current	kAp	
4.7	Rated current at site reference ambient temp	A °C	
4.8	Type of operating mechanism		
4.9	Minimum no. of auxiliary Contacts for purchaser's use		
4.10	Control voltage		
a	For Spring charging motor	V AC/DC	
b	For closing/tripping	V AC/DC	
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	
b	Closing at normal voltage	%	
c	Trip coil	%	
4.12	Power required for closing at normal voltage	W	
4.13	Power required for tripping at normal voltage	W	
4.14	Spring charging motor details:		

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S. No.	DESCRIPTION	UNIT	DATA
a	Rating	kW	
b	Rated voltage	V, AC/DC	
c	Spring charging	Sec.	
	Electrical and mechanical anti-pumping features been provided	Yes/No	
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		
5.2	Rated operating duty		
5.3	Rated breaking capacity	kA (rms)	
5.4	Rated making current	kA (Peak)	
5.5	On/Off operation		
5.6	Manual	Yes/No	
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	
5.8	Auxiliary contacts required	Yes/No	
6.0	Contactors		
6.1	Make		
6.2	Rated duty	AC3/AC4	
6.3	No of poles		
6.4	Utilization category		
6.5	Rated voltage of auxiliary contacts	V	
6.6	Rated voltage of coil	V	
6.7	Rated breaking capacity	Factor of rated current	
6.8	Rated making capacity	Factor of rated current	
6.9	Limits of operation		
a	Supply voltage variation		
b	Supply frequency variation for closing		

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S. No.	DESCRIPTION	UNIT	DATA
c	Drop out voltage		
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		
7.1	Voltage Ratio		
7.2	CT Ratio		
7.3	Measuring CTs		
7.4	Protection CTs		
7.5	Measuring VTs		
7.6	Protection VTs		
8.0	Control transformers		
8.1	Make		
8.2	Type		
8.3	Applicable standards		
8.4	Ratio		
8.5	Class of insulation		
8.6	Rated output	VA	
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		
10.2	Make		
10.3	Type designation		
10.4	Setting range		
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		
11.2	Make		
11.3	Type		
11.4	Current setting range		
11.5	Time setting range at 10 times the current setting	Sec	
12.0	Under voltage relay		

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S. No.	DESCRIPTION	UNIT	DATA
12.1	Make		
12.2	Type		
12.3	Voltage rating	V	
12.4	Setting range	V	
13.0	Auxiliary relays and timers		
13.1	Make		
13.2	Type		
13.3	Coil voltage	V	
14.0	Control/selector switch		
14.1	Make		
14.2	Type designation		
15.0	Meters		
15.1	Applicable Standards		
15.3	Accuracy Class		
15.4	Make		
15.5	Type		
16.0	<u>Voltmeter</u>		
16.1	Make		
16.2	Type		
16.3	Applicable standards		
16.4	Accuracy class		
17.0	<u>Ammeter</u>		
17.1	Make		
17.2	Type		
17.3	Applicable standards		
17.4	Accuracy class		
18.0	<u>Indicating lamps</u>		
18.1	Make		
18.2	Type		

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S. No.	DESCRIPTION	UNIT	DATA
18.3	Voltage	V	
18.4	Wattage of lamp	W	
19.0	<u>Push buttons</u>		
19.1	Make		
19.2	Type designation		
19.3	Contact rating	A	
20.0	<u>Space heater</u>		
20.1	Make		
20.2	Type		
20.3	Rated voltage	V	
21.0	<u>Wiring and terminal blocks</u>		
21.1	Voltage grade		
21.2	Insulation		
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	
b	Control wiring	Sq.mm	
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		
	II) For Fixed Type		
21.5	Minimum current rating of terminal blocks	A	

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5 415V NON SEGREGATED PHASE BUS DUCT

S. No.	DESCRIPTION	UNIT	DATA
1.	Make/ Name of Manufacturer		
2.	Type of Busduct	Segregated /non segregated	
3.	Type of cooling	Natural/Forced	
4.	Reference Standard		
5.	Rated Voltage	V	
6.	No of phase and Frequency	Hz	
7.	Insulation level a) Min Power frequency Voltage b) Impulse withstand voltage	kVrms kVp	
8.	Rated Continuous current	Amp	
9.	Short time withstand capability a) Symmetrical for 1 sec b) Momentary	kA kAp	
10.	Maximum temperature rise over 50 degree design ambient temperature a) Bus bar b) Enclosure	Degree	
11.	Degree of protection of enclosure		
12.	Bus bar a) Material & Grade b) Conductivity c) Size		
13.	Enclosure a) Material & Grade b) Thickness c) Ph- ph spacing d) Over all dimension		
14.	Dc resistance in micro ohm/metre/phase a) At 20 degree b) At 85 degree		

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S. No.	DESCRIPTION	UNIT	DATA
15.	Reactance in ohm/meter/phase		
16.	Capacitance to ground		
17.	Losses in watt/meter/phase		
18.	Insulators		
	a) Make		
	b) Material		
	c) No per support		
	d) Voltage Glass		
	e) Compression strength		
	f) Cantilever strength		
19.	Size and material of ground bus		
20.	Support steel structure		
21.	Whether the following has been provided		
	a) Thermostat controlled space heater		
	b) Silica gel breather		
	c) Drain plug		
	d) Neoprene rubber gaskets at joints		
	e) Disconnecting links		
22.	Painting shade		
	a) Interior		
	b) Exterior		

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6 HV CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.1.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
a)	In air	A	
b)	In ground	A	
c)	In duct	A	
d)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
a)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
b)	Grad and Shape of conductor		
c)	Nominal cross section area	mm ²	
d)	Number of wires		
e)	Diameter of wire	mm	
f)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	i. Between cores	mm	
	ii. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.20	Inner sheath		
a)	Material, confirming standard / type		
b)	Extruded	Yes/No	
c)	Calculated diameter over laid up cores		
d)	Thickness (min)	mm	
e)	Diameter of cable over inner sheath	mm	
f)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
g)	Filler Material details		
1.21	Armouring		
a)	Material		
b)	Type of armouring		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

S. No.	DESCRIPTION	UNIT	DATA
c)	No. and size of strip/wire		
d)	Whether galvanized	Yes/No	
e)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
a)	Material confirming standard/ type		
b)	Extruded	Yes/No	
c)	Minimum Thickness of sheath	mm	
d)	Tolerance on thickness of sheath	mm	
e)	Min. tensile strength	N/sq mm	
f)	Min. elongation percentage at rupture		
g)	Colour of Outer sheath		
h)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification and standards	Yes/No	
1.23	Overall diameter of cable and and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous current		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/k m	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		
	Min. tensile strength	N/sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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7 LT POWER & CONTROL CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.2.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
e)	In air	A	
f)	In ground	A	
g)	In duct	A	
h)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
g)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
h)	Grad and Shape of conductor		
i)	Nominal cross section area	mm ²	
j)	Number of wires		
k)	Diameter of wire	mm	
l)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	iii. Between cores	mm	
	iv. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.20	Inner sheath		
h)	Material, confirming standard / type		
i)	Extruded	Yes/No	
j)	Calculated diameter over laid up cores		
k)	Thickness (min)	mm	
l)	Diameter of cable over inner sheath	mm	
m)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
n)	Filler Material details		
1.21	Armouring		
f)	Material		
g)	Type of armouring		

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--	--------------------------

S. No.	DESCRIPTION	UNIT	DATA
h)	No. and size of strip/wire		
i)	Whether galvanized	Yes/No	
j)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
i)	Material confirming standard/ type		
j)	Extruded	Yes/No	
k)	Minimum Thickness of sheath	mm	
l)	Tolerance on thickness of sheath	mm	
m)	Min. tensile strength	N/sq mm	
n)	Min. elongation percentage at rupture		
o)	Colour of Outer sheath		
p)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification	Yes/No	
1.23	Overall diameter of cable and and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous currents		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/km	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		
	Min. tensile strength	N/sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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8 ILLUMINATION SYSTEM

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC	
1.2	Variation in Supply		
	a) Voltage	%	
	b) Frequency	%	
	c) Combined voltage & frequency	%	
1.3	Design Ambient Air Temperature	°C	
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	
	b) At 220V DC (For DC LP)	kA(DC)	
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		
b	Conductor size	SWG	
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		
2.2	Rated Voltage, phase and Frequency	AC	
2.3	One Minute Withstand Voltage	V	
2.4	Mounting Type		
	a) LDBs		
	b) Single Phase LP		
2.5	Type and no of circuits & feeder rating		
2.6	Colour shade		
2.7	Lighting Transformer		
	a) Type		
	b) Voltage Ratio	V	
	c) Taps	%	
	d) Vector Group		
	e) Impedance	%	
	f) Rating	KVA	
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		
3.2	Luminaries		
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		
	a) Luminaires		

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S. No.	DESCRIPTION	UNIT	DATA
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		
	a) Luminaires		
	b) Accessories		
4.0	Schedule of fitting and Accessories		
5.0	Technical details of luminaries		
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumens	
	ii) After 1000 burning hours	Lumens	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		
a	Power factor		
5.4	Luminaires		
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		
	ii) Suitable upto conductor size	SWG	
c	Internal wiring size	Sq.mm	
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		

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S. No.	DESCRIPTION	UNIT	DATA
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		
8.1	Make		
8.2	Type		
8.3	Output	VA	
8.4	Accuracy Class		
8.5	Literature enclosed	Yes/No	
9.0	Meters		
9.1	Make		
9.2	Type		
9.3	Accuracy Class		
9.4	Literature enclosed	Yes/No	
10.0	Relays (if any provided)		
10.1	Make		
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a) Normally open		
	b) Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		
11.2	Suitable for use in hazardous area		
	a) Area classification		
	b) Gases/Vapor group		
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	
12.0	Lighting Control Switches		
12.1	Make		
12.2	Decorative		

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S. No.	DESCRIPTION	UNIT	DATA
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	
14.0	Lighting wires		
14.1	Make		
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	CONDUITS		
15.1	Make		
15.2	Rigid Steel		
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	Lighting poles/towers		
17.1	Make		
17.2	Type of Poles/Towers		
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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9 CABLE CARRIER SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		
2.	Size of Tray	mm	
3.	Material		
4.	Application		
5.	Type of Tray		
6.	Thickness of Tray	mm	
7.	Thickness of Galvanization	mm	
8.	Tray Cover Size	mm	
9.	Cable Tray Accessories		
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	

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10 EARTHING & LIGHTNING PROTECTION SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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11 VARIABLE FREQUENCY DRIVE

S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
1	Manufacturer Name		
2	Model No.		
3	Application		
4	Quantity		
5	Enclosure Protection Rating		
6	Output Current Rating at ambient temperature		
7	% derating considered for specific ambient		
8	Rated Voltage (volts) Input		
9	Output Frequency Range (Hz)		
10	Number of Phases and Frequency (Hz)		
a.	Short time current rating		
b.	Dynamic rating		
11	Rectifier type & Design		
12	Inverter type & Design		
13	Min/Recommended / Max switching frequencies (kHz)		
14	Filters		
a.	Line Side		
b.	Load Side		
15	Drive Input		
16	Output Modulation Method		
17	Speed Accuracy (+/- %)		
18	Response time (speed)		
19	Response time (Torque)		
20	Type of cooling		
21	Whether VVFD is suitable for outdoor installation		
22	Drive Control Capabilities		
a.	Start/Stop Push button		
b.	Modbus control		
23	Permissible % variation		
a.	Voltage		
b.	Frequency		
24	Load parameters at rated voltage & frequency		
a.	Output Frequency (Hz)		
b.	Full Load current (Amp)		
c.	VVF Heat dissipation (w)		
25	VVF Efficiency		
a.	At Full rated Torque		
b.	At 75% of full load torque		
c.	At 50% of full load torque		
26	Drive Power factor range		
	At rated speed, Torque		

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S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
27	DC Voltage		
28	Fundamental power factor		
29	Switching Frequency		
a.	Drive Dimensions		
b.	Length		
c.	Height		
d.	Depth		
e.	Weight		
30	Metering		
a.	Applicable Standards		
b.	Accuracy Class		
c.	Make		
d.	Type		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BOILER & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-01)
VOLUME-III
PART-C
TECHNICAL SCHEDULES-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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6. Forms and Schedules

* * * * *

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1. Intent of Specification
2. Site & Project Specific Information
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5. Terminal Points & Exclusions
6. General Technical Requirements
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SECTION-II:DETAILED TECHNICAL SPECIFICATION

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

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* * * * *

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

BOILER & AUXILIARIES (PACKAGE NUMBER: R&M-SP-01)

VOLUME-III, PART-C TECHNICAL SCHEDULES-I&C (TO BE FILLED BY BIDDER)

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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{Only the Applicable portion of the Data Sheet based on the scope of work as firmed up in Section-I, Volume-II should be retained and the remaining portion should be deleted. The scope of work in Section-I, Volume-II is based on Residual Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA) Report. The bidder is to provide datasheet for each type and make of the instrument/equipment offered by them.}

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1 PROGRAMMABLE LOGIC CONTROLLER (PLC)

Table 1.1
Data Sheet for PLC

S.N	Feature	To be Filled by Bidder
1	Type of the system offered and Model No.	
2	Make -	
3	Year of launching of the system	
4	Is the system offered, the latest system available/ being marketed in the international market by the vendor	
5	Place of Manufacturing	
6	Is the offered system confirms to the Specification provided in the tender document with regard to Spare Capacity, Expandability, Redundancy,	
7	Is the System offered is with open system architecture to enable integration of third party hardware/ software applications	
8	Support direct connectivity to Ethernet based LAN	
9	Deterministic and secure architecture	
10	On-line removal/replacement of I/O modules/ drive control modules possible without switching off power supply to the corresponding rack & without affecting controller operation	
11	Total I/O handling capacity of Controller	
12	No. of Tags handling capacity of Controller	
13	Total Power requirement for the offered system	
14	Total Heat Load of all cabinets	
15	Scanning rate for	
a	Analog Signal	
b	T/C Signal	
c	RTD Signal	
d	Binary Signal	
16	Loop Execution Time for	

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S.N	Feature	To be Filled by Bidder
a	Interlocks	
b	Close loops	
17	Auto switchover to backup redundancy Level	
a	Controller Level	
b	Power supply Level	
c	Communication Level	
18	Output Status on Controller Failure	
19	Battery back-up duration for control processor	
20	Non-volatile memory capacity to store programs, standard software to perform control, DAS & Diagnostic functions	
21	Maximum no. of Channels for	
a	Analog Input module	
b	T/C Input module	
c	RTD Input module	
d	Analog Output module	
e	Binary Input Module	
f	Binary Output module	
22	Optical Isolation for Binary Input/Output provided.	
23	Galvanic isolation for Analog Input/Output provided	
24	Can the analog and binary controls be implemented at different execution speeds, in the multi-function controllers.	
25	Simulation of Analog/Digital Input/Output possible.	
26	Data Transmission speed for	
a	Ethernet LAN	
b	Data Highway	
c	I/O Bus	

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Table 1.2
Data Sheet for High Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	No. of Inputs/Module	
2	Types of Input (Linear)	
3	Accuracy	
4	A/D Converter	
5	Temperature Effect	
6	CMRR	
7	NMRR	
8	MTBF	
9	Stability	
10	Diagnostic	
11	Isolation	

Table 1.3
Data Sheet for Low Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input (Grounded/ Ungrounded)	
4	Cold junction compensation	
5	Accuracy	
6	A/D Converter	
7	Temperature Effect	
8	CMRR	
9	NMRR	
10	MTBF	
11	Stability	
13	Diagnostic	
14	Isolation	

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Table 1.4
Data Sheet for Binary Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Contact Bounce Filtering Provided	

Table 1.5
Data Sheet for SOE Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Time stamping provided	
14	Time Resolution	

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S.N	Feature	To be Filled by Bidder
15	Filter Delay Time	

Table 1.6
Data Sheet for Smart Transmitter Interface Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Protocol	
6	Accuracy	
7	Function	
8	Diagnostic	
9	Isolation	

Table 1.7
Data Sheet for Pulse Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Minimum Pulse Width	

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Table 1.8
Data Sheet for Analog Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Isolation	
6	Accuracy	
7	Load	
8	Diagnostic	
9	Isolation	
10	Power supply	
11	Short circuit Protection	

Table 1.9
Data Sheet for Binary Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Contact rating	
6	Contact Voltage	
7	Switching Frequency	
8	Contact Life	
9	Power supply	
10	Isolation	

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Table 1.10
Data Sheet for Controller

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	Processor make	
3	Type of Processor/minimum word length	
4	Memory Size	
5	No. of Loops	
6	No. of I/O	
7	Configuration	
8	Battery Backup Available	
9	Duration of Battery backup	
10	Redundancy	
11	Change Over Time	
12	Failure of any one of the processor not to affect system operation	
13	What could be the maximum loading of the Controller CPU with the configuration offered	
14	Cycle Time	
15	Expansion facility available	
16	Data Transfer mode	
17	MTBF & MTTR	

Table 1.11
Data Sheet for Engineering Station

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Processor	
3	Cache Memory	
4	RAM	
5	Hard disk Drive	
6	CD Drive	
7	Video card	
8	Operating System	

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S.N	Feature	To be Filled by Bidder
9	Interfacing Ports	
10	Monitor	
a	Type	
b	Size	
c	Resolution	
d	Colors	
e	Sync	
f	Dot per inch	
g	Glare Filter	
h	Make & Model no.	
11	Keyboard	
a	Type	
b	Make & Model No.	
c	Key lock control	
12	Mouse	
a	Type	
b	Make & Model no.	
13	Is on line program modification (Control algorithms, logic, sequence programs etc.) and loading possible from Engineering console through data highway without taking the controller in 'standby' mode? Specify limitation, if any	
14	Is it possible to access the control configurations (both regulatory and discrete) along with dynamic updating of process variables (analog values and binary status) from the Engineering station.	
15	Can the system configuration modified and loaded into controller from engineering station	
16	Programming language used for implementing logics / control schemes	

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2 FIELD INSTRUMENTS

Table 2.1
Data Sheet for Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	Turn Down ratio	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Operating Voltage	
13	Output Signal	

Table 2.2
Data Sheet for Thermocouple

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Wire Gauge	
4	Protection tube OD/ Material/ Filling	
5	Response time	
6	Accuracy	
7	Characteristics	
8	MOC Head/ Protection Class	
9	Cable connection	

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Table 2.3
Data Sheet for RTD

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	No. of Elements	
4	Wire Gauge	
5	Protection tube OD/ Material/ Filling	
6	Response time	
7	Accuracy	
8	Characteristics	
9	MOC Head/ protection class	
10	Cable connection	

Table 2.4
Data Sheet for Thermowell

S.N	Features	To be Filled by Bidder
1	Make	
2	MOC	
3	Process Connection	
4	Immersion Length	

Table 2.5
Data Sheet for Pressure Gauge/DP Gauge/ Draught Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Sensing Element Material	
4	Movement Material	
3	Case Material / Protection Class	
5	Dial Size	
6	Scale	
7	Over range Protection	

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S.N	Feature	To be Filled by Bidder
8	Adjustment	
9	Element Connection	
10	Process Connection	
11	Accuracy	
12	Repeatability	
13	Response time	
14	Chemical Seal Unit	

Table 2.6
Data Sheet for Temperature Gauge

S.N	Feature	To be Filled by Bidder
1	Make/Model No.	
2	Type	
3	Stem	
4	Movement Materials	
5	Case Material/Protection class	
6	Dial Size	
7	Scale	
8	Adjustment	
9	Range Selection	
10	Over range Protection	
11	Instrument Connection	
12	Process Connection	
13	Accuracy	
14	Repeatability	
15	Response Time	

Table 2.7
Data Sheet for Level Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	

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S.N	Feature	To be Filled by Bidder
3	Sensing Element & material	
4	Body Material	
5	End Connection	
6	Accuracy	
7	Housing	
8	Zero / Span adjustment	
9	Packing material	

Table 2.8
Data Sheet for Pressure/DP Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing Element material	
4	Wetted Parts material	
5	Case Material	
6	Over range for Pressure / Vacuum Switch	
7	Process Connection	
8	Switch Configuration	
9	Switch Rating	
10	Cable Connection	
11	Enclosure Class	
12	Accuracy	
13	Repeatability	

Table 2.9
Data Sheet for Conductivity Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Sensing elements	
3	Probe Material	
4	Repeatability	

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S.N	Feature	To be Filled by Bidder
5	Accuracy	
6	Probe length	
7	End connection	
8	Rating of contacts	
9	Enclosure class	
10	Housing material	
11	Electrical Connection	

Table 2.10
Data Sheet for Capacitance Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Sensing elements	
3	Probe Material	
4	Repeatability	
5	Accuracy	
6	Probe length	
7	End connection	
8	Rating of contacts	
9	Enclosure class	
10	Housing material	
11	Electrical Connection	

Table 2.11
Data Sheet for Displacer Type Level Switch

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	MOC of Float/Stem	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	

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S.N	Features	To be Filled by Bidder
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Electrical Connection	
13	Output Signal	

Table 2.12

Data Sheet for Displacer Type Level Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	MOC of Float/Stem	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Electrical Connection	
13	Output Signal	

Table 2.13

Specification for Ultrasonic Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	
10	Mounting	
11	Transmitter housing material/enclosure	

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Table 2.14
Data Sheet for Radar Type Level Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	
10	Mounting	
11	Transmitter housing material/enclosure class	

Table 2.15
Data Sheet for RF Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Particle size	
3	Insertion length	
4	Mounting	
5	Process connection	
6	Protection Class	
7	Cable connection	

Table 2.16
Data Sheet for Flow Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Insertion length	
3	Mounting	
4	Process connection	

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S.N	Feature	To be Filled by Bidder
5	Protection Class	
6	Cable connection	

Table 2.17
Data Sheet for Rotameters

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Fluid media	
4	Float Material	
5	Accuracy	
6	Process connection	
7	Enclosure material & protection class	

Table 2.18
Data Sheet for Flow Glass

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Size	
4	Body Material	
5	Glass material	
6	Pressure Rating	
7	Temperature Rating	
8	Protection class	
9	Connection	

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Table 2.19
Data Sheet for Hydrogen Analyzer

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Type	
5	Measurement Range	
6	Accuracy	
7	Linearity	
8	Response time	
9	Temperature compensation	
10	Sample filter	
11	Zero & Span Adjustment	
12	Indication	
13	Enclosure Type/Material	
14	Type of Electronics	
15	Calibration	
16	Output signals	

Table 2.20
Data Sheet for Pneumatic Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Diaphragm Material	
4	Spring Material	
5	Body Material	
6	Stem material	
7	Coupling type & material	
8	Pneumatic Connection	
9	Action on Air Failure	
10	Angle of operation	

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S.N	Feature	To be Filled by Bidder
11	Signal Range	
12	Manual Operation	

Table 2.21
Data Sheet for Electrical Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Motor rating	
4	Power supply	
5	Control Supply	
6	Electrical Connection	
7	Body Material & Protection Class	
8	Gear Train Material	
9	Input Signal	
10	Output Signal	
11	Manual Operation	

Table 2.22
Data Sheet for I-to-P Converter

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Air Supply	
3	Input Signal	
4	Output Signal	
5	Linearity	
6	Hysteresis	
7	Mounting	
8	Protection class	
9	Enclosure	
10	Drift	
11	Direct/Reverse action Facility	

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Table 2.23

Data Sheet for Smart Positioner

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Input	
3	Power Supply	
4	Type of Electronics	
5	Valve position sensing	
6	Enclosure Type/Material	
7	Operating Range	
8	Modes of operation	
9	Flow characteristics	
10	Fail safe/Freeze feature	
11	Air supply pressure	
12	Process Connection	

Table 2.24

Data Sheet for Air Filter Regulator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Inlet Pressure	
4	Output	
5	Filter Element size	
6	Filter Element Material	
7	Drain	
8	Bowl Material	
9	Enclosure Protection class/ Material	
10	Process connection	

Table 2.25

Data Sheet for Position Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Power Supply	
3	Type	

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S.N	Feature	To be Filled by Bidder
4	Output	
5	Accuracy	
6	Enclosure Protection class/ Material	
7	Cable Entry	

Table 2.26
Data Sheet for Limit Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Sensing Element	
3	Material	
4	Repeatability	
5	No. of Contacts	
6	Contact Ratings	
7	Enclosure type/material	
8	Electrical Connection	
9	Set point	
10	Mounting	

Table 2.27
Data Sheet for Solenoid Valve

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Operating Principle	
3	Coil Voltage Rating	
4	Body	
5	Trim	
6	Manual Operation	
7	Duty	
8	Sealing	
9	Coil enclosure	
10	Coil Insulation Class	

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S.N	Feature	To be Filled by Bidder
11	Cable Connection	

Table 2.28
Specification for Aerofoil

S.N	Feature	Minimum Requirement
1	Type	
2	Material	
3	Tapping's	
4	Material of Branch Pipe	
5	Root Valve type	
6	Root Valve material	
7	Root Valve size	
8	Accessories	

Table 2.29
Specification for Venturi

S.N	Feature	Minimum Requirement
1	Design standard	
2	Material	
3	Type	
4	Mounting	
5	Root Valve type	
6	Root Valve material	
7	Root Valve size	
8	Accessories	

Table 2.30
Specification for Flow Nozzle

S.N	Feature	Minimum Requirement
1	Type	
2	Material	
3	Thickness	
3	Beta ratio	

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S.N	Feature	Minimum Requirement
4	Tapping's	
5	Material of Branch Pipe	
6	Root Valve type	
7	Root Valve material	
8	Root Valve size	
9	Accessories	

Table 2.31
Specification for Oxygen Analyzer

S.N	Feature	Minimum Requirement
1	Type	
2	Principle	
3	Sensor Type	
4	Measurement Range	
5	Accuracy	
6	Linearity	
7	Response time	
8	Drift	
9	Operating Temperature Range	
10	Temperature compensation	
11	Sample filter	
12	Zero & Span Adjustment	
13	Ambient Temperature	
14	Indication	
15	Enclosure Type/Material	
16	Type of Electronics	
17	Calibration	
18	Output signals	
19	Digital Signal transmission	
20	Other requirement	

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Table 2.32
Specification for Coriolis Flow meter

S.N	Feature	Minimum Requirement
1	Service	
2	Primary Element	
3	Heating arrangement	
4	Temperature control	
5	Allowable pressure drop	
6	End Connection type/size	
7	Cable entry	
8	Accuracy	
9	Power supply	
10	Drain	
11	Enclosure	
12	Display	
13	Output	
14	Load	
15	Turn down Ratio	
16	Housing	
17	Hazardous duty Version	
18	Accessories	.

Table 2.33
Specification for Carbon Monoxide Analyzer

S.N	Feature	Minimum Requirement
1	Type	
2	Principle	
3	Sensor Type	
4	Measurement Range	
5	Accuracy	
6	Linearity	
7	Response time	
8	Drift	

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S.N	Feature	Minimum Requirement
9	Operating Temperature Range	
10	Temperature compensation	
11	Sample filter	
12	Zero & Span Adjustment	
13	Ambient Temperature	
14	Indication	
15	Enclosure Type/Material	
16	Type of Electronics	
17	Calibration	
18	Output signals	
19	Digital Signal transmission	
20	Other requirement	

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3 INSTRUMENTATION CABLES & ACCESSORIES

Table 3.1
Data Sheet for Thermocouple Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of pairs	
4	Conductor material/Size	
5	No. of Strands/Area of cross section	
6	Conductor Insulation	
7	Lay	
8	Shielding	
9	Drain Wire	
10	No. of twist per metre	
11	Pair Identification	
12	Inner Sheath	
13	Armour	
14	Outer Sheath	
15	Color Coding	
16	Voltage Grade	
17	Code/Standard	

Table 3.2
Data Sheet for RTD Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Triads	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	

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S.N	Feature	To be Filled by Bidder
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Triad Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 3.3

Data Sheet for Instrumentation Signal Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Pairs	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Pair Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	

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S.N	Feature	To be Filled by Bidder
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 3.4
Data Sheet for Fibre Optic Cable (Single Mode)

S.N	Feature		To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@1310 nm	
		@1550 nm	
2	Mode field Diameter	@1310 nm	
		@1550 nm	
3	Maximum Cable Cut-off Wavelength		
4	Maximum Zero Dispersion Wavelength		
5	Minimum Zero Dispersion Wavelength		
6	Maximum Zero Dispersion Slope		
7	Maximum Polarization Mode Dispersion		
8	Gigabit Ethernet Length 1000BASE-LX		
9	Ten Gigabit Ethernet Length	10GBASE-LX	
		10GBASE-LX4	
10	Maximum Core/cladding Concentricity Error		
11	Cladding Diameter		
12	Cladding Non-circularity		
13	Coating Diameter		
14	Maximum Coating Concentricity Error		
15	Temperature Dependence (-60 to +85C)		
16	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		
17	Minimum Proof Test		
18	Bending Induced Attenuation (100 turns, 75mm diameter)		

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Table 3.5
Data Sheet for Fibre Optic Cable (Multi Mode)

S.N	Feature		To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@850 nm	
		@1300 nm	
2	Overfilled Launch Bandwidth	@850 nm	
		@1300 nm	
3	Gigabit Ethernet Length	1000BASE-SX	
		1000BASE-LX	
4	Ten Gigabit Ethernet Length	10GBASE-SR	
		10GBASE-LX4	
5	Numerical Aperture		
6	Core Diameter		
7	Maximum Core Non-circularity		
8	Maximum Core/cladding Concentricity Error		
9	Cladding Diameter		
10	Cladding Non-circularity		
11	Coating Diameter		
12	Maximum Coating Concentricity Error		
13	Temperature Dependence (-60 to +85C)		
14	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		
15	Minimum Proof Test		
16	Bending Induced Attenuation (100 turns, 75mm diameter)		

Table 3.6
Data Sheet for Cable Tray

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size (Width/Height)	
4	Perforation	
5	Length	

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

S.N	Feature	To be Filled by Bidder
6	Thickness	
7	Coating of Hot dip Galvanizing	
8	Accessories	
9	Code/Standard	

Table 3.7
Data Sheet for Cable Glands

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Protection	
3	Compression	
4	Threading Type	
5	Material	
6	Check Nut	

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4 PROCESS CONNECTION PIPING & ACCESSORIES

Table 4.1
Data Sheet for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	

Table 4.2
Data Sheet for Copper Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	
6	PVC Coating thickness	

Table 4.3
Data Sheet for Fittings for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Fitting	
3	Material	
4	Size	
5	Pressure Rating	
6	Temperature Rating	

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Table 4.4

Data Sheet for Compression Fittings for Impulse Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Fitting	
3	Material	
4	Size	
5	Ferrule	
6	Pressure Rating	
7	Temperature Rating	

Table 4.5

Data Sheet for CS Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	
6	Type of threading	
7	Thickness of galvanization	

Table 4.6

Data Sheet for Ball Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	

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S.N	Feature	To be Filled by Bidder
9	Ball Material	
10	Seat Material	
11	Stem material	

Table 4.7
Data Sheet for Globe Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	
9	Ball Material	
10	Seat Material	
11	Stem material	

Table 4.8
Data Sheet for Air Header

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Thickness	
5	Test Pressure	
6	Inlet Connection	
7	Outlet Connection	
8	Drain Connection	
9	Inlet Valve type/size	
10	Drain Valve type/size	
11	Distribution Valve type/size	

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Technical Specification For R&M of Unit No. [...] Capacity [...] of <i>[Name of the Power Plant]</i>	<i>[Logo of Utility]</i>
--	--------------------------

Table 4.9
Data Sheet for Instrument Manifolds

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Type	
5	Ports	
6	Rating	
7	Connection	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-001	02	Technical Specification for R&M Works of Boiler & Auxiliaries Volume-III, Part-C	[33]	25.09.2014

5 SYSTEM CABINETS & JUNCTION BOX

Table 5.1
Data Sheet for Cabinets

S.N	Feature	To be Filled by Bidder
1	Make	
2	Cabinet Dimension	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Anti vibration pad	
8	Painting	
9	Gland Plate thickness	
10	Grounding	
11	Ventilation	
12	Lighting	
13	Lifting arrangement	
14	Tag Plates	

Table 5.2
Data Sheet for Junction Box

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Dimension	
3	Mounting	
4	Protection class	
5	Material & Thickness	
6	Doors	
7	Cable entry	
8	Gasket	
9	Painting	
10	Gland Plate thickness	

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

S.N	Feature	To be Filled by Bidder
11	Grounding	
12	Tag Plates	
16		

Table 5.3
Data Sheet for LIE/LIR

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Mounting	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Gland Plate thickness	
8	Air Connection	
9	Sample line Entry	
10	Drain Pipe	
11	Painting	
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13	Grounding	
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15	Dimension	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-I
COMMERCIAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
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	---	Part-D	Not Used

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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List of Acronym

CIF	:	Cost Insurance Freight
CPBG	:	Contract Performance Bank Guarantee
CST	:	Central Sales Tax
EDI	:	Electronic Data Interchange
EUR	:	Euro
FOB	:	Free on Board
GCC	:	General Conditions of Contract
GOI	:	Government of India
GST	:	Goods & Service tax
ICB	:	International Competitive Bidding
INR	:	Indian Rupees
I&C	:	Instrumentation & Control
ITB	:	Instruction to Bidder
JV	:	Joint Venture
LOA	:	Letter of Award
LOI	:	Letter of Intent
MoEF	:	Ministry of Environment and Forests
MSL	:	Mean Sea Level
PERT	:	Program evaluation and review technique
RBI	:	Reserve Bank of India
R & M	:	Renovation and Modernization
SCC	:	Special Conditions of Contract
TMCR	:	Turbine Maximum Continuous Rating
UNCITRAL	:	United Nations Commission on International Trade Law
USD	:	US Dollar
VAT	:	Value added Tax

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(e)	Last Date & Time of Receipt of Bid (Both Part I & Part II)	:	[-----]
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of facilities and performance guarantee test shall be as per SCC.

1.6 Bid Submission

- (a) The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.
- (b) The Bid proposals are to be submitted in two parts in separate sealed covers as follows:
 - Part I** : Bid Guarantee and Technical & Commercial Proposal without prices
 - Part II** : Price Schedule and Schedule of Functional Guarantee parameters with values.
- (c) All other terms and conditions along with the Technical Specifications, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- (d) Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:
[Designation, Address and Contact details.....]
.....]
- (e) Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- (f) The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the respective quoted Foreign Currencies.
- (g) Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- (h) The Tender Documents are meant for the exclusive purpose of bidding against the subject package and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Owner, intends to carry out the Renovation & Modernization of [Unit no.-XX ----- of the XXXX Power Plant].

Under the subject Tender, [Utility] invites bid for Renovation & Modernization of Turbo Generator & Auxiliaries package of the said Renovation & Modernization work to be carried out as per the accompanying Technical Specifications. The Bidder shall submit the offer for complete scope of work indicated in the Technical Specification.

2.2 Address and Contact Details of Owner

[Designation, Address and Contact details

-----]
-----]

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Owner's Consultant

[-----], hereinafter referred to as "Consultant" is the Consulting Engineer for the project, appointed by the Owner, [-----], to provide project consultancy services.

2.5 Sources of Fund

[Utility] intends to finance the subject Package of the said renovation & modernization work, through Internal and other sources & External/ Domestic Commercial/ Borrowing from international development funding agencies. [Utility] has tied up the required fund for this package.

2.6 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Owner will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.7 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.8 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents. It shall include the following:

- Disassembly of existing equipment/ systems as required.
- Detailed design of the systems/equipment covering all Mechanical, Electrical, Control & Instrumentation, Civil and Structural works.
- Complete manufacture, including shop inspection and testing.
- Providing engineering drawings, data, operational & maintenance manuals, etc., for the Owner's review/ approval.

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- (e) Packing, forwarding and transportation including insurance from the manufacturer's works to plant site and transportation from storage yard to erection site.
- (f) Receipt, storage, preservation and conservation of system/equipment at site including construction of storage facility viz. covered, semi-covered, air-conditioned, open yard at the space allocated at site by Owner including storage-cum-erection and all other specified & statutorily required insurance.
- (g) Pre-assembly, if any, erection, testing, commissioning, completion of plant and equipment/ system, conducting trial operation, performance guarantee test and handing over of all the plant and equipment/ system covered under this specification.
- (h) Carrying out all related civil and structural works at site including construction of foundations, buildings, structures etc. Including supply of cement and steel and all other required materials.
- (i) Supply of mandatory spares and tools & tackles.
- (j) Training of Owner's personnel.

Detailed scope is provided in Volume-II of the Technical Specifications.

Bids not covering the entire scope mentioned hereinabove may be treated as incomplete and hence are liable for rejection.

2.9 Time Schedule

The completion Time Schedule for Completion of R&M work and Performance Guarantee Tests shall be as given in the SCC.

2.10 Tender Documents

The scope of contract, technical specification, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following volumes:

Volume – I	:	Commercial
Volume – I Chapter-1	:	Invitation for Bid
Volume – I Chapter-2	:	Instructions To Bidders
Volume – I Chapter-3	:	General Project Information
Volume – I Chapter-4	:	General Condition of Contract (GCC)
Volume – I Chapter-5	:	Special Condition of Contract (SCC)
Volume – I Chapter-6	:	Forms & Schedules
Volume – II	:	Technical Specifications
Volume – II Section-I	:	Project Technical Specification
Volume – II	:	Detailed Technical Specification-Mechanical

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Section-II, Part-A		
Volume – II Section-II, Part-B	:	Detailed Technical Specification-Electrical
Volume – II Section-II, Part-C	:	Detailed Technical Specification-I&C
Volume – II Section-II, Part-D	:	Detailed Technical Specification-Civil
Volume – III	:	Technical Schedules
Volume – III, Part-A	:	Technical Schedule-Mechanical
Volume – III, Part-B	:	Technical Schedule-Electrical
Volume – III, Part-C	:	Technical Schedule-I&C

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Owner.

The Bidder is expected to examine all instructions, forms, terms, conditions, specifications and other information in the bidding documents. Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Owner in writing by post or by e-mail followed by postal confirmation at the Owner's address indicated in ITB. The Owner will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than twenty-one (21) days prior to the deadline for submission of bids prescribed by the Owner. Owner's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Owner will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operation and does not in any way adversely impact the interest of the Owner. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Owner may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the bidding documents.

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The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.11 Preparation of Bids

2.11.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.11.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

The bidders are required to submit, the bids for the Renovation and Modernization work in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical Data Sheets, List of Tools & Tackles, Deviations to Technical and Commercial Specifications/Conditions, Overall Completion Time Period & L-1 Network Schedule, Resource Deployment Schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part-II Bid will comprise Quoted Price and Quoted Performance Guarantee Parameters. Initially, only the Part-I Bid will be opened and Part-II Bid is kept in safe custody.

After evaluation of the Techno-Commercial (Part-I) Bids, each Bidder who has submitted a broadly responsive Part-I Bid, will be invited for Techno-Commercial Discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a memorandum. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions. The date & time for opening of Price Bid will be intimated separately.

Techno-Commercial Bid should not contain any price data.

Price Bid should not contain any matter in respect of Technical and / or Commercial aspects other than the details specifically sought by the Owner.

2.11.3 Bid Submission

- (1). Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2). All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered. All bids shall be prepared in the English language only, by typing or printing.

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- (3). [One original and 9 (nine) identical] copies of the original with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., "Original", "Copy No. 1", "Copy No. 2" etc.).
- (4). All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (5). The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (6). The Bidder's Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (7). In the event of discrepancy between "Original" and any copy of the bids, the hard copy of Original shall prevail.
- (8). The Bid shall be submitted to [-----]. Bid submitted to any other office of Owner is liable for rejection. Bids submitted by Telefax or e-mail will be rejected
- (9). Owner will receive Bids in respect of all the equipment/systems and scope of work as set forth in the accompanying Technical Specifications. All bids shall be prepared and submitted in accordance with the Tender Documents.
- (10). Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Technical Specifications in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11). A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Owner's rights or the successful Bidder's obligations under the contract.
- (12). Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13). Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Contractor under the Contract.
- (14). Either the Indian agent or the foreign Principal directly could bid in a tender, but not both. The same applies to an Indian agent/dealer representing and Indian manufacturer. In case both submit the tenders, the tender of the manufacture will alone be considered.
- (15). An agent representing one manufacturer in a tender will not be allowed to quote on behalf of another manufacturer along with previous manufacturer in a subsequent / parallel tender for the same item.

2.11.4 Bid Guarantee

- (1). The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of "[-----]" payable at "[-----]".

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- (2). The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank. Foreign Bidders may submit the Bank Guarantee from any bank in India as above or from any foreign bank which is in the approved list of RBI.
- (3). Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Owner at ([-----]). In the event of any deviation in this regard, the decision of Owner as to whether the same could be accepted or not, will be final and binding on the Bidder.
 - d) In case of foreign Bidder, the Bid Guarantee amount shall be in US Dollar / Euro/ Indian Rupee.
- (4). The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Owner.
- (5). No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified herein above or from banks not specified hereinabove will be liable for rejection.
- (6). Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7). The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Owner or fails to submit Contract Performance Guarantee.
- (8). The Bid Guarantee of all unsuccessful Bidders shall be returned after price cover opening and price evaluation. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Owner and acceptance thereof.

2.11.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part– I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part–I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Owner, at its discretion, may consider appropriate, shall be read out. The Part – II (Price Bid) will be lodged and opening date of the same will be intimated separately to those Bidders whose Part-I Bid will be determined to be substantially responsive to Tender Conditions and Technical specifications in all respects.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.

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3. Owner takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

2.12 Composition of Techno Commercial Bid (Part-1 Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 9 (nine) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B & Annexure-C of this Volume).
- (ii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iii). Letter of consent: To be furnished by the Bidder and Consortium Partners/Individual Companies of the Group (as the case may be)- as per Annexure—D of this Volume
- (iv). Letter of Unequivocal Consent to be furnished by the Bidder and Assignee as per Annexure-E of this Volume
- (v). Bid Guarantee- as per Annexure A.
- (vi). Schedule of Prices as per Schedule – F1 (Table 1 to Table-7) with the word "Quoted" in lieu of Price data and all other details except price data.
- (vii). Mandatory spares as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (viii). Recommended spares (with the word "Quoted" in lieu of Price data)
- (ix). Tools & Tackles as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (x). Schedule of Performance Guarantees- as per Schedule – F1 (Table-8) with the word "Quoted" in lieu of Performance Guarantee parameters
- (xi). Signed copy of all the corrigendum's/amendments/clarifications, if any issued for the tender
- (xii). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (xiii). Deviations to the Commercial specification, if any, as per Schedule – F3.
- (xiv). Deviations to Technical Specifications, if any, as per Schedule – F4.
- (xv). Requirements of the Contractor at site, as per Schedule – F5.
- (xvi). Resource deployment schedule as per Schedule – F6
- (xvii). Details of the present commitments of the Bidder, details of contracts in hand
- (xviii). Details of Sub-Contractors/Sub-Suppliers/Sub-Vendors, if any
- (xix). Quality Assurance Programme
- (xx). Technical Details to be furnished with the Bid as called for in the Technical Specification Vol-II and Technical Bid Data Sheet Vol-III.
- (xxi). Schedule of weights and dimensions
- (xxii). Coefficients and indices for price variation formula

The Part-I Bid shall not contain any Price data.

2.13 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices and the Performance Guarantee parameters only in the specified format. Price given in Part-II should cover the entire

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scope of work as given in Part-I of the offer including list of mandatory spares and Tools & tackles with itemized price and should be as per Schedule of Price enclosed. **[One original and 9 (Nine) identical]** copies shall be submitted.

1. The Price Bid shall contain the following :

- (i). Duly filled in Form of bid as per Annexure-B & Annexure-C
 - (ii). Completely filled in Schedule of Prices Schedule – F1 (Table 1 to Table-7)
 - (iii). Completely filled in Schedule of Performance Guarantees Schedule – F1 (Table-8).
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed formats. The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
 3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Owner shall be final. All entries shall be in English language only.
 4. The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the quoted Foreign Currencies.
 5. Prices in Indian supply shall be quoted on Ex-works supply of plant & equipment basis including Packing & forwarding. Inland transportation, Insurance charges, etc. shall be indicated separately.
 6. Prices of imported supply of plant & equipment directly consigned to site shall be quoted on CIF Indian port on entry basis. The bidder shall also quote separately for FOB port of shipment price for ocean freight for Marine insurance, all port charges including customs clearance and inland transport charges from port of destination to Owner's site.
 7. Custom Duty, Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation.

2.14 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the Contractor's obligations mentioned in tender document specification or to be reasonably inferred from the tender documents/ specification in respect of the disassembly/ dismantling of existing equipment facility as specified, design, manufacture, including procurement and subcontracting (if any), delivery, construction, installation, commissioning, completion of the facilities and conductance of Performance Guarantee tests for the facilities including supply of mandatory spares, recommended spare & tools/ tackles (if any). This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the facilities, conducting Guarantee tests and, where so required by the tender documents, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the tender documents, all in accordance with the requirements of the Conditions of Contract and Technical Specifications.

Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the tender documents.

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Prices quoted by the Bidder shall be subject to adjustment during performance of the Contract to reflect changes in the cost of labour, material, etc. A bid submitted with a fixed price quotation will not be rejected, but the price adjustment will be treated as zero. The price adjustment provision will not be taken into consideration in bid evaluation.

2.15 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if any shall be signed by the person signing the Bid. Printed literature, it enclosed need not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.16 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Owner may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Specifications by amendment.
2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Specifications, which will be notified. Amendments will be hosted in Owner's website. Bidders are requested to visit Owner's website and note amendments, if any, before submission of bid. Owner shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.17 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

2.18 Information to be Furnished with the Bid

1. The Bid (Part-I) must clearly indicate the name of the manufacturer, the type or model of each principal item of equipment proposed to be supplied and erected. The Bid should also contain drawings and descriptive materials indicating general dimensions, material from which the parts are manufactured, principles of operation and the extent of pre-assembly involved, major erection equipment required to be deployed, method of erection and the proposed erection Organization structure.
2. The above information shall be provided by the Bidder in the form of separate sheets, drawings, catalogues, etc.
3. Any Bid not containing sufficient descriptive material to describe accurately the system / equipment proposed may be treated as incomplete and hence rejected. Such descriptive materials and drawings submitted by the Bidder will be retained by the Owner. Any major departure from these 'drawings and descriptive material submitted will not be permitted during the execution of the Contract' without specific written permission of the Owner.
4. Oral statements made by the Bidder at any time regarding quality, quantity or arrangement of the equipment or any other matter will not be considered.

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5. Standard catalogue pages and other documents of the Bidder may be used in the Bid to provide additional information and data as deemed necessary by the Bidder.
6. In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy of all data sheets, Schedule, List of Mandatory spares, tools & tackles and Bar Chart/PERT as well as deviation tables in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation. Bidder shall submit all the filled in datasheet also in soft copy. Bidder shall also furnish soft copies and hard copies of Data Sheet with filled in details wherever details are required to be indicated by the Bidder.

2.19 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other interested parties are advised to refrain from contacting by any means, the Owner and/or his employees/ representatives on matters related to the Bids under consideration. The Owner, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

2.20 Validity of Bid

1. The Bid shall be kept valid for acceptance for **[180 days]** from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Owner from participating in any of the Owner's tenders.

2.21 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully informs himself as to all the conditions and matters which may in any way affect the 'Renovation and Modernization work to be carried out or the cost thereof. Bidders are required to visit the plant to get familiarized with local conditions. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Owner.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Owner at least **[7 (seven) days]** before the date stipulated for pre-bid meeting. The Owner then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till **[21 days]** prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Owner. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.

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3. Pre-Bid Conference will be organized and outcome of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Owner to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.
5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

2.22 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Owner not later than [-----] Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

2.23 Single Bidder Responsibility

1. The scope of supply and services shall be under single Bidder responsibility.
2. The successful Bidder should not sub contract the entire work on back to back basis or otherwise.

2.24 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Owner for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Owner, even though the Owner may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

2.25 Deputation of Representatives for Discussion

After opening of the Bid, if the Owner desires to have techno-commercial discussion on the Bid, the Bidder shall be in a position to depute his competent representatives of various disciplines at short notice with full authority for finalising technical parameters as well as Commercial Terms and Conditions of the Tender.

2.26 Evaluation of Bid

1. For evaluation and comparison of price bid, the prices indicated at [-----] summary of Prices as per Schedule [-----] will be considered. The Bids received will be evaluated by the Owner to ascertain the lowest evaluated substantially responsive Bid vis-à-vis the Tender Specifications. The Bidder has to satisfy himself that full information is furnished as required in the specifications. Lack of particulars or incomplete information furnished will run the risk of rejection of the bid. The following major procedures would be followed for evaluation of bids.
2. All the Bidders would be brought on par with reference to Technical Specification, Commercial Condition, Instructions to Bidders and subsequent techno-commercial discussions/ clarifications.

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3. After the evaluation of Part-I bids (techno-commercial bids) and before opening of Part-II bids (Price Bids), in case the bidders are asked to make changes to their techno commercial offer that may have price implications, Owner may give the bidders opportunity to submit addendum to price bid covering the price implication only against such changes before the opening of Part-II bids (Price Bids). All the bidders will be notified, at least 15 days before the Price Bid opening date, about such changes against which they can submit addendum to Price Bid.
4. Commercial loading would be done for non-compliance of commercial terms and conditions of the Tender Specifications other than the vital clauses, as the case may be.
5. To facilitate evaluation and comparison, the Owner will convert all bid prices expressed in foreign currencies into Indian Rupee at State Bank of India Bills Selling exchange rates prevailing on the date of opening of the price bid.
6. The Bidder is eligible for a price variation as per Tender Condition. However Price variation shall not be considered for Bid evaluation.
7. Technical loading will be done for omission of price data in respect of equipment/facilities, spares, tools & tackles, etc. The highest quoted corresponding price will be loaded against such omission. If no quoted price is available, the loading will be done as per the corresponding price as estimated by the Owner.
8. The Bidder has to meet the minimum functional performance levels indicated in Volume-II Technical Specification for all categories of Guarantees. If one or more of Functional Performance Parameters offered by the Bidder is inferior to the minimum functional performance level (i.e. higher or lower than maximum or minimum value specified in Technical Specification), then such bid will be considered non-responsive and rejected.
9. The quoted values for Performance Guaranteed Parameters given in Table below would be evaluated using evaluation factors specified. The evaluation factors shall be applicable to the differential values calculated from among the Bidders of corresponding item with appropriate highest or lowest value (i.e., the best quoted value) as the base. The evaluation will be based on the guarantee parameters inclusive of all tolerance furnished at the Guaranteed Condition. Bidders to note that the values indicated in the Schedule of Performance Guarantees shall be inclusive of all tolerances including measurement uncertainty.

Table-Bid Evaluation Factors

Sl. No.	Functional Performance Parameter	Evaluation Factor Rate
1.	Turbine Cycle Heat Rate	[-----]INR per kCal/kWhr
2.	Auxiliary Power	[-----] INR per kW
3.	[TG output]	[-----] INR per kW

{NOTE: The utilities may decide whether credit has to be given for higher TG output during Bid Evaluation and structure the Tender Document accordingly. If the bidders are asked quote the value of TG output, then credit will be given for higher quoted TG Output during Bid Evaluation. However, if Owner specifies the TG Output, it may decide not to give any credit to Bidders offering TG Output higher than specified value and structure the Tender Documents accordingly.}

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The evaluation factors rate shall be prorated for any fractions of the specified value.

- (1). Arithmetical errors will be rectified on the following basis:
 - If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.
 - If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
 - If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.
- (2). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder shall not charge any amount separately for that item from the Owner. If the terms, such as 'not applicable' "----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.27 Local Conditions

1. The Bidder shall inspect the site and shall satisfy himself of the site conditions and shall apprise himself of the procedure for engagement of agencies/labour and shall collect any other information, which may be required before submitting the Bid.
2. Wages not less than Minimum wages for Contract labour shall be paid as applicable in this region from time to time. Claims and objections due to ignorance of site conditions will not be considered after submission of Bid.
 - (i). The Bidder is required to carefully examine the Technical & General Specification, commercial Terms and Conditions, drawings and other details relating to work given in the Tender Specification and get fully acquainted as to all conditions and matters which may in any way affect the work or the cost thereof.
 - (ii). The Bidder shall be deemed to have exhaustively examined the Tender Specifications including the Form of Contract, to have obtained all information and clarifications on all matters whatsoever that might affect the carrying out of the work and to have satisfied himself as to the adequacy of his Bid. He is deemed to have known the scope, nature and magnitude of the work and the requirements of materials and labour involved etc. and as to all work he has to complete in accordance with the Contract for the adequacy of his Bid.
 - (iii). The Bidder shall be deemed to have visited and carefully examined the plant/ site and surroundings, to have satisfied himself about the nature and details of all existing structures, if any, and also as to the nature and conditions of the railways, roads, bridges and culverts, means of transport and communications, whether by land, water or air and as to possible interruptions thereto and the access to and from the site, to have made independent enquiries, examined and satisfied himself as to the sources for obtaining earth, gravel, sand, stones, bricks and all other construction

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materials, the site for disposal of surplus earth and debris, the available accommodation, underground existing services, sub-soil water conditions, storms, prevailing winds, climatic conditions and all other similar matters which may affect the work.

- (iv). The Bidder shall be deemed to have acquainted himself with the Indian Income tax Act, 1961, Indian Companies Act, 1956, Indian Customs Act, 1962, Indian Central Excise Act, Value Added Tax, Indian Sales Tax Act, Indian Electricity Act, Central Electricity Authority Regulations, Indian Boiler Regulations, Factories Act, Pollution Control Regulations and other related Acts & Laws prevalent in the State of [-----] and in India and as amended from time to time. The Owner shall not entertain any request for clarifications from the Bidders regarding such local conditions.
- (v). Any neglect or omission or failure on the part of the bidder in obtaining necessary and reliable information as stated above or on any other matter affecting the Bidder shall not relieve him from any risk or liabilities or the entire responsibility for completion of the work in accordance with the Tender Specifications.

2.28 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and technical specification. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with “Original” of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily rejected and ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.
2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Owner at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Owner towards Owner’s cost, loss and damage to Owner.

2.29 Blacklisting/Debarring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Owner. Owner would also be at liberty to inform the matter to other PSUs of the Government of India / Statutory Bodies.

2.30 Award of Contract

1. Award Criteria

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- The Owner will award the contract to the successful Bidder whose Techno-commercial bid has been determined to be substantially responsive and Price Bid to be the lowest evaluated bid, further provided that the Bidder is determined to be qualified to perform the contract satisfactorily.
- The Owner reserves the right to vary the quantity of any of the Items / Spares and / or delete any Item / Spares altogether at the time of Award of Contract.

2. Owner's Right to Accept Any Bid and to Reject Any or All Bids

The Owner reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Owner's action.

3. Notification of Award

Prior to the expiration of the period of bid validity, the Owner will notify the successful Bidder in writing by registered letter (Letter of Award or LOA) or by email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Owner will promptly notify each unsuccessful Bidder and will discharge its bid security.

4. Signing the Contract Agreement

At the same time as the Owner notifies the successful Bidder that its bid has been accepted, the Owner will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

Within **[twenty-eight (28)]** days of receipt of the Contract Agreement, the successful Bidder / assignee of foreign bidder (if applicable) shall sign and date the Contract Agreement and return it to the Owner.

5. Corrupt or Fraudulent Practices

The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, the Owner:

- The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, the Owner :
 - "corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution; and
 - "fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner, and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition;

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- will reject a proposal for award if it determines that the Bidder recommended for award has engaged in corrupt or fraudulent practices in competing for the contract in question;
- Will declare a firm ineligible, either indefinitely or for a stated period of time, to be awarded a contract if it at any time determines that the firm has engaged in corrupt or fraudulent practices in competing for or in executing a contract of the Owner.

6. Fraud Prevention Policy

The Bidder along with its associate/collaborator/sub-contractors/sub-vendors/consultants/service providers shall strictly adhere to the Fraud Prevention Policy of Owner displayed on its tender website and shall immediately apprise the Owner about any fraud or suspected fraud as soon as it comes to their notice. A certificate to this effect shall be furnished by the bidder along with his bid.

2.31 Agency Commission

No Agency commission shall be payable under the Contract.

2.32 Contract Performance Bank Guarantee (CPBG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPBG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period. If the contract price is in more than one currency, CPBG shall be 10% of respective currency.

If the bidder is a joint venture of two firms who collectively meet the Qualifying Requirement, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the bidder, each of the JV partner shall furnish Additional Contract Performance Guarantee equal to 1% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder and Additional Contract Performance Bank Guarantee furnished by the JV partners taken together shall be 12% of the Contract Price.

If the bidder is a Consortium of two firms, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the Consortium Leader, the other consortium member will furnish Additional Contract Performance Bank Guarantee equal to 2% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder (Consortium Leader) and Additional Contract Performance Bank Guarantee furnished by the other consortium member taken together shall be 12% of the Contract Price.

In case of a successful foreign bidder, if the Owner accepts to enter into the Second Contract and / or Third Contract with the assignee, then, within Thirty (30) days after receipt of Letter of Award, the assignee shall furnish an additional Contract Performance Bank Guarantee for five percent (5%) of the value of the Contract entered into with the assignee (i.e. for five percent of aggregate value of component Contract(s) entered into with the assignee).

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2.33 Contract Quality Assurance

1. The Bidder shall include in his Bid a detailed Quality Assurance Programme containing the overall quality, management and procedures which he proposes to follow in the performance of the 'Works' during various phases.
2. After Letter of Award (LOA) the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall form a part of the 'Contract'.

2.34 Codes & Standards

Specifications give reference to Indian or internationally accepted Standards. However, equipment or materials meeting other recognized National or International Standards, which ensure an equal or superior quality than Standards specified, will also be accepted. For details of codes and standards refer Technical specification, Volume-II.

2.35 Vital Clauses

The following clauses in the Tender Specification & Draft Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Warranty
- Liquidated Damages
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Owner / Purchaser : [-----]
- Consultant : [-----]
- Project Title : [-----]
- Location : [-----]
- Latitude : [-----]
- Longitude : [-----]
- Elevation above MSL : [-----]
- Nearest Railway Station : [-----]
- Nearest Sea Port : [-----]
- Nearest Airport : [-----]
- Road Access/Approach to Site : [-----]

For Project & Site related detailed information, refer Clause No. 2 of Section-I of Volume-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Works, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract Agreement.
- iv. **"Contract"** means the Agreement entered into between Owner and Contractor as per the 'Contract Agreement' signed by the parties, including contract documents, contract schedules, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Contractor's Equipment"** means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities.
- vii. **"Contractor"** means the person(s), Firm or a Company whose bid to perform the Contract has been accepted by the Owner and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Contractor.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Owner for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.
- ix. **"Contractor's Representative"** means any person nominated by the Contractor & approved by the Owner hereof to perform the duties delegated by the Contractor.
- x. **"Consulting Engineer"** means Owner's Engineer appointed by the Owner. Also refers to any other firm(s) or person(s) as may be appointed by the Owner from time to time.

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- xi. **“Commissioning”** means the construction of plant and equipment for operation of the Facility at rated capacity are complete and the plant and equipment achieves the designated full load/full capacity, at designated fuel/input.
- xii. **“Completion”** means that the Facilities (or a specific part thereof where specific parts are agreed) have been completed operationally and structurally and put in a tight and clean condition, and that all work in respect of pre-commissioning of the Facilities or such specific part thereof has been completed and commissioning has been attained as per Technical Specifications.
- xiii. **“Competent Authority”** means any agency, authority, department, inspectorate, ministry or statutory person (whether autonomous or not) of GOI, [Name of the State], Ministry of Environment and Forests (MoEF) any other State of the Republic of India or any local authority.
- xiv. **“Day”** means calendar day of the Gregorian calendar.
- xv. **“Defect Liability Period”** means the period of validity of the warranties given by the Contractor, commencing at completion of the Facilities or a part thereof, during which the Contractor is responsible for defects with respect to the Facilities.
- xvi. **“Effective Date”** means the date from which the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor shall be determined.
- xvii. **“Erection Services”** means those entire services ancillary to the supply of the plant and equipment for the Facilities, to be provided by the Contractor under the Contract. e.g. transportation and provision of marine or other similar insurance, inspection, expediting, site preparation works (including the provision and use of Contractor's Equipment and the supply of all construction materials required), installation, testing, Pre-commissioning, commissioning, operations, maintenance, the provision of operations and maintenance manuals, training of Owner's Personnel etc.
- xviii. **“Facilities”** means the plant and equipment to be supplied and installed, as well as all the Erection Services to be carried out by the Contractor under the Contract.
- xix. **“Force Majeure”** means mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- xx. **“GCC”** means the General Conditions of Contract hereof.
- xxi. **“Good Industry Practice”** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Contractor, equipment manufacturer or operator applying the standards generally adopted by global Contractors, global equipment manufacturers and operators in the construction or operation of power generation facilities or the manufacture of equipment therefore, except in so far as inconsistent with any applicable Indian law or directive.
- xxii. **“Guarantee Test(s)”** means the test(s) specified in the Technical Specifications to be carried out to ascertain whether the Facilities or a

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- specified part thereof is able to attain the Functional/Performance Guarantees specified in the Technical Specification.
- xxiii. **"Incoterms"** means International rules for interpreting trade terms published by the International Chamber of Commerce (latest edition), Paris (France). Unless inconsistent with any provisions of the contract, the meaning of any trade term and the rights and obligations of the parties there under shall be as prescribed by Incoterms.
 - xxiv. **"Inspector/Inspecting Engineer"** means the Owner or any person nominated by the Owner from time to time, to inspect the equipment of works under the contract and/or the duly authorized representative of the Owner.
 - xxv. **"Latent Defect"** means the defects inherent in the material or arising out of design deficiency which does not manifest itself during the Warranty Period/Defect Liability Period, as described in this GCC.
 - xxvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Owner notifying the Contractor that its Bid Proposal has been accepted.
 - xxvii. **"Month"** means calendar month of the Gregorian calendar.
 - xxviii. **"Manufacturer's Works" or "Contractor's Works"** means the place used by the Contractor, its manufacturer, supplier, collaborators or sub-contractors/vendors/sub-vendors for the performance of the works.
 - xxix. **"Operational Acceptance"** means the acceptance by the Owner of the Facilities (or any part of the Facilities where the Contract provides for acceptance of the Facilities in parts), which certifies the Contractor's fulfillment of the Contract in respect of performance guarantees of the Facilities.
 - xxx. **"Owner" or "Purchaser"** shall means the [Name of the Utility], and includes its legal successors or permitted assignees.
 - xxxi. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
 - xxxii. **"Pre-commissioning"** means the testing, checking and other requirements specified in the Technical specifications that are to be carried out by the Contractor in preparation for commissioning.
 - xxxiii. **"Project"** means the Owner's [-----] in respect of which the Contract has been signed.
 - xxxiv. **"Project Consultant" or "Owner's Consultant"** means the engineering firm or person(s) appointed by the Owner to render engineering project consultancy services for the project.
 - xxxv. **"Project Manager"** means the person appointed by the Owner thereof and named as such, to perform the duties delegated by the Owner.
 - xxxvi. **"Plant and Equipment"** means permanent plant, equipment, systems, machinery, apparatus, articles and things of all kinds to be provided and incorporated in the Facilities by the Contractor under the Contract (including the spare parts to be supplied by the Contractor under the Contract Agreement), but does not include Contractor's Equipment.
 - xxxvii. **"SCC"** means the Special Conditions of Contract hereof.

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- xxxviii. **“Site”** means the land and other places upon which the Facilities are to be installed, and such other lands or places as may be specified in the Contract as forming part of the Site.
- xxxix. **“Sub Contractor”, including “Vendors/Sub-Vendors”**, means any firm or person to whom execution of any part of the Facilities, including preparation of any design or supply of any plant and equipment is subcontracted directly or indirectly by the Contractor, and includes its legal successors or permitted assignees.
- xl. **“Technical Specification / “Tender Documents”** means the document, setting out a description and specification of the Works and statement of the technical and other standards to which the Works are to be performed including any modifications thereto made in accordance with the Conditions. This includes the technical & commercial specifications and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xli. **“Tenderer”/“Bidder”** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Owner, for the Project.
- xl.ii. **“Time for Completion”** means the time within which completion of the Facilities as a whole (or of a part of the Facilities where a separate time for completion of such part has been specified) is to be attained in accordance with the stipulations and provisions of the Contract.
- xl.iii. **“Warranty Period” or “Defect Liability Period”** means the period during which the Contractor shall remain liable for repair or replacement of any defective part of the works performed under the contract, free of cost.
- xl. iv. **“Work(s)”** means and includes the tasks of furnishing of equipment, labour & services, transport, handling, unloading and storage at site, civil construction and complete erection, testing, commissioning putting into satisfactory operation and completion of successful performance tests, reliability tests and any other guaranteed parameters as defined in the Contract, replacement, modification, repair of defective parts or equipment during warranty period and rectification of latent defects during latent defect period.
- xl. v. **“Writing” or “Written”** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Owner. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

Terms and expressions not herein defined shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

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4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Owner.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing submitted by the contractor.
- vi. The bid & schedules/ attachment.

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Construction of the Contract

The Contracts to be entered between the Owner and the Contractor shall be as under:

- 'First Contract' for CIF Supply of all Offshore Plant and Equipments and Materials including Mandatory Spares to be supplied from abroad.
- 'Second Contract' for Ex-Works Supply of all Plant and Equipments and Materials including Mandatory Spares of Indian origin.
- 'Third Contract' for providing all services i.e. Port Handling, Port Clearance and Port Charges for the imported goods, further Loading and Inland Transportation for Delivery at Site, Unloading, Storage, Handling at Site, Installation, Insurance, Testing and Commissioning including carrying out Guarantee Tests for all the Equipments supplied under the First Contract and the Second Contract and all other services specified in the Tender Documents.

All the above Contracts will contain a cross-fall breach clause specifying that breach of one Contract will constitute breach of the other Contracts which will confer a right on the Owner to terminate the other Contracts also at the risk and the cost of the Contractor.

The foreign bidder, however, has the option, to be exercised as a part of its bid proposal, to propose an Assignee in its bid to execute the Second Contract and/or the Third Contract. Such foreign bidder shall furnish a written unequivocal consent (with

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Part-I Bid) of the proposed Assignee to work as independent Contractor on the terms and conditions offered by the bidder For the scope of work envisaged by the foreign bidder, in its bid, to be executed by Assignee, the Assignee should have relevant/required capacity and experience of executing similar job. The bidder shall substantiate with relevant/required documents in the bid to establish capacity and experience of the Assignee.

If the foreign bidder has proposed an Assignee in its bid to execute the Second Contract and/or the Third Contract and has also furnished written unequivocal consent of the proposed Assignee to work as an independent Contractor on the terms and conditions offered by the bidder and if the Owner is satisfied with the capacity and experience of the Assignee proposed in the bid, the Owner will enter into the "Second Contract" and/or the "Third Contract" with the Assignee. However, if the Owner in its judgment does not find acceptable the Assignee proposed in the bid as its Contractor, then on the request of the Owner, the Bidder shall have option to propose an alternate Assignee on the same terms and conditions and cost as offered in its bid. In case the Assignee option is not exercised by the Bidder or if the Assignee fails to enter into Contract(s) with the Owner or if the Owner in its judgment does not find acceptance of the Assignee as its Contractor, then the foreign bidder shall be obliged to enter into and execute all the contracts envisaged to be entered upon this Tender with the Owner covering the entire scope of work envisaged in the Tender Documents on the same terms and conditions and cost as offered in its Bid.

If any foreign bidder has proposed an Assignee in his bid to execute the Second Contract and/or the Third Contract and has also furnished written unequivocal consent of the proposed Assignee to work as independent Contractor on the terms and conditions offered by the bidder and if the Owner is satisfied with capacity and experience of the Assignee, the Owner will enter into the 'Second Contract' and/or 'Third Contract' with the said Assignee. In case no Assignee has been proposed by the foreign bidder in his bid or if the Assignee fails to enter into the Second Contract and/or Third Contract with the Owner or if the Owner in its judgment does not find acceptance of the proposed Assignee as its Contractor, then the foreign bidder shall be obliged to enter into and execute all the three Contracts with the Owner.

If the Owner accepts to enter into Second Contract and/or Third Contract with the Assignee of foreign bidder, the said Assignee, in addition to the Contract Performance Securities to be provided by the foreign Contractor shall provide within [twenty eight (28)] days of Notification of Award, separate Contract Performance Bank Guarantee equivalent to five percent (5%) of the value of the Contract(s) entered into with the Assignee for the due performance of the Contract, with an initial validity up to [ninety (90) days] beyond the scheduled Defects Liability Period.

The award of the separate Contracts shall not in any way dilute the responsibility of the Contractor for the successful completion of the Facilities as per Contract Documents and a breach in one Contract shall automatically be construed as a breach of the other Contract(s) which will confer a right on the Owner to terminate the other Contract(s) also at the risk and the cost of the Contractor.

4.6 Independent Contractor

The Contractor shall be an independent contractor performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Contractor shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or Subcontractors engaged by the Contractor in connection with the performance of the

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Contract shall be under the complete control of the Contractor and shall not be deemed to be employees of the Owner, and nothing contained in the Contract or in any subcontract awarded by the Contractor shall be construed to create any contractual relationship between any such employees, representatives or Subcontractors and the Owner.

4.7 Joint Venture or Consortium

If the Bidder/Contractor is a joint venture or consortium of two or more firms, all such firms shall be jointly and severally bound to the Owner for the fulfillment of the provisions of the Contract and the Bidder shall submit a letter of consent to this effect (with Part-I Bid) signed by all joint venture partners / consortium members. The joint venture/consortium partners shall designate one of such firms to act as a leader with authority to bind the joint venture or consortium. The composition or the constitution of the joint venture or consortium shall not be altered without the prior consent of the Owner.

4.8 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.9 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.10 Origin

"Origin" means the place where the materials, equipments and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.11 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or E-mail to the address of the relevant party indicated in the Contract.

Either party may change its postal address, telefax number, or E-mail ID or addressee for receipt of such notices by ten (10) days' notice to the other party in writing

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

4.12 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [.....] shall have exclusive jurisdiction in all matters arising under the Contract.

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4.13 Settlement of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Owner and the Contractor in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Owner & Contractor shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

Either Owner or the Contractor may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities

Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Owner and the Contractor shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within [twenty eight (28)] days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by the Appointing Authority for arbitrator is given below.

Appointing Authority for Arbitrator:

- President, Institution of Engineers in case of an Indian Contractor.
- President, International Chambers of Commerce, Paris in case of a Foreign Contractor.

If one party fails to appoint its arbitrator within [forty-two (42)] days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Arbitration proceedings as follows:-

- In case of a foreign contractor the arbitration proceeding shall be conducted in accordance with the United Nations Commission on International Trade Law (UNCITRAL) Arbitration Rules of 1976.
- In case of an Indian Contractor Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996.
- In case of a foreign associate of the contractor, the arbitration proceedings shall be conducted in accordance with the United Nation Commission on International Trade Law (UNCITRAL) Arbitration Rules of 1976.

The Place for Arbitration shall be: [New Delhi], India.

The language of arbitration shall be English.

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The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- the parties shall continue to perform their respective obligations under the Contract unless they otherwise agree
- The Owner shall pay the Contractor consideration due to the Contractor.

4.14 Scope of Facilities

- a) Unless otherwise expressly limited in the Technical Specifications, Facilities the Contractor's obligations cover the provision of all Plant and Equipments including spares and the performance of all Services required for design, manufacture (including procurement, quality assurance, construction, installation, associated civil works, Structural and others construction works, precommissioning and delivery) of the Plant and Equipment and the installation, commissioning, completion of facilities and performance testing of the Facilities in accordance with the plans, procedures, specifications, drawings, codes and any other documents as specified in the Technical Specifications. Such specifications include, but are not limited to, the provision of supervision and engineering services; the supply of labour, materials, equipment, spare parts and accessories; Contractor's Equipments; construction utilities and supplies; temporary materials, structures and facilities; transportation loading & unloading.
- b) The Contractor shall, unless specifically excluded in the Contract, perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for attaining Completion of the Facilities.

4.15 Time for Commencement and Completion

- a) The Contractor shall commence work on the scope of work under this Tender from the date of Letter of Award. Contractor shall thereafter proceed with the Facilities in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- b) The Contractor shall attain Completion of the Facilities (or of a part where a separate time for Completion of such part is specified in the Contract) within the time stated in the SCC subject to time extensions, the contractor is entitled under the contract conditions or time extension expressly grouted by the Owner.

4.16 Spare Parts

In addition to the supply of Mandatory Spare Parts included in the Contract, the Contractor agrees to supply other spare parts (recommended spares) required for the operation and maintenance of the Facilities for 3 years. However, the identity, specifications and quantities of such spare parts and the terms and conditions relating to the supply thereof are to be agreed between the Owner and the Contractor, and the price of such spare parts shall be that given in Price Schedule for recommended spares. The price of such spare parts shall include the purchase price thereof and other costs and expenses (including the Contractor's fees) relating to the supply of spare parts. The prices of recommended spares covered in price schedule shall be

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valid for a period of six months after the date of Notification of Award of Main Equipment and Mandatory Spares.

- The Contractor shall supply the recommended spares at the same terms and conditions as are otherwise applicable to this Contract.
- All the spares for the equipment under the Contract will strictly conform to the Specification and other relevant documents and will be identical to the corresponding main equipment/components supplied under the Contract and shall be fully interchangeable.
- All the Mandatory Spares covered under the Contract shall be manufactured along with the main equipments as a continuous operation and the delivery of the spares will be affected along with the main equipments in a phased manner and the delivery would be completed by the respective dates for the various categories of equipment as per the agreed schedule. If order for the Recommended Spares has been placed with the Contractor prior to commencement of manufacture of the main equipment this shall be applicable for manufacturer of recommended spares as well.
- The Contractor will provide the Owner with the manufacturing drawings, catalogues, assembly drawings and any other document required by the for the recommended spares. Such details will be furnished to the Owner as soon as they are prepared but in any case not later than six months prior to commencement of manufacture of the corresponding main equipment.
- In addition to the spares recommended by the Contractor, if the Owner further identifies certain particular items of spares, the Contractor will submit the prices and delivery quotation for such spares within [30] days of receipt of such request with a validity period of 6 months for consideration by the Owner and placement of order for additional spares, if the Owner so desires.
- The quality plan and the inspection requirement finalised for the main equipment will also be applicable to the corresponding spares.
- The Contractor will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/components/equipment covered under the Contract and will further ensure with his vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.
- The Contractor shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered under the Contract. The same provision will also be applicable to spares supplied by Sub-contractors.
- For the first 6 years from the schedule date of completion of facilities the prices will be derived from the corresponding Ex-Works Price at which the order for such spares have been placed by Owner as a part of Mandatory Spares or Recommended Spares, or from the rates of Mandatory Spares or Recommended Spares as quoted by/negotiated with the Contractor. Ex-Works order price of future spares shall be computed in accordance with the price adjustment provisions covered under the main Contract excepting that the base indices will be counted from the scheduled date of Commissioning of the last equipment under the main project. The Contractor will indicate in advance the delivery period of the items of spares, which the Owner may procure in accordance with this clause. In case of emergent requirements of

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spares, the Contractor would make every effort to expedite the manufacture and delivery of such spares on the basis of mutually agreed time schedule.

- In case the Contractor fails to supply the mandatory or recommended spares in the terms stipulated above, the Owner shall be entitled to purchase the same from the alternate sources at the risk and the cost of the Contractor and recover from the Contractor, the excess amount paid by the Owner over the rates worked on the above basis. In the event of such risk purchase by the Owner, the purchases will be as per the Works and Procurement Policy of the Owner prevalent at the time of such purchases and the Owner at his option may include a representative from the Contractor in finalising the purchases.
- It is expressly understood that the final settlement between the parties in terms of relevant clauses of the Contract Documents shall not relieve the Contractor of any of his obligations under the provision of long term availability of spares and such provisions shall continue to be enforced till the expiry of 6 years period reckoned from the scheduled date of Commissioning of the Plant and Equipment unless otherwise discharged expressly in writing by the Owner.
- The Contractor shall warrant that all spares supplied will be new and in accordance with the Contract Documents and will be free from defects in design, material and workmanship. The defects liability period for spares shall be 12 months from the date it is put to use. In case of failure of any spare part due to fault in design material or workmanship the same part will be replaced by the contractor without any extra cost of the Owner.

In case of any failure in the original component/equipments due to faulty designs, materials and workmanship, the corresponding spare parts, if any, supplied will be replaced without any extra cost to the Owner unless a joint examination and analysis by the Owner and the Contractor of such spare parts prove that the defect found in the original part that failed, can safely be assumed not to be present in spare parts. Any replaced spare parts will have the Defects Liability period of 12 months from the date it is put in use. The discarded spare parts will become the property of the Contractor as soon as they have been replaced by the Contractor. In any case the defect liability of spares will expire at the end of 48 months from the date of their receipt at site

The Defects Liability of spares that are not used within 18 months from the respective date of the delivery at Site will, be subject to condition that all such spares are stored in accordance with Contractor's standard recommended practice, if any, and the same has been furnished to the Owner.

4.17 Contractor's Responsibilities

- a) The Contractor shall design, manufacture (including associated purchases and/or subcontracting), disassemble/dismantle wherever required, install, commission and complete the Facilities and carryout the Guarantee tests with due care and diligence in accordance with the Contract.
- b) Before entering into this contract the Contractor is responsible to have examined the data relating to the Facilities provided by the Owner, and on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve contractor of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.

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- c) The Contractor shall acquire all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Contractor's and Subcontractor's personnel and entry permits for all imported Contractor's Equipment.
- d) The Contractor shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any and all liabilities, damages, claims, fines, penalties and expenses of whatever nature arising or resulting from the violation of such laws by the Contractor.

4.18 Owner's Responsibilities

- a) The Owner shall be responsible for acquiring and providing legal and physical possession of the Site and access thereto, and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract, including all requisite rights of way.
- b) The Owner shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Owner to obtain them in the Owner's name, are necessary for the execution of the Contract.
- c) If requested by the Contractor, the Owner shall use its best endeavours to assist the Contractor in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Contractor or Subcontractors or the personnel of the Contractor or Subcontractors, as the case may be, to obtain.
- d) The Owner shall be responsible for the continued operation of the Facilities after Completion.

4.19 Taxes & Duties

- a) Custom Duty, Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation. The reimbursement of these taxes shall be on actual subject to the quoted value of these taxes as ceiling corresponding to the base price. Additional liability of taxes and duties arising out of price variation shall be reimbursed against documentary evidence over and above the ceiling (quoted value). Statutory variation in Indian taxes and duties will be dealt with as per the relevant stipulations of the specification.
- b) Except as otherwise specifically provided in the Contract, the Contractor shall bear and pay all Taxes, Duties, Levies and Charges including Entry Tax, Service Tax, if applicable in connection with the Facilities in India and outside India. All taxes, duties & levies on works contract, if any, shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- c) All taxes, duties and levies including entry tax/octroi (if any) in respect of all components, equipments and material to be dispatched directly from the sub-vendor's works to site shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.

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- d) In case there is introduction of GST or any other tax in lieu of existing Excise Duty/Service Tax and VAT/ Sales Tax, the contract price will be adjusted for the impact of any differential tax liability subject to documentary evidence. This will be restricted to direct transaction between the owner and contractor, and bought out items directly dispatched from sub-vendor's works to project site.
- e) Further all taxes, duties and levies including sales tax on works contract, Entry Tax, if any, in respect of civil construction works, erection & commissioning if any and custom duty/sales tax as applicable on the materials used for such construction works shall be to the contractor's account and no separate claim in this regard will be entertained by the Owner. Incidence of Service Tax & cess on any component of the Bid Price shall be to the Contractor's account and bidders shall include Service Tax as applicable at the date seven (7) days prior to the date of bid submission in the bid price. The Contract Price will be adjusted for impact of any change in the rate of service tax or cess on service tax subsequent to this date for direct transactions between the Owner and the Contractor.
- f) If any tax exemptions, reductions, allowances or privileges may be available to the Contractor, the Owner shall use its best endeavours to enable the Contractor to benefit from any such tax savings to the maximum allowable extent.

4.20 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Owner by the Contractor herein shall remain vested in the Contractor or, if they are furnished to the Owner directly or through the Contractor by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Owner shall however be free to reproduce all drawings, documents and other material furnished to the Owner for the purpose of the contract including, if required, for operation and maintenance.

4.21 Confidential Information

- a) The Owner and the Contractor shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Contractor may furnish to its Subcontractor(s) such documents, data and other information it receives from the Owner to the extent required for the Subcontractor(s) to perform its work under the Contract, in which event the Contractor shall obtain from such Subcontractor(s) an undertaking of confidentiality similar to that imposed on the Contractor.
- b) The Owner shall not use such documents, data and other information received from the Contractor for any purpose other than the operation and maintenance of the Facilities. Similarly, the Contractor shall not use such documents, data and other information received from the Owner for any purpose other than the design, procurement of Plant and Equipments, construction or such other work and services as are required for the performance of the Contract.
- c) The obligation of a party, shall not apply to that information which
 - now or hereafter enters the public domain through no fault of that party
 - can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto

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- Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

4.22 Representatives

a) Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Owner shall appoint and notify the Contractor in writing of the name of the Project Manager. The Owner may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Contractor without delay. The Owner shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Owner at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

All notices, instructions, information and other communications given by the Contractor to the Owner under the Contract shall be given to the Project Manager, except as herein otherwise provided.

b) Contractor's Representative & Construction Manager

- If the Contractor's Representative is not named in the Contract, then within [fourteen (14) days] of the Effective Date, the Contractor shall appoint the Contractor's Representative and shall request the Owner in writing to approve the person so appointed. If the Owner makes no objection to the appointment within [fourteen (14)] days, the Contractor's Representative shall be deemed to have been approved. If the Owner objects to the appointment within [fourteen (14)] days giving the reason there for, then the Contractor shall appoint a replacement within [fourteen (14) days] of such objection.
- The Contractor's Representative shall represent and act for the Contractor at all times during the currency of the Contract and shall give to the Project Manager all the Contractor's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Owner or the Project Manager to the Contractor under the Contract shall be given to the Contractor's Representative or, in its absence, its deputy, except as herein otherwise provided. The Contractor shall not revoke the appointment of the Contractor's Representative without the Owner's prior written consent, which shall not be unreasonably withheld. If the Owner consents thereto, the Contractor shall appoint some other person as the Contractor's Representative.
- The Contractor's Representative may, subject to the approval of the Owner (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Contractor's Representative, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Owner and the Project Manager.
- From the commencement of installation of the Facilities at the Site until Operational Acceptance, the Contractor's Representative shall appoint a

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suitable person as the construction manager (hereinafter referred to as “the Construction Manager”). The Construction Manager shall supervise all work done at the Site by the Contractor and shall be present at the Site throughout normal working hours except when on leave, sick or absent for reasons connected with the proper performance of the Contract. Whenever the Construction Manager is absent from the Site, a suitable person shall be appointed to act as his or her deputy.

- The Owner may by notice to the Contractor object to any representative or person employed by the Contractor in the execution of the Contract who, in the reasonable opinion of the Owner, may behave inappropriately, may be incompetent or negligent, or may commit a serious breach of the Site regulations.
- If any representative or person employed by the Contractor is removed.

4.23 Work Program

a) Contractor’s Organization

The Contractor shall supply to the Owner and the Project Manager a chart showing the proposed organization to be established by the Contractor for carrying out work on the Facilities. The chart shall include the identities of the key personnel together with the curricula vitae of such key personnel to be employed within *[twenty one (21)]* days of the Effective Date. The Contractor shall promptly inform the Owner and the Project Manager in writing of any revision or alteration of such an organization chart.

b) Program of Performance

Within *[twenty-eight (28)]* days after the date of Notification of Award of Contract, the Contractor shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply, transport, assemble, install and precommissioning the Facilities, as well as the date by which the Contractor reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Contractor to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Contractor shall accord with the Time Schedule included in Contract Schedule-3 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Contractor shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Contractor’s actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Contractor shall, at the request of the Owner or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

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e) Work Procedures

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Owner and the Contractor, the Contractor may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

4.24 Subcontractors and Subvendors

- a) The Contract Agreement specifies major items of supply or services and a list of approved Subcontractors against each item, including vendors. Insofar as no Subcontractors are listed against any such item, the Contractor shall prepare a list of Subcontractors for such item for inclusion in such list. The Contractor may from time to time propose any addition to or deletion from any such list. The Contractor shall submit any such list or any modification thereto to the Owner for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Owner for any of the Subcontractors shall not relieve the Contractor from any of its obligations, duties or responsibilities under the Contract.
- b) The Contractor shall select and employ its Subcontractors/Subvendors for such major items from those listed.

4.25 Design and Engineering

a) Specifications and Drawings

The Contractor shall execute the basic and detailed design and the engineering work in compliance with the provisions of the Contract, or where not so specified, in accordance with good engineering practice. The Contractor shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents that it has prepared, whether such specifications, drawings and other documents have been approved by the Project Manager or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Contractor by or on behalf of the Owner.

b) Codes and Standards

Wherever references are made in the Contract to codes and standards in accordance with which the Contract shall be executed, the edition or the revised version of such codes and standards current at the date *[twenty eight (28)]* days prior to date of bid submission shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

c) Approval/Review of Technical Documents by Project Manager

The Contractor shall prepare (or cause its Subcontractors to prepare) and furnish to the Project Manager the documents for its approval Any part of the Facilities covered by or related to the documents to be approved by the Project Manager shall be executed only after the Project Manager's approval thereof.

Project Manager shall either return one copy thereof to the Contractor with its approval endorsed thereon or shall notify the Contractor in writing of its disapproval thereof and the reasons there for and the modifications that the Project Manager proposes. The Project Manager shall not disapprove any document, except on the grounds that the document does not comply with some specified provision of the

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Contract or that it is contrary to good engineering practice. The procedure for submission of the documents by the Contractor and their approval by the Project Manager shall be discussed and finalised with the Contractor.

If any dispute or difference occurs between the Owner and the Contractor in connection with or arising out of the disapproval by the Project Manager of any document and/or any modification(s) thereto that cannot be settled between the parties within a reasonable period, then such dispute or difference may be referred to an Adjudicator. If such dispute or difference is referred to an Adjudicator, the Project Manager shall give instructions as to whether and if so, how, performance of the Contract is to proceed. The Contractor shall proceed with the Contract in accordance with the Project Manager's instructions, provided that if the Adjudicator upholds the Contractor's view on the dispute, then the Contractor shall be reimbursed by the Owner for any additional costs incurred by reason of such instructions and shall be relieved of such responsibility or liability in connection with the dispute and the execution of the instructions as the Adjudicator shall decide, and the Time for Completion shall be extended accordingly.

The Project Manager's approval, with or without modification of the document furnished by the Contractor, shall not relieve the Contractor of any responsibility or liability imposed upon it by any provisions of the Contract except to the extent that any subsequent failure results from modifications required by the Project Manager.

4.26 Procurement

a) Plant and Equipment

The Contractor shall manufacture or procure and transport all the Plant and Equipments in an expeditious and orderly manner to the Site.

b) Transportation

The Contractor shall at its own risk and expense transport all the Plant and Equipments and the Contractor's Equipments to the Site by the mode of transport that the Contractor judges most suitable under all the circumstances. Unless otherwise provided in the Contract, the Contractor shall be entitled to select any safe mode of transport operated by any person to carry the Plant and Equipments and the Contractor's Equipment. Upon dispatch of each shipment of the Plant and Equipments and the Contractor's Equipments, the Contractor shall notify the Owner by telex, cable, telefax, facsimile or Electronic Data Interchange (EDI) of the description of the Plant and Equipments and of the Contractor's Equipments, the point and means of dispatch, and the estimated time and point of arrival in the country where the Site is located, if applicable, and at the Site. The Contractor shall furnish the Owner with relevant shipping documents to be agreed upon between the parties.

The Contractor shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Plant and Equipments and the Contractor's Equipments to the Site. The Owner shall use its best endeavours in a timely and expeditious manner to assist the Contractor in obtaining such approvals, if requested by the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any claim for damage to roads, bridges or any other traffic facilities that may be caused by the transport of the Plant and Equipments and the Contractor's Equipments to the Site.

c) The Contractor shall, at its own expense, handle all imported Plant and Equipments and spares and Contractor's Equipments at the point(s) of import and shall handle any formalities for customs clearance.

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4.27 Installation

a) Setting Out/Supervision/Labour

Bench Mark: The Contractor shall be responsible for the true and proper setting-out of the Facilities in relation to bench marks, reference marks and lines provided to it in writing by or on behalf of the Owner.

If, at any time during the progress of installation of the Facilities, any error shall appear in the position, level or alignment of the Facilities, the Contractor shall forthwith notify the Project Manager of such error and, at its own expense, immediately rectify such error to the reasonable satisfaction of the Project Manager. If such error is based on incorrect data provided in writing by or on behalf of the Owner, the expense of rectifying the same shall be borne by the Owner.

Contractor's Supervision: The Contractor shall give or provide all necessary superintendence during the installation of the Facilities, and the Construction Manager or its deputy shall be constantly on the Site to provide full time superintendence of the installation. The Contractor shall provide and employ only technical personnel who are skilled and experienced in their respective callings and supervisory staff who are competent to adequately supervise the work at hand.

The Contractor shall provide and employ on the Site in the installation of the Facilities such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the Contract. The Contractor is encouraged to use local labour that has the necessary skills. Unless otherwise provided in the Contract, the Contractor shall be responsible for the recruitment, transportation, accommodation and catering of all labour, local or expatriate, required for the execution of the Contract and for all payments in connection therewith.

The Contractor shall at its own expense provide the means of repatriation to all of its and its Subcontractor's personnel employed on the Contract at the Site to their various home countries. It shall also provide suitable temporary maintenance of all such persons from the cessation of their employment on the Contract to the date programmed for their departure. In the event that the Contractor defaults in providing such means of transportation and temporary maintenance, the Owner may provide the same to such personnel and recover the cost of doing so from the Contractor.

The Contractor shall, in all dealings with its labour and the labour of its Subcontractors currently employed on or connected with the Contract, pay due regard to all recognized festivals, official holidays, religious or other customs and all local laws and regulations pertaining to the employment of labour.

b) Contractor's Equipments

All Contractors' Equipments brought by the Contractor onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Contractor shall not remove the same from the Site without the Project Manager's consent that such Contractor's Equipments are no longer required for the execution of the Contract. Unless otherwise specified in the Contract, upon completion of the Facilities, the Contractor shall remove from the Site all Equipments brought by the Contractor onto the Site and any surplus materials remaining thereon.

The Owner will, if requested, use its best endeavours to assist the Contractor in obtaining any local, state or national government permission required by the Contractor for the export of the Contractor's Equipments imported by the Contractor for use in the execution of the Contract that is no longer required for the execution of the Contract.

c) Site Regulations and Safety

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The Owner and the Contractor shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. The Contractor shall prepare and submit to the Owner, with a copy to the Project Manager, proposed Site regulations for the Owner's approval, which approval shall not be unreasonably withheld.

Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Facilities, gate control, sanitation, medical care, and fire prevention.

d) Opportunities for Other Contractors

The Contractor shall, upon written request from the Owner or the Project Manager, give all reasonable opportunities for carrying out the work to any other contractors employed by the Owner on or near the Site. If the Contractor, upon written request from the Owner or the Project Manager, makes available to other contractors any roads or ways the maintenance for which the Contractor is responsible, permits the use by such other contractors of the Contractor's Equipments, or provides any other service of whatsoever nature for such other contractors, the Owner shall fully compensate the Contractor for any loss or damage caused or occasioned by such other contractors in respect of any such use or service, and shall pay to the Contractor reasonable remuneration for the use of such equipments or the provision of such services.

The Contractor shall also so arrange to perform its work as to minimize, to the extent possible, interference with the work of other contractors. The Project Manager shall determine the resolution of any difference or conflict that may arise between the Contractor and other contractors and the workers of the Owner in regard to their work.

The Contractor shall notify the Project Manager promptly of any defects in the other Contractors' work that come to its notice, and that could affect the Contractor's work. The Project Manager shall determine the corrective measures, if any, required to rectify the situation after inspection of the Facilities. Decisions made by the Project Manager shall be binding on the Contractor.

e) Emergency Work

If, by reason of an emergency arising in connection with and during the execution of the Contract, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Facilities, the Contractor shall immediately carry out such work.

If the Contractor is unable or unwilling to do such work immediately, the Owner may do or cause such work to be done as the Owner may determine is necessary in order to prevent damage to the Facilities. In such event the Owner shall, as soon as practicable after the occurrence of any such emergency, notify the Contractor in writing of such emergency, the work done and the reasons there for. If the work done or caused to be done by the Owner is work that the Contractor was liable to do at its own expense under the Contract, the reasonable costs incurred by the Owner in connection therewith shall be paid by the Contractor to the Owner. Otherwise, the cost of such remedial work shall be borne by the Owner.

f) Site Clearance

Site Clearance in Course of Performance: In the course of carrying out the Contract, the Contractor shall keep the Site reasonably free from all unnecessary obstruction, store or remove any surplus materials, clear away any wreckage, rubbish or temporary works from the Site, and remove any Contractor's Equipments no longer

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required for execution of the Contract. Clearance of Site after Completion: After Completion of all parts of the Facilities, the Contractor shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site and Facilities clean and safe.

g) Watching and Lighting

The Contractor shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper execution and the protection of the Facilities, or for the safety of the owners and occupiers of adjacent property and for the safety of the public as per specification.

4.28 Testing & Inspections

- a) The Contractor shall at its own expense carry out at the place of manufacture and/or on the Site all such tests and/or inspections of the Plant and Equipments and any part of the Facilities as are specified in the Contract.
- b) The Owner and the Project Manager or their designated representatives shall be entitled to attend the aforesaid test and/ or inspection, provided that the Owner shall bear all costs and expenses incurred in connection with such attendance including, but not limited to, all travelling and board and lodging expenses.
- c) Whenever the Contractor is ready to carry out any such test and/or inspection, the Contractor shall give a reasonable advance notice of such test and/or inspection and of the place and time thereof to the Project Manager. The Contractor shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Owner and the Project Manager (or their designated representatives) to attend the test and/or inspection.
- d) The Contractor shall provide the Project Manager with a certified report of the results of any such test and/or inspection. If the Owner or Project Manager (or their designated representatives) fails to attend the test and/or inspection, or if it is agreed between the parties that such persons shall not do so, then the Contractor may proceed with the test and/or inspection in the absence of such persons, and may provide the Project Manager with a certified report of the results thereof.
- e) The Project Manager may require the Contractor to carry out any test and/or inspection not required by the Contract, provided that the Contractor's reasonable costs and expenses incurred in the carrying out of such test and/or inspection shall be added to the Contract Price. Further, if such test and/or inspection impede the progress of work on the Facilities and/or the Contractor's performance of its other obligations under the Contract, due allowance will be made in respect of the Time for Completion and the other obligations so affected.
- f) If any Plant and Equipment or any part of the Facilities fails to pass any test and/or inspection, the Contractor shall either rectify or replace such Plant and Equipment or part of the Facilities and shall repeat the test and/or inspection upon giving a notice.
- g) If any dispute or difference of opinion shall arise between the parties in connection with or arising out of the test and/or inspection of the Plant and Equipments or part of the Facilities that cannot be settled between the parties within a reasonable period of time, it may be referred to the Adjudicator.
- h) The Contractor shall afford the Owner and the Project Manager, at the Owner's expense, access at any reasonable time to any place where the Plant and Equipments are being manufactured or the Facilities are being installed, in order to inspect the progress and the manner of manufacture or installation, provided that the Project Manager shall give the Contractor a reasonable prior notice.

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- i) The Contractor agrees that neither the execution of a test and/ or inspection of Plant and Equipments or any part of the Facilities, nor the witnessing of any test by the Owner, nor the issuance of any test certificate shall relieve the Contractor of any obligation under this Contract.
- j) No part of the Facilities or foundations shall be covered up on the Site without the Contractor carrying out any test and/or inspection required under the Contract. The Contractor shall give a reasonable notice to the Project Manager whenever any such part of the Facilities or foundations is ready or about to be ready for test and/or inspection; such test and/or inspection and notice thereof shall be subject to the requirements of the Contract.
- k) The Contractor shall uncover any part of the Facilities or foundations, or shall make openings in or through the same as the Project Manager may from time to time require at the Site, and shall reinstate and make good such part or parts.

4.29 Completion of the Facilities

- a) As soon as the Facilities or any part thereof has, in the opinion of the Contractor, been completed operationally and structurally and put in a tight and clean condition as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Contractor shall so notify the Owner in writing.
- b) The Owner shall supply the operating and maintenance personnel as specified in the Contract for Precomissioning of the Facilities or any part thereof.
- c) As soon as all works in respect of Precomissioning are completed and, in the opinion of the Contractor, the Facilities or any part thereof is ready for Commissioning, the Contractor shall commence Commissioning as per procedures stipulated in Technical Specifications, and as soon as Commissioning is satisfactorily completed, the Contractor shall so notify the Project Manager in writing.
- d) If the Project Manager notifies the Contractor of any defects and/ or deficiencies, the Contractor shall then correct such defects and/or deficiencies.
If the Project Manager is satisfied that the Facilities or that part thereof have reached Completion, the Project Manager shall, within [seven (7)] days after receipt of the Contractor's notice, issue a Completion Certificate stating that the Facilities or that part thereof have reached Completion as at the date of the Contractor's notice.
If the Project Manager is not so satisfied, then it shall notify the Contractor in writing of any defects and/or deficiencies within [seven (7)] days after receipt of the Contractor's notice, and the above procedure shall be repeated.
- e) If the Project Manager fails to issue the Completion Certificate and fails to inform the Contractor of any defects and/or deficiencies within [seven (7)] days after receipt of the Contractor's notice, or if the Owner makes use of the Facilities or part thereof, then the Facilities or that part thereof shall be deemed to have reached Completion as of the date of the Contractor's notice, or as of the Owner's use of the Facilities, as the case may be.
- f) As soon as possible after Completion, the Contractor shall complete all outstanding minor items so that the Facilities are fully in accordance with the requirements of the Contract, failing which the Owner will undertake such completion and deduct the costs thereof from any monies owing to the Contractor.
- g) Upon Completion, the Owner shall be responsible for the care and custody of the Facilities or the relevant part thereof, together with the risk of loss or damage thereto, and shall thereafter take over the Facilities or the relevant part thereof.

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4.30 Commissioning & Operation Acceptance

a) Commissioning

Commissioning of the Facilities or any part thereof Acceptance shall be completed by the Contractor as per procedures detailed in the Technical Specifications. The Contractor shall, unless otherwise specified in Contract/ Tender Specifications, supply the utilities, lubricants, chemicals, catalysts, facilities, services and other matters required for Commissioning.

b) Guarantee Test

The Guarantee Tests (and repeats thereof) shall be conducted by the Contractor after Commissioning of the Facilities or the relevant part thereof to ascertain whether the Facilities or the relevant part can attain the Functional Guarantees specified in the Contract Documents. The Contractor's and Project Manager's advisory personnel shall attend the Guarantee Test. The Owner shall promptly provide the Contractor with such information as the Contractor may reasonably require in relation to the conduct and results of the Guarantee Tests (and any repeats thereof). If for reasons not attributable to the Contractor, the Guarantee Tests of the Facilities or the relevant part thereof cannot be successfully completed within the period from the date of Completion, specified in the SCC or any other period agreed upon by the Owner and the Contractor, the Contractor shall be deemed to have fulfilled its obligations with respect to the Functional Guarantees.

c) Operational Acceptance

Operational Acceptance shall occur in respect of the Facilities or any part thereof when

- the Guarantee Tests have been successfully completed and the Functional Guarantees are met; or
- The Guarantee Tests have not been successfully completed or has not been carried out for reasons not attributable to the Contractor within the period from the date of Completion specified in the SCC or any other agreed upon period as specified in GCC.
- The Contractor may give a notice to the Project Manager requesting the issue of an Operational Acceptance Certificate in respect of the Facilities or the part thereof specified in such notice as at the date of such notice.
- The Project Manager shall, after consultation with the Owner, and within forty five (45) days after receipt of the Contractor's notice, issue an Operational Acceptance Certificate. If within [forty five (45)] days after receipt of the Contractor's notice, the Project Manager fails to issue the Operational Acceptance Certificate or fails to inform the Contractor in writing of the justifiable reasons why the Project Manager has not issued the Operational Acceptance Certificate, the Facilities or the relevant part thereof shall be deemed to have been accepted as at the date of the Contractor's said notice.

d) Partial Acceptance

If the Contract specifies that Completion, Commissioning and Guarantee Tests shall be carried out in respect of parts of the Facilities, the provisions relating to Completion and Commissioning including the Guarantee Tests shall apply to each such part of the Facilities individually, and the Operational Acceptance Certificate shall be issued accordingly for each such part of the Facilities. If a part of the Facilities comprises facilities such as buildings, for which no

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Commissioning or Guarantee Tests are required, then the Project Manager shall issue the Operational Acceptance Certificate for such facility when it attains Completion, provided that the Contractor shall thereafter complete any outstanding minor items that are listed in the Operational Acceptance Certificate.

4.31 Completion Time and Liquidated Damage

a) Completion Time Period

The Contractor guarantees that it shall attain Completion of the Facilities (or a part for which a separate time for completion is specified in the SCC) within the Time for Completion specified in the SCC.

b) If the Contractor fails to attain Completion of the Facilities or any part thereof within the Time for Completion, the Contractor shall pay to the Owner liquidated damages in the amount computed at the rates specified in the SCC. The aggregate amount of such liquidated damages shall in no event exceed the amount specified as "Maximum" in the SCC.

However, the payment of liquidated damages shall not in any way relieve the Contractor from any of its obligations to complete the Facilities or from any other obligations and liabilities of the Contractor under the Contract.

c) No bonus will be given for earlier completion of the facilities or part thereof.

4.32 Defects Liability

a) The Contractor warrants that the Facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the Plant and Equipments supplied and of the work executed.

b) The Defects Liability Period shall be [eighteen (18)] months from the date of Completion of the Facilities (or any part thereof) or [twelve (12)] months from the date of Operational Acceptance of the Facilities (or any part thereof).

If during the Defects Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipments supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect. The Contractor shall not be responsible for the repair, replacement or making good of any defect or of any damage to the Facilities arising out of or resulting from any of the following causes:

- improper operation or maintenance of the Facilities by the Owner
- operation of the Facilities outside specifications provided in the Contract
- Normal wear and tear.

c) The Owner shall give the Contractor a notice stating the nature of any such defect together with all available evidence thereof, promptly following the discovery thereof. The Owner shall afford all reasonable opportunity for the Contractor to inspect any such defect.

d) The Owner shall afford the Contractor all necessary access to the Facilities and the Site to enable the Contractor to perform its obligations.

e) If the repair, replacement or making good is of such a character that it may affect the efficiency of the Facilities or any part thereof, the Owner may give to the Contractor a notice requiring that tests of the defective part of the Facilities shall be

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made by the Contractor immediately upon completion of such remedial work, whereupon the Contractor shall carry out such tests.

- f) If the Contractor fails to commence the work necessary to remedy such defect or any damage to the Facilities caused by such defect within a reasonable time (which shall in no event be considered to be less than fifteen (15) days), the Owner may, following notice to the Contractor, proceed to do such work, and the reasonable costs incurred by the Owner in connection therewith shall be paid to the Owner by the Contractor or may be deducted by the Owner from any monies due to the Contractor or claimed under the Performance Security.
- g) If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defects Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the Defects Liability Period extended by a period of **[twelve (12) month]** from the time such replacement/repair of the Facilities or any part thereof.

4.33 Functional Guarantees

The Contractor guarantees that during the Guarantee Tests, the Facilities and all parts thereof shall attain the Functional Guarantees as per the Contract. If, for reasons attributable to the Contractor, Functional Guarantees are not met either in whole or in part, the Contractor shall, within a mutually agreed time, at its cost and expense make such changes, modifications and/or additions to the Plant or any part thereof as may be necessary to meet such Guarantees. The Contractor shall notify the Owner upon completion of the necessary changes, modifications and/or additions, and shall seek the Owner's consent to repeat the Guarantee Test. If the specified Functional Guarantees are not established even during the repeat of the Guarantee Tests, the Owner may at its option, either reject the plant and equipment and recover from the Contractor payments already made or Accept the equipment/system/plant after levying Liquidated Damages as specified.

4.34 Patents Indemnity

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Owner may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Contractor or the use of the such Facilities.

4.35 Limitation of liability

Except in cases of criminal negligence or wilful misconduct by the Contractor, the aggregate liability of the Contractor to the Owner, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Contractor to indemnify the Owner with respect to patent infringement.

Except in cases of criminal negligence or wilful misconduct by the Contractor, the Contractor shall not be liable to the Owner, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or

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loss of profits or interest costs, provided that this exclusion shall not apply to any obligation of the Contractor to pay liquidated damages to the Owner.

4.36 Transfer of Ownership

Ownership of the Plant and Equipments (including spare parts) to be imported into India shall be transferred to the Owner upon loading on to the mode of transport to be used to convey the Plant and Equipments from the country of origin to that country.

Ownership of the Plant and Equipments (including spare parts) procured from within India shall be transferred to the Owner when the Plant and Equipments including spares are loaded on to the mode of transport to be used to convey the Plant and Equipments including spares from the works to the site and upon endorsement of the despatch documents in favour of the Owner. Ownership of the Contractor's Equipments used by the Contractor and its Subcontractors in connection with the Contract shall remain with the Contractor or its Subcontractors. Ownership of any Plant and Equipments in excess of the requirements for the Facilities shall revert to the Contractor upon Completion of the Facilities or at such earlier time when the Owner and the Contractor agree that the Plant and Equipments in question are no longer required for the Facilities, provided quantity of any Plant and Equipments specifically stipulated in the Contract shall be the property of the Owner whether or not incorporated in the Facilities. Notwithstanding the transfer of ownership of the Plant and Equipments, the responsibility for care and custody thereof together with the risk of loss or damage shall remain with the Contractor until Completion of the Facilities.

4.37 Care of Facilities

The Contractor shall be responsible for the care and custody of the Facilities or any part thereof until the date of Completion of the Facilities, where the Contract provides for Completion of the Facilities in parts, until the date of Completion of the relevant part, and shall make good at its own cost any loss or damage that may occur to the Facilities or the relevant part thereof from any cause whatsoever during such period. The Contractor shall also be responsible for any loss or damage to the Facilities caused by the Contractor or its Subcontractors in the course of any work carried out.

4.38 Loss of or Damage to Property; Accident or Injury; Indemnification

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with the supply and installation of the Facilities and by reason of the negligence of the Contractor or its Subcontractors, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Owner, its contractors, employees, officers or agents.

4.39 Insurance

- a) The Contractor shall at its expense take out and maintain in effect, or cause to be taken out and maintained in effect, during the performance of the Contract, the insurances set forth below in the sums and with the deductibles and other conditions as specified. The identity of the insurers and the form of the policies shall be subject to the approval of the Owner, who should not unreasonably withhold such approval.

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- Cargo Insurance during Transport:-Covering loss or damage occurring while in transit from the Contractor's or Subcontractor's works or stores until arrival at the Site, to the Plant and Equipments (including spare parts thereof) and to the Contractor's Equipments.
 - Installation All Risks Insurance:-Covering physical loss or damage to the Facilities at the Site, occurring prior to Completion of the Facilities, with an extended maintenance coverage for the Contractor's liability in respect of any loss or damage occurring during the Defects Liability Period while the Contractor is on the Site for the purpose of performing its obligations during the Defects Liability Period.
 - Third Party Liability Insurance: - Covering bodily injury or death suffered by third parties (including the Owner's personnel) and loss of or damage to property occurring in connection with the supply and installation of the Facilities.
 - Automobile Liability Insurance:-Covering use of all vehicles used by the Contractor or its Subcontractors (whether or not owned by them) in connection with the execution of the Contract.
 - Workers' Compensation:-In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Owner's Liability: - In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Other Insurances Such other insurances as may be specifically agreed upon by the parties.
- b) The Owner shall be named as co-insured under all insurance policies taken out by the Contractor pursuant except for the Third Party Liability, Workers' Compensation and Owner's Liability Insurances, and the Contractor's Subcontractors shall be named as co-insured's under all insurance policies taken out by the Contractor except for the Cargo Insurance During Transport, Workers' Compensation and Owner's Liability Insurances. All insurers' rights of subrogation against such co-insured's for losses or claims arising out of the performance of the Contract shall be waived under such policies.
- c) The Form of Contract Agreement, deliver to the Owner certificates of insurance (or copies of the insurance policies) as evidence that the required policies are in full force and effect. The certificates shall provide that no less than twenty one (21) days' notice shall be given to the Owner by insurers prior to cancellation or material modification of a policy.
- d) The Contractor shall ensure that, where applicable, its Subcontractor(s) shall take out and maintain in effect adequate insurance policies for their personnel and vehicles and for work executed by them under the Contract, unless such Subcontractors are covered by the policies taken out by the Contractor.
- e) The Owner shall at its expense take out and maintain in effect during the performance of the Contract those insurances specified.
- f) the Owner may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Contractor under the Contract any premium that the Owner shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Contractor. If the Owner fails to take out and/or maintain in effect the insurances the Contractor may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Owner under the Contract any premium that the Contractor shall have paid to the insurer, or may otherwise recover such amount as a debt due from the

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Owner. If the Contractor fails to or is unable to take out and maintain in effect any such insurances, the Contractor shall nevertheless have no liability or responsibility towards the Owner, and the Contractor shall have full recourse against the Owner for any and all liabilities of the Owner herein.

- g) The Owner shall give to the Contractor all such reasonable assistance as may be required by the Contractor. With respect to insurance claims in which the Owner's interest is involved, the Contractor shall not give any release or make any compromise with the insurer without the prior written consent of the Owner. With respect to insurance claims in which the Contractor's interest is involved, the Owner shall not give any release or make any compromise with the insurer without the prior written consent of the Contractor.
- h) Wherever total damages/loss of equipments/materials, would occur, the Contractor will be entitled to payment of all payments received from the underwriters except the following amounts:
 - The amount paid to the Contractor under the Contract in respect of equipments/materials damaged/lost (excluding the pro-rata initial advance) but including the entire amount of escalation, if any, already paid to the Contractor.
 - Custom Duties and taxes which have already been paid by the Owner.
 - In case of damage to any equipments/materials during any stage, the Contractor upon rectification of the damaged equipment to the satisfaction of the Owner shall be paid to the extent of full claims settled by the underwriters.
- i) All the Plants & Equipment being supplied by the Owner free of cost for installation of the equipment, cabling, earthing and lightning protection etc. by the Contractor, covered by this specification shall be kept insured by the Contractor against loss, damage, theft, pilferage, fire etc. from the point of unloading at Site up to the time of taking over by the Owner including handling, in plant transportation, storage, installation, testing and commissioning, etc. and the Contractor shall be fully responsible for making good of any loss or damage at his own cost within a reasonable time as mutually agreed upon by the Owner and the Contractor. Any loss/damage shall be brought to the Owner's notice immediately. The premium paid by the Contractor to the Insurance Company for such insurance shall be reimbursed by the Owner to the Contractor at actual against documentary proof to be furnished by the Contractor. The Contractor shall obtain competitive quotation for such insurance and shall take prior approval from the Owner before taking the insurance. The insurable value of the equipment being procured by the Owner will be intimated to the Contractor for the purpose of insurance.
 - It will be the responsibility of the Contractor to lodge, pursue and settle all claims with the Insurance Company in case of any damage, loss, theft, pilferage, fire, etc. and the Owner shall be kept informed about it. The losses, if any, will have to be borne by the Contractor, if the claims are not lodged and pursued properly or in the time or if the same are not settled by the Insurance Company.

4.40 Change in Laws & Regulation

- a) If, after the date [seven (7)] days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Contractor and/or the Time

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for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Contractor has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Owner and the Contractor and not on procurement of raw materials, intermediary components etc. by the Contractor. Notwithstanding the foregoing, such additional or reduced costs shall not be separately paid or credited if the same has already been accounted for in the price adjustment provisions wherever applicable.

4.41 Force Majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected. Force Majeure events include Acts of God, Acts of Government, war, sabotage, riots, civil commotion, revolution, flood, earthquake, cyclone, fire, epidemic etc.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within *[fourteen (14)]* days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfil its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
 - constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby
 if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.
- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than *[sixty (60)]* days or an aggregate period of more than one hundred and *[twenty (120)]* days on account of one or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.
- (g) Force Majeure shall not apply to any obligation of the Owner to make payments to the Contractor herein.

4.42 Change in the Facilities

(a) Introducing a Change

- The Owner shall have the right to propose, and subsequently require, the Contractor during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Facilities (hereinafter called "Change"), provided that such Change falls within the general scope of the Facilities and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the Facilities

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and the technical compatibility of the Change envisaged with the nature of the Facilities as specified in the Contract.

- The Contractor may from time to time during its performance of the Contract propose to the Owner (with a copy to the Project Manager) any Change that the Contractor considers necessary or desirable to improve the quality, efficiency or safety of the Facilities. This includes any additional scope of work that the contractor thinks is essential for achieving the minimum performance level specified in the SCC or the Contract. The Owner may at its discretion approve or reject any Change proposed by the Contractor.
- No change made necessary because of any default of the Contractor in the performance of its obligations under the Contract shall be deemed to be a Change, and such change shall not result in any adjustment of the Contract Price or the Time for Completion.

(b) Changes Originating from Owner

- If the Owner proposes a Change, it shall send to the Contractor a "Request for Change Proposal," requiring the Contractor to prepare and furnish to the Project Manager as soon as reasonably practicable a "Change Proposal," which shall include the following:
 - ✓ brief description of the Change
 - ✓ effect on the Time for Completion
 - ✓ estimated Cost of the Change
 - ✓ effect on Functional Guarantees (if any)
 - ✓ effect on any other provisions of the Contract.
- The pricing of any Change shall, as far as practicable, be calculated in accordance with the rates and prices included in the Contract. If the rates and prices of any change are not available in the Contract, the parties thereto shall agree on specific rates for the valuation of the Change.
- If before or during the preparation of the Change Proposal it becomes apparent that the aggregate effect of compliance therewith and with all other Change Orders that have already become binding upon the Contractor to increase or decrease the Contract Price as originally set forth in the Contract Agreement by more than fifteen (15) percent, the Contractor may give a written notice of objection thereto prior to furnishing the Change Proposal as aforesaid. If the Owner accepts the Contractor's objection, the Owner and the Contractor shall agree on specific rates for valuation of the change.
- Upon receipt of the Change Proposal, the Owner and the Contractor shall mutually agree upon all matters therein contained including agreement on rates if such rates are not available in the Contract or if the limit of 15% set forth has been exceeded. Within *fourteen (14)* days after such agreement, the Owner shall, if it intends to proceed with the Change, issue the Contractor with a Change Order.
- If the Owner is unable to reach a decision within *fourteen (14)* days, it shall notify the Contractor with details of when the Contractor can expect a decision.
- If the Owner decides not to proceed with the Change for whatever reason, it shall, within the said period of *fourteen (14)* days, notify the Contractor accordingly.

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- If the Owner and the Contractor cannot reach agreement on the price for the Change, an equitable adjustment to the Time for Completion, or any other matters identified in the Change Proposal, the Owner may nevertheless instruct the Contractor to proceed with the Change by issue of a "Pending Agreement Change Order."

Upon receipt of a Pending Agreement Change Order, the Contractor shall immediately proceed with effecting the Changes covered by such Order. The parties shall thereafter attempt to reach agreement on the outstanding issues under the Change Proposal.

(c) Changes Originating from Contractor

- The Contractor shall submit to the Project Manager a written "Application for Change Proposal," giving reasons for the proposed Change and including the information. Upon receipt of the Application for Change Proposal, the parties shall follow the procedures indicated above for "Request for Change Proposal."

4.43 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Contractor is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:

- Any Change in the Facilities or
- any occurrence of Force Majeure or
- any suspension order given by the Owner or reduction in the rate of progress or
- any changes in laws and regulations or
- any default or breach of the Contract by the Owner, or any activity, act or omission of any other contractors employed by the Owner or
- any other matter specifically mentioned in the Contract;

By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Contractor.

- (b) Except where otherwise specifically provided in the Contract, the Contractor shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Owner and the Contractor shall agree upon the period of such extension.
- (c) The Contractor shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.44 Suspension

- (a) The Owner/ Project Manager may, by notice to the Contractor, order the Contractor to suspend performance of any or all of its obligations under the Contract. Such notice shall specify the obligation of which performance is to be suspended, the effective date of the suspension and the reasons thereof. The Contractor shall thereupon suspend performance of such obligation (except those obligations necessary for the care or preservation of the Facilities) until ordered in writing to resume such performance by the Project Manager/ Owner.

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If, by virtue of a suspension order given by the Project Manager/ Owner, other than by reason of the Contractor's default or breach of the Contract, the Contractor's performance of any of its obligations is suspended for an aggregate period of more than *[ninety (90)]* days, then at any time thereafter and provided that at that time such performance is still suspended, the Contractor may give a notice to the Project Manager requiring that the Owner shall, within *[twenty eight (28)]* days of receipt of the notice, order the resumption of such performance or request and subsequently order a change, excluding the performance of the suspended obligations from the Contract.

- (b) If the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas;

Then the Contractor may by *[fourteen (14)]* days' notice to the Owner suspend performance of all or any of its obligations under the Contract, or reduce the rate of progress. If the Contractor's performance of its obligations is suspended or the rate of progress is reduced, then the Time for Completion shall be extended, and any and all additional costs or expenses incurred by the Contractor as a result of such suspension or reduction shall be paid by the Owner to the Contractor in addition to the Contract Price, except in the case of suspension order or reduction in the rate of progress by reason of the Contractor's default or breach of the Contract.

- (c) During the period of suspension, the Contractor shall not remove from the Site any Plant and Equipment, any part of the Facilities or any Contractor's Equipment, without the prior written consent of the Owner.

4.45 Termination

(a) Termination for Owner's Convenience

The Owner may at any time terminate the Contract for any reason by giving the Contractor a notice of termination. Upon receipt of the notice of termination, the Contractor shall either immediately or upon the date specified in the notice of termination

- (i) cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition.
- (ii) terminate all subcontracts, except those to be assigned
- (iii) remove all Contractor's Equipments from the Site, repatriate the Contractor's and its Subcontractors' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as at the date of termination, and, as may be required by the Owner, in

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any subcontracts concluded between the Contractor and its Subcontractors

- ✓ Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Contractor the following amounts

- ✓ the Contract Price, attributable to the parts of the Facilities executed by the Contractor as on the date of termination
- ✓ the costs reasonably incurred by the Contractor in the removal of the Contractor's Equipment from the Site and in the repatriation of the Contractor's and its Subcontractors' personnel
- ✓ any amounts to be paid by the Contractor to its Subcontractors in connection with the termination of any subcontracts, including any cancellation charges
- ✓ costs incurred by the Contractor in protecting the Facilities and leaving the Site in a clean and safe condition
- ✓ the additional cost of satisfying other obligations, commitments and claims that the Contractor may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Contractor's Default

- (i) The Owner, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons thereof to the Contractor:

- If the Contractor becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Contractor is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Contractor takes or suffers any other analogous action in consequence of debt
- If the Contractor assigns or transfers the Contract or any right or interest therein in violation of the provision.
- If the Contractor, in the judgement of the Owner has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at

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artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

(ii) If the Contractor

- has abandoned or repudiated the Contract
- has without valid reason failed to commence work on the Facilities promptly the progress of Contract performance for more than **[twenty eight (28)]** days after receiving a written instruction from the Owner to proceed
- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient materials, services or labor to execute and complete the Facilities in the manner specified in the program at rates of progress that give reasonable assurance to the Owner that the Contractor can attain Completion of the Facilities by the Time for Completion as extended

then the Owner may, without prejudice to any other rights it may possess under the Contract, give a notice to the Contractor stating the nature of the default and requiring the Contractor to remedy the same. If the Contractor fails to remedy or to take steps to remedy the same within **[fourteen (14)]** days of its receipt of such notice, then the Owner may terminate the Contract forthwith by giving a notice of termination to the Contractor.

(iii) The Contractor shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d) below
- deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Works and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

(iv) The Owner may enter upon the Site, expel the Contractor, and complete the Facilities itself or by employing any third party. The Owner may, to the exclusion of any right of the Contractor over the same, take over and use with the payment of a fair rental rate to the Contractor, with all the maintenance costs to the account of the Owner and with an indemnification by the Owner for all liability including damage or injury to persons arising out of the Owner's use of such equipment, any Contractor's Equipments

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owned by the Contractor and on the Site in connection with the Facilities for such reasonable period as the Owner considers expedient for the supply and installation of the Facilities.

Upon completion of the Facilities or at such earlier date as the Owner thinks appropriate, the Owner shall give notice to the Contractor that such Contractor's Equipment will be returned to the Contractor at or near the Site and shall return such Contractor's Equipments to the Contractor in accordance with such notice. The Contractor shall thereafter without delay and at its cost remove or arrange removal of the same from the Site.

- (v) The Contractor shall be entitled to be paid the Contract Price attributable to the Facilities executed as at the date of termination, the value of any unused or partially used Plant and Equipments on the Site, and the costs, if any, incurred in protecting the Facilities and in leaving the Site in a clean and safe condition. Any sums due to the Owner from the Contractor accruing prior to the date of termination shall be deducted from the amount to be paid to the Contractor under this Contract.
- (vi) If the Owner completes the Facilities, the cost of completing the Facilities by the Owner shall be determined.

If the sum that the Contractor is entitled to be paid, plus the reasonable costs incurred by the Owner in completing the Facilities, exceeds the Contract Price, the Contractor shall be liable for such excess.

The Owner and the Contractor shall agree, in writing, on the computation described above and the manner in which any sums shall be paid.

(c) Termination by Contractor

- i. If
 - the Owner has failed to pay the Contractor any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Contractor may give a notice to the Owner that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Owner to remedy the same, as the case may be. If the Owner fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within **[fourteen (14) days]** after receipt of the Contractor's notice, or
 - the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas or failure to obtain any governmental permit necessary for the execution and/or completion of the Facilities which the Owner is required to obtain as per provision of the Contract or as per relevant applicable laws of the country,
- then the Contractor may give a notice to the Owner thereof, and if the Owner has failed to pay the outstanding sum, to approve the invoice or

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supporting documents, to give its reasons for withholding such approval, or to remedy the breach within *[twenty eight (28) days]* of such notice, or if the Contractor is still unable to carry out any of its obligations under the Contract for any reason attributable to the Owner within twenty eight (28) days of the said notice.

then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.

- ii. If the Owner becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Owner takes or suffers any other analogous action in consequence of debt, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner,.
 - iii. If the Contract is terminated, then the Contractor shall immediately
 - cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
 - terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d)(ii)
 - remove all Contractor's Equipment from the Site and repatriate the Contractor's and its Subcontractor's personnel from the Site
 - In addition, the Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as of the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
 - ✓ Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as of the date of termination in connection with the Facilities.
 - iv. If the Contract is terminated, the Owner shall pay to the Contractor all payments, and reasonable compensation for all loss or damage sustained by the Contractor arising out of, in connection with or in consequence of such termination.
- (d) The expression "Facilities executed" shall include all work executed, Erection Services provided, any all Plant and Equipments acquired (or subject to a legally binding obligation to purchase) by the Contractor and used or intended to be used for the purpose of the Facilities, up to and including the date of termination.
- (e) In calculating any payment due from the Owner to the Contractor, account shall be taken of any sum previously paid by the Owner to the Contractor under the Contract, including any advance payment paid.

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4.46 Assignment

The Contractor shall not, without the express prior written consent of the Owner, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Contractor shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Renovation & Modernization of Turbo Generator & Auxiliaries Package for [-----]
- **Bid Document No. :** [-----]
- **The Owner is:**
 - Name of Owner: [-----]
 - Address of Owner: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]
- **The Project Manager is:**
 - Name of Project Manager: [-----]
 - Address of Project Manager: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]

5.2 Effective Date

The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor.

The following three activities will be completed within **[two (2)]** months from the date of Letter of Acceptance:

(a) The contract agreement will be executed by the Owner and the Contractor. (b) The Contractor will submit to the Owner the Contract Performance Bank Guarantee, any Additional Contract Performance Bank Guarantee by assignee, JV Partner, Consortium Member etc if applicable, and the Advance Payment Bank Guarantee.

(c) The Owner will pay the Contractor the Advance Payment as per the Terms of Payment.

The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Owner shall be as follows:

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1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Owner) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Owner may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

5.4 Liquidated Damage for Delay

5.5 Rate of Liquidated Damage for Delay

If the Contractor fails to successfully achieve completion of R&M activities and commissioning of the retrofitted facilities as per the scope of work within the time period specified in SCC, the Contractor shall pay to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

1.	Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	Liquidated Damage payable at the rate Rs.[.....] for each week of delay
2.	Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	Liquidated Damage payable at the rate Rs [.....] for each day of delay

The Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender are independent and shall be applied separately.

5.6 Liquidated Damage for Non-fulfillment of Functional Guarantees

If the Contractor fails to successfully achieve the Functional Guarantees during Performance Guarantee Test as per the Tender Specification, the Contractor shall pay

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to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

Sl. No.	Functional Guarantee Parameter	Rate of Liquidated Damage
1	Gross Output of each unit	[.....] INR per kW shortfall
2	Turbine Cycle Heat Rate	[.....] INR per kCal/kWhr increase
3	Condenser Pressure (mm of Hg)	[.....] INR per mm HG increase in Condenser Pressure
4	Auxiliary Power in kW	[.....] INR per kW increase

The reference condition for Performance Guarantee Parameters shall be as per Volume-II Technical Specification.

The Liquidated Damage for non-fulfillment of the different Functional Guarantee Parameters are independent of one another and shall be applied separately.

{Note: The rate of LD for any Functional Guarantee Parameter shall be at least 1.5 times the corresponding Bid Evaluation Factor}

5.7 Maximum Leviable Liquidated Damages

The amount of Liquidated Damage for delay shall be limited to a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd)contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares. This limit is applicable for the Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender taken together.

The aggregate amount of **Liquidated Damage for non-fulfilment of functional guarantee shall be limited to** a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd)contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The limit on maximum leviable Liquidated Damage for Delay and maximum leviable Liquidated Damage for non-fulfillment of functional guarantee are independent of each other and shall apply separately.

5.8 Contract Price

- The Contract Price shall be as (Contract Price and Terms of Payment) of the Form of Contract Agreement.
- The Contractor shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

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5.9 Terms of Payment

- a) The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement. The procedures to be followed in making application.
- b) No payment made by the Owner herein shall be deemed to constitute acceptance by the Owner of the Facilities or any part(s) thereof.
- c) The currency or currencies in which payments are made to the Contractor under this Contract to the Form of Contract Agreement, subject to the general principle that payments will be made in the currency or currencies in which the Contract Price has been stated in the Contractor's bid.

5.10 Bank Guarantees

- a) The Contractor shall provide the Bank Guarantees specified below in favour of the Owner at the times, and in the amount, manner and form specified below.
- b) Advance Payment Bank Guarantee
 - The Contractor shall, within [thirty (30)] days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to [ninety (90)] days beyond the date of Completion of Facilities.
 - The security shall be in the form of an Unconditional Bank Guarantee. The Advance payment Bank Guarantee shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of equipment/facilities received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Facilities supplied and received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of those Facilities. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Contractor's responsibility and liabilities under the Contract including in respect of the Facilities for which the reduction in the value of security is allowed.
- c) Performance Bank Guarantee
 - The Contractor shall, within [twenty-eight (28)] days of the notification of award, provide a Bank Guarantee for the due performance of the Contract for ten percent (10%) of the Contract Price with an initial validity upto [ninety (90)] days beyond the Defects Liability Period. If the Owner enters into the Contract with the Assignee of a foreign Contractor, the said Assignee, in addition to the Contract Performance Bank Guarantee to be provided by the Contractor for ten percent (10%) of the value of all the Contracts shall provide within [thirty (30)] days of the Notification of Award, a separate Contract Performance Bank Guarantee equivalent to five percent (5%) of the value of Contract entered into with the assignee (i.e. five percent of the aggregate value of the component Contracts entered to with the Assignee) , for the due performance of Contract with an initial validity up to [Ninety (90)] days beyond the Defects Liability Period.
 - If the bidder is a joint venture of two firms who collectively meet the Qualifying Requirement, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the bidder, each of the JV partner shall furnish Additional Contract Performance Guarantee equal to 1% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder and Additional Contract Performance Bank Guarantee furnished by the JV partners taken together shall be 12% of the Contract Price.

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- If the bidder is a Consortium of two firms, in addition to the Contract Performance Guarantee (CPBG) of 10% furnished by the Consortium Leader, the other consortium member will furnish Additional Contract Performance Bank Guarantee equal to 2% of Contract Price. To clarify further, in such a case, the value of Contract Performance Bank Guarantee furnished by the Bidder (Consortium Leader) and Additional Contract Performance Bank Guarantee furnished by the other consortium member taken together shall be 12% of the Contract Price.
- d) The performance Bank Guarantees shall be denominated in the currency or currencies of the Contract, or in a freely convertible currency acceptable to the Owner.

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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	Sample Format for Letter of Consent to be furnished by The Bidder And Consortium Partners / Individual Companies of the Group
Annexure-E	Sample Format Letter Of Unequivocal Consent To Be Furnished By The Bidder and The Assignee
Schedule F1 Table-1	Summary Of Price Schedule
Schedule F1 Table-2	Price Schedule For Supply Of Plant And Equipment Including Packing And Forwarding Charges
Schedule F1 Table-3A	Price Schedule For Mandatory Spares
Schedule F1 Table-3B	Price Schedule For Recommended Spares
Schedule F1 Table-4	Price Schedule For Tools & Tackles
Schedule F1 Table-5	Price Schedule For Unloading, Handling, Storage, Preservation At Site, Erection, Testing, Commissioning And Performance Guarantee Tests Of Plant And Equipment
Schedule F1 Table-6	Price Schedule For Civil works
Schedule F1 Table-7	Price Schedule For Training Charges
Schedule F1 Table-8	Schedule Of Performance Guarantee Parameters
Schedule F2	Over All Time Schedule
Schedule F3	Deviation Schedule To Tender Document Vol-I Commercial
Schedule F4	Deviation Schedule To Technical Specification

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Schedule F5	Requirements Of The Contractor At Site
Schedule F6	Contractor's Resource Deployment Schedule
Schedule F9	Coefficients And Indices for Price Variation Formula
II	Forms and Appendices to form part of Contract
Annexure-F	Form of Contract Agreement
Contract Schedule-1	Terms of Payment
Contract Schedule-2	Price Adjustment
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Approved Subcontractors
Contract Schedule-5	Scope of Works and Supply by the Owner
Contract Schedule-6	Functional Guarantees
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Bank Guarantee

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

ANNEXURES & SCHEDULES

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.:

Bank Guarantee No:

Date

:

To:

[Details of Designated Official]

[-Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [...] dated [...] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [...] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [Name of package and R&M project], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [...] (in words and figures) valid for 300 days from [...] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [...] Bank at (local address) [...] having our Head Office at [...] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of [...] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

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This Guarantee shall be irrevocable and shall remain valid upto [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorised officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
Name :
Designation :
Staff Code No. :

Banker's Seal :
Date :

Witness:

1. Signature :
Full name in block letters :
Designation :
Address :
2. Signature :
Full name in block letters :
Designation :
Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[Name of Utility] [.....]

Sub : ____ (Name of Package) [.....]

Tender

No.

[.....]

Having carefully examined the Tender Specifications issued to us for your Tender No. [.....] dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the 'works' in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification. The plant, equipment and systems offered are of the best and latest technology and of international standards.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR _____ (Indian Rupees [.....] only)/US\$ _____ (US Dollars [.....] only)/Euro _____ (Euro [.....] only) in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of 180 (One Hundred and Eighty) days from the date of opening of bids by Purchaser and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to [Name of Utility], assignees or authorized nominees such sums of money as are stipulated in conditions contained in Tender Specification and agree to furnish Bank

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Guarantee for Contract Performance as per the proforma prescribed by Purchaser and for the sum equal to 10% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Purchaser is not bound to accept the lowest or any Bids received and Purchaser has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Purchaser and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From:

Dated:

[.....]

[.....]

[.....]

To :

[.....]

[.....]

[.....]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire works as described in the specifications in conformity with the specifications and Tender Specifications, as per prices quoted by us in the Schedule of Prices and Schedule of Performance Guarantees [Schedule] enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Employer [Name of Utility] and for the sum equal to 10% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Employer is received and accepted by the Employer

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

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1. Signature
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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**ANNEXURE – D
(SAMPLE FORMAT)**

LETTER OF CONSENT

TO BE FURNISHED BY THE BIDDER and CONSORTIUM PARTNERS / INDIVIDUAL COMPANIES OF THE GROUP (as the case may be)

We hereby declare that the undersigned firm [-----] (Name and Complete address of the Consortium Partners / Individual Companies of the Group) hereby agrees to associate with [-----] (Name and Complete address of the Bidder) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Bidder and Consortium Partner / Individual Companies of the Group) [-----] Package for the [-----] Project at [-----] in the state of [-----], India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of [-----] package, fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Owner's Project site.

On award of LOA, we the Associate(s) / Consortium Partners / Individual Companies of the Group (as the case may be) agree to furnish an on demand back up bank guarantee for 5 % for our portion of work.

1. Witness

For Consortium Partner / Individual Companies of the Group (as the case may be)

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address

Seal of the Company

2. Witness

For Bidder

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address:

Seal of the Company:

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ATTACHMENT TO THE LETTER OF CONSENT

Scope of Work of the Each Consortium Partner / Individual Company of the Group (as the case may be):

For Bidder

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

For Each Consortium Partner / Individual Company of the Group (as the case may be)

(Signature of the Authorized Signatory)

Name:

Designation:

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ANNEXURE – E

SAMPLE FORMAT

LETTER OF UNEQUIVOCAL CONSENT TO BE FURNISHED BY THE BIDDER AND THE ASSIGNEE

We hereby declare that the undersigned firm [-----] (Name and Complete address of the Assignee) hereby agree to act as a Assignee to the Firm [-----] (Name and Complete address of the Bidder) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Bidder and the Nominee) of [-----] Package for the [-----] Project at [-----] in the state of [-----], India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of [-----] package, fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Owner's Project site.

We, the Assignee, agree to work as an independent contractor, with respect to the 2nd/3rd Contract or both, on such additional terms and conditions, as may be agreed to, between the Owner and the Foreign Bidder.

On award of LOA, we the ASSIGNEE agree to furnish an additional Contract Performance Bank Guarantee for 5%, of the aggregate value of the component contracts entered in to with us.

1. Witness

For Assignnee

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address

Seal of the Company

2. Witness

For Bidder

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address:

Seal of the Company:

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ATTACHMENT TO THE LETTER OF UNEQUIVOCAL CONSENT

1 Scope of Work of the Assignee:

For Bidder

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

For Assignee

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

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SCHEDULE – F1: TABLE - 1

SUMMARY OF PRICE SCHEDULE

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.1	Supply of imported Plant & equipment including technological and misc. structures with all accessories (FOB) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum and firm price basis.		
1.2	Ocean freight on lumpsum and firm price basis for 1.1 above.		
1.3	Marine insurance on lumpsum and firm price basis for 1.1 above.		
1.4	CIF Cost (1.1+1.2+1.3)		
2.	All port charges including port handling, port rent, and port clearance on lumpsum and firm price basis.		
3.	Supply of indigenous Plant & Equipment including Technological and misc. structures with all accessories (Ex-Works) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum price basis.		
4.	Sales Tax Payable on Indigenous equipment - on Ceiling basis. (a) VAT (b) Central Sales Tax (CST)		
5.	(a) Inland transport of imported plant & equipment on lumpsum and firm price basis.		
	(b) Inland transport of Indigenous plant & equipment on lumpsum and firm price basis		
6.	Lumpsum price for Civil Works including, supplies such as cement, reinforcement steel, all foundation bolts etc.at site cost, including Design & Engineering and Construction of entire Civil works.		
7.	Erection services including dismantling/disassembly, unloading, handling, storage and preservation at site, Erection, testing, commissioning and PG tests of plant & equipment on lumpsum price basis		
8.	Marine cum erection insurance on lumpsum and firm price basis (excluding marine insurance indicated in Sl. No. 1.3 above)		
9.	Foreign supervision charges in India during erection, commissioning & PG test on firm price basis with ceiling.		

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(In Figures and Words)

S.No.	Description	Foreign Currency	INR
10.	Training charges on firm price basis with ceiling.		
11.	VAT on Works Contract on ceiling basis		
12.	Service Tax including Education Cess on Ceiling basis		
13.	Others, if any (Please specify),		
14.	Total price of package (excluding mandatory spares and Tools & Tackles. (Total of SI.Nos.1.4 + 2 to 13).		
15.	Mandatory Spares on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-3)		
16.	Tools & Tackles on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-4)		
17.	Grand total price of package including Mandatory Spares and Tools & Tackles. (Total of SI Nos 14+15+16).		

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 2

PRICE SCHEDULE FOR SUPPLY OF PLANT AND EQUIPMENT INCLUDING
PACKING AND FORWARDING CHARGES

(In Figures and Words)

S.No.	Description	Foreign Supply	Indigenous Supply
		FOB Price in Foreign Currency	Supply price including packing and forwarding in INR
1	Mechanical Equipment		
1.1			
1.2			
...			
...			
...			
...			
...			
...			
...			
	Sub Total (1)		
2.	Electrical Equipment		
2.1			
2.2			
...			
...			
...			
	Sub Total (2)		
3	Control & Instrumentation Equipment		
3.1			
3.2			
...			

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(In Figures and Words)

S.No.	Description	Foreign Supply	Indigenous Supply
		FOB Price in Foreign Currency	Supply price including packing and forwarding in INR
...			

	Sub Total (3)		
4	Total (1 + 2 + 3)		

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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**SCHEDULE – F1: TABLE – 3A
PRICE SCHEDULE FOR MANDATORY SPARES**

(In Figures and Words)

S. No.	Description	Foreign Price In Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Mandatory Spares including Packing and Forwarding on lumpsum and firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	CIF Cost (1.1 +1.2+1.3)		
2	All port charges including port rent, port handling charges, port clearance on lumpsum and firm price		
3	Supply (Ex-works) of Mandatory Spares including Packing and Forwarding on lumpsum and Firm Price		
4.	a) Inland transport for Imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5	Insurance excluding 1.3 above (Lumpsum and firm price basis)		
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7	Total price of Mandatory Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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**SCHEDULE – F1: TABLE – 3B
PRICE SCHEDULE FOR RECOMMENDED SPARES**

(In Figures and Words)

S. No.	Description	Foreign Price In Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Recommended Spares including Packing and Forwarding on lumpsum and firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	CIF Cost (1.1 +1.2+1.3)		
2	All port charges including port rent, port handling charges, port clearance on lumpsum and firm price		
3	Supply (Ex-works) of Recommended Spares including Packing and Forwarding on lumpsum and Firm Price		
4.	a) Inland transport for Imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5	Insurance excluding 1.3 above (Lumpsum and firm price basis)		
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7	Total price of Recommended Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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**SCHEDULE – F1: TABLE-4
PRICE SCHEDULE FOR TOOLS & TACKLES**

(In Figures and Words)

S. No	Description	Foreign Price in Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Tools and Tackles including Packing and Forwarding on Lumpsum and Firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	C.I.F Cost (1.1 +1.2+1.3)		
2.	All port charges including port rent, port handling charges, port clearance on Lumpsum and firm price		
3.	Supply (Ex-works) of Tools and Tackles including Packing and Forwarding on Lumpsum and firm Price		
4.	a) Inland transport for imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5.	Insurance excluding 1.3 above (lumpsum and firm price basis)		
6.	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7.	Total price of Tools and Tackles (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-5

**PRICE SCHEDULE FOR ERECTION SERVICES INCLUDING
DISMANTLING/DIASSEMBLY, UNLOADING, HANDLING, STORAGE,
PRESERVATION AT SITE, ERECTION, TESTING, COMMISSIONING AND
PERFORMANCE GUARANTEE TESTS OF PLANT AND EQUIPMENT**

(In Figures and Words)

S.No.	Description	Total Price for complete work at Site in Indian Rupees
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		
	Sub Total (3)	
4	Total (1 + 2 + 3)	

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 6

PRICE SCHEDULE FOR CIVIL WORKS

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.			
2			
3			
4			
5			
.....			
.....			
	Total		

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 7

PRICE SCHEDULE FOR TRAINING CHARGES

(In Figures and Words)

S.No.	Description	Man-Months	Foreign Currency	INR
1.				
2				
3				
4				
5				
.....				
.....				
	Total			

Signature :

Name :

Designation :

Company :

Company Seal

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SCHEDULE – F1: TABLE - 8

SCHEDULE OF PERFORMANCE GUARANTEE PARAMETERS

The Bidder shall furnish performance guarantee of the Package in respect of all items listed below.

Category – I: Performance Guarantees under Liquidated Damages [L.D]

S. No	Particulars	Unit	Value inclusive of design, manufacture and all other Tolerances including measurement uncertainty
1			
2			
3			
.....			
.....			

Category – II: Mandatory Performance Guarantees

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			

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S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
3			
.....			
.....			

Category -III: Requirement under Demonstration Category

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			
3			
....			
.....			
.....			

Signature :

Name :

Designation :

Company :

Company Seal

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SCHEDULE – F2
OVER ALL TIME SCHEDULE
 (Bidder to fill-in and submit with its Bid)

S.No	Work Description	Days from Effective Date	
		Start	Finish
1	Design & Engineering		
2	Manufacture of Plant/Equipment		
	(a)		
	(b)		
	(c)		
		
		
3	Delivery of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
4	Dismantling/Disassembly of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
5	Civil work at Site		
6	Erection of of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
7	Trial Operation & Provisional Take Over		
8	Performance Guarantee tests Completion and Final Take Over		

Signature :

Name :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I) . The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I) , then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F4

DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Purchaser's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Purchaser's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :

Name :

Designation :

Company :

Company Seal

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SCHEDULE – F5
REQUIREMENTS OF THE CONTRACTOR AT SITE
(Bidder to fill-in and return with its Bid)

The Bidder shall state his requirements against each of the following including the basis of requirements:

A.	Requirements Description	Quantity

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE - F6
CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE

A) Construction Equipment

The Bidder shall indicate the schedule of construction equipment, proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
1									
2									
3									
...									
...									

B) Resource Deployment Schedule

The Bidder shall indicate the schedule of manpower resources proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
2.	Human Resources								
2.1	Engineering Category								
2.1.1	Project Engineers								
2.1.2	Mechanical Engineers								
2.1.3	Electrical Engineers								
2.1.4	Civil Engineers								
2.1.5	C&I Engineers								
2.1.6	Commissioning Engineers								
2.1.7	Structural Engineers								
2.1.8	Others (bidder shall indicate) as applicable for the work								
2.2	Supervisory Category								
2.2.1	Const. Manager								
2.2.2	Electrical Supervisors								
2.2.3	Mechanical Supervisors								
2.2.4	C&I Supervisors								
2.2.5	Civil Supervisors								
2.2.6	Purchase Officer (s)								
2.2.7	Finance/Site Office								
2.2.8	Inspection/Quality Control								
2.2.9	Others (Bidder shall indicate) as applicable for the work								

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S. No.	Type of Resource	Months						
2.3	Labour Category							
2.3.1	Welder							
2.3.2	Fitter							
2.3.3	Rigger							
2.3.4	Un-skilled labour							
2.3.5	Others (Bidder shall indicate) as applicable for the work							

Signature :

Name :

Designation :

Company :

Company Seal

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SCHEDULE – F9
COEFFICIENTS AND INDICES FOR PRICE VARIATION FORMULA
(Bidder to fill-in and return with its Bid)

Sl No	Component of Contract Price	Coefficients	Indices
1	Ex-Works/FOB price component of Plant and Equipment excluding mandatory spares	a= b= c L _b	A= B= C= L=
2	Erection Services Component		EF=
3	Civil Works Component	a= b= c= d= e=	MI= LI= FI= SI= CI=

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Form of Contract Agreement

Document Number	Rev No	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-002	02	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-I, Annexure & Schedules-2	[1]	30.09.2015

Form of Contract Agreement

THIS CONTRACT AGREEMENT is made the _____day of _____, 20_____.
 BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of [country of Employer] and having its principal place of business at [address of Employer] (hereinafter called “the Employer”), and (2) [name of Contractor], a corporation incorporated under the laws of [country of Contractor] and having its principal place of business at [address of Contractor] (hereinafter called “the Contractor”)

WHEREAS the Employer desires to engage the Contractor to dismantle/disassemble, design, manufacture, test, deliver, install, complete and commission certain Facilities, viz.

[.....]
 [.....]
 [.....]

(“the Facilities”) and the Contractor have agreed to such engagement upon and subject to the terms and conditions hereinafter appearing.

NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

a) Contract Documents means this signed Contract agreement and its annexure/appendices, and the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. The following will constitute the Contract Documents:

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing submitted by the contractor.
- vi. The bid & its schedules/ attachment.

a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.

b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing submitted by the contractor.
- vi. The bid & schedules/ attachment.

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1.3 Definitions

The Definitions of terms and expressions shall be as per GCC clause 4.1. Terms and expressions not defined in GCC shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder:

The Contract Price shall be the aggregate of: [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Employer shall be as follows:

1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Employer) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Employer may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

The detailed Time Schedule shall be as per Contract Schedule 2.

Contract Schedules

The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

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Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]

-----[Title]

In the presence of -----

Signed by for and on behalf of the Contractor

-----[Signature]

-----[Title]

In the presence of -----

CONTRACT AGREEMENT

dated the -----day of-----, 20-----

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

- | | |
|-----------------------|---|
| Contract Schedule 1 : | Terms of Payment |
| Contract Schedule 2 : | Price Adjustment |
| Contract Schedule 3 : | Time Schedule |
| Contract Schedule 4 : | List of Approved Subcontractors |
| Contract Schedule 5 : | Scope of Works and Supply by the Employer |
| Contract Schedule 6 : | Functional Guarantees |

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Contract Schedule-1

Terms of Payment

The Employer shall pay the Contractor in the following manner and at the following times, on the basis of the Price Break down given in the Section on Price Schedules. Payments will be made in the currencies quoted by the Bidder unless otherwise agreed between the parties. Application for payment in respect of part deliveries may be made by the Contractor as work proceeds.

I. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares) supplied from Abroad:

1	10% of the total FOB price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	60% of FOB price for each identified equipment as progressive payment and 100% of Ocean Freight and Marine Insurance Charges pro-rata to the value of the equipment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of FOB price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer
4	10% of the total FOB price	On Completion of Facilities
5	5% of the total FOB price	Successful completion of Performance Guarantee Test

II. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares) supplied from within India:

1	10% of the total Ex-Works price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	60% of Ex-Works price for each identified equipment as progressive payment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of Ex-Works price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer

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4	10% of the total Ex-Works price	On Completion of Facilities
5	5% of the total Ex-Works price	Successful completion of Performance Guarantee Test

III. Terms of Payment for Supply of Mandatory Spares and Recommended Spares

1	70% of the CIF Price of each Spare from Abroad or 70% of the Ex-Works Price of each Spare from within India	Upon dispatch of the identified Spare after dispatch clearance by employer on raising of invoice by the Contractor and submission of evidence of shipment
2	30% of the CIF Price of each Spare from Abroad or 30% of the Ex-Works Price of each Spare from within India	On receipt of Spare at site and physical verification and certification by the Employer

IV. Terms of Payment for Local Transportation, Inland Transit Insurance and port clearance charges & port charges

For Plant & Equipment except Spares		
1	100% of Local Transportation, Inland Transit Insurance and Port Clearance & Port Charges pro-rata to value of the equipment	On receipt of Equipment at site and upon raising of Invoice by the Contractor
For Spares		
2	100% of Local Transportation, Inland Transit Insurance and Port Clearance & Port Charges pro-rata to value of Spare	On receipt of Spare at site and upon raising of Invoice by the Contractor

V. Terms of Payment for Erection of Plant & Equipment

1	10% of Total Price for Erection of Plant & Equipment	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Erection of Plant & Equipment as progressive payment pro-rata to value of plant & equipment erected	On certification by Employer of successful erection of plant & equipment and successfully passing of quality checks
3	10% of Total Price for Erection of Plant & Equipment	On Completion of Facilities
4	5% of Total Price for Erection of Plant & Equipment	Successful completion of Performance Guarantee Test

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VI. Terms of Payment for Civil Works

1	10% of Total Price for Civil Works	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Civil Works as progressive payment	On certification by Employer regarding value of work completed & successfully passing of quality checks
3	10% of Total Price for Civil Works	On Completion of Facilities
4	5% of Total Price for Civil Works	Successful completion of Performance Guarantee Test

VII. Terms of Payment for Price Adjustment Amount

Any increase in the Price of any component Contract shall be paid as per the Terms of Payment for base price. The initial 10% advance payment pertaining to increase in price shall be paid along with progressive payment of that equipment. Reduction to the Contract Price, if any, due to price adjustment provisions, shall be effected by recovering 100% of the reduction amount (including advance) from any of the Contractor's bills falling immediately due for payment.

VIII. Terms of Payment for Taxes & Duties

Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other Tax or Duty payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon receipt of corresponding Plant & Equipment or Spare at site and submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such Taxes & Duties.

IX. Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such variation.

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Contract Schedule-2

PRICE ADJUSTMENT

- (i) The Contract Price shall be subject to price adjustment during performance of the Contract to reflect changes in the cost of labour and material in accordance with the provisions described below.
- (ii) Only following components of the Contract Price will be subject to Price adjustment :
 - (a) Ex-Works (India) price of plant and equipment excluding Mandatory Spares manufactured within India and FOB price component for plant and equipment excluding Mandatory spares supplied from abroad. The price adjustment amounts towards these price components shall be without any ceiling.
 - (b) Erection Services component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
 - (c) Civil Works component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
- (iii) Price adjustment amounts towards aforesaid components of Contract Price shall be paid in the respective currencies of Contract.
- (iv) The indices for price adjustment shall necessarily be of the country of origin of goods/labour and shall be well established and nationally recognized in that country. Preferably Government indices shall be used.
- (v) The price adjustment formula for the components of the Contract Price above shall be as stipulated hereinafter.
- (vi) **Ex-Works/FOB price component of Plant and Equipment excluding mandatory spares**

The price component of the equipment for any shipment/ dispatch comprises of a fixed portion (designated as 'F' and the value of which is specified hereunder) and a variable portion linked with the indices for various materials and labour.

The amount of price adjustment towards variable portion payable/recoverable on each shipment/dispatch shall be computed as under:

$$ES = ES_1 - ES_0$$

ES₁ will be computed as follows:

$$ES_1 = ES_0 \left\{ F + a \times \frac{A_1}{A_0} \times f_1 + b \times \frac{B_1}{B_0} \times f_2 + c \times \frac{C_1}{C_0} \times f_3 + Lb \times \frac{L_1}{L_0} \times f_{lb} \right\}$$

Where

ES = Adjustment to Ex-Works/FOB price component expressed in the currency of the Contract payable to the contractor for each shipment/dispatch

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- ES₁ = Adjusted amount of Ex-works/FOB price component expressed in the currency of the Contract payable to the Contractor for each shipment/dispatch
- ES₀ = Ex-works/FOB price for the plant and equipment in the currency of the Contract, shipment/dispatch wise.
- The fixed portion of the ex-works/FOB component of the Contract Price (F) shall be 0.15.
 - a, b, c etc. shall be co-efficient of major materials/items involved in the ex-works/FOB component of the Contract Price. The sum of these co-efficient shall be between 0.50 to 0.60.
 - A, B, C etc. shall be published price indices of corresponding major materials/items. Such indices shall necessarily be of the country of origin of goods.
 - 'Lb' shall be co-efficient for labour component in the ex-works/ FOB component of the Contract Price which shall be between 0.25 to 0.35.
 - 'L' shall be labour index.
 - Sum of all the material co-efficient and the labour co-efficient shall be 0.85.
- f₁, f₂, f₃, f_{lb} etc - f₁, f₂, f₃ etc. are Exchange rate correction factors for the respective materials and f_{lb} is the exchange rate correction factor for labour with reference to the currency of the country of origin of index and the respective contract currency, such that

$$f = \frac{Z_0}{Z_1}$$

where Z is the no. of units of the currency of the country of the origin of index, which is equivalent to one unit of the respective contract currency. The exchange rates to be used for calculation of factor 'f' shall be as per State Bank of India Bills Selling Exchange Rates.

For the indices(A, B, C etc.), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid.. For 'Z₀', subscript 'o' refers to value as on the date of opening of Part-I Bid.

Subscript '1' refers to indices/exchange rates as of:

(a) three months prior to the date of shipment/dispatch for labour, and

(b) six months prior to the date of shipment/dispatch for material.

In case of shipments/dispatches which are delayed beyond the schedule date of shipment/dispatch for reasons attributable to the Contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of shipment/dispatch and the actual date of shipment/dispatch.

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The above formula for price adjustment will be applicable if the currency in which the contract price is expressed is different from the currency of the country of origin of labour and material indices. In other case, formula shall be applied without the exchange rate correction factor 'f'.

(vii) Erection Services Component

The price component for erection services comprises of a fixed portion and a variable portion linked with the index of labour.

The monthly price adjustment amount for the erection services component of the Contract Price will be computed separately for Indian currency and for foreign currency part, if any, related to expatriate supervision/labour as per the formula given below:

(a) Indian Rupee part of the Erection Services

$$ER = ER_1 - ER_0$$

ER₁ will be computed as follows:

$$ER_1 = ER_0 (0.15 + 0.85 \frac{FL_1}{FL_0})$$

Where:

ER	=	Adjustment to erection services component of contract price expressed in Indian Rupees payable to the contractor for each billing.
ER ₁	=	Adjusted amount of erection services component of Contract Price expressed in Indian Rupees payable to the Contractor.
ER ₀	=	Value of the Erection work done in the billing period (month)
FL	=	Indian field labour index namely, All India Consumer Price Index for Industrial Workers (All India Monthly Average) as published by Labour Bureau, Simla, Government of India.

(b) Foreign Currency portion of the Erection Services

$$EE = EE_1 - EE_0$$

EE₁ will be computed as follows:

$$EE_1 = EE_0 (0.15 + 0.85 \frac{EF_1}{EF_0} \times f)$$

Where:

EE	=	Adjustment to erection services component of Contract Price expressed in foreign currency payable to the contractor for each billing.
EE ₁	=	Adjusted amount of erection services component of Contract Price expressed in foreign currency payable to the contractor for each billing.
EE ₀	=	Value of foreign currency portion of Erection work done in the billing period (month)

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EF = Index for Expatriate field labour component of the Erection Price of Installation work. Such index shall necessarily be of the country of nationality of the labour.

f = Exchange rate correction factor for expatriate labour with reference to currency of country of origin of index for expatriate labour and the respective contract currency, such that

$$f = \frac{Z_0}{Z_1}$$

where Z is the no. of units of the currency of the country of origin of index, which is equivalent to one unit of the respective contract currency. The ex-change rates to be used for calculation of factor 'f' shall be as per State Bank of India Bills Selling Exchange.

For the indices, subscript 'o' refers to indices as on 30 days prior to date set for opening of bids. For 'Z₀', subscript 'o' refers to value as on the date of opening of Part-I Bid.

For the indices, subscript '1' refers to the indices as applicable for the month of execution of the erection work. For the exchange rates, subscript '1' refers to the exchange rates as applicable on the last day of the month of execution of the erection work.

In case of erection activities which are delayed beyond the schedule date for reasons attributable to the contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of completion and actual date of completion of the respective erection activity.

(viii) The following components of the contract price shall not be subject to price adjustment and shall remain firm during the execution of the contract :

- (1) Ocean Freight and Marine Insurance for Plant and Equipment, mandatory spares and recommended spares.
- (2) Ex-works/FOB price component for Mandatory spares & Recommended Spares.
- (3) Inland Transportation charges (including Inland Transit Insurance, port clearance, port handling & port charges) for plant & equipment and Spare Parts.

(ix) Civil Works Component

The Price of Civil Works for any month comprises a fixed part designated as 'F' and variable parts linked to indices for labour, steel, cement, other commodities and Fuel & Power. The monthly price adjustment amount for the civil works component of the Contract Price will be computed as per the formula given below:

$$EC = EC_1 - EC_0$$

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EC₁ will be computed as follows:

$$EC_1 = EC_0 \left\{ F + a \times \frac{MI_1}{MI_0} + b \times \frac{LI_1}{LI_0} + c \times \frac{FI_1}{FI_0} + d \times \frac{SI_1}{SI_0} + e \times \frac{CI_1}{CI_0} \right\}$$

Where

EC = Adjustment to Civil Works price component expressed in the currency of the Contract payable to the contractor for each month

EC₁ = Adjusted amount of Civil Works price component expressed in the currency of the Contract payable to the Contractor for each month

EC₀ = Value of Civil Works done expressed in the currency of the Contract for the billing period (month).

- The fixed portion (F) of the Civil Works component of the Contract Price shall be 0.15.

- 'a' is the coefficient for material cost other than cement and steel involved in the Civil Works component of the Contract Price and it shall be 0.15.

'b' is the coefficient for labour cost involved in the Civil Works component of the Contract Price and it shall be 0.3.

'c' is the coefficient for Fuel & Power cost involved in the Civil Works component of the Contract Price and it shall be 0.05.

'd' is the coefficient for steel cost involved in the Civil Works component of the Contract Price and it shall be 0.25.

'e' is the coefficient for cement cost involved in the Civil Works component of the Contract Price and it shall be 0.10.

- MI shall be All India Whole Sale Price Index for all commodities as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry.

LI shall be All India Consumer Price Index for industrial labour as published by Labour Bureau, Government of India

FI shall Index Number of Wholesale Price for group Fuel & Power as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

SI shall Index Number of Wholesale Price for Steel as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

CI shall Index Number of Wholesale Price for Cement as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

For the indices(MI, LI,FI, SI and CI), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid. Subscript '1' refers to indices as of one prior to the month for which Civil Works is being billed.

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Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

SI No.	Work Description	Start (Months from Effective Date)	Finish (Months from Effective Date)
1			
2			

Note: Detailed PERT network agreed between Owner and Contractor to be placed below above table.

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Contract Schedule-4

LIST OF SUB-CONTRACTORS

[List of approved subcontractors shall be placed]

SI No.	Equipment / Work Description	Approved Sub-Vendor / Sub-Contractor
1		1.
		2.
		3
		4
		5
2		1.
		2.
		3
		4
		5
3		1.
		2.
		3
		4
		5

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Contract Schedule-6
FUNCTIONAL GUARANTEES

[Functional Guarantees shall be placed]

SI No.	Functional Guarantee Parameter	Unit	Guaranteed Value
Category-I Performance Guarantee			
1			
2			
3			
4			
....			
Category-II Performance Guarantee			
1			
2			
3			
4			
....			
Category-III Performance Guarantee			
1			
2			
3			
4			
....			

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Contractor]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:

Bank Guarantee No:

Date:

To:

[Name & Address of Owner (Utility)]

.....]
.....]

Dear Sirs,

- 1 In consideration of the [.....] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Contractor's Name] having its registered office at.....hereinafter referred to as the 'CONTRACTOR', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures] and the same having been unequivocally accepted by the CONTRACTOR and the CONTRACTOR having agreed to provide a **Contract Performance BANK Guarantee** for the faithful performance of the entire CONTRACT including the Warranty Obligations /Liabilities under the CONTRACT equivalent to 10% (ten percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

- 2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONTRACTOR by reason of any breach of the said CONTRACTOR of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to

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Rs.....(Rupees.....only). Any such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONTRACTOR or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The Bank further irrevocably guarantees and undertakes to pay any amount due and payable by the CONTRACTOR by reasons of non-fulfilment of any of the following obligations of the Contractor:
 - (a) Successful and satisfactory operation of the plant & equipment supplied and erected under the said Contract as per the Technical Specifications and other Tender/Contract documents.
 - (b) That the equipment installed under the said Contract shall be new and in accordance with Contract Documents and be free from all defects in design, engineering, material workmanship and performance for a period of 12 calendar months after final takeover of the equipment by the OWNER and that upon written notice from the OWNER, the CONTRACTOR shall remedy free of any expense to the OWNER, such defects as noticed and developed under the normal use of the said plant & equipment, within the said guarantee period.
- 4 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONTRACTOR. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 5 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONTRACTOR and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONTRACTOR or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 6 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONTRACTOR to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 7 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Contractor or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 8 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONTRACTOR's liabilities.

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- 9 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONTRACTOR(S).
- 10 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended from time to time for such period as may be desired by [Name of Contractor.....] on whose behalf this guarantee has been given.
- 11 Signed at.....this.....day of.....20.....

Signature :
 Name :
 Designation :
 Staff Code No :

Bank Seal

Date :

Witness:

1. Signature :
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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ABBREVIATIONS

{The utilities are advised to use the following standard abbreviations while preparing Model Tender Document for their power plant.}

ACB	Air Circuit Breaker
ACG	Automatic Control Gear
ASME	American Society of Mechanical Engineers
ATRS	Automatic Turbine Run up System
ATT	Automatic Turbine Testing
AVR	Automatic Voltage Regulator
BOD	Biochemical Oxygen Demand
BFP	Boiler Feed Water Pump
BMCR	Boiler Maximum Continuous Rating
BOP	Balance of Plant
CAVT	Cold Air Velocity Air Flow Test
CBD	Continuous Blow Down
CCTV	Closed Circuit Television
CCW	Circulating Cooling Water
CEA	Central Electricity Authority
CEMS	Continuous Emission Monitoring System
CERC	Central Electricity Regulatory Commission
CFBC	Circulating Fluidized Bed Combustion
CMMS	Computerized Maintenance Management System
COD	Chemical Oxygen Demand

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COLTCS	Condenser Online Tube Cleaning System
CRH	Cold Re-Heat
CT	Current Transformer
CLCS	Closed Loop Control System
CV	Control Valve
CW	Cooling Water
DCA	Drain Cooler Approach
DCDB	Direct Current Distribution Board
DDCMIS	Digital Distributed Control Monitoring Information System
DG	Diesel Generator
DGA	Dissolved Gas Analyser
DM	Demineralization
DMCW	Demineralized Cooling Water
DP	Differential Pressure
DVR	Digital Voltage Regulator
ECO	Economizer
EHC	Electro-Hydraulic Control
ELCID	Electromagnetic Core Imperfection Detection
EOT	Electrically Operated Travelling Crane
ESV	Emergency Stop Valve
EWS	Engineer's Work Station
PF	Pulverized Fuel
GC	Gland Condenser

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GCV	Gross Calorific Value
GT	Generator Transformer
HMI	Human Machine Interface
HP	High Pressure
HPTBV	HP Turbine Bypass Valve
HRH	Hot Re-Heat
HT	High Tension
HVAC	Heating, Ventilation and Air Conditioning
HWWS	High Velocity Water Spray System
IBD	Intermittent Blow Down
ICB	International Competitive Bidding
IGV	Inlet Guide Vane
I/O	Input / Output
IPT	Intermediate Pressure Turbine
IPR	Inter Posing Relay
ISMB	Indian Standard Medium Beam
IV	Interceptive Valve
LAVT	Lightning Arrestor & Voltage Transformer
LE	Life Extension
LP	Low Pressure
LPT	Low Pressure Turbine
LPTBV	LP Turbine Bypass Valve
LT	Low Tension

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LTSH	Low Temperature Super Heater
LVS	Large Video Screen
MCC	Motor Control Centre
MCCB	Module Case Circuit Breaker
MOCB	Minimum Oil Circuit Breaker
MoEF&CC	Ministry of Environment & Forest and Climate Change
MS	Main Steam
MSSV	Main Stream Safety Valve
OPC	Object linked embedded Process Control
OWS	Operator Working Station
P.I.V	Peak Inverse Voltage
PLF	Plant Load Factor
PRDS	Pressure Reducing De-superheating Station
PLC	Programmable Logic Controller
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RH	Reheater
RLA	Residual Life Assessment
RSO	Recurrent Surge Oscillograph
RTD	Resistance Temperature Detector
SADC	Secondary Air Damper Control
SH	Super Heater

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SPM	Solid Particulate Matter
SSE	Shunt Static Exciter
STMS	Smart Transmitter Maintenance Management System
SWAS	Steam and Water Analysis System
TFT	Thin Film Transistor (Monitor)
TMCR	Turbine Maximum Continuous Rating
TPS	Thermal Power Station
TC	Thermocouple
TSE	Turbine Stress Evaluator
TSI	Turbine Supervisory Instruments
TTD	Temperature Terminal Difference
UCR	Unit Control Room
UPS	Uninterruptible Power Supply
VWO	Valve Wide Open
VT	Voltage Transformer
VVVFD	Variable Voltage and Variable Frequency Drive

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1 INTENT OF SPECIFICATION

- 1.1 This Project Specification is for the Renovation & Modernization of Unit No [..] of [Name of the Power Plant] located at [...], [District], [State]. The intent of this Specification is to Renovate and Modernize various equipment & systems of Turbo Generator and it's auxiliaries including but not limited to *[HP & LP bypass valve, HP & LP Heaters, Deaerator, Condenser, Boiler Feed Pump (BFP), Condensate Extraction Pump (CEP), Turbine Cycle Piping (Excluding Main Steam, Cold Reheat, Hot Reheat, Upstream & downstream piping of HP & LP Turbine bypass valve and Auxiliary Steam Piping), Valves and all associated Electrical system, Control & Instrumentation systems and associated Civil & Structural work]* as envisaged at Clause No. 4.6. The renovated Turbo Generator shall be capable of producing the output of *[210/215/220/250]* MW with the given steam/water parameters at the terminal point of Turbine as per Table:1.1 below:

Table: 1.1

Description	Units	Design Parameters
Steam Flow at Final ESV inlet	T / hr	[...]
Steam Pressure at ESV inlet	kg/cm ²	[...]
Steam Temperature at ESV inlet	deg C	[...]
Re-heater Flow	T / hr	[...]
Steam Pressure at IV inlet	kg/cm ²	[...]
Steam Temperature at IV inlet	deg C	[...]
Feed Water Flow	T / hr	[...]
CW flow to Condenser	m ³ /h	[...]
CW Temperature at Condenser Inlet	deg C	[...]
Allowable Temperature Rise across Condenser	deg C	[...]
Available CW pressure at condenser inlet	mwc	[...]
Allowable Pressure drop across condenser	mwc	[...]

- 1.2 The Bidder shall carry out the required replacement / refurbishment / retrofitting of the Turbo Generator & its Auxiliaries as per the requirements of his design so as to make the same capable of operating for an extended life of *[20/25]* years

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and producing the output as mentioned in Clause No. 1.1 above with defined number of start-ups/shut down and stipulated steam parameters as delineated in Table-1.1. The scope of replacement / refurbishment / retrofitting shall include but shall not be limited to the scope of work mentioned at clause 4.6 which is based on the recommendation of RLA/CA and EA studies conducted during [.....]. However, any other items/systems which have not been specifically mentioned but are considered necessary by the Bidder for giving the intended performance of the Turbo Generator & its Auxiliaries, shall also be included in the scope of Bidder and shall be separately highlighted by the Bidder in his proposal.

- 1.3 Bidders are required to quote the performance guarantee values for Turbo Generator output, Turbine Cycle Heat Rate and the Auxiliary power consumption in response to the minimum performance parameters specified in the Table 1.2 below.

Table: 1.2

S.No.	Parameter	Performance Guarantee Values
1	Turbo Generator Output (MW)	[.....]
2	Turbine Cycle Heat Rate (kCal/kWh)	[.....]
3	Auxiliary Power Consumption (kW)	[.....]

Bidders to note that in case performance guarantee values quoted for Turbo Generator output is inferior to the minimum specified value, the bids will be considered as non responsive. In case of Turbine Cycle Heat Rate and Auxiliary power consumption, the best quoted value shall be considered as base parameter and other bids shall be cost loaded as per difference between base parameter and respective quoted guaranteed parameter multiplied by evaluation factors specified in the Commercial Volume (Volume-I).

- 1.4 The modified/replaced/retrofitted equipment will conform to the requirement of the Specification prescribed in Section-II of Volume-II. The relevant technical details like OEM's Specifications and Drawings for the existing equipment required to be modified / replaced / retrofitted have also been provided in Volume-II, Section-II for the reference of the Bidders.
- 1.5 Bidders are required to carry out necessary modifications / replacement in the existing mechanical / electrical /C&I equipment or systems including related civil/structural works as per Specification requirement and also based on their own assessment.
- 1.6 The scope of work for R&M shall include designing / re-designing, basic and detailed engineering, re-engineering, refurbishing / retrofitting, supply, inspection and testing at supplier's works, packing, forwarding to site, forwarding from site to Bidder's facilities, unloading and storage at site, pre-assembly, machining if required, site fabrication, erection, replacing of various equipment and systems,

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application of thermal insulation, carrying out all pre-commissioning checks/ tests and any other work required to complete the system, commissioning and trial operation, performance tests of various equipment and systems covered under this Specification. Bidder's scope shall also include dismantling of the existing equipment/ facilities, including unloading & transportation to designated storage / disposal yard, wherever required as a result of augmentation of existing mechanical, electrical, I&C and civil/structural/ architectural works. The Bidder shall restore the equipment/ facilities, whenever applicable, after carrying out necessary renovations/modifications under the scope of R&M works.

All the tools & tackles, labour and other facilities required for dismantling and restoration shall also be in the scope of the Bidder.

Bidder shall also put back into service all the systems/equipment of the units after completion of R&M works, whether any modification is carried out on the same or not. All necessary tools, tackles, labour, instruments, spares, consumables etc. required for putting back into operation shall also be provided by the Bidder.

- 1.7 It is not the intent to specify completely herein all aspects of services and equipment to be provided by the Bidder who in any case shall be responsible for fulfillment of the intent of Specification. Irrespective of whether specifically mentioned or not, the services, equipment and systems to be provided in accordance with this Specification shall also form a part of the scope of work and shall conform in all respects to the highest standard of engineering, design, quality and workmanship so that after completion of R&M work by the Bidder, the plant shall be capable of performing completely in a safe, reliable and sustained manner under various modes of operations as acceptable to the Owner.
- 1.8 Unless otherwise specifically clarified by the Owner, interpretation by the owner in respect of scope of supplies & services and the meaning of the Specifications, drawings, requirements of operation, maintenance, redundancy etc., shall be final and binding on the Bidder. Owner shall have the right to reject or accept any work or material which in his assessment is not technically complete and proven to meet the requirements of this Specifications and/or applicable National and International Codes & Standards mentioned elsewhere in this Specification.
- 1.9 The requirements, conditions, appendices etc, given in various parts/ sections of technical Specifications shall form integral part of this Specification. Bidder is required to carefully examine and understand the Specifications and seek clarifications, if required, to ensure that he has understood the Specifications as intended by the Owner. In the absence of any specific clarifications made to the Owner during bidding stage, the interpretation of Owner shall be final. The Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. All such points are required to be clarified & resolved during bidding stage.

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- 1.10 Any deviation or variation from the scope of supply and services or the intent of the Specification shall be clearly brought out under the schedule of Technical / Commercial deviations, irrespective of the fact that such deviation / variation may be standard practice or possible interpretation of the Specifications by the Bidder. In case, no clear and specific deviation is taken by the Bidder in the relevant schedule of Bid Proposal Sheet while making his Bid proposal, it will be construed that the Bidder shall comply with the stipulations of the Specification fully with regard to scope of services and supplies to be provided by him to achieve the objective of R&M. Further, unless otherwise specifically clarified by the Owner, the interpretation by the Owner in respect of scope of supplies and services to be performed by the Bidder shall be final and binding.
- 1.11 If the Bidder feels that, in his opinion certain features brought out in his offer are superior to what has been specified, these may be highlighted separately in the Bid. The Bidder at his own discretion may also make alternate offers, which in his opinion are of superior technology, material etc. to the specified requirements leading to better performance like efficiency / output etc. of the units after renovation. In such case, the Bidder shall carry out a comprehensive study and clearly identify the scope of offer in his alternate proposal. The Bidder shall furnish that detailed study to Owner along with the Bid where the Bidder shall bring out in detail the scope of modifications required to be carried out by him in the various systems and equipment including but not limited to *[Turbo Generator and its Auxiliaries, HP & LP Bypass Valve, HP & LP Heaters, Deaerator, Condenser, Boiler Feed Pump (BFP), Condensate Extraction Pump (CEP), Turbine Cycle Piping (Excluding Main Steam, Cold Reheat, Hot Reheat, Upstream and downstream piping of turbine bypass valve and Auxiliary Steam Piping), Valves and all associated Electrical system, Control & Instrumentation systems and associated Civil & Structural work etc.]*
- Such Alternate proposals shall be supplemented with sufficient amount of information like specified design standards and performance requirements, Bidder's experience, operating feedback, provenness, etc. for justifying such proposals. Implications of such Alternate offers on the performance, output, efficiency, auxiliary power consumption, etc. shall be clearly brought out in the Bid to enable the Owner to determine the advantages, superiority and acceptability of the proposals.
- However the Bidder's Base offer shall necessarily be in line with the Specification requirements. Under no circumstances the equipment and services as specified shall be brought out as an Alternate offer.
- The Base offers will be evaluated as per procedure outlined in the Bid documents and the Alternate Offers of the lowest evaluated Bidder will only be considered for acceptance or otherwise. Owner may reject alternative proposals submitted by the Bidder at his sole discretion, without assigning any reason what so ever.
- 1.12 In the event of conflict between requirements of any two clauses of the Specification documents or requirements of different Codes/ Standards specified,

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the more stringent requirement as per the interpretation of the Owner shall apply, unless confirmed otherwise by the Owner in writing.

- 1.13 The General technical conditions pursuant to the Contract, placed separately in this Specification, shall form an integral part of the Specification. These conditions shall supplement all the detailed technical Specification and requirement identified in this Specification.
- 1.14 Out of complete unit comprising of mechanical, electrical, C&I systems and equipment, some components/systems are envisaged to be replaced with new ones having better design features while some of the other components are to be refurbished / upgraded by the Bidder under present R&M Work. It shall be the responsibility of the Bidder to ensure that components/ equipment/ systems being supplied new OR components/ equipment/ systems being refurbished / upgraded by him are fully compatible and integrated with the existing equipment / systems so as to give safe, reliable and sustained operation of the complete unit. Modifications needed on the assembled equipment to ensure complete integration are to be brought out by the Bidder in the Bid and such modifications, if any, after Owner's approval shall be carried out by the Bidder to the satisfaction of the Owner.
- 1.15 The unit shall be designed to operate continuously in base load, cyclic load operation. The systems shall operate without any restriction over the entire range of operating conditions. The Bidder shall ensure that after R&M there are no restrictions/ alterations in modes of operations of this unit, as per the original/existing plant operation philosophy, including achieving base load, peak load and cyclic load operation.
- 1.16 As the various equipment/ systems/ components are to be fitted in the unit, Bidder is advised to visit the plant site to get fully conversant with the job, site conditions, and constraints, and collect all the information as required and as available before quoting against this Specification.
- 1.17 A brief extract of the existing unit, the original design details/ performance parameters along with plant details, operating history and known problem areas; wherever possible are brought out in the successive section of this Specification. Relevant plant layout drawings and certain key schematic drawings, as available, have also been furnished in Annexure-I of this section of the Specification for the purpose of familiarization & guidance only. The successful Bidder shall prepare and provide the additional drawings and documents describing the design and engineering details and the manuals for carrying out erection, commissioning and operation of the renovated unit.

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2 SITE & PROJECT SPECIFIC INFORMATION

2.1 Project Name

Project Title: [.....]

Existing Capacity: [.... xMW]

2.2 Project Location

The proposed project site is located at [....], in District [....] in the state of [....].

The location details of the project site are as indicated below:

Table-2.1

Latitude	[.... Deg....'"] N
Longitude	[....Deg'"] E
Height above mean sea level	[....] m
Seismic Zone	Zone - [....]
Distance from [.....] town	[....] km
Distance from national highway No. [.....]	[....] km
Distance from state highway No. [.....]	[....] km
Distance of nearest airport [.....]	[....] km
Distance of nearest seaport [.....]	[....] km

2.3 Climatological Data

Table-2.2

Highest monthly mean of daily maximum temperature	[....] deg C
Lowest monthly mean of daily maximum temperature	[....] deg C
Highest monthly mean of daily minimum temperature	[....] deg C
Lowest monthly mean of daily minimum	[....] deg C

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temperature	
Annual mean of daily maximum temperature	[...] deg C
Annual mean of daily minimum temperature	[...] deg C
Extreme highest temperature	[...] deg C
Extreme lowest temperature	[...] deg C
Design ambient temperature (unless specified otherwise)	{50} deg C
Relative Humidity: Maximum	[...] %
Minimum	[...] %
Design Relative Humidity	[...] %
Average annual rainfall	[...] cm
Heaviest rainfall in 24 hours so far	[...] cm
Number of rainy days in a year	[...]
Highest monthly mean of wind speed	[...] km/h
Lowest monthly mean of wind speed	[...] km/h
Maximum wind speed	[...] km/h

Table-2.3

Season	Dry bulb temperature	Wet bulb temperature
Summer	[...] deg C	[...] deg C
Monsoon	[...] deg C	[...] deg C
Winter	[...] deg C	[...] deg C

2.4

Fuel

At present the power station is sourcing coal from [...] coal mines/ [...] port {incase of imported coal}. The coal is being transported to the project site by [Indian Railways/ MGR system/ cross country conveyor]. Proximity of Railway line to site from Railway Station is about [...] km. The

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railway link shall also be used for transportation of heavy equipment to site during execution phase and to bring main and secondary fuel to the power plant during operation of plant.

2.5

Water Analysis

[Source (sea or river or Bore Well etc.) and quality of cooling water (sea water or clarified water etc.) for condenser and other heat exchangers and type of cooling system (once through or closed cycle), type is in use to be described herein.]

Chemical analysis of water which is used for this project is indicated as below:

Table-2.4

Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
A	Raw Water Analysis		
1	Calcium	mg/l	[...]
2	Magnesium	mg/l	[...]
3	Sodium	mg/l	[...]
4	Potassium	mg/l	[...]
5	Total Cations	meq/l	[...]
6	Bicarbonates	mg/l	[...]
7	Carbonates	mg/l	[...]
8	Nitrate	mg/l	[...]
9	Chloride	mg/l	[...]
10	Sulphate	mg/l	[...]
11	Total Anions	meq/l	[...]
12	Silica	mg/l	[...]
13	Iron Fe	mg/l	[...]
14	pH value	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
15	Turbidity	NTU	[...]
16	Total Dissolved Solids	mg/l	[...]
17	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[...]
18	BOD	mg/l	[...]
19	COD	mg/l	[...]
B	Clarified Water Analysis		
1	Calcium	mg/l	[...]
2	Magnesium	mg/l	[...]
3	Sodium	mg/l	[...]
4	Potassium	mg/l	[...]
5	Total Cations	meq/l	[...]
6	Bicarbonates	mg/l	[...]
7	Carbonates	mg/l	[...]
8	Nitrate	mg/l	[...]
9	Chloride	mg/l	[...]
10	Sulphate	mg/l	[...]
11	Total Anions	meq/l	[...]
12	Silica	mg/l	[...]
13	Iron Fe	mg/l	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
14	pH value	[....]
15	Turbidity	NTU	[....]
16	Total Dissolved Solids	mg/l	[....]
17	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[....]
C	Demineralised Water for Power Cycle Make up		
The quality parameters of demineralised water is in use for make up to the condenser hotwell and make up to the closed cycle equipment cooling water (ECW) system is as below:			
1	pH	{6.8 – 7.2}
2	Silica, as SiO ₂	ppm	≤{0.01}
3	Conductivity	micro mho/cm	≤{0.1}

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3

EXISTING PLANT DETAILS

The Power Plant, is of the configuration of [...x...MW]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The boiler for the unit is of [PF/CFBC] design. The boiler is provided with [front & rear/ corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [... substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...&...] coal mines. The consumptive water for the power plant is being sourced from [...river /...sea].

3.1

Operational Background

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The deterioration experienced over the years in Plant's Average Performance Parameters is shown in Table 3.1.

{Furnish in the Table 3.1 below, the Average Values over the life (say 25 years)}

Table-3.1

Unit's Average Performance Parameters over the life

Years after Installation	PLF (%)	Availability (%)	Output (MW)*	Unit's Gross Heat Rate (kCal/kWh)	Unit's Gross Efficiency (%)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)
5	[...]	[...]	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]	[...]	[...]

Table 3.2 indicated below, illustrates variations over the last five years in the performance parameters.

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{Furnish in the Table 3.2 below, the Average Values for the last five years. However, for the Parameters in respect of ‘One Year back’ and ‘Current Year’, furnish the Maximum, the Minimum and the Average Values.}

Table-3.2
Unit’s Average Performance Parameters during the last five years

Period	PLF (%)	Availability (%)	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit’s Gross Efficiency (%)	Unit’s Gross Heat Rate (kCal/kWh)
Four Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Three Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Two Years back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
One Year back	[...]	[...]	[...]	[...]	[...]	[...]	[...]
Current year	[...]	[...]	[...]	[...]	[...]	[...]	[...]

3.1.1

Auxiliary Power Consumption of Turbine Generator & Auxiliaries

Table-3.3

Sl. No.	Equipment/System	Units	Power Consumption
1	Boiler Feed Water Pumps (BFPs) including booster pumps and lube oil pump sets of BFPs	kW	[...]
2	Condensate Extraction Pumps	kW	[...]
3	Condenser Vacuum Pumps	kW	[...]
4	Excitation Power of Turbo Generator Set	kW	[...]
5	DM CCW Pumps for Turbo Generator Auxiliaries	kW	[...]
6	LP Drain Condensate Pumps (if Applicable)	kW	[...]

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Sl. No.	Equipment/System	Units	Power Consumption
7	Turbine Oil Pumps	kW	[...]
8	Control Oil Pumps	kW	[...]
9	Seal Oil Pumps	kW	[...]
10	Oil Vapor Extractor Fans	kW	[...]
11	Gland Steam Condenser Vapor Extractor Fans	kW	[...]
12	Any other continuous running loads	kW	[...]
13	Total Auxiliary Power Consumption of Turbine Generator and Auxiliaries	kW	[...]

3.1.2

Stack Emissions, Ambient Air Quality and Process Effluents

The Project has been regularly monitoring the environmental parameters such as stack monitoring, ambient air quality (AAQ), noise pollution and liquid waste pollution in accordance with applicable norms by employing [M/s....., which is an agency approved by State Pollution Control Board].

The existing environmental data at rated load and the limits specified for different pollutants, the locations of their measurements and the frequency of monitoring are given in the table below.

Table 3.4

Status of Stack Emissions, Ambient Air Quality and Process Effluents

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
Stack Emissions	SPM (mg/Nm ³)	Not to exceed [...]	[...]		[...]	[...]
Ambient Air Quality		On 24 Hrs Basis	On 24 Hrs Basis	On Annual Basis		
	SPM	[...]	[...]	[...]		

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)			Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
	(µg/m³)					[...]	[...]
	RPM	[...]	[...]	[...]	[...]		
	(µg/m³)						
	SO ₂	[...]	[...]	[...]	[...]		
	(µg/m³)						
	NO _x	[...]	[...]	[...]	[...]		
	(µg/m³)						
Process Effluent Leaving the Plant Boundary	ETP Treated Water Quality					[...]	[...]
	pH	[...]		[...]			
	Colour	[...]		[...]			
	Odour	[...]		[...]			
	Temperature	[...]		[...]			
	TSS (mg/l)	[...]		[...]			
	Oil & grease (mg/l)	[...]		[...]			
	COD (mg/l) (mg/l)	[...]		[...]			
	BOD (mg/l)	[...]		[...]			
	Chloride (mg/l)	[...]		[...]			

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
	Sulphate (mg/l)		
	TDS (mg/l)	...	...
	Zinc (mg/l)	...	...
	Fluoride (mg/l)	...	...
	Mercury (mg/l)	...	...

3.1.3

Feedback from the Plant Operators

Detailed discussions with the Plant operators provided the feedback about the design and operation related problems about the various systems which are listed in the Table 3.5 below.

Table 3.5

Feedback from the Plant Operators

S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
1
2
3
4
5
6
7

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S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
8	[.....]	[.....]	[.....]
9	[.....]	[.....]	[.....]
...	[.....]	[.....]	[.....]

3.1.4 Tripping and Maintenance Record

{Indicate in the table below the tripping and maintenance record for the past three years.}

Table: 3.6

Year	Total Trippings	No. of Trippings due to Turbo Generator & Auxiliaries	Other Major Causes of Trippings	Maintenance carried out
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current Year	[.....]	[.....]	[.....]	[.....]

3.1.5 Maximum Achievable Load due to performance constraint

[Due to performance constraints of various equipment of Turbine Generator & Auxiliaries, the maximum generation from the unit is restricted to [...] MW. The operational data at the above maximum load is indicated in the table below.]

Table: 3.7

Nature of constraint	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
[...]	[...]	[...]	[...]	[...]	[...]

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Nature of constraint	Output (MW)	Aux. Power Consumption (%)	Specific Oil Consumption (ml/kWh)	Unit's Gross Efficiency (%)	Unit's Gross Heat Rate (kCal/kWh)
...
...

3.1.6

Record of Reportable Accidents

[The record of reportable accidents for the past three years, is mentioned in the Table below]

Table-3.8

Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Two Years Back
One Year Back
Current Year

3.1.7

Operation & Maintenance Difficulties due to Plant Limitations

[Difficulties are being experienced in day to day maintenance of the plant due to design deficiency, layout of the plant, obsolescence of equipment and non availability of spare parts etc. These are mentioned in the Table below]

Table: 3.9

S.No.	Nature of Difficulty	Specific Reason
		(Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)

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1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

3.1.8 Start up History of the Plant over the life

[The record of Plant Start-up history under various conditions over the plant life is mentioned in the Table below:]

S.No.	Type of Start	No. of Starts	Shut down time (Duration in hours)	Average Start-up Time in hours
1	Hot Start	[.....]	[.....]	[.....]
2	Warm Start	[.....]	[.....]	[.....]
3	Cold Start	[.....]	[.....]	[.....]

3.2 Salient Technical Feature of Power Plant

{Describe in this chapter, the Design Parameters and Salient Features of all the important Equipment and Systems of the Turbine Generator & Auxiliaries as mentioned below}

3.2.1 Turbine & Auxiliaries

A) Steam Turbine

[The steam turbine is of three cylinder, 3000rpm, tandem compound, condensing type designed to operate on a re-heat and re-generative feed water cycle. The LP stage of turbine is designed with Bauman exhaust. The turbine is provided with HP/LP bypass system of 30% / 60% capacity of Steam Generator MCR. The turbine is provided with an electro - hydraulic control system, automatic turbine run up system and turbo supervisory instrumentation. The condensing system consists of a surface condenser of single shell and two pass, divided water box construction. Cooling water being supplied to the condenser is of raw water/ clarified water quality. The design parameters of the steam turbine are furnished below]

Table-3.8

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Description	Units	Design Parameters
(i) TURBINE		
Manufacturer	[...]
Rated Output at TMCR	MW	[...]
Rated Output at VWO	MW	[...]
Rated Speed	rpm	[...]
Critical Speed of rotor	rpm	1 st - [...] 2 nd - [...] 3 rd - [...] 4 th - [...] 5 th - [...]
Type of Governing	.....	[Nozzle/Throttle]
Steam Flow at TMCR condition	T/hr	[...]
Steam Flow at VWO condition	T/hr	[...]
HP Turbine Efficiency	%	[...]
No. of Stages in HP Turbine	.....	[...]
IP Turbine Efficiency	%	[...]
No. of Stages in IP Turbine	.....	[...]
LP Turbine Efficiency	%	[...]
Turbine Heat Rate	kCal/kWh	[...]
Pressure of Steam at inlet of ESV of HPT	kg/cm ²	[...]
Temperature of Steam at inlet of ESV of HPT	deg C	[...]
Pressure of Cold Reheat (CRH)	kg/cm ²	[...]

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Description	Units	Design Parameters
Steam at HPT exhaust		
Temperature of Cold Reheat (CRH) Steam at HPT Exhaust	deg C	[...]
Pressure of Hot Reheat (HRH) Steam at IPT Interceptor Valve inlet	kg/cm ²	[...]
Temperature of Hot Reheat (HRH) Steam at IPT Interceptor Valve inlet	deg C	[...]
Pressure at the inlet of LP Turbine	kg/cm ²	[...]
Temperature at the inlet of LP Turbine	deg C	[...]
Rated pressure at the exhaust of L.P. turbine	mm of Hg	[...]
Height of working blade of 1st stage in H.P. Turbine	mm	[...]
Mean diameter of 1st stage moving blade in H.P. Turbine	mm	[...]
Height of last stage moving blade	mm	[...]
Mean diameter of last stage moving blade	mm	[...]
Number of ESV	No.	[...]
Nominal diameter of ESV	mm	[...]
Number of Interceptor Valve	No.	[...]
Nominal Diameter of Interceptor Valve	mm	[...]
Number of HPT control Valve	No.	[...]

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Description	Units	Design Parameters
Nominal diameter of HPT control Valve	mm	[...]
Number of IPT control Valve	No.	[...]
Nominal diameter of IPT control Valve	mm	[...]
LPT Exhaust Area	m ²	[...]
LPT Exhaust Loss	kg/cm ²	[...]
LPT Last Blade Length	mm	[...]
Material of Construction of HP casing	.....	[...]
Applicable Correction Curve	.....	[Drawing No. (Applicable Correction curve to be attached)]
Material of Construction of IP casing	.....	[...]
Material of Construction of LP casing	.....	[...]
Material of Construction of Rotor	.....	[...]
Total weight of Turbine	Tones	[...]
Weight of the heaviest part of turbine for erection (weight of the lower half of LPC)	Tones	[...]
Weight of the heaviest part for operation (weight of upper half of LPC in assembled stages)	Tones	[...]
Weight of H.P. Rotor	Tones	[...]
Weight of I.P. Rotor	Tones	[...]

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Description	Units	Design Parameters
Weight of L.P. Rotor	Tones	[...]
Overall length of turbine	mm	[...]
Overall length of H.P. rotor	mm	[...]
Overall length of I.P rotor	mm	[...]
Overall length of L.P rotor	mm	[...]
Length of H.P rotor between axes of bearings	mm	[...]
Length of I.P rotor between axes of bearings	mm	[...]
Length of L.P rotor between axes of bearings	mm	[...]
(ii) TURNING GEAR		
Number	No.	[...]
Turbine rotor turning speed	rpm	[...]
Motor Type	.....	[...]
Rated Volts	kV	[...]
Rated Output	kW	[...]
Motor speed	rpm	[...]
Gear Ratio	.....	[...]
(iii) TURBINE LUBE OIL SYSTEM		
<p><i>[The lube oil system consists of Main Oil Tank, Turbine driven main oil pump, 2x100% AC driven starting oil pumps, 1x100% DC driven emergency oil pump, 1x100% each AC&DC driven jacking oil pumps and oil coolers of 3x50% capacity and Lube Oil Filters. Lube oil is being purified by means of a centrifuge. Oil storage tanks consisting of Clean Oil Tank and Dirty Oil Tank have been provided.]</i></p>		

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Description	Units	Design Parameters
<i>Also provision of Central Lube Oil purification system, if applicable, should also be described in this chapter.]</i>		
Turbine Oil Specification		
Trade Name	.....	[...]
Specific gravity at 50 deg C	.....	[...]
Flash point	deg C	[...]
Kinematic Viscosity at 50 deg C	Centistokes	[...]
Neutralization Number	.....	[...]
Pour point	deg C	[...]
Mechanical Impurities	.....	[...]
Ash content	%	[...] by weight
Turbine Lub Oil Equipment		
a) Turbine Driven Main Oil Pump		
Type	.....	[...]
Location	.....	[...]
Drive	.....	[...]
Speed	rpm	[...]
Discharge Pressure	kg/cm ² (a)	[...]
b) AC Driven Starting Oil Pumps		
Type	[...]
Drive	[...]

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Description	Units	Design Parameters
Speed (Starting)	rpm	[...]
Speed (Testing)	rpm	[...]
Pressure developed (Starting)	mwc	[...]
Pressure developed (Testing)	mwc	[...]
Capacity (Starting)	m ³ /hr	[...]
Capacity (Testing)	m ³ /hr	[...]
Motor rating (Starting)	kW	[...]
Motor rating (Testing)	kW	[...]
Rated Volts (Starting)	kV	[...]
Rated Volts (Testing)	kV	[...]
Supply	.....	[...]
c) AC&DC driven jacking Oil Pumps		
Type	.....	[...]
Capacity	m ³ /hr	[...]
Drive	.....	[...]
Discharge Pressure	kg/cm ² (a)	[...]
Speed	rpm	[...]
Motor Rating	kW	[...]
d) DC Driven Emergency Oil Pump		
Type	[...]
Capacity	m ³ /hr	[...]

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Description	Units	Design Parameters
Drive	[...]
Discharge Pressure	kg/cm ² (a)	[...]
Speed	rpm	[...]
Motor Rating	kW	[...]
e) Turbine Oil Tank		
Capacity	Liter	[...]
Circulation Capacity	Changes/hr	[...]
Location	.....	[...]
f) Oil Coolers		
Type of coolers	.....	[...]
Number of coolers	No.	[...]
Cooling Surface area	m ²	[...]
Quantity of Oil cooled	Liter/m	[...]
Cooling Water Flow	m ³ /h	[...]
Working pressure of oil to be cooled (design)	kg/cm ²	[...]
Working pressure of water (design)	kg/cm ²	[...]
No. of water paths	No.	[...]
Diameter of tubes	mm	[...]
Length of tubes	mm	[...]
Hydraulic resistance of water	mwc	[...]
g) Oil Filters		

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Description	Units	Design Parameters
Quantity	No.	[...]
Size	-	[...]

B) Condenser

[The condenser is a [single/double] pass, horizontal, surface type with integral air cooling section designed to maintain a pressure of 76 mm of Hg at turbine exhaust with a cooling water temperature of [...] deg C and an outlet temp of [...] deg C. The condenser is capable of operation with [...] tubes plugged and has hot well storage capacity of [...] minutes.]

Table-3.9

Description	Units	Design Parameters
Make and Model	.....	[...]
Type of Condenser	.....	[...]
Condenser Heat Load	kCal/h	[...]
Total Cooling Surface	m ²	[...]
Number of Cooling Water Tubes	.....	[...]
Length of Tubes	mm	[...]
Material of Tubes	.....	[...]
Diameter and thickness of tubes	mxmm	[...]
Design Cleanliness Factor	.....	[...]
Nature of connection to exhaust neck of turbine	.....	[...]
Type of condenser support	.....	[...]
Water Side Pressure drop across condenser	mwc	[...]
Cooling Water Quantity through	m ³ /h	[...]

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Description	Units	Design Parameters
Condenser		
Cooling Water Temperature at the inlet to Condenser	deg C	[...]
Cooling Water Temperature at Condenser Outlet	deg C	[...]
Condenser Vacuum	mm Hg	[...]
[On Load Tube Cleaning System]	.....	[Yes/No]
[Cleanliness of Tube]	.....	[...]
[Details of Debris Filter]	.....	[...]
[Details of Screens in case of Once Through System]	.....	[...]

C) Ejectors

[The Condenser is provided with two quick starting ejectors which operate in parallel to remove large volumes of air for raising the initial vacuum during the starting of the Unit. Two main ejectors of 100% capacity each have been provided remove air and non condensable gases from the condenser to maintain the required vacuum in the condenser during the normal operation of the unit.]

Table-3.10

Description	Units	Design Parameters
(i) Starting Ejector		
Number	No.	[...]
Type	[...]
Working steam pressure	kg/cm ² (a)	[...]
Steam temp.	deg C	[...]
Steam Consumption	kg/h	[...]

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Description	Units	Design Parameters
(ii) Main Air Ejector		
Type	[....]
Working steam pressure	kg/cm ² (a)	[....]
Steam temp.	deg C	[....]
Steam Consumption	kg/h	[....]

D) Vacuum Pump (If Applicable)

[The Condenser is provided with [2x100%] vacuum pumps with all accessories for condenser air evacuation. Capacity of each pump in free dry air at standard condition with condenser operating at design pressure of 25.4 mm of Hg (abs) and sub-cooled to 4.17 deg C below temperature corresponding to absolute suction pressure is scfm (.... m³ per hour) under standard condition. The capacity of each pump during hogging is [....] scfm. Details of existing vacuum pump is given below:]

Table: 3.11

S.No.	Description	Units	Value
1	Source of vacuum pump heat exchanger cooling water	.....	[....]
2	Source of sealing water	.....	[....]
3	Source of make-up water	.....	[....]
4	Design pressure (cooling water side) for vacuum pump heat exchanger	kg/cm ² (a)	[....]
5	Pressure of make-up water	kg/cm ² (a)	[....]
6	Maximum temperature of condenser cooling water	deg C	[....]
7	Duty code	....	[....]
8	Design back pressure	mm	[....]

E) Condensate Extraction Pumps

[Condensate extraction pumps are of vertical, multistage, centrifugal pumps of cannister type.]

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Table-3.12

Description	Units	Design Parameters
Make and Model	[...]
Type	[...]
Number of Pumps	[...]
Number of Impeller Stages	.....	[...]
Capacity	m ³ /h	[...]
Total Developed Head	mwc	[...]
Efficiency of Pump	%	[...]
Condensate temp	deg C	[...]
Speed	rpm	[...]
Suction pressure	kg/cm ²	
Minimum flow	m ³ /h	[...]
NPSH required at design condition	mwc	[...]
Motor make	.....	[...]
Rated Voltage	kV	[...]
Motor Speed	rpm	[...]
Frequency	Hz	[...]
Phase	[...]
Motor Rating	kW	[...]
Auxiliary Power Consumption	kW	[...]

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F) Gland Steam Cooler

[A Gland Steam Cooler has been provided to condensate the leak-off steam from intermediate chambers of end sealings of HP and IP turbine, thereby heating the main condensate water. The Gland Steam Cooler consists of shell, tube bundle and removable water box.]

G) LP Heaters and Drain Coolers

[Each steam turbine is provided with four numbers of low pressure heaters to increase the temperature of the condensate in stages. LP Heater -1 consists of two halves and is installed in neck of the condenser. The remaining LP Heaters are of shell and tube design and have been placed vertically. An integral drain cooling section is provided in each LP Heater. The design details of LP Heaters and Drain coolers are furnished in the table below.]

Table-3.13

LP Heaters				
Heater No.	[1]	[2]	[3]	[4]
Type	[...]	[...]	[...]	[...]
Tube Size (Dia./Thick.)	[...]	[...]	[...]	[...]
Tube Material	[...]	[...]	[...]	[...]
Shell Size (Dia./Thick.)	[...]	[...]	[...]	[...]
Shell Material	[...]	[...]	[...]	[...]
Extraction Nozzle Location	[...] stage of LP turbine	[...] stage of LP turbine	[...] stage of LP turbine	[...] stage of LP turbine
Bled Steam Flow (kg/h)	[...]	[...]	[...]	[...]
Bled Steam Pressure (kg/cm ²)	[...]	[...]	[...]	[...]
Bled Steam	[...]	[...]	[...]	[...]

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Temperature (°C)				
Saturation Pressure	[...]	[...]	[...]	[...]
Condensate Flow (kg/h)	[...]	[...]	[...]	[...]
Condensate Inlet Temperature (°C)	[...]	[...]	[...]	[...]
Condensate Outlet Temperature (°C)	[...]	[...]	[...]	[...]
Drain Temperature (°C)	[...]	[...]	[...]	[...]
Drain Coolers				
Description	Units	Design Parameters		
Type	-----	[...]		
Number per Unit	No.	[...]		
Orientation	.....	[...]	
Material of Construction				
• Shell	.....	[...]	
• Tubes	.....	[...]	
• Tube Plate	.....	[...]	
Tube side Design Pressure	mwc	[...]		
Shell side Design Pressure	mwc	[...]		

H) Deaerator

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[The deaerator is of [horizontal spray cum tray type]. It is designed to remove dissolved oxygen from the condensate in excess of 0.005 cc per liter. The feed water storage tank has a capacity of [...] minutes feed water requirement of the boiler corresponding to TMCR Heat Balance]

Table-3.14

Description	Units	Design Parameters
Make	.....	[...]
Type and Arrangement	.....	[...]
Shell		
Diameter	mm	[...]
Overall length	mm	[...]
Overall thickness	mm	[...]
Design pressure	kg/cm ² (g)	[...]
Design Temperature	deg C	[...]
Relief valve set pressure	kg/cm ² (g)	[...]
Trays		
Total No. of trays	No.	[...]
Total surface area of trays	m ²	[...]
Dimension of each tray	mxm	[...]
Spray System		
No. of spray nozzles	No.	[...]
Type of spray nozzles	[...]
Size of each nozzle	mm	[...]
Feed Water Storage Tank		

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Description	Units	Design Parameters
Make	[...]
Outside Dia	m	[...]
Overall length	m	[...]
Wall thickness	mm	[...]
Water Level		
Normal Operating Water level (from tank bottom)	mm	[...]
Highest water level (from tank bottom)	mm	[...]
Lowest water level (from tank bottom)	mm	[...]
Storage capacity with normal operating water level	m ³	[...]
Start-Up Steam		
Source	.....	[...]
Quantity	T/h	[...]
Operating Pressure	kg/cm ² (a)	[...]
Operating Temperature	deg C	[...]

I) Boiler Feed Pumps

[The boiler feed pumps are horizontal, multi stage centrifugal pumps of barrel type, motor driven pumps coupled with hydraulic coupling, taking the suction from the deaerator. The boiler feed pumps discharge feed water through HP heaters to the economizer of the boiler.]

Table-3.15

Description	Units	Design Parameters
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Description	Units	Design Parameters
Booster Pump		
Make and Model	[....]
Type	[....]
Number of Pumps	Nos.	[....]
No of stages	Nos.	[....]
Capacity	m ³ /h	[....]
Total Developed Head	mwc	[....]
Efficiency of Pump	%	[....]
Feed water temp	deg C	[....]
Speed	rpm	[....]
Suction pressure	kg/cm ²	[....]
Power Consumption	kW	[....]
Main Pump		
Make and Model	.....	[....]
Type	.....	[....]
No of Pumps	Nos.	[....]
No of stages	Nos.	[....]
Capacity	m ³ /h	[....]
Total Developed Head	mwc	[....]
Efficiency	%	[....]

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Description	Units	Design Parameters
Feed water temp	deg C	[....]
Speed	rpm	[....]
Suction pressure	kg/cm ²	
Gland sealing arrangement	....	[....]
Minimum flow	m ³ /h	[....]
NPSH required at design condition	mwc	[....]
Motor make	.....	[....]
Rated Voltage	kV	[....]
Motor Speed	rpm	[....]
Frequency	Hz	[....]
Phase	....	[....]
Motor Rating	kW	[....]
Power Consumption	kW	[....]
Details of worm-up water	[....]
Fluid Coupling		
Make and Model	[....]
Type	[....]
Duty	[....]
Efficiency	%	[....]
Range of Operation	[....]

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Description	Units	Design Parameters
Material of Construction	[....]
Cooling Water Parameters	[....]

J) HP Heaters

[Each steam turbine is provided with three numbers of high pressure heaters to increase the temperature of the feed water in stages. The Heaters are of shell and tube design and have been placed vertically. The design details of HP Heaters are furnished in the table below.]

Table-3.16

Heater No.	[6]	[7]	[8]
Type	[...]	[...]	[...]
Tube Size (Dia./Thick.)	[...]	[...]	[...]
Tube Material	[...]	[...]	[...]
Shell Size (Dia./Thick.)	[...]	[...]	[...]
Total Heat Transfer Area (m2)	[...]	[...]	[...]
Shell Material	[...]	[...]	[...]
Extraction Nozzle Location	[...] stage of IP turbine	[...] stage of IP turbine	[...] stage of IP/HP turbine
Bled Steam Flow (kg/h)	[...]	[...]	[...]
Bled Steam Pressure (kg/cm2)	[...]	[...]	[...]
Extraction Line Pressure drop	[...]	[...]	[...]

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Bled Steam Temperature (□C)	[...]	[...]	[...]
Saturation Pressure	[...]	[...]	[...]
Feed Water Flow (kg/h)	[...]	[...]	[...]
Feed Water Inlet Temp (□C)	[...]	[...]	[...]
Feed Water Outlet Temp (□C)	[...]	[...]	[...]
Drain Temperature(deg C)	[...]	[...]	[...]

K) HP/ LP Bypass

[HP/LP bypass system has a capacity of 30% / 60% of BMCR (Boiler Maximum Continuous Rating). HP bypass system has been provided between the Main Steam Line and Cold Reheat Line. LP bypass system has been provided between the Hot Reheat Line and the Condenser. HP bypass water spray has been taken from the discharge of Boiler Feed Pumps. LP bypass water spray has been provided from the discharge of Condensate Extraction Pumps.]

Table-3.17

Description	Units	Design Parameters	
		HPTBV	LPTBV
Make	[...]	[...]
Model	[...]	[...]
Capacity			
Opening through full travel	mm	[...]	[...]

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Description	Units	Design Parameters	
		HPTBV	LPTBV
Closing through full travel	mm	[...]	[...]
Opening Time	Sec.	[...]	[...]
Closing time	Sec.	[...]	[...]
Pressure Reducing & Desuperheating Station <i>{In case of pressure reducing & desuperheating station is not integral, the parameters as mentioned below shall be provided separately for pressure reducing valve & desuperheater}</i>			
Type	.....	[...]	[...]
Number of Valves	No.	[...]	[...]
Size	mm	[...]	[...]
Actuation type	.....	[...]	[...]
Spray quantity at different load (% TMCR)	m ³ /h	60% [...] 70% [...] 80% [...] 90% [...]	[...] [...] [...] [...]
Spray water pressure	kg/cm ² (a)	[...]	[...]
Spray water Temperature	deg C	[...]	[...]
Type of pressure control	.....	[...]	[...]
Type of temperature control	[...]	[...]
MOC of valve body	[...]	[...]
MOC of Valve seat	[...]	[...]
MOC of Valve internals	[...]	[...]

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Description	Units	Design Parameters	
		HPTBV	LPTBV
Oil Supply Unit			
No of pumps	[...]	[...]
Capacity of the tank	m ³	[...]	[...]
Method of purification of oil	.....	[...]	[...]
No. and capacity of accumulators	.....	[...]	[...]

L) Turbine Governing System

[The turbine is equipped with an electro-hydraulic system of automatic governing for the smooth and stable operation of turbo-set under all conditions of operation. The system is designed to sustain full load dump from the generator. The system is provided with a quick closing Emergency Stop Valve (ESV), to interrupt the supply of steam from the boiler and stop the turbine under emergency conditions. The turbine governing system includes, speed governor]

M) Generator Seal Oil System

Table-3.18

Description	Units	Design Parameters
A.C. Seal Oil Pump		
Manufacturer	[...]
Type	[...]
Number	No.	[...]
Discharge Head	kg/cm ²	[...]
Capacity	m ³ /hr	[...]
Speed	rpm	[...]

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Description	Units	Design Parameters
Efficiency	%	[...]
Motor Manufacturer	[...]
Motor Rating	kW	[...]
Power Consumption	kW	[...]
D.C. Seal Oil Pump		
Manufacturer	.....	[...]
Type	.....	[...]
Number	No.	[...]
Discharge Head	kg/cm ²	[...]
Capacity	m ³ /hr	[...]
Speed	rpm	[...]
Efficiency	%	[...]
Motor Manufacturer	.....	[...]
Motor Rating	kW	[...]
Power Consumption	kW	[...]

N) **Condensate Storage Tank**

Number	[...]
Design code	[...]
Capacity of each tank	m ³	[...]
Overall Dimension of the Tank	[...]

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Free Board	mm	[...]
Type and pressure class	[...]
Material of construction and Thickness	[...]

O) DM Make-UP Pumps

No. of Pumps	.....	[...]
No. of Pumps Working	.....	[...]
No. of Pumps Stand-by	.....	[...]
Suction Lift/Head Available	mlc	[...]
Flow	m ³ /h	[...]
Total Dynamic Head	mlc	[...]
Rated Speed	rpm	[...]
Range of Operation	%	[...]
Suction specific speed	US unit	[...]
Pump Efficiency	%	[...]
Motor Rating	kW	[...]
Material of Construction	.....	[...]

P) Miscellaneous Operational Parameters of Turbo Generator

Table-3.19

Description	Units	Design Parameters
Turbine oil cooler oil outlet temp.	deg C	[...]
Cold gas temp.	deg C	[...]
Stator cooling water flow	m ³ /hr	[...]

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Description	Units	Design Parameters
Stator cooling water pp discharge pr.	kg/cm ²	[...]
Seal oil cooler oil outlet temp.	deg C	[...]
Stator cooling water expansion tank volume	m ³	[...]
Hydrogen cooler water inlet pr.	kg/cm ²	[...]
Stator cooling water temp. at inlet to stator winding and distillate temp. at outlet of stator winding	deg C	[...]
M.O.T. Level	cm	[...]
Stator cooling water resistivity	kΩ-cm	[...]
Under steady state condition, normal turbine differential expansion	mm	HPT= [...] IPT= [...] LPT= [...]

Q) Piping

Table-3.20

Description	Units	Design Parameters
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	[...]
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]
Class	[...]

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Description	Units	Design Parameters
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]

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Description	Units	Design Parameters
Material	[...]
Class	[...]
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]
Class	[...]
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	

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Description	Units	Design Parameters
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]
Class	.....	[...]
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	.....	[...]
Size	mm	[...]
Material	.....	[...]
Class	.....	[...]
[Line Designation..... & Tag No.....]		
Flow	T/hr	[...]
Velocity	m/s	
Schedule/Thickness	[...]
Size	mm	[...]
Material	[...]
Class	[...]

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3.2.2 Electrical System

A brief extract of the existing Equipments and Systems of Turbo Generator & Auxiliaries package describing the original design details are given below. Relevant plant layout drawings and certain key schematic drawings have also been furnished in Annexure-I of this section of the specification for the purpose of familiarization and modification if required.

A) Generator & its Auxiliary system

[Turbo Generator is having rated output of 210/215/220/250 MW with the Voltage rating of [as per existing generator voltage] kV provided with Static/Brushless excitation system. The design parameters of Generator and Its auxiliary system are furnished below:].

Description	Units	Design Parameters
Generator		
Name of the manufacturer	.....	[...]
Model No.	.....	[...]
Rated MW Capacity	MW	[...]
Rated MVA Capacity	MVA	[...]
Rated Terminal Voltage	kV	[...]
Rated Power Factor	.....	[...]
Rated Stator Current	kA	[...]
Rated Speed	rpm	[...]
Rated Frequency	Hz	[...]
Efficiency at Rated Power Output and Rated Power Factor	%	[...]
Excitation Current	kA	[...]
Excitation Voltage at Rated Power Output and Rated Power Factor	kV	[...]
Short Circuit Ratio	[...]

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Description	Units	Design Parameters
Rated Hydrogen Pressure	kg/cm ²	[...]
Negative Sequence Current	Amp	[...]
Phase Connection	.....	[...]
Type of Excitation	.....	[...]
Method of Cooling the Rotor	.....	[...]
Line charging capability	.....	[...]
Efficiency	%	[...]
Method of Cooling the Stator	.....	[...]
Reactances		
Direct Axis Sub-Transient Reactance, Xd''	P.U.	[...]
Direct Axis Transient Reactance, Xd'	P.U.	[...]
Direct Axis Synchronous Reactance, Xd	P.U.	[...]
Negative Phase Sequence Reactance, X2	P.U.	[...]
Zero Sequence reactance, X0	P.U.	[...]
Short Circuit Currents		
Sub transient current on 3 phase short circuit	P.U.	[...]
Transient current on 3 phase short circuit	P.U.	[...]
Steady State current on 3 phase short circuit	P.U.	[...]
Time Constants		

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Description	Units	Design Parameters
Field Time Constant with open circuited Stator Winding, T _{do}	Sec.	[...]
Field Time Constant with 3 Phase Short Circuit of Stator Winding, T' _{d3}	Sec.	[...]
Field Time Constant with 2 Phase Short Circuit of Stator Winding, T' _{d2}	Sec.	[...]
Field Time Constant with 1 Phase Short Circuit of Stator Winding, T' _{d1}	Sec.	[...]
Time Constant of the aperiodic component for 3 Phase, 2 Phase short circuit, T _{a1}	Sec.	[...]
Time Constant of the periodic component of the sub-transient current for 3 Phase, 2 Phase and single phase short circuit, T _{d''}	Sec.	[...]
Hydrogen in Stator Casing		
Permissible pressure of H ₂	kg/cm ² (g)	[...]
Permissible variation on above	kg/cm ² (g)	[...]
Nominal Temperature of Cold Gas	deg C	[...]
Purity of H ₂	%	[...]
Oxygen content	%	[...]
Distillate to Stator Winding		
Nominal pressure at inlet to winding	kg/cm ² (g)	[...]
Permissible variation on above	kg/cm ² (g)	[...]
Nominal temperature cold distillate at inlet to stator winding	deg C	[...]
Permissible variation on above	deg C	[...]

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Description	Units	Design Parameters
Rated flow of distillate	m ³ /hr	[...]
Permissible variation on above	m ³ /hr	[...]
Nominal specific resistivity of distillate	Ω-cm	[...]
Minimum permissible specific resistivity	Ω-cm	[...]
Water to Gas Cooler		
Nominal temp. of Cooling Water at Inlet	deg C	[...]
Minimum allowable temp. of water	deg C	[...]
Nominal Flow of Water	m ³ /hr	[...]
Maximum permissible pressure of cooling water in the gas cooler	kg/cm ² (g)	[...]
Water to Stator Winding Water Cooler:		
Nominal consumption of cooling water at a temp of [35°C]	m ³ /hr	[...]
Nominal consumption of cooling water at a temp of [37°C]	m ³ /hr	[...]
Nominal consumption of cooling water at a temp of [40°C]	m ³ /hr	[...]
Permissible Temperature Rating		
Class of Insulation of generator Windings	.....	[...]
Maximum temp of Stator Core (measured by embedded RTD)	deg C	[...]
Maximum temp of Stator Winding (measured by embedded RTD)	deg C	[...]

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Description	Units	Design Parameters
Maximum temp of Rotor Winding (measured by resistance method)	deg C	[...]
Permissible temp rise of Rotor Winding over Cold gas temp	deg C	[...]
Maximum temp of distillate at the outlet of Stator Winding as measured by RTD	deg C	[...]
Maximum temp of Hot gas measured by RTD and Mercury Thermometer	deg C	[...]
Maximum temp of Stator Winding as measured by RTD placed under the wedges	deg C	[...]
Difference between the readings of RTDs showing maximum and minimum tem	deg C	[...]
Consumption of oil per generator bearing (excluding shaft seal)	lit/min	[...]
Oil pressure at the inlet of bearing	kg/cm ² (g)	[...]
Consumption of oil in both the shaft seals	lit/min	[...]
Total gas volume of the generator	m ³	[...]
Number of passes in the gas cooler water	.....	[...]
Critical speed of the rotor	rpm	[...]
Flywheel moment of the rotor	T-m ²	[...]
Ratio of Short circuit torque to Full Load Torque	[...]

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Description	Units	Design Parameters
Line charging capacity	MVAR	[...]
Basic impulse insulation level w.r.t body	kV _{peak}	[...]
Basic impulse insulation level between turns	kV _{peak}	[...]
Resistance of Stator Winding per phase at 20°C	Ohm	[...]
Resistance of Rotor Winding at 20°C	Ohm	[...]
Capacitance of Stator Winding (calculated value) in hot condition	μF	[...]
Overall diameter of Stator	mm	[...]
Length of the Stator	mm	[...]
Length of the rotor	mm	[...]
Diameter of Rotor Barrel	mm	[...]
Weight of the heaviest lift (Stator with Gas Coolers and Lifting trunions)	Tones	[...]
Weight of Rotor	Tones	[...]
Weight of Gas Cooler	Tones	[...]
Weight of Bearing with Brush Gear along with foundation plates	Tones	[...]
Weight of end terminal	kg	[...]
Weight of end shield	Tones	[...]
Total weight of the generator	Tones	[...]

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LII-GETS12021-G-00129-002	03	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-II, Section-I	[51]	15.01.2016

Description	Units	Design Parameters
Static Excitation System		
Excitation Transformer:		
Make	.....	[...]
Type	.....	[...]
Cooling	.....	[...]
Rating	kVA	[...]
Voltage ratio	.....	[...]
Phase	.....	[...]
Frequency	Hz	[...]
Vector Group	.....	[...]
% Impedance	.....	[...]
Static Converter		
Make	.....	[...]
Type	.....	[...]
Cooling	.....	[...]
Rated Rectifier current	A	[...]
Rated Rectifier voltage	V	[...]
Ceiling Current	A	[...]
Ceiling Voltage	V	[...]
Ceiling duty duration	Sec	[...]
Rated P.I.V.	V	[...]

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LII-GETS12021-G-00129-002	03	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-II, Section-I	[52]	15.01.2016

Description	Units	Design Parameters
Voltage drop across thyristor	V	[...]
Total No. of Parallel Thyristor Bridges	.....	[...]
No. of redundant Thyristor Bridges	.....	[...]
Cooling Power Requirement	kW	[...]
Amount of heat dissipated	kW	[...]
Excitation System with DVR		
Make	.....	[...]
Type	.....	[...]
Accuracy of voltage regulator	%	[...]
Range of Voltage control in auto	%	[...]
Range of Voltage control in manual	%	[...]
Response time	sec	[...]
Response ratio	.....	[...]
Field forcing	sec	[...]
Operating frequency	Hz	[...]
Dead band	.....	[...]
Range of reactive drop adjustment	%	[...]
Rated current & Voltage of SSE	%	[...]
Brushless Excitation System		
Pilot exciter		
a) Manufacturer	[...]
b) Type	[...]

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Description	Units	Design Parameters
c) Type of drive	[...]
d) Normal Speed	rpm	[...]
e) Rated Voltage	Volts	[...]
f) Rate frequency	Amp	[...]
g) Rated current	Amp	[...]
h) Type of insulation		[...]
Rectifier for pilot exciter		
a) Manufacturer	....	[...]
b) Type	....	[...]
c) Rated rectifier voltage	Volts	[...]
d) Rated rectifier current	Amp	[...]
e) Total number of rectifier cells per parallel path of a bridge	....	[...]
f) Number of parallel paths per bridge arm	....	[...]
g) No. of bridge arms	....	[...]
Main Exciter		
a) Manufacturer	....	[...]
b) Type	....	[...]
c) Type of drive	....	[...]
d) Normal Speed	rpm	[...]
e) Rated rectifier voltage	Volts	[...]
f) Rated rectified current	Amp	[...]
g) Ceiling rectified voltage	Volts	[...]
h) Ceiling rectified current	Amp	[...]
i) Exciter field voltage with manual control (rectified)	Volts	[...]
i) Maximum	Volts	[...]
ii) Minimum	Volts	[...]

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Description	Units	Design Parameters
k) Nominal exciter response ratio	[...]
l) Class of insulation	[...]
Exciter rectifier assembly		
a) Manufacturer	[...]
b) Type of rectifier	[...]
c) Total number of rectifier cells per ring	[...]
d) Number of parallel paths per bridge arm	[...]
e) Number of bridge arms	[...]
Air/Water Coolers (For Exciter)		
a) Number of Coolers	[...]
b) Material of		[...]
i) Tubes	[...]
ii) Fins	[...]
c) Material of tube plates	[...]
d) Material of water boxes	[...]
e) Quantity of circulating water required per cooler	m ³ /hr	[...]
f) Maximum allowable water temperature	deg C	[...]

B) Generator Protection & Metering Panel

[Generator protection panel is covering Protection requirements of Turbo Generator, Generator Transformer (GT) and Unit Transformer (UT). It has been envisaged that there are two groups of protection each are physically, mechanically and electrically separated into two separate systems. And Metering systems will comprise of Metering requirements of Generator, GT and UT transformers. The design parameters of Generator Protection panel and Metering Panel are furnished below:]

Description	Unit	Design Parameters
Make/Manufacturer of Panel	[.....]

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Description	Unit	Design Parameters
Model No	[.....] {For Protection/Metering panel}
Panel Designation	....	[.....] {Relay/Metering panel of GT/UT/Generator}
Type of Panel	....	[.....] {Simplex/Duplex}
Sheet Steel Thickness		
(a) Load bearing members	mm	[.....]
(b) Non-loading members	mm	[.....]
Colour Shade of Panel	....	[.....]
Cable Entry of Panel	....	[.....] {Top/Bottom}
Degree of protection	....	[.....]
Auxiliary Voltage Requirement of Panel		
(a) AC	....	[.....]
(b) DC	....
Minimum rating of contacts for auxiliary relays :		
(a) Voltage	V, DC	[.....]
(b) Continuous current	A, DC	[.....]
(c) Make & carry for 1 sec.	A, DC	[.....]
(d) Breaking capacity (i) Resistive (ii) Inductive	Watts	[.....] [.....]
Weight of Each Panel	kg	[.....]
Dimension of each panel	mm	[.....]

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Description	Unit	Design Parameters
Relay type and protection [For Generator]	[.....] {List out protections envisaged for Generator in Group I and Group II separately}
Relay type and protection [For Generator Transformer]	....	[.....] {List out protections envisaged for Generator Transformer in Group I and Group II separately}
Relay type and protection [For Unit Transformer]	....	[.....] {List out protections envisaged for Unit Transformer in Group I and Group II separately}
Tripping Relays	....
(a) Make / designation	....	[.....]
(b) Static / Electromagnetic	....	[.....]
(c) Rated voltage	V, DC	[.....]
Trip circuit Super Vision Relays		
(a) Make / designation	....	[.....]
(b) Static / Electromagnetic	....	[.....]
(c) Rated voltage	V, DC	[.....]
Indicating Lamps		
Type	[.....]
Ratings	
(a) Voltage	V	[.....]
(b) Wattage	W	[.....]
Energy Meters		
Make	

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Description	Unit	Design Parameters
Type of measurement	[.....]
Measuring range in primary watts.	[.....]
CT ratio	A/A	[.....]
VT ratio	V/V	[.....]
Accuracy class	....	[.....]
Burden	....	[.....]
(a) Current coil	VA	[.....]
(b) Voltage coil	VA	[.....]
Transducers		
a) Output	....	[.....]
b) Accuracy	....	[.....]
c) Burden	VA	[.....]

C) ISOLATED PHASE BUS DUCT

[Isolated Phase Bus duct is envisaged for main connection between Generator to Generator transformer and Tap off connection is envisaged to Unit Transformer. Connection to Station Transformer is tapped from Switchyard. Isolated bus duct are natural cooled and having voltage rating of [to suit generator terminal voltage.] kV. The design parameters of Isolated Phase Bus Duct are furnished below:].

Description	Unit	Design Parameters
Make/Manufacturer	....	[.....]
Type of Bus Duct	....	[.....] {IPBD}
Type of Cooling	....	[.....]
System Voltage	kV	[.....]
Rated Voltage of Bus duct	kV	[.....]
Rated frequency	Hz	[.....]
Current Rating- Continuous i) Main Connection	Amp	[.....]

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Description	Unit	Design Parameters
ii) Tap off connection to UT/any other system (Exct. Transf / LAVT Cubicle)		[.....]
Current Rating- Short Time		
i) Main Connection		[.....]
ii) Tap off Connection to UT/any other system (Exct. Transf / LAVT Cubicle)	kAmp	[.....]
Dynamic withstand Rating		[.....]
i) Main connection	kApeak	[.....]
ii) Tap off connection		
Basic impulse withstand level	kVpeak	[.....]
One minute power frequency withstand voltage	kV	[.....]
Phase to phase spacing	mm	[.....] { List out for Main/Tap off}
Bus Conductor		{List out for Main/Tap off}
Material and Grade	....	[.....]
Shape and dimension	....	[.....]
Cross sectional area	Sq.mm	[.....]
Method of joining adjacent sections		[.....]
Resistance per phase at 20 deg.C	Ohms	[.....]
Bus Enclosure		{List out for main and tap off}
Material and Grade	[.....]
Shape and dimension	[.....]
Diameter and thickness	mm	[.....]

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Description	Unit	Design Parameters
Cross Sectional area	Sq.mm	[.....]
Method of joining adjacent sections	[.....]
Resistance/metre/Phase at 20°C for bus duct	Ohm/ph/m	[.....]
Inductive reactance/metre/phase at 20°C for bus duct	Ohm/ph/m	[.....]
Capacitive reactance/metre/phase at 20°C for bus duct	Ohm/ph/m	[.....]
Length of Bus duct	....	[.....]
i) Generator to Generator Transformer		[.....]
ii) Tap off to UT	....	[.....]
iii) Tap off to other system (if applicable)	....	[.....]
Maximum temperature rise of conductor over 50°C ambient	deg C	[.....]
Maximum temperature rise of enclosure over 50°C ambient	deg C	[.....]
Power Loss		
Power loss in bus conductor @ rated current	kW/ ph/meter.	[.....]
Power loss in bus enclosure @ rated current	kW/ ph/meter.	[.....]
Total power loss as per length of bus duct	kW	[.....]
Bellows		
Manufacturer	[.....]
Material and grade	[.....]

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Description	Unit	Design Parameters
Maximum permissible expansion	[.....]
Gasket for Inspection cover	[.....]
i) Material		[.....]
ii) Grade		
Insulator and seal of bushing		
Manufacturer	....	[.....]
Type of Insulator	....	[.....]
Rated Voltage Class	kV	[.....]
One Minute Power frequency withstand Voltage	kV	[.....]
Impulse withstand Voltage	kVpeak	[.....]
Pressurization equipment		
Pressure of supply air	kg/cm ²	[.....]
Pressure to be maintained inside bus ducts	kg/cm ²	[.....]
Scavenging rate	l/hr	[.....]
Guaranteed leakage rate	l/hr	[.....]
Quantity of air required	....	[.....]
Location of opening for hot air blowing	....	[.....] <i>{List out no of opening at generator, GT and UT}</i>
Sun shade Provided	Yes/No	[.....]
Paint Shade of Bus duct	....	[.....]
Disconnecting Link	....	[.....]
i) Rated Current		
ii) Location	....	[.....]
Whether CT are provided in Bus duct (if yes)	[.....] [.....]
i) Application		<i>{List out CT details wherever</i>

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Description	Unit	Design Parameters
CT parameters – CT Ratio & ii) Core iii) Accuracy class iv) Rated burden v) Knee point voltage vi) Magnetization Current		<i>applicable</i> }

D) **6.6 kV SEGREGATED PHASE BUS DUCT**

[6.6 kV segregated phase bus duct is envisaged for connection between Unit Transformer to 6.6 kV unit switchgear, Station Transformer to 6.6 kV Station switchgear and Tie between 6.6 kV Unit and Station switchgear. The design parameters of 6.6 kV segregated phase bus duct are furnished below:].

Description	Unit	Design Parameters
Make/Manufacturer	....	[.....]
Type of Bus Duct	....	[.....] {SPBD}
Type of Cooling	....	[.....]
System Voltage	kV	[...6.6....]
Rated Voltage of Bus duct	kV	[...7.2....]
Rated frequency	Hz	[.....]
Current Rating- Continuous i) UT to 6.6 kV unit switchgear ii) ST to 6.6 kV station switchgear iii) Tie between 6.6 kV Unit and Station Switchgear	Amp	[.....] [.....] [.....]
Current Rating- Short Time i) UT to 6.6 kV unit switchgear ii) ST to 6.6 kV station switchgear	kAmp	[.....] [.....]

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Description	Unit	Design Parameters
iii) Tie between 6.6 kV Unit and Station Switchgear		
Dynamic withstand Rating		[.....]
i) UT to 6.6 kV unit switchgear	kA _{peak}	[.....]
ii) ST to 6.6 kV station switchgear		
iii) Tie between 6.6 kV Unit and Station Switchgear		
Basic impulse withstand level	kV _{peak}	[.....]
One minute power frequency withstand voltage	kV	[.....]
Phase to phase spacing	mm	[.....]
Phase to Earth spacing	mm	[.....]
Bus Conductor		
Material and Grade	....	[.....]
Shape and dimension	....	[.....]
Cross sectional area	Sqmm	[.....]
Method of joining adjacent sections		[.....]
Resistance per phase at 20 deg.C	Ohms	[.....]
Bus Enclosure		{List out for main and tap off}
Material and Grade	....	[.....]
Shape and dimension	....	[.....]
Diameter and thickness	mm	[.....]
Cross Sectional area	Sqmm	[.....]
Method of joining adjacent sections	[.....]

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Description	Unit	Design Parameters
Material of Phase Barrier	[.....]
Resistance/metre/Phase at 20°C for bus duct	Ohm/m/ph	[.....]
Inductive reactance/metre/phase at 20°C for bus duct	Ohm/m/ph	[.....]
Capacitive reactance/metre/phase at 20°C for bus duct	Ohm/m/ph	[.....]
Length of Bus duct	meter	[.....]
i) UT to 6.6 kV unit switchgear		[.....]
ii) ST to 6.6 kV station switchgear		[.....]
iii) Tie between 6.6 kV Unit and Station switchgear		[.....]
Maximum temperature rise of conductor over 50°C ambient	deg C	[.....]
Maximum temperature rise of enclosure over 50°C ambient	deg C	[.....]
Power Loss		
Power loss in bus conductor @ rated current	kW/ ph/meter.	[.....]
Power loss in bus enclosure @ rated current	kW/ ph/meter.	[.....]
Total power loss as per length of bus duct	kW	[.....]
Insulator and seal of bushing		
Manufacturer	[.....]
Type of Insulator	[.....]
Rated Voltage Class	kV	[.....]
One Minute Power frequency	kV	[.....]

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Description	Unit	Design Parameters
withstand Voltage		
Impulse withstand Voltage	kV (Peak)	[.....]
Bus Duct Space heating		
No of heaters	....	[.....]
Voltage and Wattage required	....	[.....]
Sun shade Provided	Yes/No	[.....]
Paint Shade of Bus duct	....	[.....]
Disconnecting Link	....	[.....]
iii) Rated Current		[.....]
iv) Location		

E) 415 V NON SEGREGATED BUS DUCT(NSPBD)

[The 415 V Non Segregated Bus Duct (NSPBD) which connects LV Transformer to 415 V switchgears of TG and its Auxiliaries packages. The design parameters of the 415V NSPBD are furnished below:

Description	Units	Design Parameters
Make/Manufacturer	....	[.....]
Type of bus duct	....	[.....]
Rated voltage and No. of phase	V	[.....]
Material of Bus bar and Enclosure	....	[.....]
Rated Current	A	[.....]
Designation (From and To)	....	[.....]
Type of cooling (NSPBD)	[.....]
Maximum temperature rise of conductor over 50oC ambient	deg C	[.....]

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Maximum temperature rise of enclosure over 50°C ambient	deg C	[.....]
One minute power frequency voltage withstand	kV (RMS)	[.....]
Continuous current rating at 50°C design ambient air temperature	A	[.....]
One second short circuit withstand rating	kA (RMS)	[.....]
Momentary short circuit withstand current	kA (Peak)	[.....]

F) 6.6 kV Switchgear

6.6 kV Switchgear is envisaged for feeding unit auxiliaries as well as station auxiliaries at {6.6} kV level. These 6.6 kV Unit and Station switchgear are connected to Unit Transformer and Station Transformer respectively through 6.6 kV segregated phase bus duct. Motors of rating greater than [160] kW is envisaged at these boards. And also provided power to Mechanical system of AHS, CHS, Intake Water system etc at this level. The design parameters of 6.6 kV switchgear are furnished below:.

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Rated voltage, phases & frequency	V, Hz	[.....]
System neutral earthing	....	[.....]
Maximum system voltage	V	[.....]
One minute power frequency Voltage	kV (rms)	[.....]
Impulse withstand voltage	kV (Peak)	[.....]
Continuous current rating of bus	[.....]

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Description	Units	Design Parameters
bars		
Short Circuit rating of Bus bar with duration	kA & sec	[.....]
Dynamic Withstand rating	kAp & sec	[.....]
Bus bar Material	Al/Cu	[.....]
Type- Fully Draw out/Fixed	....	[.....]
Maximum temperature of Bus Bars, dropper, connectors & contacts at continuous current rating under site reference ambient temperature	....	[.....]
Cable Entry	....	[.....]
Degree of Protection	....	[.....]
i) Bus bar		[.....]
ii) Others		
Thickness of steel	....	[.....]
i) Load bearing members		[.....]
ii) Non load bearing members	....
Paint Shade	....	[.....]

G) 415 V SWITCHGEAR/MCC

[415 V Switchgear/MCC is envisaged for feeding unit auxiliaries as well as station auxiliaries at {0.415} kV level. These 415V unit and station auxiliary switchgear are connected to its respective LV transformer through 415V Non Segregated Phase Bus Duct. Motors of rating less than and equal to [160] kW is

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envisaged at these 415 V switchgear. The design parameters of 415 switchgear are furnished below:].

Description	Units	Design Parameters
Make/Manufacturer	....	[.....]
Rated voltage, phases & frequency	V, Hz	[.....]
System neutral earthing	....	[.....]
Maximum system voltage	V	[.....]
One minute power frequency Voltage	....	[.....]
Continuous current rating of bus bars	....	[.....]
Short Circuit rating of Bus bar with duration	kA & sec	[.....]
Dynamic Withstand rating	kAp & sec	[.....]
Bus bar Material	Al/Cu	[.....]
Type- Fully Draw out/Fixed	....	[.....]
Maximum temperature of Bus Bars, dropper, connectors & contacts at continuous current rating under site reference ambient temperature	[.....]
Cable Entry	[.....]
Degree of Protection		
-Bus bar	[.....]
- Others	[.....]
Thickness of steel	[.....]

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Description	Units	Design Parameters
-Load bearing members	[.....]
-Non load bearing members		[.....]
Paint Shade	[.....]

H) LV TRANSFORMER (DRY/OIL) TYPE

[The LV Transformer is designed to cater 100% of Power plant auxiliary load of respective system like Boiler, Turbine, HVAC etc, with 2 x100% configuration is followed. The design parameters of the LV Transformer {Oil/Dry} type are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer	....	[.....]
Type	....	[Oil/Dry.....]
Duty	....	[..Continuous.....]
Transformer application	....	[..Service
Installation	....	[...Indoor/Outdoor.]
Insulation Class	....	[.....]
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap	[.....]
Rated frequency	Hz	[.....]
Winding connection and vector group		[.....]

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Description	Units	Design Parameters
System fault level	kA	[HV.....]; [LV.....]
Impulse withstand voltage / Power frequency withstand voltage of windings	kV(rms)/ kV(Peak)	[.....]
System earthing (a) HV (b) LV	....	[.....] [.....]
Type of tap changer	....	[.....]
Termination Details a) HV side b) LV side	....	[.....] [.....]
Maximum operating temperature for i) Oil(if applicable) ii) Winding	....	[.....] [.....]
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at a) Full load b) 75% load	%	[.....]
Noise Level		[.....]

I) MOTORS

[The design parameters of motors of TG and its Auxiliary package are furnished below:].

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Description	Units	Design Parameters
Make/Manufacturer	[.....]
Application	[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Frame Size	[.....]
Type of Cooling	[.....]
Installation	[.....]
Duty Type	[.....]
Load Factor	[.....]
Full load current	[.....]
Starting current & Starting PF	Times Normal current	[.....]
Winding connection	Star/Delta	[.....]
Full load speed	[.....]
Power factor and Efficiency	[.....]
Class of insulation and temperature rise	[.....]
Starting Duty	[.....]
Method of starting	[.....]
Main terminal box details	[.....]
Space Heater Details	[.....]
CT details if provided with differential	[.....]

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Description	Units	Design Parameters
protection		
RTD/BTD Details		[.....]

J) MOTORIZED ACTUATORS

[The design parameters of Motorized Actuators used for TG and its Auxiliary package are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer	....	[.....]
Application	....	[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Installation	....	[.....]
Duty Type	....	[.....]
Load Factor	....	[.....]
Type	....	[... Integral/Non Integral.....]
Class of Insulation	....	[.....]

K) VARIABLE FREQUENCY DRIVES (VFD) {If applicable}

[The design parameters of VFD used for TG and its Auxiliary package are furnished below]:

Description	Units	Design Parameters
Mains connection	[...]
Voltage and power range	[...]
Frequency	[...]
Power factor	[...]

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Description	Units	Design Parameters
Motor connection	[...]
Voltage	[...]
Frequency	[...]
Continuous loading capability (constant torque at design ambient temperature )	....	[...]
Overload capacity (at design ambient temperature )	....	[...]
Switching frequency Selectable	kHz	[...]
Acceleration time	Sec	[...]
Deceleration time	Sec	[...]
Speed control	....	[...]
Open loop	%	[...]
Closed loop	%	[...]
Torque control	....	[...]
Open loop	%	[...]
Closed loop	%	[...]
Programmable control connections	....	[...]
Two analog inputs	[...]
Voltage signal	[...]
Current signal	[...]
Potentiometer	[...]
Reference value	[...]

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Description	Units	Design Parameters
Maximum delay	ms	[....]
Resolution	%	[....]
Accuracy	%	[....]
Serial communication EIA-485	....	[....]

L) 220 V DC SYSTEM

[The 220 V DC system covered in TG package will be provided with 2 x100% battery with Battery Charger. This 220 V DC system will comprise of DC load requirement of Boiler, TG package and other mechanical system packages except CHS, Intake Water System. The design parameters of the 220 V DC system comprising of Battery and Battery Charger are furnished below:

Description	Units	Design Parameters
BATTERY		
Make/Manufacturer	....	[.....]
DC System Voltage	V	[220V.....]
Battery Type	....
AH Rating/Rated Capacity	AH	
Number of cells	....
End Cell Voltage	V	
Expected fault level at bus due to battery	kVA	
AH Efficiency at Rated load	%	
BATTERY CHARGER		
Make/Manufacturer	[.....]

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Description	Units	Design Parameters
Type of Battery Charger	[...Float & boost/Float cum Boost.....]
Battery Charger Rating	Amp	
AC Input Voltage , Phase , Frequency	V,Hz	
Short Circuit Level	kA/Sec	
Efficiency of Charger	%	
Guaranteed Efficiency	....
a) At 50% load	%	
b)At rated load	%	
Power Factor	....
a) At 50% load	....
b)At rated load	....
Description	Units	Design Parameters

M) HV CABLES

[The HV cables of 6.6kV UE Voltage grade is used for feeding HV motors as well as LV Transformers and feeding other mechanical packages like CHS , AHS, HVAC , Water system etc. The design parameters of the HV Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer	....	[.....]
Voltage Grade	[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]

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Description	Units	Design Parameters
System Neutral Earthing	[.....]
No. of Cores	[.....]
Conductor Material	[.....]
Conductor (stranded/solid)	[.....]
Conductor Screen	[.....]
Insulation	[.....]
Insulation Screen	[.....]
Inner Sheath	[.....]
Outer Sheath	[.....]
Armoured/Unarmoured	[.....]
Material of cable drum	[.....]
Type of End Sealing	[.....]

G) **LV CABLES**

[The LV cables of 1.1kV Voltage grade are used for feeding LV motors as well as for sub distribution system boards. The design parameters of the LV Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer	....	[.....]
Voltage Grade	....	[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing	[.....]
No. of Cores	[.....]

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Description	Units	Design Parameters
Conductor Material	[.....]
Conductor (stranded/solid)	[.....]
Conductor Screen	[.....]
Insulation	[.....]
Insulation Screen	[.....]
Inner Sheath	[.....]
Outer Sheath	[.....]
Armoured/Unarmoured	[.....]
Material of cable drum	[.....]
Type of End Sealing	[.....]

N) CONTROL (CORE) CABLES

[The Control cables of 1.1kV Voltage grade are used for Protection, CT, VT connection and feedback/interlock signals. The design parameters of the LV Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer	....	[.....]
Voltage Grade	....	[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing	[.....]
No. of Cores	[.....]
Conductor Material	[.....]
Conductor (stranded/solid)	[.....]

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Description	Units	Design Parameters
Conductor Screen	[.....]
Insulation	[.....]
Insulation Screen	[.....]
Inner Sheath	[.....]
Outer Sheath	[.....]
Armoured/Unarmoured	[.....]
Material of cable drum	[.....]
Type of End Sealing	[.....]

O) ILLUMINATION SYSTEM

[The illumination system is categorized mainly as Normal, Emergency and DC lighting. The illumination system requirement of TG area and its boundary, perimeter and road lighting within TG area battery limit is covered in this specification. Other areas like Boiler area, Balance of plant, Ash Handling Plant and Coal Handling Plant are covered in respective package itself. Lighting Distribution Board (LDB) is normally getting supply from 415V PMCC. Each LDB is provided with lighting transformer for isolation of lighting circuit from power circuit and also for limiting short time current rating. Outgoing circuits of LDB will feed Lighting panels which is placed local to fixtures. It is envisaged that separate LDB for indoor as well as for outdoor area will be provided. Emergency Lighting system is same as normal system however it will get supply from Emergency 415V PMCC backed up with DG set. The Design parameters of Illumination System and its major components comprising of LDB with transformer, Lighting Panel, Lighting Fixtures, Lighting wires and Lighting Poles are furnished below]:

Description	Units	Design Parameters
Lighting System:		
Voltage		
a) AC system		

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Description	Units	Design Parameters
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
b) 220 V DC system		
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
One Minute Withstand Voltage	V	[.....]
System Short-Circuit Level		
a) 415V AC	kA(rms)	[.....]
b) 220V DC	kA(DC)	[.....]
LDB/LP:		
Manufacturer Name	....	[.....]
Mounting		
a) LDB	....	[...Floor.....]
b) LP	....	[...Wall.....]
Installation	....	[.....](For each application ie for Indoor/Outdoor and area)
Type, No of Circuits/Feeder rating	....	[.....]
Lighting Transformer:		
Make of Transformer	[.....]
Type of Transformer	[Dry]
Rating	kVA	[.....]
Voltage Ratio	[.....]

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Description	Units	Design Parameters
Impedance	%	[.....]
Lighting Wires:		
Make	[.....]
Voltage Grade	V	[.....]
Conductor Material	Cu/Al	[.....]
Size	Sq.mm	[.....]
Lighting Fixtures:		
Make	....	[.....]
Type of Luminaries	....	[.....]
Ballast Type	....	[.....]
Lighting Poles:		
Make	....	[.....]
Type of Poles	....	[.....]

P) CABLE CARRIER SYSTEM

[The Cable Carrier system is described as below: Indoor Buildings are provided with Cable cellar/Trench and outdoor areas are provided with Pipe cum cable rack/Duct bank/Trench. Separate Tray is envisaged for HV cables. LV cables, Control cables and Instrumentation cables in the order that HV cables Tray at the top followed by LV, Control and Instrumentation Tray. Ladder type tray is used for HV, LV and Control cables, however Perforated Tray to be used for Instrumentation cables. The Cable carrier system other than TG area battery limit is covered in respective packages. The Design parameters of Cable Carrier System are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer	[.....]
Size of Tray	mm	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Description	Units	Design Parameters
Material	[.....]
Application	[.....] (i.e. HV/LV/Control/Inst.)
Type of Tray	....	[.....] (i.e.Ladder/Perforated)
Thickness of Tray	mm	[.....]
Thickness of Galvanization	mm	[.....]
Tray Cover Size	mm	[.....]
Cable Tray Accessories		
Tee	mm	[.....] {List out all size}
Cross	mm	[.....]{List out all size}
Bends	Deg	[.....]{List out all size}
Reducer	mm	[.....] to [.....]{List out all size}
Steel Supports		
a) ISMC	mm	[.....]{List out all size}
b) ISA	mm	[.....]{List out all size}

Q) EARTHING AND LIGHTNING PROTECTION SYSTEM

[The Earthing & Lightning System of TG package is described as below: In this specification above ground earthing and lightning protection system is covered in bidder's scope of work. Connection to main earth grid riser and electrode is covered in other packages. The Design parameters of Earthing and Lightning Protection System are furnished below]:

Description	Units	Design Parameters
-------------	-------	-------------------

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Description	Units	Design Parameters
Earthing System:		
Make/Manufacturer	[.....]
Main Earthing Conductor		
a) Material	....	[.....]
b) Dia	....	[.....]
Treated Earth Pit/Earth Rod(Dia and Length)	mm & m	[.....]
Size of Earth Conductor		[.....]{List out size of Flat Earth conductor used for different equipments of Power plant and no of points }
a) 6.6kV Switchgear	mm x mm	
b) 415 V Switchgear		
c) HV Motors		
d) LV Motors {List out KW rating wise}		
e) Control panel, LPBS Etc.		
f) Transformer Body		
g) Transformer Neutral List out Transformer wise}		
h) Any other panel/Equipments		
Lightning System:		
Air Termination Rod		
a) Dia & Length	[.....]
b) Material	[.....]

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Description	Units	Design Parameters
Down comer		
a) Material	[.....]
b) Size	[.....]
Lightning Electrode with test link		
a) Material	[.....]
b) Dimension(Length and Dia)	[.....]

3.2.3 Control & Instrumentation

[The existing control and instrumentation system generally is an old analogue based system and requires large scale replacement owing to obsolescence of the existing equipment. Integrated microprocessor based closed loop control, open loop control, sequential control and bulk data acquisition system for TG & auxiliaries, station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level are therefore to be envisaged for the plant. DCS & other common system/items, if applicable and procured by Owner separately shall not be considered under TG package.]

3.2.4 Civil Works

Bidder shall go through the details of the existing Buildings / Structures / Foundations / Facilities mentioned hereunder (but not limited to) for the thorough understanding of conditions of the same. In order to assess the quantum of Civil / Structural / Architectural R&M work within the package, Bidder shall also carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions at site and identification of modification requirements in any other structure or foundation not included here. Conditional details of important buildings / structures / foundations / facilities which require major modifications have been described below:

{Details of the existing buildings / structures and their foundations in the Turbine Generator area like TG Building, deaerator bay, bunker bay, condenser pit,

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central control building, DG building, A/C plant building, TG foundations, BFP foundation etc. shall be indicated in this section. Also the available GA/Construction Drawing including Load Data shall also be provided.}

Turbine Generator Area

[..x200 MW units have been placed side by side. Centre to centre placing of units is [.... m.] The railway entry has been provided from the rear side of Power House Building. Turbine Generator (TG) Sets have been placed between AB rows of columns are laid out longitudinally. The TG bay, also houses, the Boiler Feed Pumps, Regenerative Heaters, Lube Oil System and other TG accessories. The total length of TG bay for ...x210 MW units is [.... m] and width [.... m]. The spacing of the column is at [..... m]. TG bay is provided with ... Nos. of overhead EOT Cranes. In order to make the handling facilities of the cranes available to the heat exchangers, boiler feed pumps and other equipment, removable chequered plates have been provided at appropriate locations.

A sub zero floor has been avoided except for the localized pits required for Condensate Pump, pipe channels and HP Heaters etc. This sub zero pits are suitably connected and provided with a common sump for drainage purposes.

Three stairs for approaching the operating floor level at [+..... m] have been provided in this bay adjacent to B row columns. In addition, there are stairs for providing access to various equipment at intermediate platforms and sub zero pits.

Switchgear and Control Room bay has been provided in the BC bay which is [.... m] wide. The length of the bay is [..... m]. A common Control Room for all the three units is provided at [..... m] floor. In BC bay at [... m] elevation, equipment for chemical dosing, air handling and MCC for soot blowers etc have been located. The deaerator is placed at an elevation of [.... m]. Air washer units and cooling water tanks are also located at [..... m] floor.

Mill Bunker Bay, designated as CD bay, has a span of [.... m] which accommodates coal bunkers, coal feeders and coal mills. CD bay houses the vertical mills at Zero m and has space for collection of disposal of mill rejects at sub zero levels adjacent to 'D' row. A stair to connect operating floor at [..... & m] of BC & CD bay has been provided.]

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4 SCOPE OF SUPPLY & SERVICES

4.1 The scope of supply and services to be provided by the Bidder shall include all such activities as required to meet the target and intent of this Specification. The scope for each unit shall generally cover, but will not be limited to the following:

- (i) Replacement of some of the existing components with new components of improved and better design.
- (ii) Incorporation of new systems / components wherever required in line with the Specification.
- (iii) Refurbishing / Retrofitting of some of the components in the existing equipment/system.
- (iv) Modification of layouts, wherever requires for Replacement/ Refurbishing / Retrofitting of new Equipment/Components.

All types of civil/structural works like modification and strengthening of foundation of existing and upgraded equipment, making new structures or foundations (if applicable), dismantling, restoration, supply and erection of any temporary supports or any other construction work required for implementation of renovation work.

All structural modifications/strengthening of existing structure of building , Turbo Generator, Condenser, Deaerator, Boiler Feed Pump, Condensate Extraction Pump, Heaters, modification of pipe supports etc. including supply, fabrication and erection of any new structure and provision of any additional platform if required for access to new equipment or existing equipment as specified.

Supply of all materials, equipments, machinery and manpower required for civil/structural R&M works.

Site enabling works as per the requirements to support civil/structural R&M works.

- (v) Design, engineering, submission of design calculations for review and approval, manufacturing, inspection and testing at suppliers' works, packing, forwarding to site, unloading, erection, supervision, pre-commissioning, testing and commissioning and performance testing of the equipment / system and works indicated in clause No. 4.6 of this technical Specification.
- (vi) Mandatory spares, start-up and commissioning spares. The general requirements in respect of various types of spares are given in Clause 9 of this section of Technical Specification.
- (vii) Packing, transportation and transit insurance of all materials required for renovation / replacement work as per this Specification from the supplier's/sub supplier's works to [Name of the Plant], unloading, preservation and storage at site. Packing, transportation, transit insurance, clearance from all concerned agencies etc. of all components/materials required to be forwarded from [Name of the Plant] to Bidder's facilities and back to [Name of the Plant].

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- (viii) Dismantling of the systems, handling and storage of dismantled equipment, reassembly and re-erection / reinstallation along with associated inspection, testing, commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.
- (ix) Materials which are removed from the existing machines but are not re-used during the re-assembly of the machines as well as those components which are found to be beyond refurbishment shall be the property of Owner and shall be deposited at Owner's designated stores. Bidder shall prepare a record of all such dismantled material and hand it over to the Owner.
- (x) Loading, transportation, unloading and disposal of scrap to the designated storage/disposal yard.
- (xi) It shall be responsibility of the Bidder to obtain on behalf of the Owner the necessary approvals of Inspection Authority / Chief Inspector as may be required for design and design calculations, manufacturing, erection procedure repairing / servicing and renovation. Bidder shall also be responsible for obtaining approval from the other statutory authorities in India, as may be required, for other plants and systems supplied by him. All such documentation submitted to statutory authorities shall also be submitted to the Owner for his review.

Handling of materials at site including handling / transportation as required to take equipment components to the workshop for carrying out the modification work and to bring it back for installation. All arrangement for such activities is to be done by the Bidder.
- (xii) Erection of all material supplied new for renovation (including erection of components, replacing old components). Re-erection of any component / equipment removed for modification so as to make complete unit consisting of Turbo Generator and related auxiliaries including electrical & control and instrumentation equipment /system ready for commissioning.
- (xiii) All gas cutting / dismantling, edge preparation, welding, bolting etc. and conductance of all NDTs like radiography, ultrasonic testing, MPI, die penetration testing etc. Any new matching pieces, piping, hangers & supports etc. required for assembly of equipment/ systems, as per system requirements shall also be included in the scope of the Bidder.
- (xiv) All Pre-commissioning activities as may be required such as hydraulic testing, air & gas tightness test, steam blowing, floating of safety valves, oil flushing etc. including erection and dismantling of all temporary systems like piping / tanks etc. and Conductance of all demonstration tests including performance test.
- (xv) Assisting and coordinating with Owner in tuning various control loops finalizing protection and control requirements of all Turbo Generator & auxiliaries.
- (xvi) Insurance for all items / activities in line with the provisions of General Condition of Contract as specified in Volume-I of this Technical Specification.

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- (xvii) Civil / Mechanical work (such as grouting, cutting, welding etc.) related to mounting of New Cabinets, CRT / Keyboards, laying & termination of associated Cables.
- (xviii) Supply of all necessary tools, tackles, commissioning spares, test instruments and deputing of experienced personnel for completion of the above erection, testing and commissioning work.
- (xix) Dismantling of existing C&I cabinets along with associated cabling, for Turbo Generator & Auxiliaries related to the unit for retrofitting the new C&I systems, based on requirement as described in clause No. 4.6.
- (xx) Providing all site execution and supervision by qualified and experienced engineering personnel during execution of all works under the scope of Bidder. Also providing all facilities and qualified personnel for implementing the approved quality assurance programme.
- (xxi) Dismantling of the existing Instrumentation Cables and relaying of new cables as may be required.
- (xxii) The Bidder shall conduct all shop and site tests as per the requirements of this specification and Owner approved "Quality Assurance Program" to be finalised before the award of this Contract. Facilitating inspection, witness of shop and site tests by the representatives of Owner shall be in the scope of the Bidder.
- (xxiii) Performance Guarantee tests after successful completion of initial operation.
- (xxiv) Construction Water
[Construction water shall be made available to Bidder at a single point in a suitable location. The Bidder shall arrange at his own cost the required pumps, distribution pipe line network for further distribution as required to carry out construction work.]
- (xxv) Construction Power
[Construction power shall be made available to bidder at single point at [....] kV level. Further distribution as required to carry out the construction work shall be carried out by Bidder at his own cost.]
- (xxvi) Providing all other services necessary for meeting the intent and requirement of this Specification. This shall include but not limited to system engineering, furnishing drawings, data, information for owner's review, participation in meeting & reviews, System warranty, revision of O&M Manuals etc.

4.2 Tools & Tackles

One (1) set of special tools and tackles required for the maintenance of equipment/systems have to be supplied by the Bidder. These tools and tackles shall be separately packed and brought to site. These shall not be used for erection/commissioning purposes and shall be in an unused and new condition,

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when they are handed over to the Owner. A list of all such special tools and tackles shall be submitted along with the offer.

For C&I system, Bidder shall supply one set for each unit of special non standard tools, module testing kit, cables, and any other equipment required for erection commissioning, testing, trouble shooting, calibration, maintenance and inspection of all systems / equipment provided. Any tools required to make changes (DIP shunt cutter, soldering irons, tips, wire wrap guns and bit unwrapping tools, strippers, terminal guard, connector repair tool, dies etc.) shall also be supplied.

Bidder's scope shall also include supply of all Cranes, welding sets and NDT testing equipment, scaffolding, special tools and tackles, jigs and fixtures as may be required during modification / erection and commissioning. Those items specifically brought to site solely for erection / modification purpose and if no more needed for regular maintenance of the equipment, can however, be taken back by the Bidder after completion of the work at site, subject to the approval of Owner.

4.3 Safety

4.3.1 The design of the equipment shall incorporate every reasonable precaution and provision for the safety of all personnel and for the safety and security of all persons and property. The design shall comply with all appropriate statutory regulations relating to safety.

Newly constructed structures and equipment shall be designed and constructed to withstand every foreseeable static and dynamic loading condition, including loading under earthquake conditions, with an adequate margin of safety.

Ready and safe access with clear head room shall be provided to all the newly supplied parts of the plant for operation, inspection, cleaning and maintenance.

4.3.2 While carrying out the R&M work as per this Specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items/ equipment supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipment / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipment / foundations / structure and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

4.4 Training Requirements

Bidder shall include in his offer the training programme for Owner's Operation & Maintenance staff in view of introduction of new systems/ equipment. This training shall be organized before handing over the unit.

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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4.5 In case there is any difference in scope of work and services as described in this section of the Specifications and individual Specification volumes, then more stringent of the Scope of work and services shall prevail.

4.6 Detail Scope of Work:

4.6.1 Steam Turbine & Its Auxiliary System

{Describe in this chapter, all the equipment/components which need to be replaced/refurbished/retrofitted as finalized in the DPR on the basis of RLA/CA and EA report. Scope with regard to Civil, structural and architectural work as required for the Power Plant due to incorporation of new equipment/components shall also be incorporated in this chapter.}

The Bidder shall include in his scope the following works for the R&M of the Unit, which are based on RLA/CA and EA studies. The overall scope of work shall include but shall not be limited to the scope of work mentioned below in Table 4.1. Any other items not specifically mentioned but considered necessary by the Bidder for carrying out the R&M work, shall also be included in his scope so as to meet the intended performance of Turbo Generator & Auxiliaries as specified in Clause No. 1.1

TABLE: 4.1

Equipment	Scope of Work	Quantity
[Steam Turbine]		
[LP Turbine Retrofit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HP Turbine Retrofit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[IP Turbine Retrofit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Turbine Governing]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[System]	[.....]	[.....]
	[.....]	[.....]
[Emergency Stop Valve Assemblies]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[IP Stop Valve Assemblies]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Main Steam Control Valve Assemblies]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Reheat Steam Control Valve Assemblies]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearing & Pedestals]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lube Oil System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Control Oil System]	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Seal Oil System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Turbine Gland Steam Sealing System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Condenser]		
[Condenser Tubes]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any Other Component of Condenser]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Condenser On load Tube Cleaning System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Condenser Air Evacuation System]		
[Starting Ejector]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Main Ejector]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Vacuum Pump, If Applicable]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Other Cycle Equipment]		
[Condensate Extraction Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Deaerator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Boiler Feed Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[LP Heaters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HP Heaters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment		Scope of Work					Quantity
		[.....]					[.....]
[HP Turbine Bypass Valve]		[.....]					[.....]
		[.....]					[.....]
		[.....]					[.....]
[LP Turbine Bypass Valve]		[.....]					[.....]
		[.....]					[.....]
		[.....]					[.....]
[DMCW System, As Applicable]							
[Plate Type Heat Exchanger (PHE)]							
[HP & LP Piping]							
Tag No.	Description	Fluid	Size	Schedule / Thickness	Class	Material	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Motorized Valves]							
Tag	Service	Size/	Class	End	Travel	Drg. No.	Qty

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Equipment		Scope of Work				Quantity	
No.	Description	Type		Conn.	time		
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Manually Operated Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Drg. No.	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Non Return Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Drg. No.	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Relief Valve]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Drg. No.	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Electric Actuator for Valve]							

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Equipment		Scope of Work		Quantity	
Tag No.	Description & Service	Torque (Nm)	Wattage (W)	Qty	
[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	
[Control Valve]		[.....]	[.....]		
		[.....]	[.....]		
		[.....]	[.....]		
[Insulation & Cladding]		[.....]	[.....]		
		[.....]	[.....]		
		[.....]	[.....]		
[Replacement and Retrofitting of Pipe Hangers]		[.....]	[.....]		
		[.....]	[.....]		
		[.....]	[.....]		
[Equipment Cooling Water System]		[.....]	[.....]		
		[.....]	[.....]		
		[.....]	[.....]		
Electrical System					
[Generator and accessories]					
[Generator Stator]		[.....]		[.....]	

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Generator Rotor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Generator Cooling Water System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Hydrogen Coolers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Excitation system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Neutral Grounding cubicle]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Generator Protection and Metering Panel]		
[Relays]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Meters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other components]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Isolated phase bus duct]		
[Conductor & Enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bellow]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Insulator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Seal off Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other components]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[6.6 kV Segregated Phase Bus Duct]		
[Conductor & Enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Insulator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Insulator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Seal off bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other components]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[415 V NSPBD]		
[.....]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[6.6kV Switchgear]		
[Breaker]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Relays]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Meters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT and VT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other components]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[415 V Switchgear (PMCC/MCC)]		
[Breaker]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[MCCB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Relays]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Meters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT & VT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other Equipment]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HV motors]		
[.....]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[LV motors]		
[.....]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motorized Actuators]		
[.....]	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Variable Frequency drive]		
[.....]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[LV Transformers(oil/dry type)]		
[.....]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[220 V DC System]		
[Battery Charger]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Battery]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[220V DCDB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HV Cables]		
[.....]	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[LV Cables]		
[.....]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Control Cables]		
[.....]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Illumination system]		
[LDB with Lighting Transformer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting Panel]		
[LDB with Lighting Transformer] [Lighting Fixtures]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting Panel] [Lighting Poles]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting Fixtures] [Wires, Conduits,	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Junction box]	[.....]	[.....]
[Lighting Poles]	[.....]	[.....]
[MCCB/MCB/ELCB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Wires, Conduits, Junction box] [Any other equipment]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[MCCB/MCB/ELCB] [Cable Carrier System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Cable Tray]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Accessories like Tee, Cross, Couplers, Bends etc.]		
[Cable Tray] [Structural members like ISMC/ISA etc.]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Accessories like Tee, Cross, Couplers, Bends etc.] [Any other Equipment]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Structural members]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
like ISMC/ISA etc.]	[.....]	[.....]
[Earthing & Lightning Protection System]	[.....]	[.....]
[Earthing Conductor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Earth Electrode(Rod/Treated]		
[Earthing Conductor]	[.....]	[.....]
[Air Termination Rod]	[.....]	[.....]
	[.....]	[.....]
[Earth Electrode(Rod/Treated]	[.....]	[.....]
	[.....]	[.....]
[Down Conductor]	[.....]	[.....]
[Air Termination Rod]	[.....]	[.....]
[Any other Equipment]	[.....]	[.....]
	[.....]	[.....]
[Down Conductor]	[.....]	[.....]
[Generator and accessories]	[.....]	[.....]
	[.....]	[.....]
[Generator Stator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
Control and Instrumentation System		
[Turbine Protection]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Turbine Controls – EHC]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Turbine –ATRS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Turbine Supervisory System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Automatic Turbine Testing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Turbine Stress Evaluator (TSE)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Gland Steam Pressure Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[BFP Scoop Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Deaerator level Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Deaerator Pressure Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Hot well level Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HP Heaters Level Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[LP heaters Level Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[BFP Recirculation valve]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Feed Water Control]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Valve]	[.....]	[.....]
	[.....]	[.....]
[Hydrogen Purity Measurement]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Hydrogen Leak Detector]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Generator Instrumentation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Station C&I (if applicable)		
[DCS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Station LAN]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Master Clock]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Panel Earthing /	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Grounding]	[.....]	[.....]
	[.....]	[.....]
[PLC System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Dosing System Instrumentation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[COLTCS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CMMS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[STMS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[SWAS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Machine Condition Monitoring System]	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Pressure / DP Gauges]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Temperature Gauges]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pressure / DP Switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Temperature Switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[RTD / TC 's]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Level Transmitters(DP Type, Displacer, Radar)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Flow Elements (Nozzle/Orifice)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Pressure & Differential Pressure Transmitters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Control Valves]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Impulse Pipeline & Instrument fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Instrumentation & Control Cabling]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Junction boxes/LIRs]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Time Synchronization System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other systems]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Civil & Structural Work		

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Equipment	Scope of Work	Quantity
[Turbo Generator Foundation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CEP Foundation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[BFP foundation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Heater Foundation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[TG Building including Deaerator and bunker bay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Central Control Building]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[DG Building]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any Other Civil &]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
Structural Work]	[.....]	[.....]
	[.....]	[.....]

4.6.2 Miscellaneous

- a. In addition to the above listed works, scope of civil / structural / architectural works and supplies shall be as detailed below.

Bidder shall be provided with the existing drawings and documents as listed in Annexure-I by the Owner to facilitate the civil / structural / architectural , refurbishment and replacement works.

Bidder shall carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions of the buildings, structures, foundations & facilities mentioned in this specification and identification of modification requirements in any other structure or foundation not included here.

Subsequently Bidder shall prepare and submit for approval by Owner, a detailed scheme including methods techniques, requirements etc. for carrying out civil/structural/architectural R&M works to executed in the plant.

- b. The scope of Civil / Structural / Architectural works to be carried out by the Bidder under this package shall generally cover the following:

- Inspection, checking the design adequacy and foundation analysis of the existing structure foundations like [turbine generator, boiler feed pump, heaters, TG building, control building, DG building etc.] for all the applicable loads and construction of new foundations / modification of existing, wherever required.
- Inspection and checking the design adequacy of existing structures [such as TG building, control building, DG building, pipe & cable racks etc.] for any corrosion/damage and rectification / strengthening of the same.
- Carrying out all interior / exterior architectural modification and replacement works [such as flooring, painting, plastering, door/windows, roof finishing, water proofing, sheet cladding, roof sheeting, new false ceiling, glass partitions, lighting works replacement or modification of AC duct where ever applicable] is also included in contractors scope. etc.
- Any other civil related work required in buildings / structures of the package from aesthetics ambience & ease of operation point of view.

In addition to this any other modification/alteration to existing nearby foundation/structural steel/concrete/underground pipes work if required for satisfactory execution of intended work covered under this specification shall be

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carried out by the Bidder. Supply of all material required for the above work is included in Bidder's scope.

c. Supplies for Civil/Structural Work

The Bidder shall supply all material needed for completion of all civil, structural and architectural works as per this specification. The Bidder's scope of supply generally includes but is not limited to the following:

- Supply of cement, steel (for reinforcement as well as for any other use), grout, admixture for RCC work, sand and all other construction/architectural / building materials as may be required for any repair/modification of existing civil works / foundation or for construction of new foundation / civil works.
- Supply of structural steel for all structural erection / modification / strengthening.
- Supply of all foundation bolts, and nuts base plates, embedments with lugs, miscellaneous steel where ever needed
- Supply of steel helical springs and viscous dampers for new equipment (if any).

d. Construction Enabling Works

[The owner shall provide the following facilities to the by Bidder to carry out the construction work.

- *Temporary Stores to store construction material.*
- *Fabrication Yard]*

e. Quality Control Laboratory

[To conduct acceptance test on all construction material, weldments, concrete cubes etc laboratory facilities if available in the existing unit shall be used. In case the laboratory facility is not available within the unit, Bidder shall get the testing at his own cost from a reputed test laboratory approved by the Owner.]

f. Construction Tools & Materials Supplied By the Bidder. The Bidder shall arrange adequate number and type of machinery and equipment for proper setting out and timely completion of the various works covered under the scope of the work. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expense.

The Bidder shall provide all fuels and lubricants required for the operation and maintenance of construction machinery and equipment as well as his transport vehicles at his own cost.

g. The Bidder shall furnish manufacturer's test certificate for all the manufactured items supplied by him. Representative specimens of the material shall also be submitted to the Owner and shall be tested at a recognised testing laboratory at the Bidder's cost in case Owner so desire.

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h. Work Execution and Supervision:

The Bidder shall have at the site accredited and qualified engineers and foremen / supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the works.

i. The Bidder shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner with full understanding of the importance of work for a R&M project of this magnitude.

j. In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accident. He shall also report such accidents to all the competent authorities wherever such reports are required by those authorities.

k. Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner is not in accordance with the specification / bid document.

l. During inclement weather, rain etc., the Bidder shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at the Bidder's cost and any damage to works shall be made good by the Bidder at his own expense.

m. Safety of Adjacent Plant/Equipment and Civil Structure

While carrying out the R&M work as per this specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items / equipments supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipments / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipments / foundations / structures and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

4.6.3 Spares

All spares as specified in Annexure-II of this Specification in accordance with Clause No. 9.

4.6.4 Consumable, Oil & Lubricants

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All the first fill and consumables such as greases, oil, lubricants, servo fluids/control fluids, gases and essential chemicals etc. as required up to the complete commissioning of the Turbo Generator & Auxiliaries, are covered in the scope of Bidder. Suitable standard lubricants as available in India are preferable. Efforts should be made to limit the variety of lubricants to minimum.

4.6.5 Embedded Parts & Fixture

All fixtures, embedded parts, steel embedment including fixing lugs and welding between them, foundation plates, grouting, nuts, bolts etc. for fixing all the equipment, piping on civil works shall be included in scope work of this package. All structures which would be required by the Bidder for supporting the piping shall also be included in scope of work of this package.

4.6.6 Other Services

The scope of Erection, Commissioning and Testing shall include the following:

- a) Complete pre-commissioning work including tests of facilities such as line flushing, hydraulic testing of various pressure parts, chemical cleaning, steam blowing, etc. and all other tests as mutually agreed in the Bidder's quality assurance programme as well as those identified in the Specification.
- b) Supply of all consumables (except coal and fuel oil for firing) like chemicals for chemical cleaning, passivation, inhibition etc., oil for line flushing, nitrogen for blanketing, consumables for air/gas tightness tests and any other consumable as required for above pre-commissioning/ commissioning activities.
- c) Necessary arrangement as requires for the start up of Turbo Generator & Auxiliaries. However, Owner will arrange start up power, instrument & service air and DM water as required for the star up purpose of the Turbo Generator & Auxiliaries system.
- d) Supply of all temporary equipment such as tanks, piping, including supports, valves, nitrogen blanketing equipment including nitrogen cylinders, pumps and all necessary instrumentation for successful conductance of pre-commissioning and commissioning activities. All temporary equipment and instruments shall be clearly listed out in the Bid.
- e) Providing safety barricades and signage during dismantling, erection and testing etc.
- f) Supply of all labour, skilled/semi skilled supervisors, engineers and any other manpower.
- g) All the erection materials and consumables like shims, welding rods, soldering and brazing alloys, industrial gases insulating tapes, compounds, chemicals etc. required for the erection and commissioning works.

Note: The temporary equipment specifically brought by the Bidder solely for the pre-commissioning and commissioning work shall, on completion of these activities, remain the property of the Bidder. Nitrogen blanketing equipment

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including nitrogen cylinders shall get included in the Bidder's permanent scope of supply and become property of the Owner.

The selection of material of all the temporary equipment/instruments shall be compatible with the service conditions expected during pre-commissioning/commissioning activities.

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5 TERMINAL POINTS & EXCLUSIONS

5.1 Terminal Points

[For all terminal points, scope of this contract shall include supply of matching flanges, gaskets, bolts, nuts etc and including any isolation valve. Terminal Points mean Engineering, Procurement and Erection in entirety. The terminal points of the complete package to be supplied shall be as follows.

(i) Mechanical

- (a) *Main Steam: Inlet of Main Steam Stop Valve at Turbine hall*
- (b) *Cold Reheat: Outlet of HP turbine*
- (c) *Hot Reheat: Inlet of Reheat Steam Stop Valve.*
- (d) *Feed Water: At Economiser Inlet*
- (e) *Turbine Bypass Piping: HP Turbine Bypass valve inlet & Outlet and LP turbine bypass valve inlet & outlet.*
- (f) *Condenser Cooling Water System (CW system):*
[CW Inlet Header near A row of TG Building at : Deg N, Deg E
CW Outlet Header near A row of TG Building at : Deg N, Deg E]
Exact elevation of the pipe shall be furnished during detail engineering.
- (g) *ACW System:*
[ACW Inlet Header near A row of TG Building at : Deg N, Deg E
ACW Outlet Header near A row of TG Building at : Deg N, Deg E]
- (h) *DM water make up to Condensate Storage Tank:*
[Bidder shall terminate the DM water lines at the inlet to the flow meter(s) to the Condensate Storage Tanks (CSTs). at Deg N, Deg E]
- (i) *Service Water:*
[One no. stub connection with isolation valve shall be provided on service water supply header Near C row at 4m elevation for TG Building atDeg N, .Deg E].
- (j) *[Drinking Water*
One no. Stub connection with isolation valve shall be provided on potable water supply header near C row at 4m elevation for TG Building at Deg N,.. Deg E].
- (k) *[Compressed (Service & Instrument air System) Air System*
Service Air Header near A row of TG Building at : Deg N, Deg E
Instrument Air Header near A row of TG Building at : Deg N, Deg E]

(ii) Electrical

The terminal points for the electrical equipment under TG package shall be as below:

- (a) *Isolated Phase Bus Duct: LV terminals of generator transformers and HV terminals of Unit transformers. Termination of Bus duct on Unit Transformer is in the scope of bidder.*

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- (b) 6.6 kV Segregated Phase Bus Duct: LV terminals of Unit transformers and Station Transformers. Termination of Bus duct on Unit/Station Transformer is in the scope of bidder.
- (c) 6.6 kV Power Supply to SG Package: At the terminal of 6.6kV Unit Switchgears for power supply to transformers and HV Motors of SG Package. All Power and control cables up to terminals of 6.6 kV Unit Switchgears and termination is included in the scope of SG package-1.
- (d) 6.6 kV Power Supply to CW Pump Motors: At the terminal of 6.6 kV Unit switchgears. All Power and control cables up to terminals and Termination at 6.6 kV Unit Switchgear are included in the scope of BOP package
- (e) 6.6 kV Power Supply to BOP Package: At the terminal of 6.6 kV Station / Unit switchgear for power supply to numerous load centers of BOP package and BOP motor loads. All Power and control cables up to terminals of 6.6 kV Station / Unit Switchgear and termination are included in the scope of BOP package
- (f) 220 V DC Power Supply to SG Package: At the outgoing terminals of Unit DCDB. Power Cables interconnection between Unit DCDB to the DCDB of SG package and termination is included in scope of SG Package.
- (g) Power Supply to Boiler MCC, Boiler Valve MCC, Soot Blower MCC: Power supply at 415V level at the outgoing terminals of 415 V Unit Switchgear / 415 V Emergency PMCC. All cables from the above terminal points and termination are included in the scope of SG package.
- (h) Power Supply to BOP MCCs: Power supply at 415V level at the outgoing terminals of 415 V Unit Service Switchgear / 415 V Station Switchgear/ MCC/ 415 V Emergency PMCC. All cables from the above terminal points and Termination are included in the scope of BOP package.
- (i) Power Supply to Illumination System of SG area: Power supply at 415V level at the outgoing terminals of 415 V Lighting Service Switchgear. All cables from the above terminal points and Termination are included in the scope of SG package.
- (j) Power Supply to Welding System of SG area: Power supply at 415V level at the outgoing terminals of 415 V Welding Service Switchgear. All cables from the above terminal points are included in the scope of SG package.
- (k) Earthing and Lightning Protection System: All above Ground earthing is in the scope of bidder. Terminal point is Riser at 300mm above FGL provided by others. Connection to Equipments of TG package and to riser is in the scope of bidder. Building with more than one floor, all the floor other than ground floor will be provided with periphery earth conductor for connecting to equipment, and intermediate floor will be connected by earth conductor at four corner of the building is included in the scope of bidder. Terminal point for Lightning system is bring the down conductor at 0.3m above FGL. Risers will be provided by others at 300m above FGL Terminal point for connection to below ground is 0.3m above FGL. Bidder Grounding for Steam Turbine Generator (TG) Island and including Main Under Ground Grounding Grid for TG Island & transformer yard and grounding connection to all equipment included in scope of TG package. Under Ground Grounding Grid shall be connected to Grounding Grid of SG package at least at four (4) points and nearby BOP Package at least at 2 points at each side.

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- (l) For the inputs required by TG package contractor from other packages, the required auxiliary relays, control cables including their laying & termination shall be in the scope of other package contractor. Similarly, necessary contacts required by other package contractors shall be provided by this package bidder.

(iii) Control & Instrumentation

- (a) Inst. & Control Cabling: Up to ATRS/ATT/ Turbine protection/ TSI panel for TG integral control systems and for rest upto DDCMIS Panels Terminal Block.
- (b) Field Instruments: Up to Economiser Inlet and Boiler steam lines (MS, CRH & HRH)

5.2 Exclusions

- (a) Boiler & Its Auxiliary Equipment including Coal Mills, Coal Feeders, Primary Air fans, Forced Draft fans, Induced Draft fans, Electro Static Precipitator, Main stem piping, Cold reheat piping, Hot reheat piping, Auxiliary Steam System
- (b) HP/LP turbine Bypass piping: Entire upstream and downstream steam piping of HPTB Valve. Entire upstream and downstream steam piping of LPTB Valve.
- (c) Plant Water System including DM plant. However; CW, ACW, DM water, potable water & service water piping, valves, fittings etc. within terminal point is under the scope of Bidder.
- (d) Air Conditioning & Ventilation System
- (e) Compressed Air System, However; service and instrument air piping, valves, fittings etc. within terminal point is under the scope of Bidder.
- (f) 400kV and 220kV switchyard.
- (g) Generator Transformer (GT).
- (h) Unit Transformer (UT).
- (i) Station Transformer (ST).
- (j) Boiler and BOP switchgear, cables, interconnection and other system.
- (k) Interplant earthing, cabling and lighting system work.
- (l) Plant communication system.
- (m) Any other equipment/system which not in battery limit of TG package.
- (n) Boiler Integral Controls]

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6 GENERAL TECHNICAL REQUIREMENTS

6.1 Codes & Standards

6.1.1 Apart from some specific application, the proposed R&M equipment shall comply with the appropriate Indian Standard / DIN or equivalent international Standard. Specification as listed below in this section and mentioned in detailed Specifications, each incorporating the latest revisions at the time of tendering.

6.1.2 Wherever specified or required the Plant & Equipment shall conform to various statutory regulations such as Indian Boiler Regulations, Indian Electricity Act / Rules / Regulations, Factories Act, etc.

6.1.3 In the event of any conflict between the codes and standards referred above, and the requirements of this Specification, the requirements, which are more stringent, shall govern.

6.1.4 In case of any change of code, standards and regulations between the date of purchase order and the date, the Bidder proceeds with manufacturing, the Owner shall have the option to incorporate the changed requirements.

6.1.5 List of Reference Codes/Standard

- a) American Society of Mechanical Engineers (ASME).
- b) American National Standards Institute (ANSI).
- c) American Society for Testing and Materials (ASTM).
- d) American Institute of Steel Construction (AISC).
- e) American Welding Society (AWS).
- f) Architecture Institute of Japan (AIJ).
- g) Bureau of Indian Standards Institution (BIS).
- h) British Standards (BS)
- i) Central Board of Irrigation and Power (CBIP) Publications.
- j) Deutsches Institut für Normung (DIN).
- k) Electricity Act 2003.
- l) Electric Power Research Institute (EPRI).
- m) Emission regulation of Central Pollution Control Board (CPCB)
- n) Federal Occupational Safety and Health Regulations (OSHA)
- o) Heat Exchanger Institute (HEI).
- p) Hydraulic Institute (HIS).
- q) Indian Electricity Rules.
- r) Indian Boiler Regulations (IBR).

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- s)** Indian Explosives Act.
- t)** Indian Factories Act.
- u)** Institute of Electrical and Electronics Engineers (IEEE).
- v)** International Electro-Technical Commission Publications.
- w)** Instrument Society of America (ISA).
- x)** International Organization for Standardization (ISO).
- y)** International Electro-technical Commission (IEC).
- z)** Japanese Standards (JIS).
- aa)** Japanese Electro-technical Committee (JEC).
- bb)** National Fire Protection Association (NFPA).
- cc)** National Electrical Manufacturer's Association (NEMA).
- dd)** National Electric Code (NEC).
- ee)** Power Test Code for Steam Turbines (PTC).
- ff)** Pollution Control regulations of Dept. of Environment, Govt. of India
- gg)** Regulations of CEA
- hh)** Standards of Manufacturer's Standardization Society (MSS).
- ii)** Stipulations made by Ministry of Environment & Forests and Climate Change while issuing clearance to the Project
- jj)** Stipulations made by State Pollution Control Board while issuing consent to the Project
- kk)** Tariff Advisory Committee (TAC) rules.
- ll)** Tubular Exchanger Manufacturer's Association (TEMA).
- mm)** VDI Standards

6.2 Name Plates

- 6.2.1** Instruction plates, nameplates or labels shall be permanently attached to each main and auxiliary item of plant in a conspicuous position. These plates shall be engraved with the identifying name, type and manufacturers serial number, together with the loading conditions under which the item of plant has been designed to operate.
- 6.2.2** Items such as valves, which are subject to hand operation, shall be provided with nameplates so constructed as to remain clearly legible throughout the life of the plant giving due consideration to the difficult climatic conditions to be encountered. Nameplates shall be securely mounted where they will not be obscured in service by insulation, cladding, actuators or other equipment. Direction of flow is also to be engraved.

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6.2.3 All trade nameplates and labels shall be in Bilingual language. All measurements shall be in M.K.S. Units.

6.2.4 The size and location of nameplates shall be subject to Approval of the Owner.

6.3 Guards and Fences

6.3.1 Effective guards and fences must be provided to prevent injury to operators.

6.3.2 Mesh guards which allow visual inspection of equipment with the guard in place are generally preferable. The guards shall be constructed of mesh attached to a rigid framework of mild steel rod, tube, or angle and the whole galvanized to prevent loss of strength by rusting or corrosion. The guards shall be designed to facilitate removal and replacement during maintenance.

6.3.3 Guards for couplings and rotating shafts shall be in accordance with BS 5304-1975 or similar approved standard. All rotating shafts and parts of shafts must be covered.

6.4 Operation, Maintenance & Availability

6.4.1 Equipment/works offered shall be designed for high availability, high reliability, low maintenance and ease of operation & maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability, availability, operability and ease of maintenance. He shall also furnish details of availability records in plants stated in his experience list.

6.4.2 Wherever required platforms and walkways with access ladders having hand rails shall be provided to facilitate operation and maintenance.

6.5 Materials

6.5.1 In selecting materials of construction of equipment, the Bidder shall pay particular attention to the atmospheric conditions existing at the Site and the nature of material/fluid handled. Wherever deviations are taken in respect of materials specified, the reasons shall be spelt out clearly in the proposal.

All materials shall be new, and shall be of the quality most suited to the proposed application.

6.5.2 As far as possible; materials shall be in accordance with Indian or international standard Specifications. Where such standards are not available, sufficient information shall be provided to allow the Owner to assess the suitability of the material for the particular application.

All materials used shall have performed lengthy satisfactory service in similar or more arduous conditions to those proposed by the Bidder.

6.5.3 All parts which could deteriorate or corrode under the influence of the atmospheric, meteorological or soil conditions at the Site, or under the influence of the working conditions shall be suitably and effectively protected so that such deterioration or corrosion is a minimum over the life of the plant.

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6.6 Lubricants, Control Fluids and Chemical

- 6.6.1 Provision shall be made for suitable efficient lubrication where necessary to ensure smooth operation free from undue wear.
- 6.6.2 Non ferrous capillary tubing shall be used throughout.
- 6.6.3 Oil baths shall be provided with filling and drain plugs, both of adequate size. An approved means of oil indication including level switches and temperature indication shall be provided.
- 6.6.4 Lubrication points shall be conveniently situated for maintenance purposes. It must be possible to carry out lubrication from a gangway or landing and without the removal of guarding or having to insert the hand into it. Where accessibility to a bearing for oiling purposes would be difficult a method of remote lubrication shall be fitted.
- 6.6.5 The Bidder shall provide a detailed and comprehensive Specification for all lubricating oils, greases and control fluids required for the for Turbo Generator and its Auxiliaries. A sufficient supply of these shall be provided by the Bidder for initial commissioning, first fill and till handing over of the unit.
- 6.6.6 The Bidder shall supply a detailed schedule giving the lubricant testing, cleaning and replacement procedures. All equipment and facilities necessary for the testing, cleaning and changing of lubricants and control fluids shall be provided. The Bidder shall endeavour to reduce the varieties and grades of required lubricants, chemicals and control fluids to a minimum, matching them where possible to those already in use in the generating station in order to simplify procurement and minimise storage requirements. All lubricants, chemicals and control fluids shall be of internationally recognised standards and shall be easily obtainable from a large number of Indian suppliers. Bidder shall also indicate the equivalent Indian Standard for the above for easy procurement in future.
- 6.6.7 No lubricant or control fluid shall have toxic or other harmful effects on personnel or on the environment.

6.7 Plant Life and Modes of Operation

- 6.7.1 On completion of the R&M project, the plant/equipment and systems individually and collectively shall be possible to operate continuously with routine maintenance and overhauls for an economic service life of not less than **[20/25 years]** under the prevailing site conditions and for the type of duty intended.
- 6.7.2 After R&M of Turbo Generator and associated auxiliaries, the unit shall be able to operate to its rated capacity continuously and there shall be no restriction of the operation of the unit during Base Load, Peak Load & Cyclic Load operation.
- 6.7.3 The capability of the unit operations including Cold, Hot & Warm Startups shall be in no way inferior to its original design capabilities. Accordingly, Bidder shall indicate the operation capabilities in various regime of operation in his Bid.

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6.8 Packaging & Marking

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing all the materials, the limitations from the point of view of availability of railway wagon sizes in India should be taken account of. The details of various wagons normally available with Indian Railways for transportation of heavy equipment shall be considered by the Bidder. The Bidder shall be responsible for all loss or damage during transportation, handling and storage due to improper packing.

The identification marking indicating the name and address of the consignee shall be clearly marked in indelible ink on two opposite sides and top of each of the packages. In addition the Bidder shall include in the marking gross and net weight, outer dimension and cubic measurement. Each package shall be accompanied by a packing note (in weather proof paper) quoting specifically the name of the Bidder, the number and date of Contract and names of the office placing the Contract, nomenclature of contents and Bill of Material.

6.9 Protection

Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures. Coated surfaces shall be protected against impact, abrasion, discoloration and other damages. Surfaces Paints which are damaged shall be repainted.

Electrical and C&I equipment shall be protected against moisture and water damages. All external gasket surfaces and flange faces, couplings, rotating equipment shafts, bearings and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection. All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors.

All piping, tubing and conduit connections on equipment and other equipment openings shall be closed with rough usage covers or plugs. Male threaded openings shall be closed with rough usage covers or plugs. Female threaded openings shall be closed with forged steel plugs. The closures shall be taped to seal the interior of the equipment. Open ends of piping, tubing and conduit shall be sealed and taped.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Bidder's expense.

6.10 Painting

6.10.1 General

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. Surfaces not easily accessible after shop assembly shall be treated before-hand and protected for life of the equipment.

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Surfaces to be finish painted after installation shall be shop painted with at least two (2) coats of primer. Steel surfaces, which are not to be painted, shall be coated with suitable rust preventive compound subject to the approval of the Owner.

All paints shall be used in accordance with the manufacturer's instructions. No thinners or other substance shall be added to the coating material without the approval of the Owner. The quality and vendor of the paints shall require approval of the Owner.

All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

All primers shall be well marked into the surface, particularly in areas where pitting is evident, and the first priming coat shall be applied as soon as possible after cleaning, within four hours maximum. If the drying interval between successive coats, which should not exceed one week, has been so long as to endanger the adhesion of the following coat, the paint already applied shall be lightly rubbed down with fine abrasive paper before putting on the next coat.

Paint spraying on large surfaces shall not normally be done indoors, except with the approval of the Owner. Spray guns shall not be used outdoors in windy weather or near unprotected surfaces of a contrasting colour and under no circumstances shall spray guns be used where spray may be carried into or onto exposed electrical equipment.

Paint containers shall not be opened until required and the paint shall be mechanically mixed thoroughly before use, and agitated occasionally during use.

Electrical equipment shall be shop finished with one or more coats of primer and two coats of high-grade oil resistant enamel. The interior of all panels' cabinets and enclosures shall be finished with gloss white enamel.

The Bidder shall furnish sufficient touch up paint for one complete finish coat on all exterior factory surfaces of each item of equipment. The touch up paint shall be of the same type and colour as the factory applied paint and shall be carefully packed to avoid damage during shipment. Complete painting instructions shall be furnished.

Shop primer for steel and iron surfaces which will have a continuous operating temperature below 35 °C shall be selected by the Bidder, in accordance to the relevant standard. Special high temperature primer shall be used on surface exposed to operating temperature above 35 °C.

The colour scheme shall be submitted during execution of Contract for approval by the Owner.

6.10.2 Preparation

Oil and grease shall be removed from the surface by washing with a suitable detergent, rinsing with clean water, and drying.

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Surfaces to be shot blasted shall be cleaned to Swedish Standard SA 2.5 or equivalent, and all dust remaining after cleaning shall be removed.

The priming coat shall be applied without delay.

6.10.3 Damaged Paintwork

Any damaged paintwork shall be corrected / modified as follows:

- a) The damaged area, together with an area extending 25mm around its boundary, shall be cleaned down to bare metal.
- b) A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm around the perimeter of the original damage.
- c) The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

6.10.4 Painting Systems

The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as stated below, unless otherwise specified elsewhere in this Specification.

a) Surfaces Subject to Weathering

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	35 micron DFT per coat

The total minimum DFT shall be 140 micron.

b) Surfaces Inside Buildings

All surfaces shall have a minimum of Four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	25 micron DFT per coat

The total minimum DFT shall be 120 micron.

The type and colour of primer & finish coat shall be selected by the Bidder after approval by the Owner.

6.11 Environment Protection

6.11.1 Environment Protection

The plant & equipment under this R&M project shall be designed for installation and operation in harmony with the surrounding environment and all measures of

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pollution control shall be ensured by the Bidder to restrict pollution from the liquid effluent and stack emission within the limits as given below with due consideration of Environment (Protection) Rules.

6.11.2 For Liquid Effluent

During construction activities, Bidder shall maintain the statutory compliance of State Pollution Control Board and MoE&F in respect of pollution control and environmental protection within and around plant boundary. Any specific requirement of State Pollution Authorities over and above shall be maintained.

6.11.3 Noise Level Requirement

The plant & equipment under this R&M project will be designed, constructed and provided with suitable acoustic measures to ensure the noise level criteria as per the following stipulations of MoEF & State Pollution Control Board.

- a) Maximum noise level shall not exceed 85 dB (A) when measured at 1.0 m away from the noise emission source.
- b) Maximum noise level from its source within the premises shall not exceed 70 dB (A) as per Environment (Protection) Rules 1986, Schedule-III, 'Ambient Air Quality Standards' in respect of noise.
- c) Any statutory changes in stipulations regarding noise limitation that may occur in future according to State Pollution Control Board or Central pollution Control Board or Ministry of Environment & Forest regulation during tenure of the contract, the Bidder shall comply with the updated/amended requirement.

An exception will be made for the plant at startup operations of other big pressure reducing devices operating during emergency periods and for the safety valves.

6.12 Inspection and Testing

6.12.1 Inspection and Tests during Manufacture

6.12.1.1 The method and techniques to be used by the Bidder for the control of quality during manufacture of all plant and equipment shall be agreed with the Owner prior to the Award of Contract.

6.12.1.2 The Owner's general requirements on quality control and shop tests is mentioned in Section II of Volume-II.

6.12.1.3 Owner shall be informed for witnessing the shop tests of any item of the plant or equipment for checking the compliance with the Specification requirement and or related standards prior to leave place of manufacturing.

6.12.1.4 Advance notice shall be given to the Owner as agreed in the Contract, prior to the stage of manufacture being reached, and the piece of plant must be held at this stage until the Owner has inspected the piece, or has advised in writing that

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inspection is waived. If having consulted the Owner and given reasonable notice in writing of the date on which the piece of plant will be available for inspection, the Owner does not attend, the Bidder may proceed with manufacture having forwarded to the Owner duly certified copies of his own inspection and test results.

- 6.12.1.5 The Bidder shall forthwith forward to the Owner the Test Certificates in [...] copies for approval.
- 6.12.1.6 Under no circumstances any repair or welding of castings be carried out without the consent of the Owner. Proof of the effectiveness of each repair by radiographic and/or other non destructive testing technique, shall be provided to the Owner.
- 6.12.1.7 All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.
- 6.12.1.8 Where accurate alignment is necessary for component parts of machinery normally assembled on site, the Bidder shall allow for trial assembly prior to dispatch from place of manufacture.
- 6.12.1.9 All materials used for the manufacture of equipment covered under this Specification shall be of tested quality. Relevant test certificates shall be made available to the Owner. The certificates shall include tests for mechanical properties and chemical analysis of representative material.
- 6.12.1.10 All pressure parts connected to pumping main shall be subjected to hydraulic testing at a pressure of 150% of design pressure. The duration of the pressure tests shall be sufficient, as approved by the Owner, to show any leakage paths and to permit a thorough examination of the component whilst under pressure.
- 6.12.1.11 All necessary non destructive examinations shall be performed to meet the applicable code requirements.
- 6.12.1.12 All welding procedures adopted for performing welding work shall be qualified in accordance with the requirements of Section-IX of ASME code or IBR as applicable. All welded joints for pressure parts shall be tested by liquid penetrant examination according to the method outlined in ASME Boiler and Pressure Vessel code. Radiography, magnetic particle examination magnaflex and ultrasonic testing shall be employed wherever necessary/ recommended by the applicable code. At least 10% of all major butt welding joints shall be radiographed. Payments in respect of IBR approvals including inspection shall be made by Owner. Bidder scope shall be limited to preparation of all necessary documents, coordination and follow up for above approvals.
- 6.12.1.13 The Bidder shall furnish the quality procedures to be adopted for assuring quality from the receipt of material at site, during storage, erection, pre-commissioning to tests on completion and commissioning of the complete system/equipment.

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6.12.2 Performance Tests at Site

- 6.12.2.1 The full requirements for testing the system shall be agreed between the Owner and the Bidder prior to Award of Contract. The completely erected System shall be tested by the Bidder on site under normal operating conditions. The Bidder shall also ensure the correct performance of the System under abnormal conditions, i.e. the correct working of the various emergency and safety devices, interlocks, etc.
- 6.12.2.2 The Bidder shall provide complete details of his normal procedures for testing, for the quality of erection and for the performance of the erected plant. These tests shall include site pressure test on all erected pipe work to demonstrate the quality of the piping and the adequacy of joints made at site.
- 6.12.2.3 For details of specific tests required on individual equipment refers to respective section of this specification.

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7 LAYOUT CONSIDERATION

{Effort shall be made to keep the Layout of the newly equipped system / packages under the R&M project unchanged to the extent possible with respect to existing layout to avoid disturbance to the existing equipment & facilities for which any modification/changes are not envisaged based on RLA/LA and EA assessment. However a general guidelines, which needs to be followed, as required, are given below :}

The broad salient features of the existing and expected layout arrangements of various equipment in the main plant building housing the turbine generator and its auxiliaries and Boiler area are given as hereunder:

- 7.1 The arrangement of the turbine- generator in the main plant building is of *[longitudinal type]*. The boiler centre line is in the *[same as that of TG condenser]*. Unit pitching distance between centre lines of two boilers is *[approximately 120m]*. The column spacing of main plant building is *[about 10 m]*.
- 7.2 *[The conventional arrangement of AB, BC and CD longitudinal bays with D row as first row of boiler columns is adopted with their respective widths of about 30m, 10m and 11m. The mill bunker building is about 12m wide].*
- 7.3 *[Two transverse bays at 0.0 m elevation equivalent to minimum area ofm² has been provided for unloading and maintenance at one end of main plant building].*
- 7.4 *[The location of control room (common for two units) is in BC bay at the operating floor level. Adjoining the control room, there is a control tower which accommodates control equipment room, AC plant room, battery room and UPS for C&I system, cable vault etc. at its different floor levels].*
- 7.5 The local pits/trenches in main plant building/ mill bunker bay building/ boiler/ ESP area is to be avoided as far as possible.
- 7.6 Clear walk ways of minimum 1.5 m width at all the levels shall be provided in the main plant building. Adequate fire escape staircases shall be provided with fire doors at each landing.
- 7.7 *[Interconnecting walkways (minimum 2.0 m clear) shall be provided between main plant building and boiler on either side of boiler at three elevations viz. mezzanine, operating and deaerator floor levels].*
- 7.8 *[The layout arrangement of critical piping connecting the steam generator and steam turbine shall be developed in such a way as to optimize the use of materials and resulting in minimum pressure losses in the steam flow].*
- 7.9 *[In the TG building area, facility of crane/ chain pulley block/ monorail hoist etc. will be provided, as required, along with provision of space for maintenance/ overhauling of equipment/components such as Turbo Generator, Boiler Feed Pump, Condensate Extraction Pump, Motors, Heaters and Valves etc.]*

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- 7.10 Trestles to be provided for routing of cables, pipes etc. shall have a clear height of 8.0m at road crossings so as to clear the road spaces, approach to maintenance bays of different equipment. A walkway with hand rails and toe guards of 750mm (minimum) width shall be provided all along length of the trestle for maintenance of cables and pipes. Ladders for approach to these platforms shall be provided near roads, passage ways.
- 7.11 Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized taking into account the fire water sprinkler system wherever provided.
- 7.12 Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 2.5 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment and clear headroom within main structures and cable trays etc.
- 7.13 Fire water pipes in main plant area may be routed in trenches filled with sand and covered with pre-cast RCC covers.
- 7.14 The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards etc. shall be observed while developing the layout.
- 7.15 The Existing layout details of the plant are indicated in the enclosed drawings as per Annexure-I. However, the Bidder to suggest his own modified layout arrangement which shall be subject to approval of the purchaser.

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8 PERFORMANCE GUARANTEES

The term "Performance Guarantees" wherever appears in this Section shall have the same meaning and shall be synonymous to "Functional Guarantees".

Similarly the term "Performance Tests" wherever appears in this Section shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

The term "BMCR" (Boiler Maximum Continuous Rating) appearing in the Technical Specification shall mean the maximum continuous steam output at super heater outlet of Boiler at rated parameters.

The term "TMCR" (Turbine maximum continuous rating) appearing in the Technical Specification shall mean [210/215/220/250] MW electrical power output at generator terminals under [3%] cycle make-up and [76] mm Hg (abs) condenser pressure, unless used in conjunction with a different cycle make-up.

8.1 General Requirements

8.1.1 The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in this technical Specifications.

8.1.2 The guaranteed performance parameters furnished by the Bidder in the Bid proposal, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.

8.1.3 The Bidder shall demonstrate all the guarantees covered herein under Category I, II & III during functional guarantee / acceptance test. The various tests which are to be carried out during performance guarantee/acceptance test are listed elsewhere in this-Section. The guarantee tests shall be conducted by the Bidder at site in presence of Owner on the unit.

8.1.4 All costs associated with the tests including the cost associated with the supply, calibration, installation and removal of test instrumentation shall be included in the price offered by Bidder.

8.1.5 At all times during the Performance Tests, the emissions and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.

8.1.6 It shall be the responsibility of the Bidder to make the plant ready for the performance guarantee tests.

8.1.7 All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Bidder shall get these instruments calibrated in an independent test institute approved by the Owner. All test instrumentation required for performance tests shall be supplied by the Bidder and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subjected to the approval of the Owner. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.

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- 8.1.8 Tools and tackles, thermowells (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the Bidder free of cost.
- 8.1.9 The Performance/ Acceptance test shall be carried out as per the agreed procedure. The PG test procedure including demonstration tests shall be submitted within **[90 days]** of the date of Notification of Award and finalization of the PG test procedure shall be done within **[180 days]** from the date of Notification of Award. After the conductance of Performance test, the Bidder shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. However, preliminary test reports shall be submitted to the Owner after completing each test run.
- 8.1.10 The P&G test procedures shall be submitted for equipment/ system & subsystem under Bidder's scope for all Guarantees under category I, II & III as mentioned below, as per ASME PTC 6 or latest International codes & standard including correction curves, meeting the Specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.
- 8.1.11 The Bidder shall submit for Owner's approval the detailed Performance Test procedure containing the following:
- Objective of the test.
 - Various guaranteed parameters & tests as per Contract.
 - Method of conductance of test and test code.
 - Duration of test, frequency of readings & number of test runs.
 - Method of calculation.
 - Correction curves.
 - Instrument list consisting of range, accuracy, least count, and location of instruments.
 - Scheme showing measurement points.
 - Sample calculation.
 - Acceptance criteria.
 - Any other information required for conducting the test.
- 8.1.12 In case, during performance guarantee tests, it is found that the equipment/systems has failed to meet the guarantees, the Bidder shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Owner. However, if the Contractor is not able to demonstrate the guarantees, even after

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the above modifications/replacements within *[ninety (90)]* days or a reasonable period allowed by the Owner after the initial performance guarantee tests have been completed, the Owner will have the right to impose the stipulated clauses under Guarantee Category I, II & III as specified in this specification:

8.1.13 For Category-I Guarantees

Reject the equipment/system/plant and recover from the Contractor payments already made

(OR)

Accept the equipment/system/plant after levying Liquidated Damages (LD) as specified in Clause No. 5.6 of Volume I of this specification. The LD's shall be prorated for the fractional parts of the deficiencies.

8.1.14 For Category-II Guarantees

Reject the equipment/plant/system and recover, from the Contractor, the payments already made. Conformance to the performance requirements under Category-II is mandatory.

8.1.15 For Category-III Guarantees

Reject the equipment/system/plant & recover, from the Contractor, the payments already made.

(OR)

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the contract price an amount equivalent to the damages as determined by the Owner. Such damages shall however be limited to the cost of replacement of the equipment/systems replacement of which shall remove the deficiency so as to achieve the guaranteed performance.

8.2 Performance Guarantees under Category-I

The performance guarantees which will attract liquidated damages shall be as follows:

- (i) Maximum continuous electrical output, in MW, at Generator terminals of each unit at rated parameters under VWO Condition.
- (ii) Turbine Cycle Gross Heat rate in kCal/kWh at rated steam conditions at 76 mm Hg (abs) design condenser pressure with 3% make up at 100% TMCR load. Heat rate shall be calculated as per the formula shown in clause 8.2.2
- (iii) Condenser Pressure with Unit Operating at VWO Condition.
- (iv) Unit Auxiliary Power Consumption at 100% TMCR unit load at condenser pressure of *[76]* mm Hg (abs)] with 3% make-up and with design ambient air condition.

Note: Power consumption of each of the pump/fan/compressors etc. wherever mentioned shall be measured with its own drive.

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8.2.1 Limit of Technical Parameters under Liquidated Damages Applicable For Category-I Guarantees:

Table: 8.1

S.No.	Parameter	Performance Limit for Rejection (LD is Applicable within below mentioned Limit. Beyond the Limit as below, the equipment/system/plant will call for Rejection.)
1	Gross Output of each unit	Shortfall beyond [1%] of guaranteed value (i.e. – [1.0 %])
2	Turbine Cycle Heat Rate	Increase beyond [1%] of guaranteed value (i.e. + [1%])
3	Condenser Pressure	Increase beyond [1%] of guaranteed value (i.e. + [1%])
4	Auxiliary Power	Increase beyond [5%] of guaranteed value/. (i.e. + [5.0 %])

8.2.2 Calculation of Turbine Heat Rate

a) Turbine Cycle Heat Rate

Turbine Cycle Heat Rate shall be calculated as follows & indicated in all computed heat balance diagrams:

$$\text{Heat Rate} = \frac{M1 (H1-h1) + M2 (H3-H2) + Mis (h1 - his) + Mir (H2 - hir)}{Pg}$$

Where,

M1 Quantity of live steam entering the turbine stop valve including any live steam supplied to valve stems, or glands etc. in kg/hr.

M2 Quantity of Reheat steam from reheater to turbine in kg/hr.

Mis Quantity of desuperheating water flowing into Superheater system for regulation of steam temperature in kg/hr.

Mir Quantity of desuperheating water flowing into reheater system for regulation of steam temperature in kg/hr.

H1- Enthalpy in kCal/kg of live steam.

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- H2 Enthalpy in kCal/kg of steam HPT Exhaust to reheat.
- H3 Enthalpy in kCal/kg of reheated steam from reheater to IP turbine.
- h1 Enthalpy of feed water in kCal/kg at the downstream of the junction of feed flow and bypass flow of HP heaters.
- hir Enthalpy of desuperheating water flowing into reheat system in kCal/Kg.
- his Enthalpy of desuperheating water flowing into Superheater System in kCal/Kg.
- Pg Unit output after deducting the power consumption by auxiliaries as listed below and the same shall be [210/215/220/250] MW at 100% TMCR unit load:
- Power taken by Excitation system (kW) including transformer losses, as applicable for various guarantee points in case of static excitation system. (The transformer losses at various points shall be based on factory test to be conducted).
 - Power required for ventilation of oil and control fluid tanks, if ventilating fans are separately driven (kW).
 - Power required for lubrication, if lubricating pumps are separately driven (kW).
 - Power required for control fluid pumps, if control fluid pumps are separately driven (kW).
 - Power required for hydrogen, seal oil auxiliaries, if separately driven (kW).
 - Power required for stator water cooling system, if cooling pumps are driven separately (kW).
 - Power required for Gland Steam Exhauster (GSC) if GSC Exhausters are separately driven.

Notes:

- Corrections Applicable for Turbine Cycle Heat rate & Turbine Generator Output tests

Based on cycle condition & covering entire range of operation for Turbine following correction curves for variation in Turbine Cycle Heat rate & Turbine Generator output to be furnished:

- Variation in main steam pressure and temperature.
- Variation in reheater steam temperature.
- Correction Curves, if applicable, due to change in superheater spray quantities with respect to coal properties.
- Correction Curves, if applicable, due to change in reheater spray quantities with respect to coal properties.
- Variation in condenser pressure for main condenser.
- Variation in power factor, frequency, generator hydrogen pressure and voltage.

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- ii) It may be noted that the heat balance diagrams and guarantees shall be furnished considering the quantities of water for super heater and reheater sprays with any mill combination in service to the Owner's choice.
- iii) The above list of correction curves is conclusive & curves in addition to above shall not be applied.

8.2.3 Condenser Pressure/Vacuum

Condenser Pressure Test, with Unit operating at VWO Condition, shall be carried out as per ASME PTC 12.2. .

8.2.4 Auxiliary Power Consumption

a) Auxiliary Power Consumption

The auxiliary power consumption shall be calculated using the following relationship.

$$P_{au} = \sum P_u$$

P_{au} = Guaranteed Auxiliary Power Consumption.

P_u = Power consumed by each of the auxiliaries of the unit under test.

While guaranteeing the auxiliary power consumption the bidder shall necessarily include all continuously operating unit auxiliaries.

[The auxiliaries to be considered shall include but not be limited to the following:

- i) *Boiler Feed Water Pumps (BFPs) including booster pumps and lube oil pump sets of BFPs*
 - ii) *Condensate Extraction Pumps*
 - iii) *Condenser Vacuum Pumps*
 - iv) *Excitation Power of Turbo Generator Set*
 - v) *DM CCW Pumps for Turbo Generator Auxiliaries*
 - vi) *LP Drain Condensate Pumps*
 - vii) *Turbine Oil Pumps*
 - viii) *Control Oil Pumps*
 - ix) *Seal Oil Pumps*
 - x) *Oil Vapor Extractor Fans*
 - xi) *Gland Steam Condenser Vapor Extractor Fans*
- Power consumption of any other continuously operating auxiliary for unit*

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operation at 100% TMCR]

Note:

1. The Bidder shall furnish a list of equipment to be covered under auxiliary power consumption, which shall be subject to Owner's approval.
2. The Bidder shall ensure that power supply to all such equipment to be covered under unit auxiliary power consumption is fed from unit board of the respective unit.

8.3 Guarantees under Category-II

Liquid Effluent:

[Liquid Effluent discharge to an outside body, from the battery limit, shall meet statutory requirements State Pollution Control Board.]

8.4 Guarantees under Category-III

The parameters/capabilities to be demonstrated for various systems/ equipment shall include but not be limited to the following:

8.4.1 Noise

All the plant, equipment and systems covered under this Specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency specified.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.

Equivalent "A" weighted Sound pressure shall be measured all around the equipment at a distance of 1.0 m from the Noise emitting source.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A - weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed the guaranteed value. Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests.

If the noise level recorded is beyond the limits specified above, the Bidder should provide suitable acoustic cladding to mitigate the noise level to within allowable limits.

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8.4.2 Start-up, loading, Unloading and Shutdown Capabilities

a) Unit Start-up

Start-up time (up to full load), and loading capabilities for the complete unit turbine generator together with associated Auxiliaries for cold start conditions [(greater than 36 hours shutdown)], warm start conditions [(between 8 and 36 hours shutdown)] and hot start conditions [(less than 8 hours shutdown)] as indicated by the Bidder in the offer and accepted by the Owner shall be demonstrated, ensuring that the various turbine operational parameters like vibration, absolute and differential expansion, eccentricity and steam-metal temperature mismatch etc.

b) Sudden Total Loss of External Load

When the steam turbine generator unit experiences sudden total loss of all external load, the steam turbine generator unit shall not trip on over speed but shall continue to be in operation (house-load conditions) under the control of its speed governor to supply power for the plant auxiliary load while staying within the agreed limits of steam metal temperature mismatch, exhaust hood temperature, absolute and differential expansion, vibration and eccentricity. The same shall be demonstrated.

c) Steam Metal Temperature

The maximum permissible steam-metal temperature differential for cold, warm and hot start conditions and loading/unloading and shutdown conditions shall be as indicated by the Bidder and accepted by the Owner.

8.4.3 Other Parameters for Steam Turbine and Auxiliaries

(a) HP & LP Bypass system should satisfy the following functional requirements under automatic interlock action. It should come into operation automatically under the following conditions:

- Generator circuit breaker opening
- HP-IP stop valves closing due to turbine tripping
- Sudden reduction in demand to house load

Under all these conditions, while passing the required steam flows as per the relevant heat balances, the condenser should be able to swallow the entire steam without increasing the exhaust hood temperature and condenser pressure beyond the maximum permissible value indicated by the Bidder in its offer and accepted by the Owner. The same shall be demonstrated.

(b) Run back Capability

Run back, rate of change of load and sudden load change withstand capabilities as guaranteed in the respective technical specifications volume.

(c) Following Parameters shall be demonstrated for steam condensing Plant:

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- i. Temperature of condensate, at outlet of condenser, shall be less than Saturation temperature corresponding to the condenser pressure at all Loads.
 - ii. Oxygen content in condensate, at hot well outlet, shall not exceed *[0.015 cc per liter]* over the entire load range and shall be determined according to calorimetric indigo – Carmine method.
 - iii. Air leakage in the condenser under full load condition shall not exceed more than 50% of design value taken for sizing the condenser air evacuation system.
 - iv. When one half of the condenser is isolated, condenser shall be capable of taking at least 60% TG load under TMCR conditions.
 - v. The air and vapour mixture from air cooling zone of condenser shall be 4.17 °C below the saturation temperature corresponding to 25.4 mm hg (abs) suction pressure. Correction curves for establishing the same at site conditions shall also be furnished.
 - vi. Life of sponge rubber balls and number of balls lost during 1000 hours of plant operation (for the Condenser on-load tube cleaning system) shall be as indicated by Bidder in the offer and accepted by the Owner.
- (d)** Following parameters shall be demonstrated for Feed Water Heaters and Deaerator:
- i. TTD's and DCA's of feed water heaters in line with 100 % TMCR heat rate guarantee heat balance.
 - ii. Dissolved O₂ content at Deaerator outlet without chemical dosing at all loads, not to exceed *[0.005 cc/liter]* determined as per ASTM-D-888 - Reference method A or Indigo Carmine method.
 - iii. Difference between saturation temperature of steam entering the Deaerator and temperature of feed water leaving Deaerator.
 - iv. Continuous & efficient operation and performance of feed heating plant without undue noise and vibrations at all loads and duty conditions.

(e) Boiler Feed Pumps

The pumps with its drives will operate satisfactorily at site for the whole range of rated operating condition as specified. The controls such as auto starting of pumps, speed, recirculation, etc. will also be tested for satisfactory performance. Parallel operation of pumps with different combinations will also be tested. During entire range of operation the vibration level will conform to VDI 2056.

(f) Condensate Extraction Pump

The pumps with its drives will operate satisfactorily at site for the whole range of rated operating condition as specified. The controls such as auto starting of pumps, speed, recirculation, etc. will also be tested for satisfactory performance. Parallel operation of pumps with different combinations will also be tested. During entire range of operation the vibration level will conform to VDI 2056.

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(g) [Drip Pump (if Applicable)]

- i. Each drip pump shall be capable of delivering flow & total dynamic head corresponding to design point as specified.
- ii. The vibration and noise level shall be demonstrated.

8.4.4 Auxiliary Water System Pumps

Capacity and head and power consumption of all the pumps dedicated to Turbo Generator & its Auxiliaries at the rated duty point (to be demonstrated and proved at shop with the respective job motors).

Vibration, noise level and parallel operation of all the pumps at the rated duty point shall be demonstrated at site.

8.4.5 Equipment Cooling Water System

- a) Parallel operation of pumps shall be demonstrated at site.
- b) Pressure drop across the heat exchanger on the primary & secondary water circuit shall be demonstrated at site.

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9 SPARE PARTS

The Bidder shall include in his scope of supply all the necessary mandatory spares, start up and commissioning spares and recommended spares and indicate these in the relevant schedules. The general requirements pertaining to the supply of these spares is given below:

9.1 Mandatory Spares

The list of mandatory spares considered essential by the purchaser is enclosed in Annexure-II of this Specification. The Bidder shall indicate the prices for each and every item (except for items not applicable to the Bidders design) in the 'Schedule of mandatory spares' whether or not he considers it necessary for the Owner to have such spares. If the Bidder fails to comply with the above, the cost of such spares shall be deemed to be included in the Contract price. The Bidder shall furnish the population per unit of each item in the relevant Schedules. Whenever the quantity is mentioned in "sets" the Bidder has to give the item details and prices of each item.

Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the R&M Contract unless specified otherwise, and the fraction will be rounded off to the next higher whole number. Wherever the requirement has been specified a 'set', it will mean as applicable for one complete Unit or each type & size of the Equipment being taken up for refurbishment or replacement. .

All mandatory spares shall be delivered at site at least two months before scheduled date of initial operation of the first unit. However, spares shall not be dispatched before dispatch of corresponding main equipment.

Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise. Price of mandatory spare parts will also be evaluated.

9.2 Recommended Spares

In addition to the mandatory spare parts mentioned above, the Bidder shall also provide a list of recommended spares for [five (5)] years of normal operation of the plant and indicate the list and total prices in relevant schedule. The list shall take into consideration the mandatory spares specified and should be independent of the list of the mandatory spares. The purchaser reserves the right to buy any or all of the recommended spares. The recommended spares shall be delivered at project site at least two months before the scheduled date of initial operation of first unit. However, the spares shall not be dispatched before the dispatch of the main equipment.

Prices of recommended spares will not be used for evaluation of the Bids. The price of these spares will remain valid up to execution of the Contract. However, the Bidder shall be liable to provide necessary justification for the quoted prices for these spares as desired by the Owner.

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9.3 Start-up & Commissioning Spares

Start up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system. The Bidder shall provide all such start up and commissioning spares and keep an adequate stock of the same to be brought by him to the site for the plant erection and commissioning. These must be available at site before the equipment are energized. The unused spares, if any, should be removed from there, only after handing over of the plant. All start up spares which remain unused at the time shall remain the property of the Bidder.

9.4 General Requirements

The Bidder shall indicate the service expectancy period for the spares parts (both mandatory and recommended) under normal operating conditions before replacement is necessary.

All spares supplied under this Contract shall be strictly inter-changeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desiccators packs as necessary.

All the spares (both mandatory and recommended) shall be manufactured along with the main equipment components as a continuous operation as per same Specification and quality plan.

The Bidder will provide Owner with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the Owner to identify and finalize order for recommended spares.

Each spare part shall be clearly marked or labeled on the outside of the packing with its description. When more than one spare part is packed in a single case, a general description of the content shall be shown on the outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.

All cases, containers or other packages are to be opened for such examination as may be considered necessary by the purchaser.

The Bidder will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on Vendors for items/ components/ equipment covered under Contract and will further ensure with his Vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such Vendors.

The Bidder shall warrant that all spares supplied will be new and in accordance with the Contract documents and will be free from defects in design, material and workmanship.

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In addition to the recommended spares listed by the Bidder, if the Owner further identifies certain particular items of spares, the Bidder shall submit the prices and delivery quotation for such spares within 30 days of receipt of such request for consideration by the Owner and placement of order for additional spares if the Owner so desires.

The Bidder shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered in the Contract. The Bidder shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the purchaser at least 2 years advance notice so that the latter may order his bulk requirement of spares, if he so desires. The same provision will also be applicable to Sub-Bidders. Further, in case of discontinuance of manufacture of any spares by the Bidder and/or his sub-Bidders, Bidder will provide the purchaser, two years in advance, with full manufacturing drawings, material Specifications and technical information including information on alternative equipment makes required by the Owner for the purpose of manufacture/procurement of such items.

The prices of all future requirements of spares beyond *[five (5)]* years shall be derived from the corresponding FOB/Ex-works price at which the order for such spares have been placed by the Owner as a part of the mandatory spares or recommended spares. FOB/Ex-works order price of future spares shall be computed in accordance with the price escalation formula to be furnished by Bidder indicating base price reference variation indices for material, labour etc. Based on the formula and considering escalation indices prevailing at the time of order of spares, order price shall be worked out. The base indices will be counted from the scheduled date of successful completion of trial operation of the last plant/equipment under the project. The above option for procuring future recommended spares by the purchaser shall remain valid for the period of fifteen *[fifteen (15)]* years from the date of successful completion of trial operation of the last plant/equipment. In case the spare parts from the same sub-Vendor are not available due to obsolescence or any other reason, the Bidder shall supply the spares for a period of *[fifteen (15)]* years from an alternative source.

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10 ANNEXURES

10.1 Annexure-I (List of Existing Drawing)

{Available as Build/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned in Annexure-I for their information & familiarization of the existing Unit}

10.2 Annexure-II (Mandatory Spares)

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II}

10.3 Annexure-III (List of Sub-Vendor)

{List of Sub-vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the format in Annexure-III}

10.4 RLA/CA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.5 EA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.6 Baseline Study Report

{Not attached with this document. This is to be provided by Utilities}

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-I, ANNEXURE-I
LIST OF EXISTING DRAWING**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-I

List of Existing Drawing

{Available as Build/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned below for their information & familiarization of the existing Unit}

i) MECHANICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[General Layout (Plot Plan)]
2	[.....]	[Main plant Layout at + 0.00 M]
3	[.....]	[Main Plant Equipment Layout Plan at Different Elevations]
4	[.....]	[Main plant Layout – Cross Section]
5	[.....]	[General layout battery limit]
6	[.....]	[Symbol /Legends]
7	[.....]	[P&ID for Main Steam, CRH & HRH Steam System]
8	[.....]	[P&ID for Feed Water System]
9	[.....]	[P&ID for HP-LP Bypass System]
10	[.....]	[P&ID for Condensate System]
11	[.....]	[P&ID for Heater Drains and Vents System]
12	[.....]	[P&ID for Extraction Steam System]
13	[.....]	[P&ID for DM water make up System]
14	[.....]	[P&ID for LP Dosing system]
15	[.....]	[P&ID for Oil purification system]
16	[.....]	[Flow Diagram DM Cooling Water System]

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S.No.	Drawing/Document No.	Title
17	[.....]	[Flow Diagram Central oil Storage & Transfer System]
18	[.....]	[Flow Diagram for Service water & Portable water]
19	[.....]	[Flow Scheme for Flash Tank, drain tank & Connection to Hotwell]
20	[.....]	[GA of Pipe and Cable Rack]
21	[.....]	[Any other Drawing]

ii) ELECTRICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[Protection diagram for Generator and its Auxiliaries]
	[.....]	[Existing Key Single Line diagram and Main One Line Diagram for Power Plant]

iii) CONTROL & INSTRUMENTATION

S.No.	Drawing/Document No.	Title
1	[.....]	[Plant DCS Configuration Drawing]
2	[.....]	[TG Integral Control System Configuration Drawing]
3	[.....]	[Instrument Installation Diagram (Pressure Transmitter)]
4	[.....]	[Instrument Installation Diagram (Flow Measurement)]
5	[.....]	[Instrument Installation Diagram (Pressure Gauge)]
6	[.....]	[Instrument Installation Diagram (DP Measurement)]
7	[.....]	[Instrument Installation Diagram (Level Measurement using gauge & switch)]
8	[.....]	[Instrument Installation Diagram (Level Measurement using DP Transmitter & Displacer type Transmitter)]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No.	Drawing/Document No.	Title
9	[.....]	[Instrument Installation Diagram (Level Measurement for Open/Close Vessels)]
10	[.....]	[Instrument Source Connection Details – Pressure Measurement on Pipe]
11	[.....]	[Instrument Source Connection Details – Temperature Measurement on Pipe]
12	[.....]	[Instrument Source Connection Details – Flow Measurement]
14	[.....]	[Instrument Source Connection Details – Level Measurement]
16	[.....]	[Grounding Scheme for Cabinets/Panels]
17	[.....]	[C&I Power Supply distribution cabling Philosophy]
22	[.....]	[C&I Instrumentation cabling Philosophy]
23	[.....]	[PLC based Control System Configuration Diagram]
24	[.....]	[Turbine Protection System Configuration Diagram]
25	[.....]	[Drive Control Philosophy-Bidirectional drive (ON-OFF Type MOV)]
26	[.....]	[Drive Control Philosophy-Bidirectional drive (Inching Type MOV)]
27	[.....]	[Drive Control Philosophy- LT drive]
28	[.....]	[Drive Control Philosophy- HT drive]
29	[.....]	[Drive Control Philosophy-Solenoid Valve]
30	[.....]	[Drive Control Philosophy-VFD]
31	[.....]	[Any Other Drawing]

iv) CIVIL

S.No.	Drawing No.	Description
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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

S.No.	Drawing No.	Description
1	[.....]	[Geotechnical Investigation Report]
2	[.....]	[Road, drains, trench layouts etc., as available]
3	[.....]	[Design documents of the existing structures]
	[.....]	[Drawings of existing structures & foundations]
4	[.....]	[Loading data for of the existing structures & foundations]

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**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-I, ANNEXURE-II
MANDATORY SPARES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-II

Mandatory Spares

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II. Available Mandatory spares of the existing Unit, which can be used after completion of R&M work, shall also be verified before finalization of the below mentioned Spare List. Mandatory Spares shall be defined as for each Unit. The unit, 'set', indicated in the table below will mean as applicable for one complete Unit or each type & size of the Equipment being taken up for refurbishment or replacement.}

A. MECHANICAL

1. TG & Auxiliaries

Sl. No	Description	Unit	Quantity	Remarks
1.0	TURBINE & AUXILIARIES			
1.1	HP Turbine			
1.1.1	All studs, bolts, washers and nuts in HP inner and outer casings other than in the inlet and outlet connections	Set	1	
1.1.2	All studs, bolts, washers and nuts for steam inlet and outlet connections to and from the HP casing.	Set	1	
1.1.3	Gland sealing rings with springs assembly	Set	1	
1.1.4	All keys, pins, bushes and screws	Set	1	
1.1.5	Inter-stage seal strip and caulking wire (both rotating and stationary)	Set	1	Set consists of total length of seal strip and caulking wire in all stages both in the casing and the rotor for 1 turbine.
1.1.6	Sealing rings for M.S inlet and CRH outlet insert connection	Set	1	
1.1.7	Balance weight along with fixing screws for	Set	1	

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Sl. No	Description	Unit	Quantity	Remarks
	<i>HP Turbine</i>			
1.2	<i>IP Turbine</i>			
1.2.1	<i>All studs, bolts, washers and nuts in IP inner and outer casings other than in the inlet outlet and extraction connections</i>	<i>Set</i>	<i>1</i>	
1.2.2	<i>All studs, bolts, washers and nuts for steam inlet and outlet connections to and from the IP casing.</i>	<i>Set</i>	<i>1</i>	
1.2.3	<i>Thread Rings & Angle Rings</i>	<i>Set</i>	<i>1</i>	
1.2.4	<i>Gland sealing rings with springs assembly</i>	<i>Set</i>	<i>1</i>	
1.2.5	<i>All keys, pins, bushes and screws</i>	<i>Set</i>	<i>1</i>	
1.2.6	<i>Interstage seal strip and caulking wire (both rotating and stationary)</i>	<i>Set</i>	<i>1</i>	<i>set consists of total length of seal strip and caulking wire in all stages both in the casing and the rotor for 1 turbine.</i>
1.2.7	<i>Sealing rings for HRH inlet insert connection</i>	<i>Set</i>	<i>1</i>	
1.2.8	<i>Balance weight along with fixing screws for IP Turbine</i>	<i>Set</i>	<i>1</i>	
1.3	<i>LP Turbine</i>			
1.3.1	<i>Bolts, washers and nuts in LP inner and outer casings other than in the inlet outlet and extraction connections</i>	<i>Set</i>	<i>1</i>	
1.3.2	<i>All studs, bolts, washers and nuts for steam inlet, outlet and extraction connections to and from the LP casing.</i>	<i>Set</i>	<i>1</i>	
1.3.3	<i>All types of gaskets, if applicable</i>	<i>Set</i>	<i>1</i>	
1.3.4	<i>Gland sealing rings with springs assembly</i>	<i>Set</i>	<i>1</i>	
1.3.5	<i>All keys, pins, bushes and screws</i>	<i>Set</i>	<i>1</i>	

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Sl. No	Description	Unit	Quantity	Remarks
1.3.6	Interstage seal strip and caulking wire (both rotating and stationary)	Set	1	set consists of total length of seal strip and caulking wire in all stages both in the casing and the rotor for 1 turbine.
1.3.7	Balance weight along with fixing screws for LP Turbine	Set	1	
1.3.8	Moving blades for last 2 LP stages (both sides for double flow)	Set	1	
1.3.9	Lacing wire for last stage moving blades (if applicable)	Set	1	set consists of total length of lacing wire required for the last stage blades
1.3.10	Last stage fixed blades	Set	1	
1.3.11	Pressure relief self closing type disc for Turbine exhaust hood	Sets	6	
1.4	Turbine Bearings and Bearing Pedestal			
1.4.1	Journal Bearings, complete	Set	1	set consists of all the journal bearings along with temperature elements, if temperature elements are integral with the bearings for HP, IP and LP

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Sl. No	Description	Unit	Quantity	Remarks
				<i>Turbine as applicable</i>
1.4.2	<i>Combined thrust and journal bearing complete, if applicable</i>	<i>Set</i>	<i>1</i>	
1.4.3	<i>Thrust bearing pads</i>	<i>Set</i>	<i>1</i>	<i>set consists of all the thrust pads in 1 bearing including the pads with thermocouple .</i>
1.4.4	<i>Auxiliary bearing, if applicable</i>	<i>No.</i>	<i>1</i>	
1.4.5	<i>Oil Guard Ring Sealing rings</i>	<i>Set</i>	<i>1</i>	
1.4.6	<i>Sealing strips (if applicable) for all the bearing pedestals</i>	<i>Sets</i>	<i>1</i>	
1.4.7	<i>All bolts, studs washers and nuts in all the bearing pedestals of Turbine</i>	<i>%</i>	<i>25</i>	<i>25% of each bearing pedestal population in one unit</i>
1.4.8	<i>All applicable pins, bushes, sleeves, keys, screws, springs, adjusting plates and locking plates</i>	<i>Set</i>	<i>1</i>	<i>1 set for each bearing pedestal</i>
1.5	<i>Coupling bolts, nuts, sleeves, washers lock plates as applicable for</i>			
1.5.1	<i>HP-IP Coupling</i>	<i>Set</i>	<i>1</i>	
1.5.2	<i>IP-LP Coupling</i>	<i>Set</i>	<i>1</i>	
1.5.3	<i>LP-Generator Coupling</i>	<i>Set</i>	<i>1</i>	
1.6	<i>Governing system</i>			
1.6.1	<i>Over speed governor</i>	<i>No.</i>	<i>1</i>	
1.6.2	<i>Over speed governor internals</i>	<i>Set</i>	<i>1</i>	
1.6.3	<i>Spares for Electro-hydraulic governor, if</i>	<i>Set</i>	<i>1</i>	

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Sl. No	Description	Unit	Quantity	Remarks
	<i>applicable</i>			
1.6.4	<i>Electro-hydraulic convertor, if applicable</i>	<i>Set</i>	<i>1</i>	
1.6.5	<i>Electro-hydraulic convertor internals, if applicable</i>	<i>Set</i>	<i>1</i>	
1.6.6	<i>Emergency trip device</i>	<i>No.</i>	<i>1</i>	
1.6.7	<i>Emergency trip device internals</i>	<i>Set</i>	<i>1</i>	
1.6.8	<i>Over speed trip testing device</i>	<i>No.</i>	<i>1</i>	
1.6.9	<i>Load limit device</i>	<i>No.</i>	<i>1</i>	
1.6.10	<i>Load limit device internals</i>	<i>Set</i>	<i>1</i>	
1.6.11	<i>Load Changer</i>	<i>No.</i>	<i>1</i>	
1.6.12	<i>Load Changer internals</i>	<i>Set</i>	<i>1</i>	
1.6.13	<i>Low vacuum tripping device</i>	<i>No.</i>	<i>1</i>	
1.6.14	<i>Low vacuum tripping device internals</i>	<i>Set</i>	<i>1</i>	
1.6.15	<i>Thrust bearing protection device</i>	<i>No.</i>	<i>1</i>	
1.6.16	<i>Thrust bearing protection device internals</i>	<i>Set</i>	<i>1</i>	
1.6.17	<i>Emergency over speed trip device</i>	<i>Set</i>	<i>1</i>	
1.6.18	<i>Vacuum breaker valve</i>	<i>Nos</i>	<i>1</i>	
1.7	<i>Turbine Valves</i>			
1.7.1.	<i>Emergency stop valve</i>			
1.7.1.1	<i>All internals of main steam stop valve</i>	<i>Set</i>	<i>1</i>	
1.7.1.2	<i>Sealing Rings</i>	<i>Set</i>	<i>1</i>	
1.7.1.3	<i>Studs, bolts, nuts and washers</i>	<i>Set</i>	<i>1</i>	
1.7.1.4	<i>Main steam stop valve Servomotor</i>			
1.7.1.5	<i>All internals of servomotor</i>	<i>Set</i>	<i>1</i>	
1.7.1.6	<i>All gaskets, 'O' rings and oil seals of servomotor</i>	<i>Sets</i>	<i>2</i>	
1.7.1.7	<i>All studs, bolts, nuts and washers</i>	<i>Set</i>	<i>1</i>	
1.7.1.8	<i>Test valve for main steam stop valve</i>	<i>Set</i>	<i>1</i>	
1.7.1.9	<i>Servomotor for main steam stop valve</i>	<i>No.</i>	<i>1</i>	

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Sl. No	Description	Unit	Quantity	Remarks
1.7.2	Main steam control valve			
1.7.2.1	All internals of main steam control valve	Set	1	
1.7.2.2	Sealing Rings	Set	1	
1.7.2.3	Studs, bolts, nuts and washers	Set	1	
1.7.2.4	Main steam control valve servomotor			
1.7.2.5	All internals of servomotor	Set	1	
1.7.2.6	All gaskets, 'O' rings and oil seals of servomotor	Sets	2	
1.7.2.7	All studs, bolts, nuts and washers	Set	1	
1.7.2.8	Test valve for MS control valve servomotor	No.	1	
1.7.2.9	Servomotor for main steam control valve	No.	1	1no. in each type
1.7.3	Reheat stop valves			
1.7.3.1	All internals of reheat stop valve	Set	1	
1.7.3.2	Sealing rings	Sets	2	
1.7.3.3	Studs, bolts, nuts and washers	Set	1	
1.7.3.4	Reheat stop valve servomotor			
1.7.3.5	All internals of servomotor	Sets	1	
1.7.3.6	All gaskets, 'O' rings and oil seals of servomotor	Set	1	
1.7.3.7	Studs, bolts, nuts and washers	Set	1	
1.7.3.8	Test valve for reheat stop valve servomotor	Set	1	
1.7.3.9	Servomotor for reheat stop valve	No.	1	
1.7.4	Reheat control valve			
1.7.4.1	All internals of reheat control valve	Set	1	
1.7.4.2	Sealing rings	Sets	2	
1.7.4.3	Studs, bolts, nuts and washers	Set	1	

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Sl. No	Description	Unit	Quantity	Remarks
1.7.4.4	<i>Reheat control valve servomotor</i>			
1.7.4.5	<i>All internals of servomotor</i>	<i>Set</i>	<i>1</i>	
1.7.4.6	<i>All gaskets, 'O' rings and oil seals of servomotor</i>	<i>Set</i>	<i>1</i>	
1.7.4.7	<i>All studs, bolts, nuts and washers</i>	<i>Set</i>	<i>1</i>	
1.7.4.8	<i>Test valve for reheat control valve servomotor</i>	<i>Set</i>	<i>1</i>	
1.7.4.9	<i>Servomotor for reheat control valve</i>	<i>No.</i>	<i>1</i>	
1.7.5	Extraction and CRH NRVs including FCNRVs			
1.7.5.1	<i>Disc</i>	<i>Set</i>	<i>1</i>	<i>1 Set means 1 no. in each size, type and rating</i>
1.7.5.2	<i>Spindle</i>	<i>Set</i>	<i>1</i>	<i>1 Set means 1 no. in each size, type and rating</i>
1.7.5.3	<i>Spindle bushing</i>	<i>Set</i>	<i>1</i>	<i>1 Set means 1 no. in each size, type and rating</i>
1.7.5.4	<i>Body/Cover gasket</i>	<i>Set</i>	<i>1</i>	<i>1 Set means 1 no. in each size, type and rating</i>
1.7.6	Actuators of Extraction and CRH NRVs			
1.7.6.1	<i>Piston rings</i>	<i>Sets</i>	<i>2</i>	
1.7.6.2	<i>Piston</i>	<i>Set</i>	<i>1</i>	
1.7.6.3	<i>Oil seals, O-rings and Gaskets</i>	<i>Set</i>	<i>1</i>	
1.7.6.4	<i>Complete Actuator</i>	<i>Set</i>	<i>1</i>	
1.7.7	Main Steam & HRH Strainers			
1.7.7.1	<i>All gaskets</i>	<i>Sets</i>	<i>4</i>	<i>4 in each type</i>

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Sl. No	Description	Unit	Quantity	Remarks
1.7.7.2	All studs / bolts, nuts & washers	Set	1	1 in each type
1.7.7.3	Strainer mesh	No.	1	1 in each type
1.8	HP-LP by pass system			
1.8.1	HP By pass System			
1.8.1.1	HP by pass steam control valve			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Sets	2	
1.8.1.2	HP by pass steam control valve actuator			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Set	1	
1.8.1.3	HP water spray valve			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Sets	2	
1.8.1.4	HP water spray valve actuator			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Set	1	
1.8.1.5	HP water stop valve			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Sets	2	
1.8.1.6	HP water stop valve actuator			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	

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Sl. No	Description	Unit	Quantity	Remarks
C	All gaskets, sealing and packing rings	Set	1	
1.8.1.7	Oil System / HP By Pass			
A	Filter housing	Nos.	2	
B	Filter element if any, in the oil supply unit	Sets	4	
C	High Pressure hoses	Sets	4	
D	Oil Supply Unit Pressure reducing valve	Sets	1	
E	Bladders	Nos.	4	1 no in each type only and total 4 nos.
F	Accumulator Connecting block	Set	1	
G	Oil supply pump with motor	Set	1	
H	Nitrogen gas filling device	Set	1	
1.8.2	LP By pass Syatem			
1.8.2.1	LP by pass valve			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Set	1	
1.8.2.2	LP by pass valve actuator			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Set	1	
1.8.2.3	LP by pass spray water valve			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Set	1	
1.8.2.4	LP by pass spray water valve actuator			
A	All internals	Set	1	
B	All bolts, studs, washers & nuts	Set	1	
C	All gaskets, sealing and packing rings	Set	1	
1.8.3.4	Oil System / LP By Pass			

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Sl. No	Description	Unit	Quantity	Remarks
A	Filter housing	Nos.	2	
B	Filter element if any, in the oil supply unit	Sets	2	
C	High Pressure hoses	Sets	4	
D	Oil Supply Unit Pressure reducing valve	Sets	2	
E	Bladders	Nos.	4	
F	Accumulator Connecting block	Set	1	
G	Oil supply pump with motor	Set	1	
1.9	Lube oil system			
1.9.1	Main Oil Pump			
1.9.1.1	Impeller	No.	1	
1.9.1.2	Bearings	Set	1	
1.9.1.3	Shaft with sleeves and lock nut	No.	1	
1.9.1.4	Mechanical seal complete	Sets	2	
1.9.1.5.	Set of bolts/studs, nuts, screws, keys, pins, circlips and washers including spring washers	Set	1	
1.9.1.6	Set of gaskets/ 'O' rings 'U' rings/ 'V' rings	Sets	2	
1.9.1.7	Coupling bolts, nuts, washers and bushes	Set	1	
1.9.2.	Auxiliary Oil Pump			
1.9.2.1	Shaft with keys	Set	1	
1.9.2.2	Impeller with locknut, lock washer and lock screw	Set	1	
1.9.2.3	Bearings	Sets	2	
1.9.2.4	Shaft seal	Sets	2	
1.9.2.5	Set of gaskets, 'O' rings 'U' rings, 'V' rings as applicable	Sets	4	
1.9.2.6	All washers other than in sl.no.1.9.2.2, screws, bolts, studs nuts, pins, circlips	Sets	2	
1.9.2.7	Coupling (connecting Pump & Motor) complete along with coupling bolts, nuts, washers and bushes	Set	1	
1.9.2.8	Auxiliary oil pump motor	No.	1	

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Sl. No	Description	Unit	Quantity	Remarks
1.9.2.9	Bearings for Auxiliary oil pump motor	Set	1	
1.9.3	Emergency Oil Pump			
1.9.3.1	Shaft with keys	Set	1	
1.9.3.2	Impeller with locknut, lock washer and lock screw	Set	1	
1.9.3.3	Bearings	Set	1	
1.9.3.4	Shaft seals	Set	1	
1.9.3.5	Set of gaskets, 'O' rings 'U' rings, 'V' rings as applicable	Set	1	
1.9.3.6	Set of washers other than in sl.no 1.9.3.2, screws, bolts, studs nuts, pins, circlips	Set	1	
1.9.3.7	Coupling (connecting Pump & Motor) complete along with coupling bolts, nuts, washers and bushes	Set	1	
1.9.3.8	Emergency oil pump DC motor	No.	1	
1.9.3.9	Bearings for Emergency oil pump DC motor	Set	1	
1.9.4	Jacking oil pump			
1.9.4.1	Bearings	Sets	2	
1.9.4.2	Rotating/Runner assembly	Set	1	
1.9.4.3	Set of gaskets, 'O' rings, 'U' rings, 'V' rings as applicable	Set	1	
1.9.4.4	Set of washers including lock washers and spring washers, screws, bolts, studs nuts, pins, circlips as applicable	Set	1	
1.9.4.5	Coupling (connecting Pump & Motor) complete along with coupling bolts, nuts, washers and bushes	Set	1	
1.9.4.6	Complete set of pressure regulating valves for jacking oil system (all regulating valves for 1 unit)	Set	1	
1.9.4.7	Jacking oil pump without motor	No.	1	
1.9.4.8	Jacking oil pump motor	No.	1	
1.9.4.9	Bearings for Jacking oil pump motor	Set	1	

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Sl. No	Description	Unit	Quantity	Remarks
1.9.5	Control oil pump			
1.9.5.1	Set of bearings	Set	1	
1.9.5.2	Rotating / Runner assembly	Set	1	
1.9.5.3	Set of gaskets 'O' rings, 'V' rings, 'U' rings as applicable	Set	1	
1.9.5.4	Set of washers, circlips, screws, studs, bolts, nuts, pins as applicable	Set	1	
1.9.5.5	Coupling (connecting Pump & Motor) complete along with coupling bolts, nuts, washers and bushes	Set	1	
1.9.5.6	Control oil pump without motor	No.	1	
1.9.5.7	Control oil pump motor	No.	1	
1.9.5.8	Bearings for Control oil pump motor	Set	1	
1.9.6	Duplex Oil Filter for Lub Oil			
1.9.6.1	Filter element	Set	1	
1.9.6.2	'O' rings/sealing rings	Sets	2	
1.9.6.3	Change over valve	Set	1	
1.9.7	Duplex Oil Filter for Control Oil, if applicable			
1.9.7.1	Filter element	Set	1	
1.9.7.2	'O' rings/sealing rings	Sets	2	
1.9.7.3	Change over valve	Set	1	
1.10	Shaft Turning Gear Spares			
1.10.1	Shaft turning gear hydraulic motor	No	1	Nozzle box for turbine type turning gear
1.10.2	Bearings in the shaft turning gear	Set	1	
1.11	Oil Coolers			
1.11.1	Set of gaskets, 'O' rings as applicable for oil coolers	Sets	2	
1.12	Oil vapour extractor			

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Sl. No	Description	Unit	Quantity	Remarks
1.12.1	Set of bearings	Set	1	
1.12.2	Shaft with sleeves, keys lock washer, lock nut if applicable	Set	1	
1.12.3	Impeller	No.	1	
1.12.4	Set of gaskets/ 'O' rings	Set	1	
1.12.5	Set of bolts, studs, washers, screws, nuts, circlips, pins	Set	1	
1.12.6	Coupling (connecting fan & Motor) complete (if applicable) along with coupling bolts, nuts, washers and bushes, if applicable	Set	1	
1.12.7	Oil vapour extractor, with motor	No.	1	
1.12.8	Bearings for Oil vapour extractor motor	Set	1	
1.13	Lube oil purification unit			
1.13.1	Centrifuge oil inlet valve	No	1	
1.13.2	Brake for centrifuge	Set	1	
1.13.3	All internals of centrifuge clutch assembly	Sets	1	
1.13.4	Clutch assembly	Set	1	
1.13.5	All types of bearings in the centrifuge	Set	1	
1.13.6	Springs, rubber rings, 'O' rings, observation glasses, seal rings, disc, gaskets, sleeves pins and bolts & nuts	Set	1	
1.13.7	All filters	Set	1	
1.13.8	Heater elements	Set	1	
1.13.9	Centrifuge motor	No.	1	
1.13.10	Bearings for Centrifuge motor	Set	1	
1.13.2	Dirty oil pump in Oil Purification System, if applicable			
1.13.2.1	Rotating assembly	Set	1	
1.13.2.2	Bearings	Set	1	
1.13.2.3	wearing rings (for centrifugal pump) if applicable	Set	1	
1.13.2.4	Dirty oil pump motor	No.	1	

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Sl. No	Description	Unit	Quantity	Remarks
1.13.2.5	Bearings for Dirty oil pump motor	Set	1	
1.13.3	Clean oil pump in Oil Purification System, if applicable			
1.13.3.1	Rotating assembly	Set	1	
1.13.3.2	Bearings	Set	1	
1.13.3.3	wearing rings (for centrifugal pump) if applicable	Set	1	
1.13.3.4	Clean oil pump motor	No.	1	
1.13.3.5	Bearings for Clean oil pump motor	Set	1	
1.14	Gland sealing system			
1.14.1	Gland seal regulator	No	1	
1.14.2	Set of gaskets and O rings	Set	1	
1.14.3	Filters and traps	Set	1	
1.14.4	Gland steam exhauster with motor	No.	1	

2. TG Cycle Auxiliary Equipment

Sl. No	Description	Unit	Quantity	Remarks
2.0	CONDENSER SYSTEM			
2.1.	Condenser			
2.1.1	All Gaskets, O-rings	Set	1	
2.1.2	All studs, bolts, nuts and washers	%	10	
2.1.3	Tubes	%	5	
2.1.4	Plugs for tube plugging	%	5	
2.2	Condenser on load tube cleaning system			
2.2.1	Sponge balls	Charges	24	
2.2.2	Abrasive balls	Charges	8	
2.2.3	Worm gear assembly for Ball separator screen	Set	1	
2.2.4	Ball separator screen	Set	1	
2.3	DP Measuring System			

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Sl. No	Description	Unit	Quantity	Remarks
	Connecting board	No	1	
	O Ring	Set	1	
	Micro switch assembly	set	1	
	DPG			
	Glass window	No	1	
	Gasket	Set	1	
	Pointer	No	1	
2.4	Ball recirculating pump for tube cleaning system			
2.4.1	Rotating assembly	Set	1	Rotating assembly consists of all the rotating parts except bearings
2.4.2	Shaft with sleeves	Set	1	
2.4.3	Wearing rings (if applicable)	Set	1	
2.4.4	Bearings	Set	1	
2.4.5	Impeller	No.	1	
2.4.6	Ball recirculating pump motor	No.	1	
2.4.7	Bearings for recirculating pump motor	Set	1	
3.0	CONDENSATE EXTRACTION PUMP			
3.1	All gaskets, O-rings, U-rings/V-rings	Sets	2	
3.2	Impellers (complete set)	Set	1	
3.3	Shaft sleeves	Sets	2	
3.4	Wearing rings	Set	1	
3.5	Guide bearings	Sets	2	
3.6	Thrust bearing including radial and axial shoes and thrust collars	Sets	2	
3.7	Pump shaft	Set	1	
3.8	Mechanical seal complete	Sets	4	

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Sl. No	Description	Unit	Quantity	Remarks
3.9	All bolts, nuts, washers, keys, pins, screws and circlips	Set	1	
3.10	Connecting coupling with motor complete with coupling bolts, nuts washers & bushes	Set	1	
3.11	Motor bearings of each type & size	Set	1	
3.12	Terminal bushings of each type	Nos.	2	
3.13	Cooling fan assembly	No.	1	
3.14	Condensate Extraction Pump Motor complete	No.	1	
4.0	FEED HEATERS AND DEAERATOR			
4.1	H.P Heaters (Spares for each HP heater)			
4.1.1	Gaskets of all sizes	Set	1	
4.1.2	Bolts, washers and nuts for Manhole cover assembly	%	10	
4.1.3	Heater vent orifice for each heater	Nos.	2	
4.2	L.P Heaters (Spares for each LP heater)			
4.2.1	Gaskets of all sizes	Set	1	
4.2.2	Bolts, washers and nuts for Manhole cover assembly	%	10	
4.2.3	Heater vent orifice for each heater	Nos.	2	
4.3	Deaerator			
4.3.1	Spray valves/nozzles assembly	Set	1	
4.3.2	Bolts, nuts and washers for fixing spray nozzle assembly	Set	1	
4.3.3	Gaskets of all types	Set	1	
4.3.4	Bolts, washers and nuts for manhole cover assembly	%	10	
5.0	BOILER FEED PUMPS			
5.0.1	Complete BFP cartridge assembly	Set	1	
5.0.2	All wearing rings with fixing screws, if any	Set	1	

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Sl. No	Description	Unit	Quantity	Remarks
5.0.3	Balancing device (stationary & rotary)	Sets	2	
5.0.4	Shaft with shaft sleeves, keys and locknuts.	Set	1	
5.0.5	All bolts, nuts, washers, screws and bushes	Set	1	
5.0.6	All O-rings, U-rings/V-rings, oil seals and gaskets	Sets	2	
5.0.7	Mechanical seal assembly complete	Sets	3	1 set consists of total no. of mechanical seal assemblies in one pump
5.0.8	All bearings	Sets	1	
5.0.9	Thrust pads	Sets	3	
5.0.10	Thrust collar if not integral with shaft	No.	1	
5.0.11	Recirculation valve with actuator	Sets	1	
5.0.12	Motor bearings of each type & size	Set	1	
5.0.13	Terminal bushings of each type	Nos.	1	
5.0.14	Cooling fan assembly	No.	1	
5.0.15	Boiler Feed Pump Motor complete	No	1	
5.1	Lubrication oil pump for Boiler Feed pump set			
5.1.1	Rotating Assembly complete	Set	1	Rotating assembly consists of all the rotating parts except bearings.
5.1.2	Bearings	Set	1	
5.1.3	Wearings rings for centrifugal pump (if applicable)	Set	1	
5.1.4	Lubricating oil pump motor	No.	1	
5.1.5	Bearings for Lubricating oil pump motor	Set	1	
5.1.6	Duplex filter assembly	Set	1	
5.1.7	Duplex Filter elements	Sets	3	

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Sl. No	Description	Unit	Quantity	Remarks
6.0	BOOSTER PUMP FOR BOILER FEED PUMP			
6.0.1	All Bearings	Set	1	
6.0.2	Shaft with shaft sleeves, keys and locknuts	Set	1	
6.0.3	Wearing rings	Sets	2	
6.0.4	Shaft coupling between Motor and booster pump along with coupling bolts, bushes, nuts and washers	Set	1	
6.0.5	All O-rings, U-rings/V-rings, oil seals and gaskets	Sets	2	
6.0.7	Mechanical seal assembly complete	Sets	3	
6.0.8	Rotating assembly complete	Set	1	Rotating assembly consists of all the rotating parts except the bearings.
6.0.9	Impeller	No.	1	
6.1	Booster pump suction strainers			
6.1.1	Fine mesh screens	Sets	3	
6.1.2	Coarse mesh screens	Sets	3	
6.1.3	Gaskets	Sets	2	
6.1.4	Bolts, nuts & washers	Set	1	
7.0	HYDRAULIC COUPLING FOR BOILER FEED PUMP			
7.0.1	All bearings	Sets	1	
7.0.2	Primary and secondary wheels along with shafts	Set	1	
7.0.3	Scoop tube & actuator	Set	1	
7.0.4	Oil filter elements	Sets	3	
7.0.5	All Gaskets, oil seals, O-rings, U-rings/ V-rings and sealing rings	Sets	2	

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Sl. No	Description	Unit	Quantity	Remarks
7.0.6	All thrust collars	Sets	2	
7.0.7	Gears for filling pump drive	Set	1	
7.0.8	Fusible plug	Set	1	
7.0.9	Guide bush for scoop tube	Nos.	1	
7.0.10	Starting lub oil pump	No.	1	
7.0.11	Duplex oil filter complete	Set	1	
7.0.12	Motor for Starting lub oil pump	No.	1	
7.0.13	Bearings for motor of Starting lub oil pump	Set	1	
7.0.14	Shaft coupling between Hydraulic coupling and Boiler Feed pump along with coupling bolts, bushes, nuts and washers	Set	1	
7.0.15	Shaft coupling between Hydraulic coupling and Motor along with coupling bolts, bushes, nuts and washers	Set	1	
8.0	NOT USED			
9.0	NOT USED			
10.0	DM COOLING WATER SYSTEM			
10.0.1	DM Cooling Water Pumps			
10.0.2	Complete rotating assembly	Set	1	Rotating assembly consists of all the rotating parts except the bearings.
10.0.3	Shaft sleeves	Set	1	
10.0.4	All wearing rings	Set	1	
10.0.5	Pump shaft	Set	1	
10.0.6	Impeller	No	1	
10.0.7	Bearings	Set	1	

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Sl. No	Description	Unit	Quantity	Remarks
10.0.8	Mechanical seal complete	Set	2	
10.0.9	All bolts, nuts, washers, pins, keys and gaskets	Set	1	
10.0.10	Coupling (connecting Pump & Motor) complete along with coupling bolts, nuts, washers and bushes	Set	1	
10.0.11	Motor bearings of each type & size	Set	1	
10.0.12	Terminal bushings of each type	Nos	2	
10.0.13	Cooling fan assembly	No	1	
10.0.14	Motor for Auxiliary Cooling Water Pump	No	1	
11.0	LP CHEMICAL DOSING SYSTEM			
11.1.1	Hydrazine Dosing Pumps			
11.1.1.1	Plunger / Diaphragm	Set	1	
11.1.1.2	Bearings	Set	1	
11.1.1.3	All gaskets, O-rings and Gland packing	Set	1	
11.1.1.4	All Ball valves	Set	1	
11.1.1.5	Relief Valves	No.	1	
11.1.1.6	Oil and Grease seals	Set	1	
11.1.1.7	Hydrazine dosing pump motor	No.	1	
11.1.1.8	Bearings for hydrazine dosing pump motor	Set	1	
11.1.2	Agitator for Hydrazine Dosing Tank			
11.1.2.1	Impeller/Propeller with Shaft	Set	1	
11.2.1	Ammonia Dosing Pumps			
11.2.1.1	Plunger / Diaphragm	Set	1	
11.2.1.2	Bearings	Set	1	
11.2.1.3	All gaskets, O-rings and Gland packing	Set	1	
11.2.1.4	All Ball valves	Set	1	
11.2.1.5	Relief Valves	No.	1	
11.2.1.6	Oil and Grease seals	Set	1	
11.2.1.7	Ammonia dosing pump motor	No.	1	

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Sl. No	Description	Unit	Quantity	Remarks
11.2.1.8	Bearings for Ammonia dosing pump motor	Set	1	
11.2.2	Agitator for Ammonia Dosing Tank			
11.2.2.1	Impeller/Propeller with Shaft	Set	1	
12.0	Condensate transfer pumps			
12.1	Complete rotating assembly	Set	1	Rotating assembly consists of all the rotating parts except the bearings.
12.2	Shaft sleeves	Set	1	
12.3	All wearing rings	Set	1	
12.4	Pump shaft	Set	1	
12.5	Impeller	No	1	
12.6	Bearings	Set	1	
12.7	Mechanical seal complete	Set	2	
12.8	All bolts, nuts, washers, pins, keys and gaskets	Set	1	
12.9	Coupling (connecting Pump & Motor) complete along with coupling bolts, nuts, washers and bushes	Set	1	
12.10	Motor bearings of each type & size	Set	1	
12.11	Terminal bushings of each type	Nos	2	
12.12	Cooling fan assembly	No	1	
12.13	Motor for Auxiliary Cooling Water Pump	No	1	
13.0	Vacuum Pumps			
13.1	Complete rotating assembly	Set	1	Rotating assembly consists of all the rotating parts except the bearings.

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Tender Document for R&M of Unit No. <i>[..]</i> Capacity <i>[..]</i> of <i>[Name of the Power Plant]</i>	<i>[Logo of Utility]</i>
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Sl. No	Description	Unit	Quantity	Remarks
<i>13.2</i>	<i>Bearings</i>	<i>Set</i>	<i>1</i>	

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B. ELECTRICAL

Sl.No	Description	Unit	Qty.	Remarks
1.0	GENERATOR			
1.1	Generator Bearing	Set	1	
1.2	Generator terminal bushings complete with hardware	Nos.	3	
1.3	Brushes	Sets	4	
1.4	Brush holders	Set	1	
1.5	Labyrinth seal for seal oil H2 side, air side	Set	1	
1.6	Labyrinth seal for Bearings	Set	1	
1.7	Seal ring for shaft seal	Sets	2	
1.8	'O' rings, gaskets, rubber chords, sealing paste	Set	1	
1.9	Slot wedges (rotor)	Set	1	
	Slot wedges (stator)	Set	1	
1.10	Current carrying bolts (inner and outer)	Set	1	
1.11	Slip rings complete with insulated bush	Set	1	
1.12	Fan blades & pins	%	10	
1.13	Gas cooler complete	No.	1	
1.14	Retaining ring complete	Set	1	
1.15	Bolts of each type used in endshields, bearings, manholes, seal body & inspection holes	Nos.	10	
1.16	Stator winding bar(lower)	Nos.	2	
1.17	Stator winding bar(upper)	Nos.	2	
1.18	Stator Water Cooling System			
1.18.1	Teflon Water hose with terminal connectors at turbine end and exciter end.	No.	6	
1.18.2	Cartridge for Stator water pump	No.	1	
1.18.3	Pump bearings	Set	1	
1.18.4	Motor bearings	Set	1	
1.18.5	Water seals for stator water pump	Set	1	
1.18.6	Filter element	No.	1	

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SI.No	Description	Unit	Qty.	Remarks
1.18.7	Gaskets	Set	1	Set comprises the complete requirement
1.19	Miscellaneous Items for Generator			
1.19.1	Sight glass	No.	1	
1.19.2	Liquid detectors	No.	1	
1.19.3	H ₂ &CO ₂ System			
1.19.3.1	Valves in H ₂ cooling system of each type & size	Set	1	
1.19.3.2	H ₂ pr. reducing valve each type in gas post	No.	1	
1.19.3.3	CO ₂ pressure reducing valve each type in gas post	No.	1	
1.19.3.4	CO ₂ vapouriser heater	No.	1	
1.19.3.5	Thermostat for CO ₂ vapouriser heater	No.	1	
1.19.3.6	H ₂ gas dryer heater	No.	1	
1.19.3.7	Thermostat for H ₂ gas dryer heater	No.	1	
1.20	SEAL OIL SYSTEM			
1.20.1	AC&DC Seal oil pump bearings	Set	1	
1.20.2	AC&DC Seal oil pump motor bearings	Set	1	
1.20.3	AC&DC Seal oil pump motors each	No.	1	
1.20.4	Vacuum pump with motor	No.	1	
1.20.5	Crank shaft seal for AC&DC seal oil pumps	Set	1	
1.20.6	Differential pressure regulator of each type	No.	1	
1.20.7	Seal oil system valve of each type	No.	1	
1.20.8	AC&DC Seal oil pumps each	No.	1	
1.20.9	Seal oil filter element	No.	1	
1.20.10	Seal oil vapour extractor	No.	1	
1.20.11	Float valve each type	No.	1	
1.20.12	Gaskets	Set	1	Set comprises the complete requirement
1.21	Local Cubicle (Seal oil system & Gas system)			

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SI.No	Description	Unit	Qty.	Remarks
1.21.1	Electronic cards/modules of each type	No.	1	
1.21.2	Relays of each type	No.	1	
1.21.3	Contactor of each rating	No.	1	
1.22	DC Starter Panels			
1.22.1	Relays of each type	No.	1	
1.22.2	Contactor of each rating	No.	1	
1.22.3	Fuses of each type & rating	Nos.	5	
1.23	Static Excitation System			
1.23.1	Thyristor cooling fan	No.	1	
1.23.2	PLC cards of each type	Nos.	2	
1.23.3	Relays of each type	Nos.	2	
1.23.4	Fuses of each type and rating	Nos.	10	
1.23.5	MCBs of each rating	No.	1	
1.23.6	Semi-conductor fuses of each type	Nos.	2	
1.23.7	Switches of each type	No.	1	
1.23.8	Push Buttons of each type	Nos.	2	
1.23.9	Power pack of each type/function	No.	1	
1.23.10	Transducers of each type	No.	1	
1.23.11	Diodes of each type	No.	1	
1.23.12	Contactors of each type	No.	1	
1.23.13	Timers of each type	No.	1	
1.23.14	Transformers of each type	No.	1	
1.23.15	Field flashing diode bridge	No.	1	
1.23.16	Field flashing contactor	No.	1	
1.23.17	DC over voltage (crow bar) protection with diode and PCB	Set	1	
1.23.18	Thyristor with fuses and micro switches for 100% load	Set	1	(2 bridges)
1.23.19	Thyristor bridge isolating switch(AC&DC) of each type	No.	1	
1.23.20	Static excitation Transformer complete	No.	1	

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SI.No	Description	Unit	Qty.	Remarks
1.23.21	Resistors and capacitors of each type	No.	1	
1.23.22	RC network for exciter circuit for AC over-voltage protection	Set	1	
1.23.23	Electronic cards/Modules of each type	No.	1	
1.23.24	Field circuit breaker	No.	1	
1.24	AVR and Brushless Excitation System (If Brush less Excitation system is offered instead of Static Excitation System)			
1.24.1	Two (2) sets of each type of cards, including One (1) set of each type of fixed connectors for cards	Lot	2	
1.24.2	Control transformer of each type and rating	sets	4	
1.24.3	Fuses of each type and rating including thyristor fuses	sets	12	
1.24.4	Terminal connectors for external connection	set	2	
1.24.5	Field breaker (Static crowbar type)	No	2	
1.24.6	Thyristors	sets	4	
1.24.7	Switches of each type and rating	sets	4	
1.24.8	Indicating lamps	sets	6	
1.24.9	Discharge resistor	no	2	
1.24.10	Power supply module	no	2	
1.24.11	Contractors and Auxiliary switches of each type and auxiliary relays	no	2	
1.24.12	Motorized fan for forced air cooling (if required)	nos	4	
1.24.13	Pulse transformer	sets	4	
1.24.14	Key board with LCD screen	no	2	
2.0	NEUTRAL GROUNDING TRANSFORMER (FOR GENERATOR)			
2.1	NGT mounted CT of each ratio, type and rating	No.	1	
2.2	Seal off bushing	No.	1	
2.3	Supporting insulator	No.	1	
2.4	Resistor unit	Set	1	

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SI.No	Description	Unit	Qty.	Remarks
3.0	PROTECTION , CONTROL & RELAY PANELS			
	(FOR Generator ,GT,& UT) (to be repeated for each panel)			
3.1	Protective relays of each type	No.	1	
3.2	Trip relays of each type	No.	1	
3.3	Auxiliary relays of each type	Nos.	2	
3.4	Timers of each type	No.	1	
3.5	Power supply module of each type	No.	1	
3.6	Meters of each type	No.	1	
3.7	Energy meter of each type	No.	1	
3.8	Switches of each type	No.	1	
3.9	Push Buttons of each type	Nos.	2	
3.10	Fuses of each type & rating	Nos.	20	
3.11	Disconnecting type Terminal Blocks for CT wiring	Nos.	5	
3.12	Non-disconnecting type Terminal Blocks	Nos.	5	
3.13	Auxiliary CTs of each ratio	No.	1	
3.14	Auxiliary VTs of each ratio	No.	1	
3.15	Transducers of each type	No.	1	
4.0	ISOLATED PHASE BUSDUCT			
4.1	Bus support insulators of each size and type	Nos.	10	
4.2	Seal off bushing of each type	Nos.	2	
4.3	Flexible connectors of each type & rating(complete set for all the phases)	Set	1	
4.4	Disconnecting links	Nos.	2	
4.5	Expansion joints(for conductor for all the phases)	Sets.	2	
4.6	Belleville washer	Nos.	20	
4.7	Silica gel breather	No.	1	
4.8	Current Transformers of each ratio, type and rating	No.	1	

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SI.No	Description	Unit	Qty.	Remarks
5.0	6.6 kV SEGREGATED PHASE BUS DUCTS			
5.1	Set of seal-off bushing of each type and rating	Nos.	3	
5.2	Set of flexible of each type and rating	Nos.	2	
5.3	Drain plug with cap	Nos.	3	
5.4	Silica gel breathers	Nos.	3	
5.5	Gaskets of each type and rating	Sets.	3	
5.6	Belleville washers	Nos	5	
5.7	Densal or equivalent compound	Kg.	1	
5.8	Space heater set	Sets	1	
6.0	415 V NON-SEGREGATED PHASE BUS DUCTS			
6.1	Set of flexible of each type and rating	Nos.	3	
6.2	Gaskets of each type and rating	Sets.	3	
6.3	Space heater set	Set	1	
6.4	Set of seal-off bushing of each type and rating(Applicable for oil type transformer)	Nos.	3	
7.0	6.6 KV SWITCHGEAR (TO BE REPEATED FOR EACH MAKE OF 6.6 kV SWITCHGEAR)			
	SPARES FOR VACUUM CIRCUIT BREAKER			
	(Spares for each rating of Breaker)			
7.1	Closing & tripping coils each	Nos.	10	
7.2	Spring charging motors	Nos.	5	
7.3	Aux. switch assembly, limit position switches	Nos. each	5	
7.4	Operating mechanism rods	Nos.	5	
7.5	Surge suppressor units	Nos.	5	
7.6	Vacuum bottles	Nos.	5	
7.7	Multi pin plug and socket for control	Sets	5	
7.8	Selector Switches of each type and rating	Nos.	2	
7.9	Busbar support insulators of each type	Nos.	20	
7.10	Switches of each type	Nos.	5	
7.11	Moving and Fixed contact Assembly of each	set	1	

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SI.No	Description	Unit	Qty.	Remarks
	<i>rating and type</i>			
7.12	<i>Numerical Relays of each type</i>	<i>No.</i>	<i>1</i>	
7.13	<i>Auxiliary relays of each type</i>	<i>No.</i>	<i>1</i>	
7.14	<i>Interposing relay for DCS each type</i>	<i>No.</i>	<i>1</i>	
7.15	<i>Clustered type LED of each type/color</i>	<i>Nos.</i>	<i>2</i>	
7.16	<i>CTs of each ratio , type and rating</i>	<i>Nos.</i>	<i>3</i>	
7.17	<i>VTs of each ratio , type and rating</i>	<i>Nos.</i>	<i>3</i>	
7.18	<i>Timer each type</i>	<i>No.</i>	<i>1</i>	
7.19	<i>Check synchronizing relay</i>	<i>No.</i>	<i>1</i>	
7.20	<i>Meters of each type</i>	<i>No.</i>	<i>1</i>	
7.21	<i>Contactors of each rating and type.</i>	<i>Nos.</i>	<i>1</i>	
7.22	<i>Disconnecting type Terminal block for CT wiring</i>	<i>Nos.</i>	<i>5</i>	
7.23	<i>Non-disconnecting type Terminal Block</i>	<i>Nos.</i>	<i>5</i>	
7.24	<i>Shrouds each type</i>	<i>Nos.</i>	<i>5</i>	
7.25	<i>MCB of each type and rating</i>	<i>Nos.</i>	<i>5</i>	
7.26	<i>Shutter mechanism complete of each type</i>	<i>Nos.</i>	<i>5</i>	
7.27	<i>Indicating lamps of each type and rating</i>	<i>Nos.</i>	<i>5</i>	
7.28	<i>Complete assembled Auxiliary Contactor of each rating</i>	<i>Nos.</i>	<i>5</i>	
7.29	<i>Bi-metal thermal overload relays with single phase preventers of each rating</i>	<i>Nos.</i>	<i>5</i>	
7.30	<i>Single phase control transformer 415V/110V of each rating</i>	<i>Nos.</i>	<i>5</i>	
7.31	<i>Fuses of each type and rating:</i>			
7.31.1	<i>Power</i>	<i>Nos.</i>	<i>10</i>	
7.31.2	<i>Control</i>	<i>Nos.</i>	<i>10</i>	
7.32	<i>Fuse puller for each type of fuse</i>	<i>Nos.</i>	<i>5</i>	
7.33	<i>MCCB of each rating & type</i>	<i>Nos.</i>	<i>2</i>	
8.0	FAST BUS TRANSFER PANEL			
8.1	<i>Relay of each type</i>	<i>No.</i>	<i>1</i>	

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SI.No	Description	Unit	Qty.	Remarks
8.2	MCB of each rating	No.	1	
8.3	Terminal block of each type	No.	1	
8.4	Fast bus transfer unit	No.	1	
9.0	415V SWITCHGEAR (Spares to be repeated for each make of board)			
	Spares for Breaker (Spares for each rating of Breaker)			
9.1	Breaker complete with operating mechanism and truck mounted	Nos.	1	
9.2	Closing & tripping coils each	Nos.	1	
9.3	Fixed and moving contact assemblies of each breaker	Nos.each	2	
9.4	Spring charging motors	Nos.	2	
9.5	Gaskets	Sets	5	
9.6	Aux.switch assembly, limit position switches	nos. each	3	
9.7.1	Busbar support insulators of each type	Nos.	10	
9.7.2	Switches of each type	No.	1	
9.7.3	Numerical Relays of each type	No.	1	
9.7.4	Auxiliary relays of each type	No.	1	
9.7.5	Interposing relay of each type for DDCMIS	No.	1	
9.7.6	Clustered type LED of each type/colour	Nos.	2	
9.7.7	CTs of each ratio , type and rating	Nos.	3	
9.7.8	VTs of each ratio , type and rating	Nos.	3	
9.7.9	Meters of each type	No.	1	
9.7.10	Fuse and fuse base assembly of each type & rating	Nos.	10	
9.7.11	Timer each type	No.	1	
9.7.12	Check synchronizing relay	No.	1	
9.7.13	Disconnecting type Terminal block for CT wiring	Nos.	5	
9.7.14	Non-disconnecting type Terminal Block	Nos.	5	
9.7.15	Selector switch of each type and rating	Nos.	2	

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SI.No	Description	Unit	Qty.	Remarks
11.0	415 V Distribution Board (ACDB/PDB/MLDB)			
	<i>(Spares to be repeated for each make of BOARD)</i>			
11.1	<i>Busbar support insulator</i>	<i>Nos.</i>	<i>10</i>	
11.2	<i>Fuses of each type and rating:</i>			
11.2.1	<i>Power</i>	<i>Nos.</i>	<i>10</i>	
11.2.2	<i>Control</i>	<i>Nos.</i>	<i>20</i>	
11.3	<i>MCB of each type & rating</i>	<i>Nos.</i>	<i>2</i>	
11.4	<i>Switch Fuse Units of each rating & type</i>	<i>Nos.</i>	<i>2</i>	
11.5	<i>MCCB of each rating & type</i>	<i>Nos.</i>	<i>2</i>	
11.6	<i>Meters of each type</i>	<i>Nos.</i>	<i>1</i>	
11.7	<i>Switches of each type and rating</i>	<i>Nos.</i>	<i>1</i>	
11.8	<i>Terminal Blocks</i>	<i>Nos.</i>	<i>10</i>	
12.0	415 V Sub-Distribution Board/FUSE DBS/LDBS/ALDBS			
	<i>(Spares to be repeated for each make of Board/panel)</i>			
12.1	<i>Fuses of each type and rating</i>	<i>Nos.</i>	<i>10</i>	
12.2	<i>Push button</i>	<i>Nos.</i>	<i>10</i>	
12.3	<i>Terminal Blocks</i>	<i>Nos.</i>	<i>10</i>	
12.4	<i>MCB of each type & rating</i>	<i>Nos.</i>	<i>2</i>	
12.5	<i>SFU of each rating & type</i>	<i>Nos.</i>	<i>3</i>	
13.0	LT TRANSFORMER (Oil/Dry type)			
	<i>(for each type and rating of transformers)</i>			
13.1	<i>Complete Winding Temperature indicating equipment</i>	<i>Set</i>	<i>1</i>	
13.2	<i>CTs of each type and rating</i>	<i>No.</i>	<i>1</i>	
13.3	<i>Support Insulators</i>	<i>Set</i>	<i>2</i>	
13.4.1	<i>HV bushing</i>	<i>Nos</i>	<i>4</i>	
13.4.2	<i>LV bushing</i>	<i>Nos</i>	<i>4</i>	

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SI.No	Description	Unit	Qty.	Remarks
13.4.3	LV neutral Bushing	Nos	2	
13.4.4	Bushing CT(LV) of each rating	Nos	2	
13.4.5	Complete set of gaskets	Sets	2	
13.4.6	One valve of each type	Sets	2	
13.4.7	Magnetic oil level gauge with contacts (for oil type)	Nos	2	
13.4.8	Winding temperature indicator(WTI) with all accessories	Nos	2	
13.4.9	Dial type Oil temperature indicator(OTI) (for oil type)	Nos	2	
13.4.10	Silica gel breather	Nos	2	
13.4.11	Buchholz relay	Nos	2	
13.4.12	Radiator unit	No.	1	
13.4.13	Pressure relief device	Nos	2	
13.4.14	Tap Changer Contact	Set	1	
14.0	220 V DC SYSTEM			
14.1	Battery			
14.1.1	Stand Insulators	Nos.	50	
14.1.2	Connectors with Nuts and Bolts	Nos.	50	
14.2	Battery Chargers			
14.2.1	Contactors of each type	Nos.	10	
14.2.2	Coils for each type of Contactor	Nos.	10	
14.2.3	Main & Aux Contact sets	Nos.	10	
14.2.4	DC Ammeter of each type	Nos.	2	
14.2.5	DC Voltmeter of each type	Nos.	2	
14.2.6	AC Ammeter of each type	Nos.	2	
14.2.7	AC Voltmeter of each type	Nos.	2	
14.2.8	Control Switch of each type	Set	1	
14.2.9	Current regulators of each type	Set	1	
14.2.10	Fuses/MCBs of each type & rating	Nos.	2	

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SI.No	Description	Unit	Qty.	Remarks
14.2.11	Over load relays of each type	No.	1	
14.2.12	Filter condenser & Filter Fuses	Set	2	
14.2.13	MCCBs of each rating	Nos.	2	
14.2.14	LED Lamps	Sets	2	
14.2.15	PCBs of each type	No.	1	
14.2.16	Control Unit Relay	Nos.	10	
14.2.17	SCR module of each type	Nos.	5	
14.2.18	Blocking diode for Battery Charger per board	Nos.	5	
14.2.19	Push Buttons	Nos.	5	
14.2.20	Cooling Fan	No.	1	
15.0	NOT USED			
16.0	NOT USED			
17.0	NOT USED			

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C. CONTROL & INSTRUMENTATION

Sl.No	Description	Unit	Qty.	Remarks
1.0	<u>TURBINE SPARES</u>			
1.1	<u>Gland seal system</u>			
1.1.1	Limit switches for positioning actuator for seal steam supply and pump valves (gland seal system)	Nos	4	
1.2	<u>Reheater stop valves</u>			
1.2.1	Proximity sensor / limit switch for Reheater stop valves position of each type and range as applicable	Nos	2	
1.2.2	Limit switches/inductive displacement transducer for Reheater interceptor valve	Nos	2	
1.3	<u>Reheater control valve</u>			
1.3.1	Limit switches/Proximity sensor of each type	Nos	5	
1.4	<u>Governing system</u>			
1.4.1	Electrical speed measuring device	Nos	2	
1.4.2	Electronic cards for governing system			
1.4.2.1	Power supply module (24V DC)	%	10	
1.4.2.2	CPU module (MPU)	%	10	
1.4.2.3	Main power supply unit	%	10	
1.4.2.4	Analog module (I/O)	%	5	
1.4.2.5	Controller module	%	10	
1.4.2.6	RS 232 / RS 422 Communication cable of each type.	%	10	
1.4.2.7	Specialized pre fabricated cable	%	5	
1.4.2.8	Digital module	%	10	
1.4.2.9	Special types of fuses of each type and rating	%	5	
1.4.2.10	Terminal strips of each type and rating	%	5	
1.4.2.11	Isolator / MCB of each type and range	%	5	

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Sl.No	Description	Unit	Qty.	Remarks
1.4.2.12	Termination module	%	5	
1.4.2.13	Contactor (of each type and range)	%	5	
1.4.2.14	Power supply for unit for governing control system	%	10	
NOTE: Cards applicable as mentioned above and any other card used in the system other than mentioned above also shall be included as 10% of each type of modules used in the system for each unit or minimum one no. Whichever is higher				
1.4.3	All types of limit switches / proximity sensors for position indication used in governing system of each type	Nos	5	
1.4.4	All type of solenoids valve in the governing system of each type	Nos	2	
1.4.5	Trip solenoids of each type	Nos	2	
1.5	<u>Oil system</u>			
1.5.1	Oil tank level indicator	Nos	1	
1.5.2	Oil tank level transmitter	Nos	1	
1.5.3	Pressure limiting valve	Nos	1	
1.6	<u>ESV</u>			
	<u>Main steam stop valve</u>			
1.6.1	Limit switches / Proximity sensor	Nos	2	
1.7	<u>MSCV (main steam control valve)</u>			
1.7.1	Limit switches / Proximity sensor of each type	Nos	5	
1.8	<u>Valves & Specialties</u>			
1.8.1	Position transmitter for all valves of each type and make	Nos	1	
1.8.2	Solenoid operated valve used in Turbine area (of each type)	Nos	2	
1.8.3	Solenoid valves (of various types) each type and make	Nos	2	
1.9	<u>Turbine instruments (for both BFP Turbine & Main Turbine)</u>			
1.9.1	Bearing oil drain temp. Indicator of each type	Nos	2	

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Sl.No	Description	Unit	Qty.	Remarks
	<i>and range</i>			
1.9.2	<i>Bearing vibration pick up each type</i>	<i>Nos</i>	<i>4</i>	
1.9.3	<i>Eccentricity pick up each type</i>	<i>Nos</i>	<i>2</i>	
1.9.4	<i>Axial shift pick up each type</i>	<i>Nos</i>	<i>2</i>	
1.9.5	<i>Differential expansion pick up for HPT each type</i>	<i>Nos</i>	<i>2</i>	
1.9.6	<i>Differential expansion pick up for LPT if applicable each type</i>	<i>No.</i>	<i>2</i>	
1.9.7	<i>Casing expansion pick up each type</i>	<i>No.</i>	<i>2</i>	
1.9.8	<i>Speed pick up each type</i>	<i>No.</i>	<i>2</i>	
1.9.9	<i>Zero speed pick up each type</i>	<i>No.</i>	<i>2</i>	
1.9.10	<i>Key phasor each type</i>	<i>No.</i>	<i>2</i>	
1.9.11	<i>Turbine Bearing RTD's supplied separately</i>	<i>%</i>	<i>10</i>	
1.10	<u>HP & LP Bypass</u>			
1.10.1	<i>Controller for HP & LP bypass system each type</i>	<i>No.</i>	<i>1</i>	
1.10.2	<i>Safety control unit for HP & LP bypass system (each type) – ON – OFF hydraulic valves each type</i>	<i>No.</i>	<i>1</i>	
1.10.3	<i>Electronic modules</i>			
1.10.3.1	<i>CPU/PLC module</i>	<i>%</i>	<i>10</i>	
1.10.3.2	<i>Analog signal module</i>	<i>%</i>	<i>10</i>	
1.10.3.3	<i>Digital signal module</i>	<i>%</i>	<i>10</i>	
1.10.3.4	<i>Electronic position module</i>	<i>%</i>	<i>10</i>	
1.10.3.5	<i>Relay module</i>	<i>%</i>	<i>5</i>	
1.10.3.6	<i>Relay contact and optical isolator</i>	<i>%</i>	<i>5</i>	
1.10.3.7	<i>Pre fabricated cable along with plug</i>	<i>%</i>	<i>5</i>	
1.10.3.8	<i>Power supply unit</i>	<i>%</i>	<i>10</i>	
1.10.4	<i>Position transmitter of each type and model</i>	<i>Nos</i>	<i>2</i>	
1.10.5	<i>Limit switches / Proximity sensors of each type and model</i>	<i>Nos</i>	<i>2</i>	
1.10.6	<i>Proportional control valve</i>	<i>Nos</i>	<i>4</i>	

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Sl.No	Description	Unit	Qty.	Remarks
1.10.7	Pressure switches for HP/LP bypass system Each type and range	Nos	2	
1.10.8	Level gauge / indicators of each type and range	No.	1	
1.10.9	Flow switch of each type and range	Nos	2	
1.10.10	Solenoid valve of each type and module	Nos	2	
1.11	<u>CEP</u>			
1.11.1	Local Temperature indicator for CEP motor bearings and pump bearings each type and range	No.	1	
1.11.2	Local Bearing oil temp. Indicator each type and range	Nos	2	
1.11.3	RTD for Bearing each type and range	Nos	2	
1.11.4	Winding temp. Sensor for CEP motor	Nos	2	
1.12	<u>Lube oil purification system</u>			
1.12.1	Temp. Indicator (0-120 deg.C)	Nos	2	
1.12.2	Level switch	Nos	2	
1.12.3	Pressure gauge range 0-6 bar	Nos	2	
1.12.4	Vacuum gauge of each type and range	No.	1	
1.12.5	Temperature switch	No.	1	
1.12.6	Pressure switch	No.	1	
1.12.7	Resistance thermostats (RTD)	Nos	2	
1.12.8	Temperature controller	Nos	2	
1.12.9	Flow meter	No.	1	
1.12.10	Flow switch	No.	1	
1.12.11	Gauge glass assembly	Sets	2	
1.12.12	Temperature indicator	Nos	2	
1.13	<u>MDBFP</u>			
1.13.1	Electronic cards of each type and model used in BFP scoop tube/speed control. (If applicable)	%	10	
1.13.2	Scoop tube position pick up sensor	Nos	4	

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Sl.No	Description	Unit	Qty.	Remarks
1.13.3	Thermometer of each type and range	Nos	2	
1.13.4	Pr. Switches of each type and range	Nos	2	
1.13.5	Diff. Pr. Gauge of each and range	Nos	2	
1.13.6	Pr. Gauges of each range	Nos	2	
1.13.7	Thermocouple / Thermo resistances	Nos	4	
1.13.8	BFP motor winding RTD's	Nos	4	
1.13.9	BFP motor Bearing Temp. Sensor	Nos	4	
1.13.10	Temp. Switches of each range	Nos	2	
1.13.11	Level switches of each range	Nos	4	
1.13.12	Solenoids of each type	Nos	4	
1.13.13	Speed sensor	Nos	5	
1.13.14	Vibration sensors (if applicable)	Nos	3	
1.13.15	Vibration monitor (if applicable)	No.	1	
1.13.16	4 channel vibration / seismic monitor cards	Nos	2	
1.13.17	110 V AC PS unit for vibration analysis	No.	1	
1.13.18	Contactor of each type and ratings	Nos	2	
1.13.19	Rack interface module	No.	2	
1.13.20	Reverse rotation switch for BFP	Nos	1	
1.14	<u>Turbo supervisory instruments</u>			
1.14.1	TSI power input module	%	10	
1.14.2	TSI dual vibration monitor	%	10	
1.14.3	TSI dual thrust position monitor	%	10	
1.14.4	TSI dual differential expansion monitor	%	10	
1.14.5	TSI casing expansion monitor	%	10	
1.14.6	Any other electronic module / monitor used in TSI and vibration monitor system if any	%	10	
1.14.7	Contactor (of each type)	%	5	
1.14.8	Rack interface module	%	5	
1.14.9	Power supply unit	%	10	
1.14.10	Special type connectors, if any	%	10	

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Sl.No	Description	Unit	Qty.	Remarks
1.15	<u>Surface condenser HP & LP Feed water heaters Deaerator, hot well and any other system to complete the scope</u>			
1.15.1	Level switches consisting of each type and model	No	2	
1.15.2	Complete level switches of each type and size	No	2	
1.15.3	Switch level mechanism of each type and model	Nos	4	
1.15.4	Mercury / Micro switch of each type and size	Nos	4	
1.15.5	Float assembly of each type and size	Nos	4	
1.15.6	Gasket of each type and model	Nos	4	
1.15.7	Magnets of each type and size	Nos	4	
1.15.8	<u>Gauge glasses as follows:</u>			
1.15.9	Glasses of each type and model of each type, model and size	Nos	4	
1.15.10	Complete gauge glass assembly including illumination arrangement & isolation valves	No.	2	
1.16	<u>Ball cleaning system</u>			
1.16.1	Diff. Pr. Transmitter of each type	Nos	2	
1.16.2	Diff. Pr. Indicators of each type	Nos	2	
1.16.3	Pressure Gauges of each type	Nos	2	
1.16.4	Ball counter of each type	Nos	2	
1.16.5	Valves, of each type	No.	2	
1.16.6	Diff. Switches of each type	Nos	2	
1.16.7	Motor operated valves and actuators	Set	2	
1.16.8	PLC and its cards	%	5	
1.17	<u>I&C Equipments for Turbine area (Feed water system, Steam extraction system, Heaters, Drain system, DM Water system, A.C.W system Service Water system, Condensate system, Drains system Main steam system and any other system to complete the scope</u>			

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Sl.No	Description	Unit	Qty.	Remarks
1.17.1	Thermocouple of each type	%	5	
1.17.2	Temperature switches of each type and range	Nos	2	
1.17.3	Local temp. Gauge / Thermometer of each type and range	Nos	2	
1.17.4	Thermo wells of each type	%	5	
1.17.5	Resistance thermometers of each type (RTD)	Nos	2	
1.17.6	Level indicators / gauge of each type and range	Nos	2	
1.17.7	Pressure switches of each type and range	Nos	2	
1.17.8	Pressure gauge of each type and range	Nos	2	
1.17.9	Level switches of each type and range	Nos	2	
1.17.10				
1.17.11	Limit switches of each type and range	Nos	4	
1.17.12	Position limit switch of each type and make (for all type of actuators)	Nos	4	
1.17.13	Torque switches of each type and model (for all type of actuators)	Nos	4	
1.17.14	Proximity sensors of each type and make	Nos	2	
1.17.15	Pressure transmitters of each type and range and make	%	10	
1.17.16	Temperature transmitters of each type, range and make	%	10	
1.17.17	Differential pressure transmitter of each type and range and make	%	10	
1.17.18	Level transmitters including Radar type Level Transmitter of each type and range and make	%	10	
1.17.19	Transmitters mounting accessories such as manifolds and its necessary fitting			
1.17.19.1	Three way manifolds	%	5	
1.17.19.2	Five way manifolds	%	5	

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Sl.No	Description	Unit	Qty.	Remarks
1.17.19.3	Two way manifolds	%	5	
1.17.19.4	Snubbers	%	5	
1.17.19.5	Isolation valves	%	5	
1.17.19.6	Drain valves	%	5	
1.18	Control valves for Turbine area (Feed water system, Steam extraction system, Heaters, Drain system, Demiwater system, A.C.W. system, Service water system, Condensate system, Drains system Main steam system and any other system to complete the scope			
1.18.1	Complete set of control valve each size and type with actuator and its control	%	5	
1.18.2	<u>Control valves internals</u>			
1.18.2.1	Valve stem with plug & seat ring each size and type	Nos	2	
1.18.2.2	Gasket of each type and Size	Nos	5	
1.18.2.3	Body seal gaskets of each size and type	Nos	5	
1.18.2.4	Cage of each size and type	Nos	1	
1.18.2.5	Gland packing each size and type	Sets	5	
1.18.2.6	Valve Trim of each size and type	Nos.	1	
1.19	<u>Actuator internals</u>			
1.19.1	Complete set of control valve each size and type with actuator and its control	%	5	
1.19.2	Diaphragm of each type and size	%	5	
1.19.3	Seal box "O" ring of each type and size	%	5	
1.19.4	Color "O" ring of each type and size	%	5	
1.19.5	Limit switch (complete instrument) of each model and type	%	5	
1.19.6	Solenoid valve (complete instrument) of each model and type	%	5	
1.19.7	Valve 420positioned (complete instrument) of each model and type	%	5	
1.19.8	Position transmitters (complete instrument)	%	5	

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Sl.No	Description	Unit	Qty.	Remarks
	<i>of each model and type</i>			
1.19.9	<i>Air set / regulator with gauge</i>	%	5	
1.19.10	<i>Air lock relay</i>	%	5	
1.19.11	<i>Air booster / accumulator</i>	%	5	
1.20	NOT USED			
2.0	<u>GENERATOR</u>			
2.1	<i>Resistance thermometer (RTD) of each type and model</i>	Nos	4	
2.2	<i>Temperature control valve</i>	no	2	
2.3	<i>Duplex RTD for Gen. Winding each type</i>	Nos	2	
2.4	<i>Duplex RTD of Gen. Bearing</i>	Nos	3	
2.5	<i>Level transmitter</i>	Nos	2	
2.6	<i>Portable gas analyzer</i>	No	2	
2.7	<i>H2 pressure gauge of each type and range</i>	Nos	2	
2.8	<i>H2 purity analyzer (complete unit)</i>	No	1	
2.9	<i>Pressure gauge of each type and range used in generator area</i>	Nos	4	
2.10	<i>Diff. Pressure instrument of each type and range in generator area</i>	Nos	4	
2.11	<i>Thermometers</i>	Nos	2	
2.12	<i>Pressure switch</i>	Nos	2	
2.13	<i>Temp. Switch</i>	Nos	2	
2.14	<i>Pr. Transmitter each type</i>	Nos	2	
2.15	<i>Diff. Pr. Transmitter</i>	Nos	2	
2.16	<i>Resistance Thermometer used in seal oil system & H2 circuit, Generator area each type</i>	Nos	2	
2.17	<i>Level indicator of each type and model</i>	Nos	1	
2.18	<i>Flow indicator</i>	Nos	1	
2.19	<i>Moisture Analyser</i>	Nos	1	

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Sl.No	Description	Unit	Qty.	Remarks
3.0	<u>TG INTEGRATED CONTROL SYSTEM</u>			
3.1	<u>Work station</u>			
3.1.1	Work station including LAN card	Nos	2	
3.1.2	TFT colour monitors	Nos	2	
3.1.3	Color Inkjet Printer A4 B/W	Nos	1	
3.1.4	Color Laser Printer A4	Nos	1	
3.1.5	Printer network connector	Nos	2	
3.1.6	21" TFT Color monitor for OS & ES	Nos	2	
3.1.7	Compact disk boxes	Nos	5	
3.2	<u>Control cabinets</u>			
3.2.1	Analog input module	%	5	
3.2.2	Analog output module	%	5	
3.2.3	Digital input module	%	5	
3.2.4	Digital output module	%	5	
3.2.5	Input temperature module	%	5	
3.2.6	Any other module used in DDCMIS	%	5	
3.3	<u>Power supply distribution & SOV</u>			
3.3.1	Breakers 220V each current rating	%	5	
3.3.2	Solenoid breaker (2A)	%	5	
3.4	<u>Relay</u>			
3.4.1	Relay for SOV	Nos	25	
3.4.2	Trip relay (master fuel trip)	Nos	2	
3.4.3	Relays	%	10	
3.4.4	Voltage monitor relay	Nos	10	
3.4.5	Supply unit 24 volt	Nos	2	
NOTE: Cards applicable as mentioned above and any other card used in TG integral control system other than mentioned above also shall be included as 10% of each type of modules used in the system for each unit or minimum one no. Whichever is higher				
3.5	<u>Push buttons</u>			
3.5.1	Trip push button each type	Nos	4	

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Sl.No	Description	Unit	Qty.	Remarks
3.5.2	Round PB each type	Nos	4	
3.5.3	Lamp test white each type	Nos	4	
3.5.4	Release black each type	Nos	4	
3.5.5	Alarm RED each type	Nos	4	
3.5.6	Reset RED each type	No	4	
3.6	Miscellaneous Items			
3.6.1	Preformed cable of each length (50 m) different cores with male/female connectors of pre fabricated cables each type & each unit	Nos	2	
3.6.2	Connectors used for pre fab. Cables each type	Nos	6	
3.6.3	Coaxial 10 Base 2 (as applicable)	%	5	
3.6.4	Coaxial 75 ohm Base 2 (as applicable)	%	5	
3.6.5	Duplex optical fiber	%	2.5	
3.6.6	Wire cable connectors	Nos	100	
3.6.7	Fuses of each type and rating	Nos	50	
3.6.8	MCB of each type and rating	Nos.	10	
3.6.9	Terminals of each type	Nos.	100	
3.6.10	Indicators of each type & model (ammeter, voltmeter) (if applicable)	%	5	
3.6.11	Digital indicators of each type & model	Nos.	2	
3.6.12	Digital bargraph indicator	Nos.	5	
3.6.13	Digital indicator MVAR	No.	1	
3.6.14	Digital indicator MW	No.	1	
4.0	PLC			
4.1	Electronics modules for each type	%	10	
4.2	Power supply unit for each type	%	10	
4.3	Graphical Interface units for each type	No.	1	
4.4	Cooling fan in PLC system / cabinet	Nos.	2	
4.5	TFT Monitor for each type & size	No.	1	

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Sl.No	Description	Unit	Qty.	Remarks
4.6	Printer for each type	No.	1	
5.0	CABLE			
5.1	FRLS cables of each size and type (1 std drum = 500 mts.)	std drum	4	
5.2	Thermocouple compensating cable of each size and type (1 std drum = 500 mts.)	std drum	1	
5.3	Turbovisory cable (special shielded cables of each size and type) (1 std drum = 500 mts.)	std drum	1	
5.5	Fibre optic cable. (1 set = maximum length used in the installed quantity along with its connectors)	Sets	2	
5.6	Serial link cable. (1 set = maximum length used in the installed quantity along with its connectors)	Sets	5	
5.7	DDCMIS cables of each type	m	200	
5.8	Communication cable. (1 set = maximum length used in the installed quantity along with its connectors)	Sets	5	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-I, ANNEXURE-III
LIST OF SUB-VENDOR**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-III

List of Sub-vendor

{List of approved vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as in the given format.}

A. MECHANICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

B. ELECTRICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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C. CONTROL & INSTRUMENTATION

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

D. CIVIL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-II, PART-A
DETAILED TECHNICAL SPECIFICATION-
MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

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1 TURBINE GENERATOR & AUXILIARIES

1.1 General Information

[The steam turbine-generator shall be located within a weather proof enclosure with a roof above the operating floor. The turbine-generator shall consist of a 3000 RPM tandem compound, single reheat, uncontrolled extraction, condensing type turbine, directly coupled to the generator. The HP, IP and LP casing shall be either independent of each other or a combination of these. The turbine low pressure ends shall be arranged for bottom exhaust to water cooled condenser.

The unit shall have nominal 210/215/220/250 MW output. The steam turbine generator shall be horizontal, fully enclosed, hydrogen cooled type or direct water-cooled stator and hydrogen cooled rotor conductors. All the auxiliaries for turbine generator shall be provided.

Each 210/215/220/250 MW Steam Turbine shall be connected to a Steam generator. The steam turbine shall be supplied with steam for generation of power and for regenerative feed heating through uncontrolled extraction points. Determination of number of turbine casing extraction points, turbine stages for extraction and final feed water temperature extraction parameters shall be based on the cycle optimization study by the Bidder considering turbine manufacturer's proven standard design.

The turbine shall provide extraction steam for feed water heating, gland sealing, as required.

This section of the specification shall be read in conjunction with the other Sections & Volumes of the specification as appropriate and the equipment offered shall meet the requirement as spelt out there-in and to complete the system requirement.]

{The double flow Baumann exhaust of LP stage of LMZ design Steam Turbine shall be retrofitted to improve the efficiency of LP Turbine. In addition retrofitting of LP Stage/ HP stage / IP stage / both HP & IP stages shall be carried out both for LMZ and KWU Turbines as per the findings of Steam Path Audit conducted during the RLA studies. The Utilities may appropriately incorporate the specifications of retrofitting the Turbines in Section-II of the specifications after the scope of work under Section-I is finalized.}

1.2 Material Requirements

The Bidder shall submit the schedule of materials used in turbine construction. The materials to be used shall not be inferior to those mentioned below.

Table: 1.1

S.No	Description	Material
i)	<i>[Turbine casing]</i>	
	HP outer casing	GS-17 Cr. Mo V 511

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S.No	Description	Material
	HP blade casing	GS-17 Cr. Mo V 511
	IP casing	GS-22 Mo 4
	LP casing	R St 37-2N
ii)	<i>[Turbine shaft and shaft coupling]</i>	
	HP shaft	28 Cr. Mo Ni V 59
	IP shaft	30 Cr. Mo Ni V 511
	LP shaft	26 Ni Cr. Mo V 145
iii)	<i>[Moving blade]</i>	
	HP turbine first stage	X 22 Cr Mo V 121
	HP turbine other stage	X 20 Cr Mo 13
	IP turbine stages	X 22 Cr Mo V 121
	LP turbine stages	X 20 Cr 13
iv)	<i>[Fixed blades]</i>	
	HP turbine first Stage	X 22 Cr Mo V 121
	HP other stages	X 20 Cr Mo 13
	IP turbine first Stage	X 22 Cr Mo V 121
	IP other stages	X 20 Cr Mo 13
	LP turbine first Stage	X 20 Cr 13
	LP other stages	X 20 Cr Mo 13
v)	<i>[Casing joint bolts]</i>	
	HP Cylinder	X 21 Cr Mo V 57
	IP Cylinder	X 21 Cr Mo V 57
	LP Cylinder	X 24 Cr Mo V 5
vi)	<i>IP/LP crossover/ Cross around piping</i>	R St 37-2 N
vii)	<i>[Turbine steam admission valves]</i>	
	Valve Body	GS-17 Cr Mo V 511
	Valve Spindle	X 22 Cr Mo V 121
	Valve seat	Stellited 21 Cr Mo V Ni 47

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1.3 Maintenance Requirements

i)	Wet Steam washing	a)	Each turbine shall be provided with Wet Steam washing facility as per standard proven practice of the OEM. For this necessary stub connections on turbine and required piping shall be provided, if required.
		b)	Recommended Washing procedures as per standard proven practice of the OEM shall be furnished.
ii)	Forced Cooling of Turbine		Necessary equipment shall be provided for forced cooling of turbine as per standard proven practice of the OEM to have quick access during emergency condition.
iii)	Turbine preservation	a)	This shall be provided to protect turbine against corrosion during non working Period.
		b)	Write up for the recommended preservation system shall be submitted.

1.4 Accessories to be Furnished

Each steam turbine-generator shall include the following equipment:

- i. *[Turbine rotor shall be of solid forged type. The Bidder shall provide material certificate including material chemical composition, high temperature mechanical properties, allowable temperature range, non-destructive testing method and manufacturer's name. Minimal contact between the rotor and the cylinder should not cause rotor damage or bending of the rotor shaft.]*
- ii. *[Steam pipe from inlet of emergency stop valve up to exhaust flange including all extraction valves and interceptor valves complete with all integral accessories. For hot reheat line, scope of Turbine proper shall be limited up to and including the interceptor valve near the turbine. For cold reheat line, scope of turbine proper shall be limited up to and including non return valve at the turbine exhaust.]*
- iii. *[Complete turbine integral piping and other piping including all valves (isolating, regulating, non-return, hand-operated and/or pneumatic, motorized), actuators, air vents, safety valves, relief valves, drains, hangers, supports, anchors and other fittings.]*
- iv. *[Power operated (hydraulic/pneumatic) quick closing non-return flow valves for each extraction line and cold reheat line at HP exhaust.]*

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- v. [60% BMCR capacity High Pressure (H.P) and Low Pressure (L.P) steam by-pass station and complete spray system, control valves, desuperheating devices, valves, controls and instrumentation etc.]
- vi. [Turbine Digital electro hydraulic governing system with triple redundancy including governors, low vacuum tripping device, bearing protective devices, solenoid trip etc. as specified hereinafter and all equipment mounted/local instruments, pressure, temperature, level switch, primary sensing devices etc. as required.]
- vii. [Suitable turning gear device, either High-speed hydraulic type or motorised turning gear as per standard proven practice of the Bidder with the provision for manual barring.]
- viii. [Complete high pressure control oil/fluid and lubricating oil systems with tanks, shaft driven oil pumps and other necessary pumps and drives, lube oil coolers, Jacking oil pumps, all connected piping, valves, filters, strainers, vapour extractors, instruments etc.]
- ix. [Turbine control and protective valve high pressure hydraulic actuation system.]
- x. [Gland steam sealing system with steam pressure regulators, desuperheater (if required), all piping, valves, steam traps, specialties and associated instruments and also gland steam condenser, vapour extractors etc Gland sealing system.]
- xi. [All piping, valves and accessories for turbine flanges, casing and stud heating system as recommended by Bidder for unitized and common system.]
- xii. [Steam turbine exhaust hood spray system including nozzles, power operated valves and specialties, hangers, supports and insulation, instruments etc.]
- xiii. [Turbine drain system complete with integral piping, valves, fittings, Motor Operated (M.O) valves, hangers, supports and insulations. Wet steam washing system for Turbines, if recommended by the OEM.]
- xiv. [Blanking discs for emergency stop and reheat interceptor and control valves and special bonnets, as required for steam blow out. Provision for steam blow-out pipe connection with cold Reheat line non-return valve.]
- xv. [Turbine exhaust casing pressure ruptures diaphragms.]
- xvi. [3x50% hot well makeup pumps taking suction from CST. Hotwell makeup pumps shall serve the makeup requirement of DM water in condenser normal/emergency makeup, ECW system, AC system chilled water expansion tank and stator water expansion tank through an alkalizer.]
- xvii. [DC solenoid operated pneumatic vacuum breaker valve with provision for remote operation.]
- xviii. [Thermal insulation and lagging for turbine equipment and piping covered under this turbine generator package.]
- xix. [All inserts / embedment / anchor bolts with necessary templates.]

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- xx. [Coupling between turbine and generator including coupling guard as necessary.]
- xxi. [Excitation system including AVR, field suppression/flushing equipment, inter-connecting cables/ bus ducts.]
- xxii. [Generator hydrogen system equipment and controls including associated piping, valves, coolers, motor starters and control panels as required and necessary CO₂ system, defrostery, manifold, piping and monitoring instruments.]
- xxiii. [Generator terminal bushings and current transformers.]
- xxiv. [Stator water cooling system (if required).]
- xxv. [All pumps and fans.]
- xxvi. [Generator protection equipment such as rotor grounding device and alarms and runback for abnormal conditions, frame grounding pads, and neutral enclosure.]
- xxvii. [Acoustic cladding for complete steam turbine generator units along with turbine generator load.]
- xxviii. [Preservation System: Turbine preservation system consisting of adequate numbers of air drives including fans, motors, filters, heater drying wheel, connecting piping, valves, fittings etc. for preservation of corrosion of turbine during idle periods shall be provided.]

Miscellaneous Items

- i. [All sole plates, sub-sole plates, shims, jack-screws and wedges, as required, to set and align the turbine generator unit.]
- ii. [All foundation frames/base plates, anchor bolts, sleeves, nuts etc. for all equipment under this section.]
- iii. [Special lifting slings, lifting beams etc. for erection and maintenance of the turbine cylinders and rotors, generator stator and rotor, bolt heating device, tongue wrenches etc.]
- iv. [Suitable lifting attachments i.e., lifting lugs, eye bolts slings, etc. for all equipment to facilitate erection/maintenance.]
- v. [Closed Cycle DM Cooling Water System along with 3 x 50% DM cooling water pumps, 3 x 50% Plate type heat exchangers, DMCW make-up tank (10 cubic m capacity), chemical dosing system to maintain pH of closed system, with all valves, distribution piping etc. for steam Turbine and auxiliaries shall be provided.]

1.5 Steam Turbine Rating

1.5.1 Indicative Steam Turbine Parameters

[Bidder is free to optimize all terminal parameters viz main pressure, temperature final feed water temperature and condenser back pressure together with turbine

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cycle configuration to offer high availability and most economical plant operation. Turbines, thus offered shall be highly reliable, proven and well established and shall be in operation for not less than two (2) years, continuously. Performance requirements shall be as follows]:

Table: 1.2

(i)	Output under maximum continuous rating (TMCR) (guaranteed output load) at generator terminals.	[210/215/220/250] MW
(ii)	Over-pressure operation	As per IEC 45
	Turbine heat rate at 100% TMCR at rated condenser vacuum and 0% make-up	Not more than [1955] kCal/kWh
(ii)	Turbine throttle steam pressure	Not less than [130] kg/cm ² (abs) at the inlet of HP turbine inlet nozzle
(iii)	Turbine throttle main steam temp.	[537] °C
(iv)	Reheat steam temp. at turbine inlet	[537] °C
(v)	Variations in rated steam temp. & pressure	As per IEC 45
(vi)	Pressure drop in reheat circuit i.e. between H.P. turbine exhaust & IP turbine inlet.	[10%] of H.P.T exhaust pressure (max.)
(vii)	Condenser design pressure	[76] mm Hg or as applicable for heat rate optimization
(viii)	Turbine speed	3000 rpm
(ix)	Frequency variation range around rated frequency of 50 Hz	+ 3% to – 5% (47.5 Hz to 51.5 Hz)
(x)	Max DM water make up to thermal cycle under	3% of throttle steam flow

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	TMCR condition	
(xi)	Final feed water temp. for Heat Rate guarantee point & TMCR condition	As optimized by the Bidder but not less than [247]° C
(xii)	Turbine protection against water induction	As per ASME-TDP-I-Latest Edition
(xiii)	Design Circulating Water(CW) Temperature	[33]° C
(xiv)	Quick start capability	Turbine shall have quick start capability under all modes of start up. Start up time shall not be more than 360 minutes during absolute cold start.

1.5.2 Operational Capabilities

Table: 1.3

(i)	H.P. heaters out of service:	Turbine Generator set shall be capable of continuous operation under HP heaters out of service with maximum output Commensurate with boiler max heat duty at BMCR condition but not less than rated output. (Heat Duty at BMCR shall be calculated based on the respective HBD)
(ii)	Variation in parameters	(a) Bidder shall indicate the turbine over pressurization (under V.W.O) possible and ensure corresponding continuous output of TG set (if applicable). (b) Turbine shall be capable of accepting variation in steam temperature & pressure as per IEC-45 in case continuous over pressure operation is possible.
(iii)	Two shift & cyclic load	Turbine shall be suitable for two-shift operation & cyclic load variations.

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(iv)	Part load & start up	<p>Turbine shall be capable of operation on constant pressure mode as well as on variable pressure. Mode during part load & start up operation</p> <p>TG set shall be capable of being started from cold condition to full load operating conditions in as short time as possible even without availability of HP/LP Bypass system.</p>
(v)	House load operation:	<p>TG set shall be capable of operating on house load during sudden total export load throw off using HP-LP bypass system. Unit shall not trip on over speed in the event of total export load throw-off. Same shall be physically demonstrated prior to handing over of the unit.</p>
(vii)	Operation in High Condenser back pressure in emergency condition	<p>Turbine Generator set shall be capable of continuous operation under high condenser pressure at 89 mm Hg to generate [210/215/220/250] MW output. (Condenser pressure corresponding to Max [36] °C water temperature).</p> <p>Bidder shall also indicate the maximum allowable condenser back pressure at the rated MCR load.</p>

The turbine generator unit shall comply with general requirements and standards of relevant latest versions of IEC & IEEE or their approved equivalents or as per the supplier's standard practices to be mutually agreed between the Bidder and Owner and the additional requirements as specified hereinafter. All materials, equipment and fabrication procedures, wherever applicable for the equipment covered in this specification, shall also be in accordance with the latest applicable code requirements of the Indian Boiler Regulations.

The generator and accessories shall withstand, without damage, any rate of acceleration/deceleration, which the steam turbine may impart and any transient electrical conditions caused by sudden load reduction or electrical trip. The steam turbine and accessories shall be able to withstand, without damage, any transient thermal stresses, acceleration and deceleration to which they may be subjected within limitations set by proper function of the supervisory and protective devices, and within the limitations set forth in the Bidder's operation and maintenance manuals.

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The turbine generator unit shall be capable of synchronizing and running in parallel with utility Power Grid. The turbine generator and all its auxiliaries including integral piping shall be designed for continuous and cyclic load operation.

The rotating components of the turbine-generator shall be statically and dynamically balanced. The Bidder shall indicate the maximum vibration level that can be tolerated on the bearing housings and shaft (and on bearing housing only for Exciter) during operation of the machines. The turbine-generator shall also be capable of operation at any speed above the rated speed up to 110 percent of the rated speed without exceeding the maximum vibration specified below, and without showing any sign of stress or instability. The unit shall be sufficiently strong to withstand without damage any stresses or deflections that might result from transient speed up to 120 percent of the rated speed.

1.5.3 Other General Requirements

In case the Bidder anticipates the use of spray and make up water during the performance guarantee test, the corresponding heat rate shall be guaranteed and the related heat balances shall be furnished with the bid.

The Bidder shall furnish correction curves applicable for heat rate calculations under varying parameters of steam (pressure and temperature), reheat circuit pressure drop, inlet temperature of condenser cooling water and condenser vacuum.

Bidder shall state the maximum continuous capability of the Turbine with valves wide open (VWO) and indicate the maximum flow passing ability of the machine corresponding to rated steam parameter and at rated condenser vacuum at [76] mm Hg absolute and with condenser cooling water temperature [33] °C.

The units shall be capable of operating with all the H.P. heaters out and no extraction steam supply to them. The Bidder shall indicate the maximum output the unit is capable of delivering continuously under such condition.

The turbine generator units shall be designed to operate satisfactorily under prevailing climate. They shall be suitable for indoor installation on reinforced concrete foundation.

The turbine generator units shall comply with general requirements and standards of relevant latest versions of IEC & IEEE or their approved equivalent or as per the Supplier's standard practices to be mutually agreed between the Bidder and Owner and the additional requirements as specified hereinafter. All materials, equipment and fabrication procedures, wherever applicable for the equipment covered in this specification, shall also be in accordance with the latest applicable code requirements of the Indian Boiler Regulations.

For quick restarting and flexibility during start-up of the Turbine-Generator, a suitable HP-LP bypass system shall be provided. Bidder should specifically

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indicate the feature considered for bypass system and the minimum flow requirement to enable warm and hot start-up of the machine.

The rotating components of the Turbine-Generator shall be statically and dynamically balanced. Bidder shall indicate the maximum vibration level that can be tolerated on the bearing housings and shaft (and on bearing housing only for Exciter) during operation of the machines. Maximum vibration shall be within "GOOD" range of VDI- 2056.

1.6 Salient Design Features of Turbine and its Accessories

1.6.1 Steam Turbine

i) Casing

The casing shall have provision for temperature sensing elements (RTD's or thermocouples) to indicate metal temperatures in casing, nozzle block, and steam chest. Dual element temperature sensing elements shall be provided. The main horizontal and vertical joints in the turbine shell shall be metal-to-metal. The turbine low-pressure ends shall be arranged for bottom exhaust condenser.

Each turbine casing shall be provided with efficient draining facility. The parts of the turbine casing which may come in contact with wet steam in normal operation or during start-up, shall be provided with an inter-stage drainage system whereby extracted water shall be prevented from re-entry to the blading and shall be transferred to either a convenient heater extraction branch or to the condenser. The casing drains shall be provided with temperature sensing devices to ensure proper evacuation of drains.

The steam extraction branches shall be located on the lower half casings and shall be machined with weld end preparation except in the case of LP casing where bolted flanges will be acceptable.

Pressure relief bursting diaphragm for LP casing(s) to limit the exhaust hood pressure within a safe margin from design pressure shall be provided. A completely self contained exhaust hood spray system for L.P casing(s) to protect the turbine against excessive temperature due to windage at no load / low load and HP/LP Bypass operations shall also be provided.

Dismantling of casing should be possible with minimum removal of insulation.

Guide rods to prevent damage to blades during erection and maintenance shall be provided.

Bearing inspection should be possible without necessity of dismantling the turbine casing.

The supports of the turbine on the foundation shall be designed considering the expansion and contraction of the machine during thermal cycling. Axial movements shall be allowed by anchoring at one point and central position shall be maintained by fitted keys.

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ii) Rotor

After the assembly of the blades, each complete rotor shall be balanced for both static and dynamic conditions so that the assembled rotor will perform satisfactorily under all conditions of operation.

Ensure heat stabilization of the rotor as per SEP 1950, ASTM-A-472, Maximum permissible shaft vibration measured at bearing housing will be as per zone A of ISO 7919 (or approved equivalent standards) and maximum permissible bearing vibration measured at bearing housing will be as per zone A of ISO 10816-2 The turbine generator unit shall be designed to withstand the stresses due to an over speed of 20% above the normal synchronous speed, without reducing the life of the machine.

iii) Nozzles & Blading

All nozzles and blading shall be of hard; corrosion and erosion resisting alloy steel suitable for the temperatures encountered. In the low pressure stages where the moisture percentage and the blade peripheral speeds are high, additional protection against erosion by way of hardened surface of blades or strips of erosion and corrosion resistant material such as stellite, secured to the leading edge, shall be provided. LP stage blade hardening upto 1/3rd (min) of blade length & width 25mm (min) or stellite as per the proven standard practice shall be provided.

Ensure stress induced in LPT blading due to back end steam loading under V.W.O. conditions not to exceed 90% of design stress value.

Suitable arrangement for the removal of moisture from at least the last LP stage shall be provided.

The method of fixing of the blades to the rotor needs to have been satisfactorily proven by long use in operation. Care shall be taken to ensure that the natural frequency of the rotor blades is far away from the rotational frequency of the machine, which may vary from 47.5 Hz to 51.5 Hz.

L.P. Turbine shall have stand-alone type blades capable of sustaining + 3% to - 5% grid frequency variations.

1.6.2 Bearings and Seals

All Turbine Generator main shaft bearings shall be provided with seals to control oil and vapor leakage along the shaft. Bearings shall be of the self-aligning type and split to permit removal of the upper half for inspection. Bearings shall be accessible for inspection without removal of the turbine shells. Each main shaft bearing shall be equipped with a minimum of one dual element type temperature-sensing element imbedded in each main bearing. In addition, thermocouples shall be located in all main bearing drains.

Each thrust bearing shall be equipped with dual element type temperature sensing elements located in each front and back thrust bearing plate or shoe to

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provide for indication of excessive thrust bearing temperature. Pressure switches sensing thrust-bearing position shall be provided and shall initiate automatic tripping of the turbine in case of excessive thrust bearing wear.

1.6.3 Couplings

The couplings connecting the turbine and generator and the various turbine shafts shall be of a type that can be readily disconnected for purposes of inspection and repair.

1.6.4 Main Steam Emergency Stop Valves

Hydraulically operated stop valves shall be provided in the main steam line and shall be capable of being tripped automatically during over speed or at other predetermined limit points. The stop valves shall be designed with provisions for sequential remote testing while the unit is in operation. Triple-coil servo valves for valve positioning using hydraulic fluid shall be provided.

Start-up bypass operation shall be controlled from TGCS and valve position shall be indicated on the DCS via redundant communications links.

1.6.5 Reheat Stop and Intercept Valves

Combination reheat stop and intercept valves, or individual reheat stop valves and intercept valves shall be furnished with provisions for sequential remote testing while the unit is in operation. All valves shall be furnished with triple redundant position transducers that input to the TGCS for control and indication. Triple-coil servo valves for valve positioning using hydraulic fluid shall be provided.

1.6.6 Steam Strainers

Each main steam stop valve and each reheat intercept valve or combination reheat stop and intercept valve shall be equipped with permanent, integral strainers made of mesh, perforated steel plate, or equivalent elements for normal operation. Each valve shall also be equipped with removable fine-mesh strainers for initial operation. Strainer screens shall be removable without disturbing steam piping.

1.6.7 Control Valves

Governor-controlled, hydraulically operated turbine control valves shall be provided. Provisions for sequential remote testing while turbine is in operation shall be provided. All valves shall be furnished with triple redundant position transducers that input to TGCS for control and indication. Triple-coil servo valves for valve positioning using hydraulic fluid shall be provided.

The Bidder shall also submit valve opening/ closing characteristic curves for both high pressure control valves (HPCV) and intermediate pressure control valves (IPCV) respectively.

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1.6.8 Turbine Oil System

Complete lubrication and oil pumping system, including, but not necessarily limited to, the following shall be provided:

- i. Oil reservoir with top mounted relief valves and access doors (manholes), and all associated instrumentation and controls.

The turbine set shall be provided with an oil reservoir of adequate capacity. The capacity of the tank shall be so chosen that the full quantity of oil circulating through the system is retained for a controlled time ensuring thereby proper sedimentation and air removal. The retention time should be indicated. The capacity of the oil tank shall also be adequate to contain the total volume of oil that can be drained from the circuit into the tank. It shall be provided with removable stainless steel basket strainers and at least two oil level indicators out of which one should be visible from turbine operating floor. High and low level alarm switches to be connected to the supervisory control panel annunciation system and overflow device shall be provided. A suitably located temperature switch (with duplicate contacts), for remote high temperature annunciation, indicating the possibility of fire inside the tank, shall be provided. Two independent connections shall be provided for the tank - one for draining and sampling and the other to facilitate connection to oil purification system. Necessary manholes with self closing covers, pipe connections with flanges etc., as required shall be provided. The proposal shall include necessary access ladders, platforms and railings. 2x100% capacity A.C. vapour extractors, driven by explosion proof motors shall be furnished. The extracted vapour shall be led outside the turbine house building and provided with mist eliminator/oil separator at the terminating end of the vapour extractor line. The necessary supports, piping, accessories etc., shall also be furnished. The outer surfaces of all piping in the reservoir and the inner surface of the tank shall be coated with corrosion resistant paint

- ii. Pumping System

(a) A self contained oil system for each TG Unit consists of:

- Centrifugal / gear type, Main oil pump (MOP) directly driven by Turbine as per Bidder's standard practice with capacity to cater control oil, lube oil for bearings & emergency seal oil requirement.
- 2x100% AC Auxiliary oil pumps for start-up shut down of TG unit and as standby to M.O.P. for automatic operation, each pump having capacity to cater to lube oil and turning gear oil requirement.
- One (1x100%) DC motor driven emergency oil pump with sufficient capacity for meeting lube oil requirement of bearings during emergency with automatic starting on low lube oil pressure preset value.
- 1x100% each AC & DC jacking oil pumps having reset solenoid with an interlocking not to start till lube oil pressure is established.

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- Each Unit Lube Oil tank to have capacity to allow 5 to 8 oil changes per hour (at normal operating level), fitted with non-corrodable strainers, level indicator visible from turbine operating floor, and necessary manholes, platforms, railings, necessary piping, supports and accessories etc.
- 2x100% DM water cooled lube oil coolers with 10 % excess tube surface area, designed as per TEMA having oil pressure greater than water pressure fitted with Dial type Thermometer and Manual 3-way valve on oil side for change over of coolers. Oil temperature at outlet of coolers to be maintained within permissible limits at the inlet to the bearings.

All the pumps shall be provided with necessary strainers, valves and other fittings. Pressure switches shall be provided for the automatic sequential starting of the motor driven oil pumps. A panel incorporating pressure switches, transmitters and testing push buttons shall be furnished for on-load testing of all interlocks. Such on-load testing shall be so arranged that safety of the system is not jeopardized at any time.

iii. Purification System

Provide permanently Connected, Continuous Oil Purification having following major equipment.

- Oil centrifuge having capacity to purify 20% of total oil charge in system per hour and constructed from high grade stainless steel. Purified oil with no free moisture & maximum particle size conforming to code 15/12 as per ISO 4406. This shall be demonstrated with inlet oil quality conforming to code: 21/18 as per ISO: 4406.
- Carbon steel anti flood tank for each purifier.
 - Positive displacement feed & discharge pumps (if required), each having capacity 10% higher than purifying unit. Necessary interlocks for preventing centrifuge operation in case these feed and discharge pumps are not operating shall be provided.
 - Indirect Electric oil heater to heat oil to temperature not more than 65°C with possibility to cut heater elements in steps.
 - Entire purification equipment to be mounted upon a substantial metal base having a raised lip around the outside with a drain connection.
- Filters & Strainers

Duplex type filters/strainers with stainless steel element, with differential pressure switches with alarm at suction of each pump and common oil supply line shall be provided. The filter element size shall be of five (5) microns or a size suited to TG manufacturer's requirements. In addition to above, the Bidder may provide filter/strainers at oil supply line to /oil return lines from bearing and generator seals as per his standard
- Fire hazard safety precautions shall determine the design of oil piping in the high temperature zones of the turbine lubrication oil system. Oil piping shall be stainless steel. Flanged joints shall be used where necessary for assembly and dismantling of oil piping.

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1.6.9 Turning Gear

The turbine generator shall be equipped with an electric motor-driven or oil driven rotor turning gear capable of continuously rotating the turbine shaft to affect fast uniform cooling and warming during the coasting down and start up respectively.

An AC motor driven turning gear shall be furnished, complete with oil piping and all associated hangers and valves, and all necessary interlocks to prevent the turning gear from operating until proper oil pressure has been established in the turbine-generator bearings. The turning gear motor shall have provisions for rotating the motor shaft manually to engage the turning gear with the main turbine shaft. The turning gear shall automatically disengage when the turbine-generator speed rises above the turning gear speed and re-engage on turbine shutdown, when the turbine speed slows down to preset speed. Local turning gear instrumentation, including control switches and indicating lights, shall be provided.

1.6.10 Turbine Governing System, Protective Devices and Unloading Gears

1.6.10.1 Governing System

The steam turbine generator unit shall be equipped with an electro-hydraulic governing system with mechanical-hydraulic back up or electro-hydraulic system with 100% hot back-up. The turbine governing system shall meet the following requirements:

- i. The governing system shall be capable of controlling with stability the turbine speed between zero to maximum power output when the unit is operating in isolation *[or in parallel with other units]*.
- ii. Over speed during full load loss shall be limited to 8% of the rated speed.
- iii. Adjustable steady state speed regulation shall be provided between +3% to +6% of rated speed.
- iv. Dead band at rated speed and at any power output within rated output shall not exceed 0.06% of rated speed.

1.6.10.2 Speed Load Changer

The governing system shall be equipped with speed and load changers to control the speed or power output of the steam turbine within the limits. The speed/load changer provided shall be capable of adjusting the speed of the turbo set to any value in the range of 94% to 106% of rated speed for manual/auto synchronization of the generator with the bus. It shall be capable of varying the load on the machine from no load to full load.

For remote control, suitable motor drive shall be provided. Indication of the speed/load changer position shall be provided on the operator's work station and console panel insert.

1.6.10.3 Load Limiting Device

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The governing system shall be equipped with a load limiting device capable of being operated both locally as well as remotely from unit control room for the purpose of limiting the amount of opening of the governor controlled valves to set the load at a pre-determined limit, while the turbine is in operation. A remote position indicator shall be provided on the console panel insert for indication of the setting of the load limit. Contacts shall also be provided on the load limiter for signaling load limited operation in unit control room.

1.6.10.4 Turbine Protection Devices

Emergency governor

- i. Bidder shall provide a separately actuated overspeed device called quick acting emergency governor to trip the unit at 110% of rated speed in case speed governor fails to limit the turbine overspeed.
- ii. The emergency governor resetting shall be as per manufacturer's standard practice. However, it shall meet the IEC-45 requirements for overspeed trip.
- iii. Bidder shall provide means for testing the operation of emergency governor when the machine is on load without exceeding the rated speed of the unit.

Emergency hand trip

Bidder shall provide emergency hand trip device on front pedestal/panel near turbine to facilitate manual tripping of the unit along with facility to trip turbine from UCB.

1.6.10.5 Other protection devices

The following other turbine protection devices shall also be included. Essentially the protection system shall include:

- i. Manual trip from control room and from local.
- ii. Mechanical over speed trip.
- iii. Electrical over speed trip with sensors independent of speed governing sensors (with triple sensors).
- iv. Thrust bearing excess wear trip (with triple sensors).
- v. Condenser very low vacuum trip (with triple sensors).
- vi. Lube oil pressure very low trip (with triple sensors).
- vii. Control oil pressure very low trip (with triple sensors).
- viii. Main steam temperature low trip (with triple sensors).
- ix. Generator trip
- x. Reverse power relay operated trip
- xi. Under frequency relay operated trip
- xii. Boiler trip operated trip (with triple signals)
- xiii. Power failure for turbine control and protection system (triple signals)

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- xiv. DDCMIS trip, closure of valve and reduction in the load and also Alarm for operator guidance in case of defects in the Turbine Control System (TCS).
- xv. Any other trips recommended by Bidder (which shall be with triple sensors)
All normal annunciations shall be configured in DDCMIS and displayed on HMI. Certain critical annunciation shall be hardwired to the panel envisaged.

1.6.10.6 Steam Turbine Supervisory Equipment

The steam turbine supervisory equipment shall indicate and record the behaviour of the steam turbine under varying conditions and provide adequate warning of the development of potentially dangerous steam turbine conditions. The steam turbine supervisory equipment shall include detection and recording of, but not limited to the following:

- i. For Bearing, shaft vibration indication in the Vibration Monitoring system (VMS) and recording in the DDCMIS (Digital distributed control management information system) shall be provided.
- ii. Shaft eccentricity
- iii. Differential expansion.
- iv. Axial shift of rotor bearing vibration indication in the Vibration Monitoring system (VMS) and recording in the (DDCMIS).
- v. Overall expansion
- vi. Vibrations in the bearing pedestals
- vii. Steam turbine speed
- viii. Load
- ix. Main steam, emergency stop and governing valve positions
- x. Interceptor stop and control valve positions
- xi. Load limiter position
- xii. Speed Changer position
- xiii. Inlet steam temperatures and pressures
- xiv. Metal temperature
- xv. Cylinder/flange metal temperatures, top and bottom casing temperatures including differentials
- xvi. Bearing metal temperatures
- xvii. Body metal temperatures of main steam and reheat steam stop and control valves
- xviii. Oil drain temperatures
- xix. Turbine Stress Control System (TSCS) capable of maintaining the thermal stresses within allowable limits and suitably integrated into plant DDCMIS.
- xx. Turbine acceleration in the DDCMIS.

1.6.10.7 Unloading Gear

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Initial Pressure Regulator

- i) Initial pressure regulator shall ensure turbine unloading to a preset point to run on house load in case main steam pressure falls below a predetermined value.
- ii) It shall be possible to adjust or bypass the initial pressure regulator from UCB at start up condition to facilitate starting with low steam pressure and during sliding pressure operation.
- iii) Contact shall be provided for signaling the device in 'Operation' and 'Reset'.

Low vacuum unloading gear (if applicable)

- i) Based on the standard proven practice of the Bidder, the Bidder shall provide a low vacuum unloading gear which shall ensure progressive decrease of steam flow to turbine below a preset value of condenser vacuum, thus restoring the condenser vacuum.
- ii) Contact shall be provided for signaling the device in 'Operation' and 'reset'.

1.6.10.8 Vacuum Breaker

Bidder shall provide suitable device for rapid reduction of vacuum in condenser for turbine rotor to be brought to rest as quickly as possible. Provision shall be made to operate it both manually and through DC actuator.

1.6.11 Gland Sealing System

The turbine shall be provided with Labyrinth type gland seals to prevent steam leakage to the atmosphere or air leakage into the turbine. The Labyrinth will be of multiple section spring backed type, which would allow for any temporary deformations of the rotor shaft without overheating the rotor due to friction. A gland seal regulator shall automatically control steam pressure to the gland seals over the entire load range. The gland exhausting system shall include a surface type seal steam condenser suitable for the inlet condensate temperature and pressure provided with drip level indicators/ gauges and two 2x100% capacity AC motor driven exhausters. The system shall operate automatically. Means shall also be provided for manual operation of the gland seal system when the regulator is out of order.

Suitable arrangement shall be provided to bypass gland steam condenser (designed to operate under vacuum condition also) along with desuperheating arrangement, if required, for the bypass. The exhaust shall be discharged above the TG hall roof level. The gland steam condenser shall be provided with bypass on water side also.

The turbine shall be self sealing during normal operation of the unit. During startup and low load operation, sealing steam shall be supplied from high temperature or low temperature auxiliary steam header or CRH depending upon the sealing requirement. Facility shall be provided for automatic switchover from alternative source to the main source and vice versa.

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During changeover of steam supply source from turbine or CRH or auxiliary steam header, there shall be no rubbing at glands and no undue increase in vibration and the system shall be capable of withstanding thermal shock

Effective drain system shall be provided along with instrumentation to monitor and maintain the required temperature to avoid thermal shock to the rotor during changeover from self sealing to alternate source of sealing steam.

Two nos. modulating type control valves shall be provided, one discharging surplus steam to condenser and other for supplying extra steam to gland sealing header from steam source to maintain sealing steam header pressure at a preset value. These control valves shall be provided with electrically operated bypass valves. Control valves shall be stay put during power failure and sealing steam header pressure shall be maintained by manual control of these valves.

Gland sealing arrangement provided by the Bidder shall permit easy examination and replacement of glands without lifting the upper half of the turbine casing.

1.6.12 High Pressure Hydraulic System

Each unit will be provided with a high pressure hydraulic system which shall supply the required active power for operation of the electro-hydraulic control system and shall utilize a phosphate ester or equivalent fire resistant fluid. All the elements of the system shall be furnished with compatible hydraulic fluid, and shall include, but not necessarily is limited to, the following:

- i) Fluid reservoir of sufficient capacity to contain all the hydraulic fluid when the turbine is shutdown. The reservoir shall be provided with access cover plates for cleaning, fluid level indicator, high and low level alarms and independent critical high alarm, high and low temperature alarms, and provisions for filling and draining by means of fluid transfer and filtering unit which shall be included.
- ii) Two (2) independent pumping systems, each consisting of motor driven variable displacement pump with automatic stroke adjustment, wire-mesh suction strainer on the intake side of the pump and a disposable cartridge filter in the pump discharge line, and a pressure compensator on each pump to maintain the preset pressure by stroke adjustment.
- iii) The filters at the pump discharge shall be designed for maximum particle size of not more than 5 microns. Excess pressure drop shall be annunciated in the unit's DCS and automatic start-up of the standby pump shall be initiated if the filter pressure drop continues to increase and no remedial action is taken.
- iv) Two (2) full capacity fluid-to-DM coolers. The coolers shall be arranged for either single or parallel operation and shall be located on the return side of the hydraulic fluid to the reservoir.
- v) Two (2) nos. thermostatically oil tank heaters indirect type to regulate the oil temperature.
- vi) One (1) air dryer for the air breather by the fluid reservoir, of the desiccant type filled with layers of activated alumina, charcoal, and silica gel.

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- vii) FRF recirculation pumps two (2) nos. to recirculate the oil in earth filters/mechanical filter and to facilitate oil top up & using oil from drain tank.
- viii) Hydraulic accumulators, charged with nitrogen, in sufficient number to provide immediate source of hydraulic fluid when required for sudden transient conditions.
- ix) Transfer and filtering unit for filling the system and filtering the fluid before it enters the reservoir. The unit shall be complete with motor-driven pump, filter, relief valve, discharge and suction hoses, and all operating valves. The unit shall form an integral part of the high pressure hydraulic system.
- x) Fuller's Earth filtering equipment, installed in the reservoir to maintain low neutralization of the hydraulic fluid.

All the above equipment shall be installed on a common skid for mounting below the turbine. High pressure stainless steel piping and tubing to all points of usage of the high pressure hydraulic fluid system with all necessary hangers and supports shall be included. Also, the initial charge of the hydraulic fluid shall be included.

1.6.13 Steam Turbine Extraction

The uncontrolled extraction steam system shall supply steam for the regenerative feedwater heaters and direct contact heater (Deaerating Heater). Extraction steam system piping shall be routed and supported in such manner as to provide for thermal expansion and to maintain end reaction forces and moments within allowable limits. All low-pressure extraction piping inside the steam turbine exhaust hood shall have sleeved inconel bellows expansion joints.

A forced closed check valve (pneumatically or hydraulically operated), SCNRV and a motor operated stop valve shall be provided in each extraction line. However, 2 nos. forced closed check valve shall be provided in the direct contact heater (deaerator). The check valves shall protect the steam turbine from over speeding due to reverse flow of steam from the extraction piping when the steam turbine is tripped and is under a vacuum condition. The motor operated shutoff valves, operating in conjunction with the automatic drain valves, which are located, both upstream and downstream of the valve station containing the reverse flow check valve and the motor operated isolation valve, shall protect the steam turbine against water induction. During a steam turbine trip, controls shall automatically initiate the closing of all forced closed check valves and the opening of all the drain valves. High water level in a heater shall initiate a high water level alarm in the affected heater and opening of its alternate drains. All piping drains shall be routed to the main condenser.

The steam shall be bled as un-controlled extractions from the high, intermediate and low pressure stages for regenerative feed heating. Suitable arrangements shall be provided to prevent induction of water into turbine in accordance with manufacturer's standard practice and the stipulations of ASME Standard No. ASME-TDP Part-I (Latest edition).

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1.6.14 HP/LP Bypass System

The HP bypass system shall have capacity not less than 60% of BMCR steam flow with [2x50%] valves considering rated main steam parameters at upstream of valves and CRH steam parameters corresponding to 60% TMCR condition on the down stream with constant pressure operation and no steam extraction for regenerative feed heating except deaerator pegging at 3.5 ata with only MDBFP in service. The system should be capable of opening in a fast mode (within 2 seconds) under emergency conditions like sudden load throw-off, turbine tripping etc. Suitable arrangement shall be made to achieve such fast opening of the bypass valves

The high pressure (HP) portion of the steam turbine bypass system shall include a pressure-reducing valve and attemperator that shall accept steam flow diverted around the HP steam turbine. The valve and attemperator shall reduce the main steam pressure and temperature to a level where it can be safely admitted to the cold reheat piping and reheater.

The LP bypass system shall consist of [2x50%] valves and shall be designed to condition the incoming steam from reheater to parameters matching with those of LP turbine exhaust steam and the capacity shall be commensurate with that of the HP bypass system plus the spray water used in HP bypass. The low pressure (LP) portion of the steam turbine bypass system shall include a pressure-reducing valve and attemperator and a diffuser in a circuit receiving steam flow diverted around the IP and LP steam turbines to the main condenser. The diffuser shall be designed to protect the condenser. Materials and design parameters for equipment downstream of the LP bypass pressure reducing valve and attemperator are set by both the condenser and bypass system suppliers. The control system for the Steam Turbine Bypass will be configured in the Turbine Control System (TCS).

HP bypass shall be designed to accept continuous spray water at temperature corresponding to all HP heaters out of service and deaerator pegged at 1.5 ata. Spray water shall be sprayed at the most turbulent zone inside the valve having steam velocity in the order of 350 to 400 m/s. The entire atomization and evaporation of spray water shall be complete within shortest possible distance but not exceeding 1.0 m from the spray point. The HP bypass spray controller shall have state controller with observer to achieve accurate control over outlet steam temperature under different operating conditions including the transients.

For LP bypass system, desuperheating may be done outside the valve body with spray water tapped from condensate pump discharge

The steam turbine bypass system shall be used mainly to reduce startup times for the steam generator under hot and cold startup situations. Feed water is the source of the high-pressure bypass spray water. Condensate is the source of low-pressure bypass spray water.

Each turbine bypass system shall consist of the following:

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- i) [Two (2)] high pressure hydraulically actuated steam pressure reducing valves with integral (or separate) desuperheaters.
- ii) [Two (2)] high pressure hydraulically actuated spray water isolation valves.
- iii) [Two (2)] low pressure hydraulically actuated steam pressure reducing valves.
- iv) [Two (2)] low pressure desuperheaters for mounting on the condenser L.P. bypass inlet nozzles.
- v) [Two (2)] low pressure hydraulically actuated spray water admission valves with split range type (i.e. low load & High Load).
- vi) [Two (2)] hydraulic supply units, each with redundant hydraulic oil pumps.

The HP/LP Bypass System is intended for use at following situations:

- i) On hot starts to facilitate matching boiler steam to turbine metal temperatures prior to steam admission to the turbine thus achieving a faster start-up and reduced thermal stresses in the turbine.
- ii) The turbine bypass system shall be utilized to warm up the boiler and main steam lines after an appropriate vacuum is established.
- iii) During cold starts, for Boiler temperature control and condensate conservation.
- iv) On load rejection or turbine trips, the bypass system will handle sufficient steam flow to avoid a boiler trip out, thus allowing rapid reloading when fault condition clears.
- v) The HP Bypass valve shall serve as pressure relief valve in case of transient main steam pressure excursion. The HPBP valve shall modulate to maintain HP turbine inlet pressure, if it goes at about 6 kg/sq.cm above normal operating pressure.

The turbine bypass system controls shall perform the following functions:

- i) The control system shall generate the steam generator pressure/flow and reheat pressure/flow characteristics.
- ii) High pressure bypass valves and low pressure bypass valves shall open to control pressure in the main steam lines and reheat steam lines.
- iii) Water shall be added to the bypasses to control high pressure bypass temperature and limit low pressure bypass enthalpy.
- iv) All valves shall be designed to fail closed.
- v) The turbine shall be protected from bypass system malfunction by temperature trips.
- vi) Water valve control shall be consistent with ASME Standard TDP-1 Fossil Fueled Plants "Recommended Practices for the Prevention of Water Damage to Steam Turbines used for Electric Power Generation" or International equivalent.
- vii) Bypass system control shall be integrated into the Turbine Control System (TCS) and fully coordinated with normal turbine operation.
- viii) The bypass system shall be operationally tested to assure acceptable functional performance of the bypass control system.

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- ix) The HP/LP bypass system shall come in operation automatically in case of (a) generator breaker opening (b) turbine trip i.e. ESV/CV close (c) sudden reduction in load.

1.6.15 Vacuum Trip and Pressure Relief Diaphragms

Triple redundant condenser vacuum sensors shall be provided as inputs to TGCS to initiate a closure of the turbine stop valves and control valves when the turbine exhaust pressure rises above a set limit. The vacuum trip shall be part of the turbine trip system and have the capability of testing via the DCS. Pressure relief diaphragms shall be provided and located in the turbine exhaust casing for condenser overpressure protection.

1.6.16 Turbine Exhaust Hood Spray Control System

Steam turbine exhaust hood spray cooling system shall be provided to permit low load operation of the turbine- generator set without excessive rise in the exhaust-hood temperature. Steam turbine exhaust hood spray cooling system shall be self-contained and complete with spray arrangements, associated piping, instrumentation and control devices, valves and fittings, motor/solenoid operated valves and specialties, hangers, supports and insulation etc. The spray arrangement shall be activated automatically under the condition of low load or exhaust hood temperature exceeding the permissible value.

1.6.17 Supplemental Protective Devices

In addition to the protective devices specified herein this technical specification, the following shall be provided:

- i) High exhaust hood temperature switches for alarm and trip.
- ii) Low bearing oil pressure switches for alarm and trip.
- iii) Thrust bearing wear and failure switches for alarm and trip.
- iv) TG shaft vibration high alarm/ trip as per the OEM's design requirements.
- v) Turbine over speed mechanical protection, mounted on turbine rotor shaft at 10% to 11% above the rated speed.
- vi) Vacuum breaker valves for an automatically initiated vacuum relief system complete with actuation initiation devices.

1.6.18 Warming Up, Drain, Vent System And Flash Tanks

1.6.18.1 The Bidder shall provide warming-up and drainage system for the turbine system to drain away the condensate which may be formed due to steam coming into contact with cooler metal during start-up and stagnant steam sections. The system shall comply with the requirements of ASME TDP-1, "Recommended practices for the prevention of water damage to steam turbines used for electric power generation". The drainage system shall be provided but not limited to the following:

- i) Main steam, CRH and HRH line drains

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- ii) Main steam stop and control valves
- iii) Reheat stop valves and interceptor valves
- iv) Steam lead and turbine drains
- v) Steam seal system
- vi) HP & LP bypass valves and warming up line
- vii) Turbine extraction steam piping system

The drains shall be provided for every low point with automatic disposal of collected condensate. The drains shall be connected to the flash tanks via headers. The connections on the header shall be graded according to the pressure, the farthest from the tank being the drain connection with highest pressure. The drains from main steam piping, HRH, CRH, and auxiliary steam headers etc. shall also be connected to the flash tanks described herein.

1.6.18.2 The following flash tanks shall be provided as a minimum to receive the drains and safety valve connections from various equipments and systems.

- i) Unit flash tank
- ii) Turbine drain flash tank (left)
- iii) Turbine drain flash tank (right)
- iv) HP drain flash tank
- v) LP drain flash tank
- vi) FWSV discharge flash tank

The arrangement for connection of various drains to the flash tanks shall be as under:

- i) The drains from MS piping and HP bypass piping including warm up line shall be connected to unit flash tank.
- ii) The turbine integral and power cycle drains shall be connected to turbine flash tanks. The left side drains shall be connected to left side flash tank and right side drains to the right side flash tank.
- iii) The drains from CRH, HRH, LP bypass piping including warm-up line, extractions to HP heaters, CRH and auxiliary steam line and deaerator (high pressure side) and drain, vent and safety valve connections on HP heaters shall be led to the HP flash tank. The drains of extractions to LP heaters, IP extractions, CRH to deaerator (low pressure side), auxiliary steam header, drain, vent and safety valve connections of LP heaters and drain coolers, deaerator overflow and CEP discharge vent shall be led to the LP flash tank.
- iv) The drains led to HP drain flash tank, LP drain flash tank and turbine drain flash tanks shall be recovered by connecting drains and vents of these vessels to the condenser. The vents of unit flash tank shall be open to atmosphere and drains of these tanks shall be led as waste to the plant drain/ channel.

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- v) The above drain connections are indicative only. The Bidder may provide alternative scheme/ arrangement for connection of drains to different flash tanks as per his standard practice which shall be subject to approval of the purchaser.

Drains shall be tapped off from main line through a drip pot with provision for removal of entrapped dirt. Each drain shall be provided with one locked open manual valve followed by one motor/ pneumatic operated leak proof angle valve on downstream side to be used for draining and warming-up the pipes as applicable. For sections having drain formation during normal plant operation such as auxiliary steam header lines and alternate steam lines to deaerator, steam trap assembly shall be provided in parallel to the motorized/ pneumatic drain valve.

The drain valves shall be located in accessible positions to facilitate their maintenance.

Facility shall be provided for remote manual operation of the drain valves from the control room. Motor operated drain valves shall be interlocked to open/ close as per the process requirements. Detailed operation philosophy/interlocks shall be furnished by the Bidder along with the bid.

1.6.18.3 On the CRH line downstream of NRV, a drain pot shall be provided at the lowest point in the CRH line. The following features shall be provided for drain pot valve control system:

- i) On high level in the drain pot, the motorized drain valve shall open automatically and an alarm shall be initiated in the control room. Closing of motorized valve shall be by remote manual.
- ii) On high-high level in the drain pot, an alarm shall be raised in the control room, and an automatic repeat command shall be given for opening of the motorized drain valve.
- iii) Position indication of drain valve shall be provided in the control room.

Flash Tanks

- i) The flash tanks shall be adequately sized to take care of the total drains in the complete power cycle piping system. There shall be sufficient margin to accommodate the possible variation in drain quantities as well as flash steam. Flash tanks shall be designed as per the requirement of ASME boiler and pressure vessels (B&PV) codes, and ANSI standard.
- ii) The design pressure and temperature for the pressure vessels (except bellows) to be designed shall be 3.5 kg/cm² and 215 °C respectively. Flash tanks shall also be designed for full vacuum condition.
- iii) Corrosion allowance of 3 mm shall be added to the design thickness of the shell and head of the vessels. The minimum thickness of the vessels including corrosion allowance shall not be less than 8 mm.
- iv) The flash tanks and manifolds shall be designed to take care of the impact forces due to incoming drains.

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- v) The temperature in the flash tanks shall be maintained by using condensate spray or service water spray (for flash tanks open to atmosphere). The spray shall be automatically controlled. However, for flash tanks open to atmosphere continuous spray through an orifice shall also be acceptable.
- vi) In case the spray is in the manifold, the material for the flash tank manifolds shall conform to ASTM A335 Gr. P22 or better and its thickness shall not be less than Schedule 100 of ANSI B36.10 irrespective of temperature of the fluid handled.

1.16.18.4 Constructional features

- i) Flash tanks shall be vertical, cylindrical design and of welded construction with torispherical or hemispherical heads.
- ii) Drain/hot water inlet nozzles shall be tangential/ radial to the vessel periphery. Suitable vortex breaker arrangement shall be made at the liquid outlet to the vessel. In case the Bidder finds better alternate arrangement, the same can be submitted for the purchaser's acceptance and approval.
- iii) A manhole shall be provided on the flash tanks for inspection purpose. It shall be of minimum 500 mm diameter. The manhole shall be of devit type and shall be provided with grip.
- iv) The flash tanks shall be located on the ground/ mezzanine floor of the power house. Necessary structural supports including anchor bolts shall be provided. Three support legs at 120 degree spacing shall be provided on each flash tank. Necessary lifting lugs for handling by the main plant building EOT crane shall be provided.
- v) The flash tanks shall be provided with a full length level indicating gauge glass complete with protective rods, isolation valves and drains. Temperature indicators and temperature switches shall be provided on the flash tanks.
- vi) The flash tanks shall be provided with access ladders.

Schedule of materials

Shell and head	: ASTM 285 Gr. C
Wear plate/ baffle	: ASTM 285 Gr. C
Nozzle neck	: ASTM A 106 Gr. B
Manhole nozzle flange and cover	: ASTM 285 Gr. C
Couplings	: ASTM A 105
Bolts and studs	: ASTM A 193 Gr. B7
Nuts	: ASTM A 194 Gr. 2H
Gaskets	: Spiral wound SS 316 with graphite

In place of ASTM 285 Gr. C material, the Bidder may also offer ASTM A 516 Gr 60 or IS 2062 Gr B materials provided the relevant code/standard permits use of these materials for the intended design parameters.

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1.6.19 Drains and Drain Valves

Drains shall be provided at all low points of the turbine shells, steam chest, valves and interconnecting pipes. The individual drains shall be brought into a common manifold header which shall discharge into the condenser. Automatic valves remotely controlled from the control room shall enable draining and warming of the turbine, piping and valves with steam during startup. A second manual locked-open shutoff valve shall be provided upstream of each drain valve.

1.6.20 Valves

All miscellaneous gate, globe, and check valves shall be designed in accordance with ASME B16.34 or International equivalent.

Electric valve operators shall be designed to withstand, in both directions, the stalled torque that may be developed at 110 percent of the rated voltage.

1.6.21 Insulation

The turbine casing, valves, piping and equipment shall be thermally insulated by non-combustible materials where the hot surface temperature is above 60 °C. The insulation above the turbine operating floor shall be covered with metal lagging formed into panel jackets arranged for convenient removal. All insulation which is normally removed during routine turbine inspection shall be of the reusable "blanket" type. All blankets shall be tagged and identified on an insulation arrangement drawing supplied with the turbine. Aluminium jacketing on all pipe insulation shall be included. The insulated portion of the steam turbines shall be provided with suitable anti-drumming and sound pressure attenuating material inside. The insulation and steel covering should be so designed and erected as to provide easy accessibility to parts requiring frequent inspection.

Thermal insulation of the crossover pipe shall be covered with aluminium sheeting. Split metal covers, packed with insulation shall be used to cover the exhaust flanges and permit bolt access. The feed heating system, drain coolers, ejectors, deaerator and its storage tank including all accessories, flash vessels, H.P. and L.P. bypass systems and all associated piping and valves shall be efficiently insulated.

1.6.22 Vibration Limits

The turbine-generator unit at the rated speed of 3000 rpm shall not exceed the vibration and shaft movements specified as follows:

With the rotor on turning gear, the rotor eccentricity measured at any bearing oil ring shall not be more than 1 mil (0.0254 mm) double amplitude. When measured directly on the turbine shaft, the eccentricity at each bearing point shall not exceed 3 mil (0.0762 mm) double amplitude during the startup period. Maximum permissible vibration measured at bearing housing will be as per zone A of ISO 10816-2 and ISO 7919-2:2001.

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1.7 Steam Turbine Performance Requirements

- i. The steam TG set apart from being capable of operation on base load shall also be suitable for two shift operation and cyclic load variations as the unit is expected to operate in automatic load-frequency control system. For catering to two shift and cyclic operation, turbine shall have following design features:

- Low thickness and weight of components
- Uniformity and symmetry of section
- Small rotor diameters
- Small size horizontal flanges for casings
- Thinner casing outer shells

- ii. Operation with HP/LP Bypass System

The unit will be provided with a HP/LP bypass system. The HP/LP bypass system will be provided primarily to enable suitable steam/metal temperature matching at the turbine for a quick restart following a steam turbine generator (STG) trip out as well as to prevent a steam generator trip in case of steam turbine generator trip. The bypass system will also be used during cold start-up of the STG unit. The capacity of the HP bypass system shall be 60% of BMCR flow.

- iii. **Operating Frequency Range**

The STG unit shall be capable of safely operating and continuously delivering 100% unit output (with maximum condenser cooling water inlet temperature to the condenser) under following operating conditions:

- With a frequency variation of +3% and -5% over the rated system frequency of 50 Hz.
- Within +5% and -5% of voltage variation of the rated generator voltage at maximum and minimum of rated frequency range.

- iv. Auxiliary Equipment Performance with Fluctuation in Power Supply conditions

- v. Although the rated system frequency is 50 Hz, it is expected that reduced frequencies will prevail over sustained periods of time. All motor driven auxiliary equipment and accessories shall be capable of continuously delivering satisfactorily their rated outputs for a voltage variation of +/-10% and a frequency variation of + 3 % and – 5% and a combined variation of +10%.

- vi. **Rate of Loading**

The unit shall be loaded as fast as practicable subsequent to synchronisation after cold/warm/hot start-up with the bypass system in service. The Bidder shall indicate the criteria that will govern the rate of loading.

Start-up, Loading, Unloading and Shutdown Requirements

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Each unit shall be capable of being started-up and loaded in the shortest possible time. The unit shall be able to start up and synchronise within the start up time indicated below:

- Cold start – *[Greater than 36 hours shutdown- To achieve Synchronization within 6.0 hours and to achieve full load within 3.5 hours from Synchronization]*
- Warm start – *[Between 8 and 36 hours shutdown- To achieve Synchronization within 3.5 hours and to achieve full load within 2.0 hours from Synchronization]*
- Hot start - *[Less than 8 hours shutdown-- To achieve Synchronization within 1.0 hour and to achieve full load within 1.0 hour from the Synchronization]*

Following cyclic loading criteria shall be considered in design:

Cold starts : *[150 nos. for 20 years]*
 Warm starts : *[1000 nos. for 20 years]*
 Hot starts : *[4000 nos. for 20 years]*

- vii. *[The units shall be designed for operation in the modified sliding pressure mode between 40 % and 90% load. The unit has to fulfill the following Indian grid code requirement:*

“The unit shall be capable of (and shall not in any way be prevented from) instantaneously picking up five percent (5%) extra load when frequency falls due to a system contingency. After an increase in generation as above, the unit may ramp back to the original level at a rate of about one percent (1%) per minute in case continued operation at the increased level is not sustainable”.

Bidder shall highlight in his bid how the above condition could be fulfilled. In any case Bidder shall consider adequate throttle reserve in the design so that Turbine VWO (valve wide open) flow capable of generating 105% TMCR loads.]

viii. **Operation without Top Feed Water Heater**

The steam turbine generator shall be designed for operating continuously corresponding to the condition when any one the top high pressure feed water heaters is out of service.

ix. **Sudden Loss of External Load**

On occasions, the unit may experience sudden total loss of all external load. Under these conditions, the HP-LP bypass system shall operate and the Boiler and the steam turbine generator together shall continue operation without tripping to supply power for the power plant auxiliaries (about 5-6% of 100% TGMCR). The complete instrumentation and control system shall be adequately designed to take care of the above operation of the power plant.

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x. **Sound Pressure Levels inside Power Plant Area**

The individual machines / components / system shall be acoustically designed for a surface sound pressure level of < 85 dB (A), measured in accordance with ISO 2746 respectively at a distance of 1 m from equipment surface and at a height of 1.5 m above floor level. The surface sound pressure level (Lp) shall be averaged over the measurement surface and corrected for effect of background noise and the influence of reflected sound at measurement surface (environmental correction).

- xi. Bidder shall provide adequate temperature measurement and other instrumentation etc. for adequately guiding the operator to regulate loading of unit to keep the thermal stresses and fatigue levels within safe limit.
- xii. TG set shall be capable of operating on constant as well as variable pressure mode. Necessary facilities shall be provided for switching over to variable pressure mode of operation from constant pressure operation and vice versa from unit control board.
- xiii. Adjustable throttling reserve from 0 to 20% shall be provided.
- xiv. TG set shall be capable of operating continuously with HP heaters out of service, with [89] mm Hg condenser pressure, 3% make-up and auxiliary steam requirement tapped from CRH, generating maximum output without overstressing turbine components.
- xv. The peak to peak value of vibration measured on bearing housing shall be minimized and shall be within limits as per ISO 10816 and ISO 7919.
- xvi. During HP and LP bypass operation, the deaerating feed water heater and accessories shall be able to heat feed water from [45 deg C to 140 deg C].
- xvii. All cycle drains shall be led to condenser through flash tanks. In addition, the provision shall be kept for main steam line drains and HP bypass line drains to be led to a separate atmospheric flash tank.
- xviii. Condenser shall be designed to accept additional flows from boiler during startup (as applicable).

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2 CONDENSER AND CONDENSER AIR EVACUATION SYSTEM

2.1 General

The condenser shall be designed to receive and condense the whole of the exhaust steam from the turbine, including HP-LP steam bypass system and drains & vents under all modes of operation. The condenser shall be designed for a temperature raise of [10 deg C]. Each Turbine Generator unit shall be provided with steam condensing plant consisting of condensers to suit the requirement of the turbo generator sets proposed by the Bidder, and a set of air extraction equipment and accessories as described in this specification. The steam inside condensers shall be cooled by cooling water pumped by circulating water pumps and recirculated through cooling towers. During start up and other operating conditions, steam will be dumped into the condensers fully or partly bypassing the steam turbine. The Condensers shall be suitably designed to receive such bypass steam.

The Air extraction equipment to be used for creating the necessary vacuum in the condensers during starting up of the unit and during normal operation by removing non-condensable vapours and gases and shall be designed suitably to work satisfactorily in conjunction with the condensing unit.

2.2 Codes and Standards

Nomenclature, definitions, design, materials and construction of the condenser and air removal equipment furnished under this specification shall comply in all respects with requirements of the latest edition of Heat Exchange Institute (HEI) standards for steam surface condenser. HEI standards or equivalent shall be followed for thermal design and IS-2825 for strength design of condenser.

Table: 2.1

S.No.	Code	Description
1	PTC 12.2	ASME Performance test codes for Steam Surface Condensers. Standards of the Hydraulic Institute of USA
2	ASTM	American Society for Testing & Materials
3	American National Standards (ANSI) on	Steel Pipe Flanges and Flanged Fittings (B 16.5) Steel Fittings S.W. and Threaded (B 16.11) Butt welding ends-Pipe, valves, & fittings (B16.25) Valves – Flanged, Threaded and Welding End (B 16.34)
		American Society for Non destructive Testing (SNT-TC-1A)
		American Society for Non destructive Testing (SNT-TC-1A)
4	OSHA	Occupational Safety and Health Act

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Other standards such as, DIN, BS, IS etc. shall also be accepted subject to the Purchaser's approval. In case bidder intends to use alternate standards (if same is acceptable to Owner), Bidder shall furnish a copy of the same in English version during detail engineering.

2.3 Design Parameters

2.3.1 Condenser

- i) The steam condensing plant shall be designed, manufactured and tested as per HEI (latest edition). The condenser(s) shall be designed for heat load corresponding to unit operation for valves wide open (VWO) conditions, 3% make-up, design condenser vacuum and other conditions specified in the given below table. The value of design condenser pressure to be measured at 300 mm above the top row of condenser tubes shall be guaranteed under VWO condition, 3% make-up, design CW inlet temperature and CW flow. The condenser vacuum shall be measured with a vacuum grid utilizing ASME basket tips. The grid is fitted with at 300 mm above top row of tubes of condenser.
- ii) The condenser hotwell shall be sized for three (3) minute storage capacity (between normal and low-low level) of total design flow with the turbine operating at VWO condition, 3% make-up, design condenser pressure. The low low level of hotwell shall be at least 200 mm above the bottom of hotwell.

Table: 2.2

S.No.	Particulars	Value
1	Condenser design parameters	
a	Number of passes	[Divided water box type, Double pass]
b	Design cold water temp/Type of water	[33 °C] Clarified water
d	Minimum thickness of the tube	22 BWG
e	Tube velocity	1.6 to 2.2 m/sec
f	Design condenser pressure	[76] mm Hg (abs)
h	Temperature rise of circulating water	[10] °C
i	Tube material	Stainless steel ASTM A249 TP304
j	Cleanliness factor	0.9
k	Fouling factor	As per HEI
l	Tube plug margin	5% under design condenser condition
m	Maximum CW side pressure drop in condenser and associated systems under CW design flow and CW inlet	6 mwc

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S.No.	Particulars	Value
	temperature with tube cleaning system CW intake and discharge ducts in bidder's scope within the terminal point..	
2	Maximum temperature of circulating water	[36 deg C]
3	Minimum temperature of circulating water	[29 deg C]
4	Flow	Able to handle exhaust steam corresponding to VWO condition with rated steam pressure and temperature at turbine inlet, 3 % make up and all feed heaters in service along with all other heat rejections and maintaining a guaranteed condenser pressure of [76] mm Hg considering tube cleanliness factor as 0.9
5	Water box design pressure	Vacuum and 5 kg/cm ²
6	Water box test pressure	1.3 times the design pressure
7	Water box design temperature	60 deg C
8	Shell side design pressure	Full vacuum and 5 kg/cm ² (g)
9	Shell side design temperature	120 deg C
10	Design parameters for expansion joints Design pressure Design temperature Test pressure	Vacuum (0.108 bar (abs)) and 5 kg/ cm ² (g) 60 deg C 1.3 times the design pressure (minimum)
11	Design parameters of isolating butterfly valves with actuator Design pressure Design temperature	Vacuum (0.108 bar (abs)) and 5 kg/ cm ² (g) 60 deg C

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S.No.	Particulars	Value
	Test pressure	1.3 times the design pressure (minimum)

- iii) Condenser shall be designed to receive exhaust steam from steam turbine, HP-LP bypass system, heater drains and vents, drains during startup, low-load and abnormal conditions.
- iv) Steam dumping device shall be provided for dumping of desuperheated steam from LP bypass. Sizing of steam dumping device shall be adequate to accept the steam from HP-LP bypass with necessary spray water including abnormal condition like HP heaters out of service etc.
- v) Air removal section shall be designed to cool the air and vapour mixture to at least 4.17°C below saturation temperature corresponding to 25.4 mm Hg (abs). Connections to air evacuation pumps shall be made at this section.
- vi) Condenser shall be designed to carry flooded weight (upto tip of last stage of LP turbine blades) for hydraulic and hydrostatic testing of condenser without installation of temporary supports or bracing.
- vii) CW butterfly valves with actuators shall be designed as per AWWA-C-504-80 or purchaser approved equivalent standards. Valve material shall be suitable for the duty intended.
- viii) CW expansion joints shall be made from high quality natural/synthetic rubber with stainless steel reinforcement rings and with flanges of 125 lb as per ANSI B16.25. The materials used shall be suitable for service intended. The expansion joints shall be designed to the deflection fluid pressures throughout plant life and shall be suitable to withstand full vacuum without collapse and the proposed arrangement for this shall be indicated in the offer. Further the design shall limit the reaction forces/ moments on condenser CW nozzles and on CW piping.
- ix) There shall not be any damaging effect due to vibrations during normal, abnormal and transient conditions and during turbine trip from full load to HP-LP bypass operation. Satisfactory operation under all operating conditions shall be ensured including HP-LP bypass operation, feed heaters out of operation, VWO condition, 100% load and start-up conditions etc.
- x) Condenser design shall provide for maximum deaeration and removal of non condensable gases from steam and make-up water. Air removal section shall be suitably baffled to prevent water carryover.
- xi) Condenser shall be provided with arrangement for complete drainage of water from the hot well.
- xii) Catch trough shall be provided below tube sheet in hotwell for detection of water leakage into steam side.

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2.3.2 Condenser Air Evacuation System

Each unit shall be provided with 2x100% vacuum pumps with all accessories for condenser air evacuation. Pumps shall be sized as per latest HEI requirements. Capacity of each pump in free dry air at standard condition with condenser operating at design pressure of 1inch (25.4 mm) of Hg (abs) and sub-cooled to 4.17°C below temperature corresponding to absolute suction pressure shall not be less than 30 scfm (51 m³ per hour) under standard condition (i.e 76 mm of Hg (abs) and 21.1°C). The capacity of each pump during hogging shall be as per criteria given in latest version of HEI plus 20% margin.

Table: 2.3

S.No.	Particulars	Value
1	Source of vacuum pump heat exchanger cooling water	Auxiliary cooling water (ACW)
2	Source of sealing water	Condensate
3	Source of make-up water	Condensate
4	Design pressure (cooling water side) for vacuum pump heat exchanger	Vacuum (0.108 bar(abs)) and 5 kg/ cm2 (g)
5	Pressure of make-up water	CEP discharge pressure
6	Maximum temperature of condenser cooling water	36 deg C
7	Duty code	HEI
8	Design back pressure	25.4 mm (1 inch) of Hg (abs)

Note: Design pressure for CW piping, valves, fittings, COLTCS equipment etc shall be for Vacuum (0.108 bar(abs)) and 5 kg/cm2 (g) minimum.

- Air evacuation pumps shall be single/two stage liquid ring type with both stages (if two stage pump required) mounted on a common shaft. The pumps shall be suitable for indoor installation and for continuous duty.
- Each pump and its accessories shall be mounted on common steel base plate. Pump shall be connected to its motor by flexible couplings.
- Heat exchangers shall be shell and tube type with tubes of SS 316, and shell and tube plates of ASTM-A285 Gr. C15. For U-tube type heat exchangers, the tube bundle shall be of removable type. Alternatively, plate type heat exchangers with SS 316 plates and 20% area margin on plates shall also be acceptable.
- Selection of materials for vacuum pumps and seal water recirculation pump shall be as below:

Casing : Nickel cast iron
 Shaft : Carbon steel (EN8)
 Impeller : Nodular iron/stainless steel

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Shaft sleeves : Nodular iron/stainless steel

- v) Air evacuation pumps shall be designed for vibration levels as per VDI – 2056.
- vi) Flexibility shall be provided for operating both pumps during hogging and must be able to evacuate the condenser in specified time as per HEI.
- vii) Standby pump shall cut-in automatically in case running pump fails or when condenser pressure falls back to a preset value.
- viii) Each pump shall be suitable for evacuating 100% designed air steam mixture and non-condensable gas as per HEI.
- ix) Pumps shall be designed for no cavitation under all operating conditions.

2.4 Design and Construction Requirements

2.4.1 Condenser Type and Duty

The condensers shall be of single/dual pressure type two pass, horizontal, surface type with integral air cooling section with water as the cooling medium. The condensers shall be so designed that it can operate satisfactorily under the different off-normal operating conditions of the turbine such as fully or partly by-passing of the turbine, closing of one or more extraction openings etc. The condenser shall be designed for efficiently deaerating the heat cycle make-up, which will be introduced into the condenser. Sub-cooling of the condensate shall be avoided.

The condenser Hotwell should have a minimum available volume sufficient to contain between its "normal" and "low" levels the condensate that may be produced in the condenser in a period of three (3) minutes under condition of maximum steam load. Hotwell shall preferably be divided longitudinally with pump suction from both sides.

The condensers shall be arranged for installation with the tubes at right angle to the axis of turbine rotor and shall be designed for a minimum width and for installation below a reinforced cement concrete turbine generator foundation. Condenser shall be furnished in two sections. Each water box shall be divided into two halves and the two sections shall be completely isolated from each other with separate inlet and outlet connections so that one half of the condenser can be isolated on the cooling water side for inspection and maintenance while the other half is in operation. The cooling water inlet connections shall be at the bottom and outlet connection at the top.

The condenser overall dimensions, together with the space required for withdrawal of condenser tubes and dismantling/opening of each water box cover shall be suitable for the T.G. building dimensions and local pipe layout so that no dismantling of any equipment or CW or other piping or breaking of wall/floor is required for condenser tube/water box maintenance or replacement.

Corrosion allowance of minimum 0.8 mm on each welded side for the shell side and 3.2 mm for water boxes and tube plates shall be applied to the design thickness of each component.

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2.4.2 Condenser Shell and Fittings

The condenser shell shall be carefully shaped in conjunction with the tube arrangement and provided with baffles as necessary to ensure proper distribution of steam over the whole of the tube nest with minimum shock load and to eliminate all areas of excessive steam velocity. Extraction pipes passing through condenser neck shall be provided with stainless steel shroud around each pipe to prevent erosion due to steam. Condenser shell shall conform to ASTM Specification A285 Gr.C or equivalent. The design shall be as per ASME pressure vessel code. The condenser shell (steam side) shall be designed for full vacuum to a minimum internal pressure corresponding to the bursting / relieving pressure of the turbine exhaust hood safety diaphragm and the same is expected to be 10% more than the saturation pressure corresponding to the condenser design temperatures whichever is greater. The shell side design temperature shall be 120 deg C. The minimum wall thickness for the shell shall be 16 mm and the tube shall be 0.7mm.

Shell shall be designed for a minimum number of site welds. Expansion joints shall be provided in the condenser shell to take care of differential expansion between the shell and tubes.

The condensers shall be adequately supported so that no upward thrust is imposed on the turbine under all conditions of operation. If the design incorporates an expansion piece, it shall preferably be in fully stabilized Austenitic stainless steel all welded type, designed to reduce flow interferences to a minimum. Design of expansion joints shall take care of the set pressure of bursting disc on turbine exhaust and corresponding temperature along with the turbine movements. Means shall be provided to prevent any load being imposed on the turbine casing when the condenser steam space is filled with water during hydrostatic testing of the condenser.

Suitable manhole with hinged covers on the upper part of the shell and hotwell portion shall be provided to facilitate maintenance. Manhole sizes shall be minimum 600 mm.

Necessary connections on the condenser shell and hotwell for air removal, introduction of make-up, recirculation from main condensate line (to maintain minimum flow through condensate extraction pump), drains, vents & instrumentation shall be provided.

At all points where steam and water enter the condenser shell, baffles shall be provided to prevent direct impingement on the tubes. All bolts, nuts, stays etc. inside the steam space shall be of approved material and where such parts project through the tube plates they shall be fitted with approved cap nuts and protective sleeves. Spray piping shall be provided to distribute cold make-up water in such a manner as to provide suitable heating and deaeration. The other fittings shall include but not be limited to the following:

- i) Drain valves with cap and one set of water level gauge for each section of the condenser hot well as also a complete arrangement for sample collection and conductivity measurement from each section.

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- ii) Nozzles with strainers and vortex breaker for connection to extraction pumps from each section of the hot well. The suction pipe of Condensate Extraction pumps should be laid above ground floor and valves should be easily accessible.
- iii) Air outlet connections.
- iv) Steam throw-off device to effect pressure reduction and condensate spraying on the steam from L. P. bypass station when the turbine is bypassed.
- v) All necessary connections for instrument and controls.
- vi) One isolating valve on the top of the steam space of each condenser shell or top of each turbine exhaust piece for vacuum gauges.
- vii) Suitable thermometer pockets on each of the cooling water inlet and outlet branches, at top of the steam space of the condenser shell, in the air suction branch of the shell, in each section of the hotwell and also thermowells on each end of the condenser shell.
- viii) Flash boxes with manifolds to receive all feed heater drains, and various other system drains; vent and drain piping from each flash box for connection to the condenser steam space and hot well.

2.4.3 Condenser Tube Plates

The condenser tube plates shall be conforming to international standards. The tube plate shall preferably be welded to the shell. The tubes shall be solid drawn type, manufactured and tested in accordance with the approved standard. All tubes shall be of tested quality and the Bidder shall submit the test certificate of the tubes. Each tube shall be eddy current tested for soundness.

Condenser tube material shall be conforming to international standards of adequate thickness and size as per unit size. The tubes shall be cleaned and annealed followed by quenching, pickling and passivation.

The tube water velocity shall be within a range suitable for the material selected as recommended by Heat Exchanger Institute (USA).

Tube nest as a whole shall be slightly inclined to provide self-draining of tubes when the condenser is shut down.

A catch trough shall be provided at the bottom of each tube-plate towards the steam side so that any leakage of cooling water through a tube-tube sheet joint will first get collected in the catch trough. A drain pipe from each catch trough shall be provided penetrating out through the condenser/hot-well shell and having an isolating cock at the outlet end for sampling connection/conductivity measurement.

2.4.4 Tube Support Plates

The tube support plates shall be of appropriate material construction and arranged suitably so that no periodic vibration of tubes may be induced by the running of the Turbo Generator and the maximum span shall be limited such that vibration induced by steam flow may not occur. Tube holes shall be accurately drilled to provide suitable clearances on the diameter of the tube. Edges of the

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tube holes in the support plates shall be chamfered to facilitate tube insertion and shall be deburred to prevent tube damage.

2.4.5 Water Boxes and Covers

The water boxes shall be designed for a pressure of 5 kg/cm² (g) minimum. (The same shall be checked against the Condenser Cooling Water Pumps shut-off heads.)

Water boxes shall be supported from condenser shell by flange connection. Condenser design and construction shall assure complete support of the fully flooded water boxes from the condenser shell without requiring auxiliary supports.

Material of construction for the water boxes and its covers shall be conforming to international standards.

Water boxes shall be tested with a hydrostatic test pressure as recommended by Heat Exchange Institute (USA).

The water boxes, covers and water side of tube sheets shall be sand blasted, applied with coal tar epoxy primer and then coated with coal tar epoxy paint of minimum 0.25 mm thickness. The outer surface shall be painted with suitable paint after the surface is cleaned and degreased. Cathodic protection of water boxes and tube sheets shall be provided.

Suitable drain and vent connection with necessary valves shall be provided for each compartment of the water box.

Design shall provide the optimum entrance condition to the tubes. Strengthening ribs shall be suitably provided on outside face only.

Access doors and inspection windows shall be provided in each compartment at minimum two levels to permit easy internal access and inspection.

Adequate arrangement shall be made for removal of water box cover for tube replacement without disturbing C.W. piping. Necessary monorail, hoist block etc. shall be included.

2.4.6 Air Evacuation System - Vacuum Pumps

- i) The condenser air evacuation system shall be suitable for operation in conjunction with the turbine and condenser offered. It should comprise 2 x 100% vacuum pumps with all accessories for condenser air evacuation. These mechanical vacuum pumps shall be sized as per latest HEI requirements. Capacity of each pump shall be sufficient to maintain continuously the condenser vacuum corresponding to the saturation pressure of the condensate in hotwell at design cooling water temperature, when the condenser is working at its design capacity of steam, condensate and heat input (VVO steam flow, 3% make-up heater drains diverted to condenser etc.), and also during operation of the unit at lowest TG load for all C.W. Temperature.
- ii) Besides, the pump capacity shall also be such that at starting, with both pumps working in parallel, it is possible to create within 30 minutes sufficient vacuum in the condenser suitable for raising the steam turbine to its full speed.

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- iii) The design capacity of each pump shall be selected to meet both the above requirements with a margin of 10%. The pump TDH shall take into account the pressure drop, in suction pipeline between pumps and condenser and in the pump discharge side including air vent pipe stack outside Turbine building, as estimated for the design capacity. The sizing calculation of the system shall be furnished with the offer.
- iv) The pumps should not trip under low system frequency (47.5 Hz) operation.
- v) The pumps shall be single stage/double stage, as necessary to meet the design conditions. The pumps shall not cavitate under all operating conditions.
- vi) Suitable compression ratio shall be selected so that the pumps operate effectively at all conditions of operation with cooling water temperatures mentioned above.
- vii) The pumps shall be designed for indoor installation and for continuous duty, to handle mixture of air, steam and non-condensable gases. Bidder shall ensure and guarantee that pumps shall not cavitate at any load, including part loads and design point.
- viii) The pumps shall be of liquid ring design with both the stages (in case of two stage pump) mounted on a common shaft. The unit shall require no internal lubrication and shall be free from damage by water vapour, entrained droplets or slugs of water.
- ix) The unit shall be complete with liquid ring vacuum pump, drive motor, flexible coupling and coupling guards, water separator in the discharge air line, (The line should be self draining to pump) with gauge glass and automatic make-up and overflow valves, suction and discharge piping, expansion joints, inlet system valve with differential pressure switches, system vacuum switch to start automatically the standby unit, heat exchanger for seal water cooling, seal water recirculation pumps, air ejector, rotameters for discharge air measurement, vacuum gauge for system inlet pressure, pressure gauge for seal water pressure, temperature gauge for seal water, outlet check valve, relief valves (if required) and other necessary instrumentation, control and wiring. The entire unit shall be mounted on a common steel base frame. Water separator in the vacuum pump discharge air line.
- x) Necessary device shall be incorporated in the design of the equipment so as to prevent loss of vacuum by flow of atmospheric air back into the condenser upon shut down of the pump.
- xi) The heat exchangers shall be arranged to permit access to tubes without disturbing the piping connections. The heat exchanger tubes shall be seamless/ welded. If U-tube heat exchangers are offered, the tube bundle shall be of removable type.
- xii) The material of the pumps shall be so chosen as to accept condensate as the source of sealing water.

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2.4.7 Air Evacuation System- Steam Jet Air Ejectors

- i) 1x100% single stage non-condensing type Starting Ejector and 2x100% two stage condensing type Main Ejectors shall be provided. The ejectors shall be suitable for operation in conjunction with the turbine and condenser offered.
- ii) Two stage main ejectors shall be provided with inter-condenser and after-condenser.
- iii) Both types of ejectors shall be complete with accessories like steam nozzle, strainer, interconnecting piping, valves, air vent, instruments and controls.
- iv) The ejectors shall be sized as per latest HEI requirements.
- v) Capacity of the starting ejector shall be such that at starting, it is possible to create within 30 minutes sufficient vacuum in the condenser suitable for raising the steam turbine to its full speed.
- vi) Capacity of main ejectors shall be sufficient to maintain continuously the condenser vacuum corresponding to the saturation pressure of the condensate in hot well at design cooling water temperature, when the condenser is working at its design capacity of steam, condensate and heat input (VVO steam flow, 3% make-up heater drains diverted to condenser etc.), and also during operation of the unit at lowest TG load for all C.W. Temperature.
- vii) The air ejectors shall be designed for indoor installation and for continuous duty, to handle mixture of air, steam and non-condensable gases.
- viii) Necessary device shall be incorporated in the design of the equipment so as to prevent loss of vacuum by flow of atmospheric air back into the condenser upon shut down of the air ejectors.

2.4.8 Nozzle Connections

All necessary nozzle connections for the system as required by the Turbine-Generator manufacturer and the heat cycle system shall be provided.

All water (make-up water, exhaust hood spray, condensate recirculation etc.) to the condenser shall be fed through perforated pipes suitably located. The supply shall include necessary internal piping with spray holes. In regions where impingement is likely to occur, the tubes shall be protected by stainless steel baffles & extraction pipes shall be protected by stainless steel shields.

2.4.9 Condensate Storage Tank and DM Make Up Pumps

For normal make up to the power cycle, DM water shall be added in the condenser hot well. The DM water shall be supplied from DM water storage tanks of DM plant, and shall be added in the hot well through a control valve. The indication for status of operating DM water supply pumps shall be provided in the UCB.

Emergency make up to the condenser hot well shall be supplied by 2x100 % centrifugal pumps of adequate capacity taking suction from the condensate storage tank which shall also receive excess flow from discharge of condensate

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extraction pumps. The condensate storage tank shall be of epoxy coated mild steel to IS 2062 Gr- B and its capacity shall be to meet 12 hour normal make up requirement of the unit subject to a minimum effective storage of [300 m³]

2.5 Inspection and Testing

- i) The water box and shell shall be hydrostatically tested as per Heat Exchange Institute Standards. During hydro test the gasket tightness shall be to measured extent. Gaskets shall be replaced by new ones after shop test.
- ii) All condenser tubes shall be hydraulically tested to 7.5 kg/cm² g internal and outside pressure and also inspected ultrasonically or by eddy current testing as per ASTM E213-68 and ASTM E243-67T respectively prior to shipment.
- iii) The completely assembled and tubed condenser shall be hydrostatically tested after erection, according to the standards of Heat Exchange Institute.
- iv) Condenser shell shall be tested for any leakage by filling the steam space with water.
- v) A field performance test shall be conducted in conjunction with approved Acceptance Tests Procedure.
- vi) Performance of the air removing equipment shall be tested at the manufacturer's shop according to the applicable ASME Performance Test Code, PTC 24 - "Ejectors" and ASME Performance Test Code, PTC 9- "Vacuum Pump".

2.6 Drawings, Data and Information Required

- i) Characteristic curves for condenser performance showing condenser pressure for heat load range of 30 percent to 120 percent of the design heat load with varying circulating water temperatures (26.9 deg C to 36 deg C) for tube cleanliness factor of 100% and 90%.
- ii) Rubber expansion joint GA drawing with material of construction.

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3 FEED WATER HEATER AND DEAERATOR

3.1 General

- i) The design shall be capable for meeting all operating conditions including sudden load throw-off, HP-LP bypass operation, one or two heaters out of operation etc.
- ii) The system shall be designed for handling drains from preceding heaters for all operating conditions and emergency drains to condenser bypassing the drain cooling zone.
- iii) Easy for floor mounting and shell dismantling except for LP heater in Condenser neck (if provided).
- iv) Provision for complete drainage from both shell and tube (water box) side.
- v) Provision of start-up and operating vents with orifices and provision for removing non condensable gases to be collected on the shell side to condenser shall be made. Vent orifices shall be sized to pass one half percent of rated steam flow to respective heater.
- vi) Material

Table: 3.1

Tube (For seamless) with circumferential joints	ASTM A 213 Gr. TP 304
Tube (For welded)	ASTM A 688 Gr. TP 304
Tube sheet	Carbon steel as ASTM A 216 Class II or SA 350-LF-2

- vii) The tube sheet shall be welded to shell and water box. Tube support plates of common quality steel of 16 mm (min.) thickness shall be provided.
- viii) Water box channels shall have access opening (manhole openings) of minimum 450 mm dia. This shall be of self sealing type. Bolted design shall not be acceptable.
- ix) The design shall provide prevention of super heated steam contact with tube to tube plate joints at entry to heaters.
- x) Preservation by nitrogen blanketing during shut down.
- xi) Minimum tube thickness shall be 20 BWG (0.89mm) after bending. Stress relieving of U tube bends shall be carried out up to a distance of 150 mm from bend area.
- xii) Minimum fouling resistance at tube side shall be 0.00004098 hr-m²-deg C /kCal and an additional 0.000061475 hr-m²-deg C /kCal on outer tubes as per HEI.

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- xiii) A corrosion allowance of 3.2 mm shall be considered for each heater shell and water box.
- xiv) Heaters shall be provided with stand pipes with necessary connections for instruments, water level gauges, isolation valves etc.
- xv) Each bled steam line shall have one number power assisted NRV and one number ordinary NRVs, motorized isolation valves except for the L.P. heater No.1, if mounted in condenser neck. However the bled steam (extraction steam) from IP turbine to deaerator shall be provided with two numbers of power assisted NRVs with motorized isolation valves.
- xvi) Baffle plates shall be provided to prevent vibration, ensure uniform steam distribution and enable free drainage of condensate.
- xvii) Shall have provision of pass partition plates to facilitate easy removal and access to tubes.
- xviii) Provide sentinel relief valve on tube side. Relief valve on shell side shall be sized to pass flow from two ruptured tubes (four open ends) or 10% of design water flow at 10% accumulation whichever is higher and set to open at heater design pressure.
- xix) Adequate handling facilities shall be provided for removing the heaters for maintenance in case of horizontal heaters.

3.2 Low Pressure Heaters and Drain Cooler

- i) Vertical / Horizontal type having U-tubes with integral drain cooler except for LP heater no. 1 if mounted in the condenser neck.
- ii) Shell shall be made of ASTM A-516 Gr. 70 with SS-304 bands at cut points on shell to prevent damage against flame impingement during torch cutting.
- iii) Water box shall be made of carbon steel as per ASTM –516 Gr. 70 and shall be welded to tube sheets.
- iv) Expansion of tubes to tube sheets shall be rolled. Tubes shall be cold bent for fabrication.
- v) Roller support shall be provided for shell removal of heaters (in case of horizontal heaters). For LPH-1 roller support shall be provided for heater channel during tube bundle removal if LPH 1 is located in the condenser neck.
- vi) Provision of shell attachments for supports of LPH in condenser neck and Anti-flash baffles to protect the turbine from water ingress shall be made.
- vii) Provision of integral desuperheating, condensing and drain cooling zones except for LPH-1, if mounted in condenser neck shall be made.
- viii) There shall be provision of differential expansion between shell and tube.
- ix) Details of tube sheets, tube to tube sheet joint, tube supports plates, material of construction for drain cooler shall be identical to other LP heaters.

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3.3 Deaerator

- i) Horizontal, spray-cum tray with integral vent condenser mounted on horizontal storage tank.
- ii) Design and construction shall be as per Indian Boiler regulations, ASME code for unfired pressure vessels, Section- VIII or any other equivalent code.
- iii) The storage tank shall have reinforced wire mesh strainer and anti-vortex baffles at discharge connections from deaerator.
- iv) Fixed and Saddles support shall be provided for the storage tank.
- v) All pressure parts such as shell, heads and nozzles shall be made of carbon steel as per ASTM A 515 Gr. 70. Shell plate shall have thickness of 15.8 mm minimum with welded construction.
- vi) Hardened 400 series stainless steel impingement plates for flashed drain inlet from HP heaters, BFP recirculation, boiler start-up drains etc shall be provided.
- vii) All water spray valves, splash plates, trays, vent condenser and other elements coming in contact with undeaerated water or non-condensable gases shall be made of stainless steel SS 304.
- viii) Deaerator safety valves shall have adequate relieving capacity and shall be made of Stainless steel disc and spindle.
- ix) Vents with orifice plate and vent with motor operated valve shall be provided.
- x) The Deaerator shall be designed for efficient steam distribution and deaeration of condensate under all operating conditions including VWO, 3% make-up, HP-LP bypass, one/both the strings of HP heaters out of operation.
- xi) The Deaerator shall be of variable pressure type (Floating pressure Type) - Pegging pressure shall be 3.5 ata during warm and hot startup, HP- LP bypass operation, major load rejection, turbine trip and low load when extraction steam pressure is less than 3.5 ata. During cold startup the deaerator pressure shall be maintained at 1.5 ata with steam from auxiliary steam header. Deaerator pressure shall vary according to load due to variation in steam parameters of turbine extraction. Design pressure & temperature shall not be less than the extraction or CRH pressure at the downstream of PCV or the worst operating conditions with sufficient design margins.
- xii) Source for heating:
 - a. [Extraction steam from turbine IP-LP crossover pipe (normal operation)].
 - b. [Steam from CRH (up to 60% load)]
 - c. [Steam from auxiliary steam header (for Initial heating & low loads)].
- xiii) Sizing of feed storage tank shall be adequate to take requirements of any steady load from 0% to 110% of rated capacity including boiler start up drains as applicable. Minimum feed storage tank capacity between normal and low-low level shall be 7 (Seven) minutes of BMCR flow.
- xiv) Design shall be adequate to withstand full vacuum and pressure decay during start-up condition.

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- xv) Shell thickness shall have corrosion allowance 3.2 mm.
- xvi) Provision of sparger pipe and nozzle for feed water heating shall be made.
- xvii) Size of vent orifice shall be for one half percent of rated flow to deaerator.
- xviii) Provision of access platform and ladders with hand rails on deaerator and storage tank shall be made.
- xix) 2 nos. of manholes of 450 mm dia. (min.) each on deaerator and storage tank for maintenance including trays shall be provided.

3.4 High Pressure Heaters

- i) Vertical/Horizontal type HP heaters having U-tubes with integral desuperheating, condensing and drain cooling sections shall be provided.
- ii) Shell shall be made of carbon steel as per ASTM A-516 Gr. 70 and water box as per ASTM A-226 class –II and shall be welded to tube sheet.
- iii) Roller supports for shell removal shall be provided in case of horizontal type.
- iv) Tubes shall be welded to tube sheets and then roller expanded.
- v) Level of condensate in the heaters is to be maintained in the preset range. In case of level rise beyond permissible limits in any of the HP heaters, group/individual (based on the configuration) hydraulic bypass arrangement shall operate and drains shall be led to the condenser.
- vi) Provision for differential expansion between shell and tube shall be made.
- vii) All other features indicated for LP heater shall be applicable to HP heaters also.

3.5 General Performance Requirement

The feed heating system shall be capable of raising the temperature of feed water from that in the condenser to the final optimized value specified at the outlet of the top high pressure heater with turbine generator (T.G) set operating at rated parameters.

The extraction steam pressures and flows shall be determined by the Bidder by working out the turbine cycle heat balance.

The maximum oxygen content of the feed water discharge from the deaerator without chemical dosing shall not exceed 0.005 cc/liter at all loads upto and including the rated capacity. The carbon dioxide content of the feed water discharge shall be nil.

Heaters shall be capable of operation under the condition of preceding lower pressure heater taken out of service. The heaters shall be designed to accommodate increased steam and drain flows (for the next higher pressure heaters and the deaerator) in such an event. Contractor shall submit performance data on affected heaters in the train when one heater at a time is removed from service. Data shall be calculated for conditions when each of the heaters is removed from service individually and/or in group, and the remaining heaters are on line. Besides submission of off-performance data, the Contractor shall also indicate limitation of service, if any, during such condition. The

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deaerator shall be designed for the maximum incoming steam flow when none of the L.P. heaters is working under HP & LP Bypass condition.

During HP & LP By-pass operation, feed water shall be heated in deaerator to a minimum permissible temperature as per boiler requirement. Minimum acceptable H.P. heater outlet temperature during turbine low load operation shall be finalized as per boiler requirement.

The operation of the deaerator shall be stable and free from vibration etc. when subject to transient condition which may occur at full load trip out conditions of the T.G. and during introduction of alternative steam service.

All equipment warrant high reliability, low down time and ease of maintenance.

Equipment offered shall have an operating noise level as per ISO - 85.

3.6 Design & Construction Requirement

3.6.1 Closed Feed Water Heaters

3.6.1.1 Design requirement

The heaters shall be of surface type. Water shall flow inside the tubes and the heating steam outside the tubes. High & Low pressure heaters shall be horizontal U tube as per Manufacturer's standard proven practice. Heaters shall have integral desuperheating sections, as required.

The lowest pressure heater may be located in the condenser neck in case that is the standard arrangement of the manufacturer. In such a case, drain cooler may be provided either internal or external to the heater. L.P Heater mounted inside the condenser neck shall be provided with required shell attachments for supports and for closure plates for sealing the penetrations through the condenser shell. The heater shall also be provided with antflash baffles to protect the turbine from water ingress. Arrangement for heater tube withdrawal shall be provided; piping connected to the heater shall be so routed as to facilitate the tube withdrawal without dismantling the pipes.

Start-up vent from the heater mounted in condenser neck shall be provided with orifice plate.

Contractor shall select the terminal temperature difference and the drain cooler approach of the feed heaters keeping in mind the overall economy. However, following shall be the minimum criteria.

- i) H.P. heaters shall be provided with desuperheating and drain cooling zones in addition to the condensing zone. The maximum terminal temperature difference and maximum drain cooler approach shall be as per the HEI guidelines.
- ii) L.P. heaters shall be provided with drain cooling zone in addition to the condensing zone. Terminal temperature difference shall be as per the HEI guidelines.
- iii) Heat transfer area shall be calculated considering 10% of the tubes plugged. Fouling factor shall be taken as per the recommendation of the Heat Exchanger Institute, USA.

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The L.P. heaters shall be designed for the shut-off pressure developed by the condensate pumps on the tube side. The H.P. heaters shall be designed for the shut-off pressure of the boiler feed pumps (at maximum speed of operation) on the tube side. The design pressure for the feed piping shall be the shut-off pressure of the boiler feed pumps. Each heater shall be designed for removal from service individually without shutdown of unit, using hydraulically operated or motorized bypass and isolating valves. In addition, spring loaded relief valves shall be provided in the bypass arrangement of HP Heaters so as not to exceed the feed water pressure in heaters above design pressure.

The shell side shall be designed for the maximum extraction steam pressure with 5% margin or 3.5 Kg/Sq.cm (g) whichever is higher. The shell side design flow shall be calculated for the normal operating as well as abnormal conditions as specified and for a tube sheet leakage of 20% of the condensate/boiler feed water flow. Nozzles shall be sized liberally considering various modes of operation and shall be subject to approval by Purchaser. The tube side velocity shall be limited to 2.5 m/sec under all operating conditions.

Corrosion allowance of 3.2 mm shall be applied to the design thickness of each heater shell and water box. Tube thickness shall be increased to compensate for tube wall thinning.

About 0.5% of the steam entering a heater shall be vented (from its condensing zone) to the condenser and orifice plates shall be fitted in the vent pipe work to control the flow. Care should be taken to prevent accumulation of pockets of gas by positioning the vents in such a manner that every part of the tube nest is swept by steam. Each heater shall be separately and continuously vented to the condenser. Cascading of vents from heater to heater will not be permitted. The vent valves shall always remain open, whenever a heater is in service.

Each heater shall be designed for removal from service individually without shutdown of unit, using hydraulically operated or motorized bypass and isolating valves.

Self sealing type hand holes shall be provided on the H.P. heater water box for access to all the tubes. A skirt shall be provided around the tube bundle to shield during a gas cutting of the shell if required for removal of the tube bundle.

The arrangement of the feed water heater internals shall be such as to minimize rapid fluctuations of heater level during operation and the heaters shall be designed to operate without excessive noise and vibration.

Shell side relief valves shall be sized for 10% of the feed water flow, or maximum feed water inflow to shell due to the rupture of two (2) nos. tubes, whichever is greater, at 10% accumulation. Tube side relief valves shall be provided to guard against overpressure from water expansion when inlet and outlet valves are closed. The shell side relief valve set pressure shall be above the maximum working pressure of the extraction steam line, connected to the feed heater, in all possible operating conditions.

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Necessary vent and drain connections with valves shall be provided. Vents and drains on the feed water side of H.P. heaters shall be provided with double valves.

The heaters shall be designed for the minimum tube side pressure drop, and the same shall be indicated (for rated operating condition) in the Bid.

3.6.1.2

Materials and Construction

The water box for the high pressure heaters shall be of forged construction and welded to the shell. The low pressure heaters may be of bolted head or with welded water box. For bolted head type, copper jacketed gaskets or other metallic packing of approved quality shall be used.

The heater shells shall be of carbon steel welded construction. The tubes shall be of U-type. The L.P. heater tubes shall be roller expanded into the tube plates provided with at least two grooves.

The H.P. heater tubes shall be joined to the tube plates by welding to the stainless steel overlay by a proven technique. The Contractor shall, in his proposal, give complete description of the process adopted.

The tube nest shall be supported by baffles which shall prevent vibration and also ensure an even distribution of steam. Stainless steel impingement plates shall also be provided at all steam and water inlet branches to prevent direct impingement and wear of the tubes. The water box baffle plates shall be positioned to give good flow distribution through the heater tubes. The heaters shall be designed for most economical length and shall have suitable lifting arrangement such that a heater or shell can be removed for maintenance purposes.

The tube sheet shall be of forged carbon steel for L.P. heaters. For H.P. heaters, the tube sheet of forged carbon steel shall be overlaid first with one layer of SS-309, and then another layer of SS-308, to a total thickness of overlay not less than 7 mm. The feed water heater tubes shall conform to the applicable requirements of ASME specification. Seamless or welded type stainless steel (SS-304) tubes shall be provided. Details of experience of the Contractor with the type of tubes provided (seamless or welded) shall be furnished in the bid. Minimum tube diameter shall be 5/8" (0.625 inch/ 15.88mm) and thickness shall not be less than 20 BWG (0.035 inch / 0.89 mm). Stress relieving of U-bends shall be carried out up to a distance of 150 mm from bend area. Drawing and bending lubricants shall be non-chlorinated.

Bolting material, not in contact with steam or water, shall be ASTM A-193 Grade B7. For other bolting, manufacturer's standard corrosion resistant material shall be used.

H.P. water box nozzle connections shall be butt-weld type for sizes above 50 mm and socket weld for sizes below 50 mm. Other connections may be flanged type.

All flanged connections shall be of the bolted type and the use of studs shall not be permitted unless with special approval.

All tube holes in the tube sheets, baffles and supports shall be deburred.

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Insulation cleats shall be provided on shell and water box.

The interior surfaces of all the heaters shall be cleaned of all mill scale. The exterior surfaces shall be painted as required.

Material of construction for different parts of the drain cooler shall be identical to those specified for LP heaters.

The design pressure of the feedwater line and feedwater heater will be in line with the recommendations of Indian Boiler Regulation (IBR), ASME Section-1 and ASME B31.1 as applicable.

3.6.2

DEAERATOR

3.6.2.1

Design Requirement

Deaerator shall be capable of operating satisfactorily with two of the adjacent L.P. heaters out of service. Adequacy shall also be checked for the condition of HP & LP bypass when no feed heating is taking place in LP heaters and also for initial heating, steam blowing, initial commissioning etc.

Storage tank shall be fabricated at shop in minimum number of sections (to be determined on the basis of the size of tank and the transportation limitations) so as to minimize fabrication work done at site.

A horizontal, direct contact, spray-cum-tray type single deaerating vessel mounted on a horizontal storage tank shall be provided. Spring loaded nozzles for spray control shall be provided for guaranteed operation of the deaerator for a flow range from 100% to 30% without water hammering. The trays shall be provided for final stages of deaeration and shall be of rigid clamped type. The terminal temperature difference shall be zero at all load conditions. The deaerator will be operated for variable pressure. During load swing, cold condensate at hot well temperature and 110% of normal flow may enter the deaerator. The extraction steam during such operation may be zero such that flash steam from the storage tank will flow to the deaerator. For this purpose adequately sized vent pipe from the storage tank to the deaerator and internal water and steam distribution shall be provided.

Alternatively, a spray type (stork or equivalent) deaerator, which otherwise fulfills all design and performance requirements stipulated here in, may be offered.

If the Deaerator is provided with an external shell and tube type vent condenser, the same shall condense all vapour and vent out non-condensable gases to atmosphere. The vent condenser shall minimise loss of steam through the vent connection under all conditions of operation by providing at least 1 deg C sub-cooling of vented vapours over entire load range. The vented gases shall be free of any visible vapour.

The deaerator shall be capable of deaerating all the incoming condensate, HP heater drips and emergency make up water at a rate adequate to provide boiler feed to match the boiler MCR requirements continuously.

The dissolved oxygen content at the discharge from the deaerator without chemical dosing shall not be more than 0.005 cc/liter in the boiler feed water at all loads, up to and including the rated capacity. The deaerator shall also

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effectively remove even traces of any other dissolved gases such as CO₂ likely to be present in the condensate/feed water.

The deaerator is proposed to be located to meet all the operating criteria Bidder, however, shall check and confirm the adequacy of this level considering the system offered, types and requirement of Boiler Feed Pumps considered etc. such that system can operate safely and smoothly under all operating conditions, abnormal and transient conditions and also for full load throw off condition.

The operation of the deaerator shall be stable and free from vibration and water hammer when subjected to pressure decay which may occur at full load trip out conditions of the T.G. and during introduction of the alternative steam service.

For supporting of the storage tank, one support leg shall be fixed and the other shall be sliding type to accommodate expansion of the equipment. The supply shall also include suitable ladder, platform & handrailing for access to various parts of the deaerating heater.

The deaerator proper may be supported from the storage tank, or independently from floor level and all support structures in either case shall be included in the Bid.

The following connections shall be provided over & above condensate/feed water inlet and outlet connections:

- i) A perforated pipe connection of suitable size for steam supply for initial heating and deaerating of water stored in feed storage tank at the time of starting of the unit.
- ii) Connections on the tank for boiler feed recirculation, chemical dosing (if required) etc.
- iii) Drain connections with valve and drain pipe to the flash box at ground floor level.
- iv) Suitable over-flow connection on the feed storage tank including control valve and motorized by-pass valve.
- v) HP Heater drip inlet.
- vi) Extraction/pegging steam inlet.
- vii) Safety valve connections.
- viii) Vent connections.
- ix) Sufficient number of inspection openings/man-holes (of minimum 600 mm diameter) with suitable covers for easy cleaning, inspection and maintenance. Covers for these openings/man-holes shall be hinged type.
- x) All local/remote instrument connections including root valves.
- xi) Stand pipe connections.
- xii) Other connections as necessary.

Number, size, location and orientation of the connections, as necessary, shall be decided by the supplier considering the performance of the deaerator. If found necessary, it shall be possible to reorient the nozzle connections of deaerator so as to match the layout of associated piping.

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Anti-vortex baffle together with a coarse strainer shall be provided for feed water outlet. Safety relief valve/s with adequate compensating pad for full relieving capacity at the worst operating conditions shall be included.

3.6.2.2 Materials of Construction

Following materials of construction shall be used for deaerator:

- i) Shell and heads : ASTM: A-285 Grade C or equivalent
- ii) Spray Nozzles : 304 stainless steel
- iii) Trays : 304 stainless steel
- iv) Tray supports : Stainless steel
- v) Internal bolting : Stainless steel
- vi) All metal parts in contact with non-condensable vapour shall be of type 316 stainless steel.
- vii) Hardened 400 series stainless steel impingement plate shall be provided for the flashed drain inlet from the high pressure heaters and boiler feed pump recirculation.

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4 POWER CYCLE PUMPS

4.1 General Information

4.1.1 Boiler Feed Pumps (BFP) and Drives

[Three (3x50% capacity)] motor driven BFP (with suction booster pumps, drives, hydraulic fluid coupling and accessories), shall be installed for supplying feed water to each Boiler unit. Out of these [three (3)] pumps, [two (2)] feed pump will be operating normally while the [third pump] shall remain as a standby unit and will come into operation automatically in case any of the working pumps fail. Each pump is having separate suction feed line to the booster pump.

The pumps shall receive the water from Deaerator and then pump it through high pressure feed water heaters to the Economizer inlet of the Boiler. The location of the pumps and design shall take care of all the transient operating conditions.

The deaerator shall be supplied with extraction steam from the turbine and shall normally operate at a variable pressure depending on the extraction pressure at different loads. A steam connection from the auxiliary steam header/cold reheat pipe shall be provided for initial heating and deaeration at start-up as well as pegging at low extraction steam pressure. However, the boiler feed pumps shall be capable of withstanding transient instabilities in the suction pressure caused due to load swing of the turbine generator from full load to no load and interruption of steam supply to the deaerator. Boiler feed pumps shall also be adequately designed for turbine by-pass operation.

The pumps shall be designed for efficient and reliable operation and shall be of proven design with at least five years of satisfactory operating experience.

4.1.2 Condensate Extraction Pumps and Drives

Each Unit shall be provided with [3x50%] Condensate extraction pumps. Pumps shall be capable of handling the full condensate from the Condenser to the Deaerator through LP heaters, gland steam condenser etc. Each Pump capacity shall be calculated considering the maximum condensate flow.

The pumps shall be required to handle hot condensate at or near saturation temperature and shall be designed for very low NPSH service. The suction specific speed selected shall be suitable to permit part load operation as per system requirement without any trouble.

The pumps shall be designed to withstand transient due to load swing of the unit from full load to no load. Adequate design margins shall be provided in the pumps for turbine bypass operation.

4.2 Equipment and Accessories to be Furnished

4.2.1 Boiler Feed Pumps and Accessories

[The equipment and accessories for each boiler feed pump and drive shall include, but not be limited to the following:

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- i) Horizontal shaft, single suction, multistage, centrifugal type pump with radially split inner assembly encased in a heavy outer barrel type casing, having both suction and delivery openings at the top.
- ii) Horizontal, single stage, split casing, double suction booster pump (if required) directly driven by the boiler feed pump drive motor.
- iii) Sole plates, pin and key blocks or other supporting structures, fabricated steel base plate/plates for the pump, hydraulic coupling, motor and accessories complete with foundation anchor bolts/inserts etc. as required. Preferably the entire pump and drive assembly shall be mounted on a common base frame, with provision for separately collecting any leakage water and leakage oil and draining through isolating valves and also arrangement to facilitate grouting on the foundation.
- iv) Flexible couplings with safety guards between BFP motor, gear box, hydraulic coupling and pump as required.
- v) Hydraulic coupling suitable for variable speed operation of the pumps.
- vi) Motor for the boiler feed pump as required.
- vii) Forced lubricating oil and working oil systems complete with oil reservoir, shaft driven main oil pump and A.C. motor driven 100% standby pump, 2 x 100% lube oil coolers, 2 x 100% working oil (Hydraulic Oil) coolers, duplex cleanable filters with all interconnecting valves, fittings, specialties, pipe work and control panels, provision for connecting purifier with oil tank.
- viii) Low load recirculation system complete with piping up to Deaerator end, all valves, pressure breakdown orifices and control valves, supports, hangers etc. as required.
- ix) The boiler feed pumps shall be capable of withstanding thermal shocks from cold to hot for emergency start and hot to cold during Deaerator transient conditions. No separate warm-up system is preferred.
- x) Balancing drum for axial thrust balance, with balancing chamber leak-off system complete with all piping, valves, fittings, instruments, supports, hangers etc. as required.
- xi) Non-return valves on the pump discharge lines.
- xii) 100% duty temporary strainers with spool pieces complete with counter flanges and fasteners etc. for mounting on Boiler Feed suction piping to each pump.
- xiii) Interconnecting piping with fittings etc. in between Booster pump discharge and Main Pump Suction, if applicable.
- xiv) Set of locally mounted instruments as specified and/or as required.
- xv) Set of interconnecting water and oil piping, valves, fittings and specialties required to render installation complete including seal water cooling system as applicable.]

4.2.2 Condensate Extraction Pump and Accessories

[Condensate Extraction pumps (3 x 50%) together with all accessories required to make complete and well integrated units to satisfy requirements of the

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specification, including but not limited to the following (for each pump, unless otherwise noted).

- i) Drive motor*
- ii) Pump and motor coupling*
- iii) Temporary strainer before pump suction.*
- iv) All instrumentation and control as specified and/or as required. The scope shall also include initiating contacts for the alarms and interlocks. A gauge board shall be supplied with each pump housing instruments.*
- v) Foundation ring/frame with bolts, nuts, sleeves etc.]*

4.3 General Performance Requirement

4.3.1 Boiler Feed Pump

Capacity and discharge pressure of the pumps shall be selected to meet the requirements of the steam generator. The Bidder shall furnish the pump sizing calculation with the Bid.

The boiler feed pump shall be driven by squirrel-cage induction motor through a variable speed hydraulic coupling. Appropriate step-up gears as required shall be provided.

Each pump shall exhibit the same type continuously rising characteristic from rated duty point to shut-off. The pumps should be capable of parallel operation without instability at all speeds and share equal load. Shut-off head shall not, however, be less than 120% and shall not be more than 130% of the head developed at pump design point.

The pumps shall have their best efficiency at the normal duty point, i.e., corresponding to [210/215/220/250] MW load, 3% (of throttle flow) make up and design CW temperature of [33] deg C.

The pump shall be designed for working at its operating temperature without setting up destructive temperature strain causing warping, buckling, misalignment, rubbing or other objectionable effects.

The pumps shall be capable of accepting, without damage, any transient reduction in suction pressure causing cavitations condition and shall accept, without distress, the re-establishment of normal suction conditions following the transient, with no necessity for a pump shut down.

The Deaerator storage tank shall be located to meet the normal and transient operating condition. Bidder shall check the requirement of NPSH against available NPSH considering the worst transient situation of load dump. Bidder to ensure that adequate margin over the required NPSH shall be available under worst condition for safe and trouble free operation. The booster pump should either be directly driven by the boiler feed pump motor shaft or driven by an independent drive motor. The head developed by the booster pump shall be sufficient to give adequate NPSH at the main pump suction.

Bidder shall furnish necessary calculations to establish the availability of excess NPSH over the actual NPSH requirement of the pump.

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Suction specific speed for BFP and Booster Pumps must not exceed 9000 US Units.

Pumps shall be capable of withstanding reverse rotation for a limited time required to close discharge shut off valve following an emergency failure of the main discharge Non-Return Valve of a standby pump. All bearings & mechanical seals shall be capable of withstanding this operation.

The capacity, head and efficiency of the pumps shall be guaranteed within the tolerances stipulated by Hydraulic Institute Standards, USA or any other equivalent International Standard.

The pump and drive assembly shall be so constructed that dismantling and repairing may be accomplished without difficulty. Complete interchangeability of parts between the pumps shall be ensured.

Pump and drive assembly shall run smooth, free from undesirable vibration, noise and leaks. Acceptable peak to peak vibration limits of the Hydraulic Institute Standards of USA will be applicable.

The Units shall be so arranged that start-up, running and shut down operation may be carried out from the central control room. Necessary interlock and provisions shall be made so that the standby pump will come into operation automatically and immediately without any thermal shock whenever any operating pump trips.

Speed control range of the BFP drive unit (with hydraulic coupling) shall cover the entire range of boiler feed pump operation, from minimum flow (i.e. pumps on recirculation) to the design head-capacity point with at least 5% margin on pump speed both on the high and low sides.

Pump drive shall be rated for cold water operation. Pumps shall be capable of re-starting following a hot or warm shut-down without recourse to barring or warming up. Bidder shall indicate the maximum allowable conditions for restarting such as maximum casing differential temperature and maximum difference between casing temperature and incoming water temperature.

Boiler Feed Pump first stage impeller and if applicable, the booster pump shall be so designed that wear due to cavitation will not restrict its service life to less than 40,000 - 45,000 running hours when operating under steady state design suction condition.

Boiler Feed Pumps and auxiliaries shall be adequately designed to meet the Turbine HP and LP by pass condition without any problem.

The drive motor shall be so selected that a margin of at least 15% is provided over the total power required by the Boiler Feed Pump, Booster Pump, Oil Pump and losses in the gear box and hydraulic coupling, at the rated condition of the pump. It should also be checked that when the pump operates with control valve stuck open, the power requirement is lower than the drive power, irrespective of whether the pump is working singly or in parallel with the other pumps. Detailed calculation for sizing of motors shall be submitted to the Owner for approval.

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Pumps shall have short, stiff shafts, with least number of stages for the specified duty. The critical speed of the rotor assembly, in dry as well as water filled conditions shall be beyond the maximum possible running speed by at least 30%, even after considering power supply to pump drive motor at 51.5 Hz.

Plain cylindrical pressure fed journal type bearings and tilting pad, double acting 100% thrust bearing shall be provided. The sleeve bearings shall be horizontally split type.

Duplex type basket strainers shall be provided on the booster pump suction to protect the fine clearances of the pump. The screening area of the strainer shall be 4-5 times the cross-sectional area of the inlet pipe.

All the design parameters are to be met during under frequency conditions of 47.5 Hz at grid.

The flow impulse for the purpose of recirculation control shall be initiated from flow measuring device installed at the pump suction. Balancing chamber leak-off shall be piped back to the suction of the respective pump.

The Boiler Feed Pump set shall be capable of continuous safe, and trouble free operation under other than normal condition, like under and over frequency (47.5 to 51.5 Hz), abnormal pressure decay in Deaerator, VWO with 3% make-up, overpressure of TG (if envisaged), H.P. heaters out of service, sudden load throw-off, start-up of unit, HP-LP bypass operation, rapid starting and load changes during cyclic load operation.

The successful bidder shall furnish necessary details and calculations establishing the suitability of the proposed pumps for meeting the above requirements.

The motors shall be able to accelerate the pumps from normal standby condition to rated pumping condition in less than 15 seconds after receipt of starting signal. It shall be possible to run the pumps singly as well as in parallel with other pumps.

4.3.2 Condensate Extraction Pump

Vertical "can" type condensate extraction pumps shall be provided.

The contractor shall submit pump sizing calculations for approval of the Owner.

The pump impellers shall be so designed that wear due to cavitations will not restrict its service life to less than 40,000 running hours when operating under steady state design suction conditions.

The pumps shall be designed for highest practicable degree of reliability under all conditions of operation.

The pumps shall have continuously rising head capacity characteristics from design point to shut-off.

The condensate extraction pumps shall be suitable (without cavitation) for handling saturated water, at the maximum possible flow rate from the condenser hot-well, with the NPSH available at hot-well "Low- Low" level.

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Suction specific speed for condensate extraction pumps must not exceed 9000 U.S. units.

Pumps shall be capable of operating either single or in parallel. Suitable Automatic Starting devices shall be provided to bring the standby pump into operation in case of failure of any operating pump.

Rating of the motor shall be selected with at least 15% margin over the maximum power required within the range of operation.

The shut-off head of the pump shall not be less than 115% of design head.

The pump rotor assembly (with guides) shall be so designed as to keep its vibration, in both wet and dry running conditions, within the safe limits as specified in relevant International Standards/Codes.

4.4 Boiler Feed Pump Design and Construction

4.4.1 General

The pump shall be of the horizontal centrifugal type supported in such a manner as to permit free expansion both axially and radially whilst maintaining alignment. The boiler feed pump and suction booster pump will be expected to accept from the main pipe work reasonable forces and moments, the least values being those stipulated in API-610. Therefore, the Bidder shall ensure that all materials and terminal connections are suitable for such terminal forces and moments.

Inter-stage bleed shall be provided in the pump for reheat desuperheating. Requirement of flow shall be decided by Bidder based on the steam generator demand.

4.4.2 Pump Casing

The casings shall be of suitable design to withstand any possible thermal shock and/or high pressure and shall be constructed of materials specifically selected to prevent erosion and corrosion.

The barrel type outer casing of the BFP as well as the booster pump casing shall be supported at horizontal centre line of the pump. The inner casing shall be of axially/radially split type in accordance with the standard proven practice of Manufacturer. The joints shall be constructed in such a way that the feed water discharge pressure acting between outer barrel and inner casing acts to seal the joints. The casing assembly complete with the rotating elements should be located accurately in the outer barrel and it should be possible to remove this assembly without disturbing the suction and discharge piping connections.

The Bidder shall supply a cradle with rollers and necessary attachments for the removal of the inner assembly.

Pump casings shall be provided with adequate number of vent and priming connections with valves. Casing drain, as required, shall be provided complete with drain valves. Necessary insulation cleats shall also be provided on the casing.

4.4.3 Rotor

i) Shaft

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The shaft shall be of tested forgings accurately machined and ground. The material specification and its heat treatment as well as particulars of thermal treatment, proposed to minimize distortion during manufacture, shall be stated in the Bid. Shafts should withstand the stresses set up when the pump will be started quickly. Shaft size should be so selected that full driver output can be easily transmitted without excessive deflection, vibration, distortion or whip.

ii) Impellers

The impellers should be accurately machined, finished to close tolerance and installed individually on the shaft giving special consideration to prevent recirculation between shaft and impeller.

The first stage of inlet impeller should be specially designed to provide most favourable conditions free from cavitation even during stringent suction condition.

Each impeller shall be balanced individually and the entire rotor assembly should be statically and dynamically balanced. The rotor shall be so designed that its first critical speed in air or water is above the operating speed. The first critical speed in water shall be at least 130% of maximum speed of the pumps.

Shaft sleeves of hardened wear resisting material shall be provided at all points of wear. Ferritic wear surfaces shall be preferred. They shall be firmly secured and keyed to the shaft. The material and design shall be such that no internal leakage occurs between shaft and sleeve. The axial thrust of the rotor shall be carried by an approved type of hydraulic balancing device and an external oil lubricated thrust bearing fitted at the outboard end of the pump integral with the journal bearing housing. No axial thrust should be transferred to the electric motor at any condition of operation. The thrust bearing shall be designed for additional load when pump gets vapour bound.

iii) Shaft Seals

Shaft seals shall be of mechanical seal type. The seals shall be designed to have a minimum life of 20,000 running hours between overhauls. Feed Water for sealing shall be supplied from pump discharge header. All pressure reducing and control valves, instruments, fittings and special integral piping etc. shall be included under Bidder's scope of supply. A filter or a fine mesh screen should be installed in the condensate feed line to the seals to ensure clear condensate. Stuffing box should be so designed that easy replacement of the mechanical seal is possible. All necessary protection to prevent damage to seal due to over temperature operation shall be provided by the bidder. Seal water cooler shall be provided if necessary.

iv) Bearings

Each pump shall be equipped with forced oil lubricated babbit lined sleeve bearings and tilting pad, double acting 100% thrust bearing. The sleeve bearings shall be horizontally split type. The thrust bearing shall be of sufficient size to carry the maximum unbalanced load in either direction due to any emergency operating conditions like the non-operation of the balancing device etc.

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Thrust bearing shall be suitable for reverse rotation of pump. Temperature sensing elements shall be provided for bearing metal temperature indication and thermometers with alarm contacts shall be provided for bearing oil drain.

v) Lubrication

Each pump, drive motor and hydraulic coupling for motor driven pump set of each unit shall be provided with a complete pressure lubrication system of sufficient capacity for both pump and drive motor, consisting of oil pump, sump tank, water cooled oil coolers (2 x 100%), duplex oil filter, level indicator, sight flow indicator, thermometers, relief valves, pressure regulators and necessary valves, all interconnected piping and accessories. Bidder may offer for common oil pressure lubrication system for each unit. The oil cooler tubes shall be of stainless steel SS-304. The coolers shall be designed for service with demineralised water. The oil pump shall be driven by the feed pump shaft and all parts of the system shall be mounted as an integral part of the feed pump assembly. Provision must be made to ensure continuity of oil supply even during reverse rotation of feed pump, and during low frequency operation of oil pumps.

In addition, a standby electric motor driven lubricating oil pump shall be furnished including the motor drive and pressure switch. This pump will come into operation automatically whenever the normal lubricating system pressure drops below a predetermined setting.

The oil system shall cover the entire lubrication of the pump, motor, step up gears, the booster pump as also the supply of oil to the hydraulic coupling. Arrangement for proper distribution shall be made using needle valves and orifice plates.

Required electrical interlock shall be provided for continuous, safe and trouble-free operation of the lubricating oil system, including supply pressure switches for automatic standby pump start, trip and alarm interlocks.

Provisions of pressure lubrication, if necessary, at the time of coasting down of the feed pump and drive in case of A.C. power failure, shall be arranged by the Bidder.

vi) Base Plate

The base plate for each pump shall be of rugged fabricated steel construction reinforced with heavy ribbing. The common base plate shall also accommodate the drive motor, the booster pump, the fluid coupling and the step up gear box as necessary. Adequate arrangement to collect leakage oil and leakage water separately and draining up to area drains of plant with piping, isolating valves, funnels etc. shall be provided.

vii) Suction and Discharge Nozzle

Heavy reinforced suction and discharge nozzles shall be located vertically upward on the centre line of the BFP casing. The suction shall be flanged raised face type and drilled in accordance with ANSI/ASME code requirement for the rated pressure and temperature. The discharge nozzle shall have approved welding ends. The construction of suction and discharge nozzle must assure

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maximum strength and reliability and eliminate possibility of leakage at the joints at any operating condition

viii) Coupling

Adequately sized spacer type, extension type or other approved type flexible couplings shall be used between the pumps, the fluid drive, the step up gear, and the motor drive. Couplings shall have adequate permanent lubrication arrangement and shall be provided with safety guards.

ix) Axial Thrust Balancing Device (Hydraulic)

A suitable device for hydraulic thrust balancing shall be supplied. The balancing drum shall be designed to balance pump axial thrust. Drum designs shall be relatively long so as to reduce the pressure per linear unit and thus the rate of wear. This should be optimized with the pump shaft span.

Combination of disc and drum or any other suitable modifications may be used if proven by satisfactorily long experience, and in every case the Bidder shall furnish in his bid the complete details of the system provided.

It is proposed to lead the balancing chamber leak off back to the respective boiler feed suction line. A flow measuring arrangement shall be provided in the balancing leak off line to monitor the condition of wear in balancing device. All necessary local instruments including leak off flow indicator with alarm contact, valves and fittings required for safe operation of this system shall be supplied by the Bidder.

x) Material of Construction

Each pump shall be constructed preferably with the following listed materials. The Bidder shall offer equivalent or better materials with suitable heat treatment as per the standard of the manufacturer for similar duty.

Part	:	Material
Base Plate	:	Structural Steel
Casing	:	Forged Steel
Shaft	:	ASTM-A-276, Type 410
Impeller	:	ASTM-A-296, Grade CA-6NM
Diffusers	:	ASTM-A-296, Grade CA-6NM
Wearing ring	:	ASTM-A-276, Type 420
Balancing drum	:	ASTM-A-276, Type 420
Balancing head	:	ASTM-A-276, Type 420
Shaft Sleeves	:	ASTM-A-176, Type 410
Bearings:		
Radial	:	Sleeve type (Babbitt metal)
Thrust	:	Tilting pad, double acting, 100% thrust bearing (suitable material)
Pressure bolting	:	Chrome-molybdenum steel

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Between rubbing faces a minimum difference in hardness of 50 BHN may be maintained.

xi) Non-return Valve

A non-return valve of approved design and manufacture shall be fitted on the discharge pipe line from each feed pump. The following requirements shall be satisfied.

The closing time of the valve, from the fully opened position, shall not be greater than the time taken for the pump to stop feeding after being tripped. This shall be of the order of one second.

The valve shall be of adequate pressure rating, alloy cast (or forged) steel body, 12-14% chrome stainless steel stellited trim, welding end joint, non-slam type.

Where internal components, other than valve seats, are of welded construction, full penetration butt welds shall be used.

xii) Low Load Protection: Recirculation System

A minimum flow recirculation arrangement shall be provided along with each pump.

Capacity of the recirculation devices shall be so selected (not less than 25% of normal rated flow) that under closed condition of the BFP discharge valve, the temperature rise within the pump remain within allowable limits and the internal recirculation at the pump suction impeller does not give rise to cavitation.

Bidder may offer ON-OFF type recirculation control valve. The impulse for the control valve shall be from the flow measuring device installed at the boiler feed pump suction.

The valve shall be of reputed make and of design proven in similar application for three (3) years.

For reducing the bypass pressure to a value suitable for returning to the deaerator, each pump shall be provided with suitable multiple stellited orifice plates of 11-13% chrome steel with companion flanges for installation in the recirculation piping and adequately designed for prolonged continuous service. Each recirculation line shall be routed independently to deaerator storage tank. An orifice, with a small pressure drop, shall be fitted in each line near the deaerator to prevent any flashing in the pipeline.

The recirculation control valves and all necessary equipment required for making the system complete shall be furnished by the Bidder for each recirculation control system. All equipment shall be welded end type.

The recirculation control valves shall be designed to open in the event of air or power failure. Signal lights shall be mounted in the local panel/remote control room to indicate open/closed position of the valve.

xiii) Pump Warming Up Device

The boiler feed pump should be designed to start working without warming up arrangement and shall accept hot fluid from deaerator immediately on starting.

xiv) High Speed Gear Unit

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The gear unit shall be specifically designed for continuous service at the speeds required by this application. Precision and accuracy of manufacture is essential in order to minimize problems of vibration, impact stress, noise (to attenuate noise level of 85 dB at one meter distance), distortion and lubrication.

Dynamically balanced double helical / epicyclic gears shall be used. The high speed pinion integral to BFP shaft and the low speed gear securely keyed to the input shaft should be of approved type of properly heat treated steel according to standard code of practice. The Bidder shall submit detailed specification of the materials used including factor of safety etc. and the detailed description of heat treatment process followed.

Bearings shall be of the split sleeve type, bronze backed with a high grade centrifugally cast tin base babbit lining. Bearings shall be adequately sized and accurately machined to assure perfect alignment. Gear journal bearings shall have babbitted thrust faces next to the gear to act as locating surfaces for the gear train.

The gearing shall be enclosed in an oil and dust proof gear case made of close grained cast iron or fabricated steel. The gear case shall be horizontally split and stress relieved before machining. Two oil level gauges, drain, fill; vent temperature switch, thermometer, dipstick, vibration limit switch and other required connections equipped with approved mountings, valves and fittings shall be furnished for the gear casing. The housing shall be of rigid construction to maintain alignment of rotating parts and keep vibration to a minimum. The arrangement shall be such that it will be possible to lift gear case cover without disturbing the alignment of shaft, gear and pinion.

Forced oil lubrication system shall be adopted to lubricate the gearing and bearings.

xv) Fluid Drive (Hydraulic Coupling)

The fluid drive shall be a full duty, generously sized, infinitely variable, remotely controlled, totally enclosed, hydraulic coupling adequately rated to meet the requirement of pump characteristics while operating in the range of capacities specified and required. The speed of the feed pump shall be varied smoothly and stably (automatic control) over the entire range.

It shall be complete with stainless steel impellers, heavy duty roller bearings, pillow blocks and Kingsbury or Mitchell type thrust bearing for input and output shafts. An enclosed steel housing with removable cover, oil tank, duplex oil filters to remove all particles up to 5 microns, oil temperature and pressure gauges, pumps for oil circulation, stainless steel scoop tube and two full duty integral oil coolers suitable for D.M. Water cooling shall be furnished. The oil cooler shall be adequately rated and shall have arrangement for changing over the cooler without discontinuing the oil flow. Necessary water inlet, outlet, drain and vent piping and valves including sight flow glasses in the water outlet shall be furnished.

Full description of the coupling with cross-section and tentative control circuits, shall be included in the Bid.

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The Bidder shall specify the quantity and grade of oil required and mention its Indian equivalent and furnish speed, torque and efficiency curve for the coupling. The power consumption data for various loads with and without couplings shall be furnished in the Bid for economic evaluation.

xvi) Booster Pumps

The booster pump shall be driven directly by the boiler feed pump motor shaft or by a separate motor and shall protect the boiler feed pump from cavitation under all operating conditions. It shall be of single casing, double suction, single stage, horizontally split, self-supported type with adequate number of bearings, designed to carry its load and axial thrust. Shaft sleeve and wearing rings shall be provided at all points of wear.

The material of construction for the booster pumps shall be identical to those specified for the main pump or better.

Each pump shall be furnished with a flanged suction strainer (the duplex strainer as already specified for the Boiler Feed Pump) complete with other accessories as per requirement.

Necessary pipe connection from booster pump discharge to the suction of the main boiler feed pump, complete with pipe hangers, flow meters and other necessary instruments, valves etc., shall be included in the supply.

Proper shaft sealing and lubrication system are to be provided to ensure safe and smooth operation of the pump.

4.5

Condensate Extraction Pump Design and Construction

The pump unit will be of vertical can type design. The unit shall consist of a vertical centrifugal pump submerged in an airtight outer barrel with a pump base plate flange, above which shall be suction and discharge nozzles, a motor mounting stand and a motor coupled to the pump.

The first stage impeller shall be specifically designed for low NPSH requirement and minimum risk of cavitation. The shaft coupling shall be of flexible type in case the thrust bearing is provided on the pump and it shall be of rigid type if the thrust bearing is provided on the motor.

The condensate extraction pumps shall be of heavy duty type suitable for long periods of uninterrupted service. These shall be fitted throughout with renewable wearing parts such as wearing rings, shaft sleeves, stage sealing rings etc.

The design and workmanship shall be such that the pumps are readily assembled or dismantled and that they will operate satisfactorily under all operating conditions without cavitations, pitting, excessive vibration, noise or undue wear.

The glands of the pumps and their associated suction valves shall be suitably sealed to avoid ingress of air into the condensate under all conditions. The casing vent shall also be complete with all valves, piping, etc., for each pump.

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In selecting material of construction of the pumps only proven material for such services shall be used. The following material of constructions is suggested for guidance only:

Bowl	: Cast Iron
Impeller for 1st stage	: Stainless steel (12% Cr.)
Stage impeller	: Bronze or chromium steel
Shaft	: Stainless steel
Can	: Fabricated steel

The impeller shall be cast in one piece finished all over and carefully balanced both statically and dynamically. Finally the assembled rotor shall be dynamically balanced and checked for eccentricity.

4.6 Drawings, Data and Information Required

The Bidder shall submit the following with his formal Bid besides the different information required/asked in Volume III of this specification.

Characteristic curves of pumps showing effective head, pump input power, efficiency, submergence and NPSH, against capacity ranging from shut-off condition to at least 120% of rated capacity (at several running speeds from minimum to maximum in the case of B.F. Pumps).

Speed Vs. torque curve of the pump corresponding to recommended mode of pump starting, super-imposed on Speed Vs. torque curve of the motor, corresponding to 80%, 90%, 100% rated voltage and also extending from Quadrant-I to Quadrant-II covering reverse flow conditions, if applicable.

Detailed calculations for deriving capacity and head of pumps and sizing of motors.

4.7 Specific Design Criteria for Power Cycle Pumps

Table: 4.1

S.No.	ITEM	CRITERIA	REMARKS
1	Boiler Feed Pump		
1.1	Type	Horizontal barrel type multistage with suction booster pump	
1.2	Number	[3x50%]	
1.3	Rating		

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S.No.	ITEM	CRITERIA	REMARKS
1.3.1	Design Point:	Combined Flow of 2x50% pumps to be based on 10% margin on feed water flow corresponding to VWO condition with 3% make-up, design Condenser pressure and corresponding head.	1. Pump shall be capable of handle BMCR flow (without taking account of 10% margin) 2.The pumps shall also be capable of sustaining emergency transient consisting like H.P.heater(s) out, Turbine HP & LP bypass in operation etc.
	Best efficiency point	TMCR with design vacuum and 3 % make-up	
	Run out point	One pump to meet 65% unit load.	
	Emergency Point	VWO flow and head corresponding to highest safety valve set pressure and 2% margin on head.	
2	Condensate Extraction Pump		
2.1	Type	Vertical can type centrifugal design.	
2.2	Number	[3x50%]	
2.3	Rating	a) Capacity - Maximum steam flow at exhaust during VWO condition with 3% make-up) operation of turbine with maximum steam inlet pressure plus all heater drains & vents diverted to Condenser.	The pumps shall also be capable of sustaining emergency transient consisting like HP heater(s) out, Turbine HP & LP bypass in operation etc.
		b) Head - Maximum deaerator pressure operation etc. plus static and dynamic head under maximum capacity condition	

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S.No.	ITEM	CRITERIA	REMARKS
2.4	Margin on Capacity	10% over highest condensate flow envisaged during Unit operation (Excluding HP/LP bypass operation).	

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5 LP CHEMICAL DOSING SYSTEM

5.1 General

This section of specification complete is for the Low Pressure chemical dosing system. It is not the intent of this specification to completely specify all details of design construction and installation here. Nevertheless, the equipment accessories and installation shall confirm to a high standard of engineering design and workmanship and capable of performing continuously and satisfactorily.

5.2 Equipment and Accessories to be Furnished

Low pressure chemical dosing system shall remove residual dissolved oxygen in feed / condensate water and shall maintain the pH of condensate and feed water. Each unit shall be provided with independent and skid mounted LP dosing system. The arrangement shall consist of the total system for dosing hydrazine and ammonia at boiler feed pump suction and on condensate discharge line. The system shall include the following:

- i) Hand pumps complete with flexible hose and couplings for transferring hydrazine from storage drum to mixing / storage tank shall be provided.
- ii) One number hydrazine solution preparation & storage tank for preparation of the hydrazine solution of about 0.6% concentration or as recommended for dosing by the Bidder whichever is higher shall be provided. The tank shall have storage capacity for 48 hours consumption of hydrazine and shall be complete with motorized stirrer, breather to arrest the hydrazine vapours coming out of the tank, graduated level indicator, over flow line with sealing arrangement etc.
- iii) One number hydrazine measuring tank to receive hydrazine from storage tank/container. The flow of hydrazine from measuring Tank to solution preparation/storage tank shall be by means of gravity flow.
- iv) Two numbers hydrazine dosing pumps of 100% capacity complete with drive motors, pressure relief valves and pressure gauges in the discharge line shall be provided. These pumps shall be of positive displacement type. The suction of these pumps shall be from the hydrazine solution metering tank. Each pump shall be provided with duplex filter in the suction line of each pump with differential pressure switch.
- v) The pump shall have the facility of adjusting the stroke to vary pumps discharge from 0 - 100% while the pump is in operation.
- vi) One (1) number bulk aqueous Ammonia storage tank common for [both units] for storing aqueous Ammonia of [33% Concentration] for 6 weeks requirements of both the units shall be provided. This shall be kept outside the main power house building. This ammonia storage tank shall be provided with a receiver tank on the vent to capture fumes during tank filling, vacuum breaker, relief valve and overflow line with sealing arrangement.
- vii) One number Ammonia mixing / storage tank of adequate capacity for 48 hours storage of 1.5% concentrated solution (or the recommended concentration for

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- dosing by the Bidder whichever is higher) complete with motorized stirrer, breather, graduate level indicator, over flow line with sealing arrangement shall be provided.
- viii) 2x100% Ammonia transfer pumps complete with drive motors shall be provided for transferring ammonia from bulk aqueous ammonia storage tank to ammonia mixing storage tank.
 - ix) One number Ammonia measuring tank to receive Ammonia from storage tank. The flow of Ammonia from measuring Tank to solution preparation/storage tank shall be by means of gravity flow.
 - x) Ammonia feed (dosing) pumps two (2) nos. each of 100% capacity complete with drive motors, pressure relief valves and pressure gauges discharge line shall be provided.
 - xi) All the inter-connecting piping, valves and fittings, locally mounted instrument and switches shall be included.
 - xii) The Bidder shall supply all necessary C&I for satisfactory operation of the chemical dosing system.
 - xiii) The normal mode of operation of the chemical dosing system shall be through DDCMIS including on/off command of the individual pumps. However Bidder shall provide local free wired control panel complete with (a) start / stop push button, (b) indicating lamps, (c) local/remote indication, (d) stroke position indicator, (e) Raise/ lower push button for stroke position, (f) local annunciation, etc.
 - xiv) Local/remote selection shall be done from control room. The stroke position and adjustment shall be done by 4-20 mA DC signal from DDCMIS and the pump stroke actuation shall be suitable for accepting 4-20 mA DC signal. The pumps shall be provided with 24 V DC, two wire LVDT type position feedback transmitter which shall generate 4-20mA signal indicating stroke position.
 - xv) The LP dosing unit shall be skid mounted. It shall be provided with necessary lifting eyes, special tools & tackles etc. for maintenance.
 - xvi) The drain of all tanks & pipes etc. shall be led to the Owner's chemical pit for neutralization.
 - xvii) All the foundation plates, foundation nuts and bolts, clamps and auxiliary structure required for supporting the equipment, shall be included in the scope of the Bidder.
 - xviii) The material of construction of all the equipment & components including tanks, pumps & valves shall be of stainless steel SS 304.
 - xix) Arrangement shall be made for flushing the various pipe lines and pumps by the condensate. The condensate shall be tapped from the main condensate line for preparation of solution and for flushing.
 - xx) The bidder shall furnish the sizing calculations of the tanks and pumps of LP dosing system for Purchaser's approval.

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5.3 Strainer

All strainers shall be Y-type with cast steel body and 50 mesh stainless steel screen. The screen opening area shall be at least 4 times the pipe cross sectional area. Necessary screwed blow off connection fitted with plug shall be provided.

5.4 Piping

All piping shall be supplied under the specification shall be of stainless steel SS 304 for LP dosing system. The size of the piping shall be selected in conformity with the maximum design temperature and pressure of the system

5.5 Valves

All manual operated valves shall be stainless steel SS 304 body and trim for LP dosing system, and shall be related to withstand the design pressure of the system. The valve shall be welded/socket welded ends as applicable.

All flanged terminal shall be provided with necessary counter flanges, bolts, nuts gaskets.

5.6 Control Skid

A group alarm for dosing system shall be provided in the control room for the following conditions:

- i) Pump and stirrer trip due to low level in the tank.
- ii) Manual starting and stopping of stirrer motors and dosing pumps from control room.

5.7 Inspection and Testing

Performance test (head, capacity, efficiency & BHP) of the pump shall be done according to the requirement of the hydraulic institute of USA or approved equivalent.

The pump accessories will be subjected to the tests as per OEM standard

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6 PIPING, VALVES & FITTINGS

6.1 General

The Bidder shall design, manufacture, supply, erection, testing and commissioning of complete power cycle piping/fittings/ accessories, associated tanks, vessels, valves and controls within the battery limit along with specialties, strainers, expansion joints, restraints, hangers/ supports with all components, thermal insulation and auxiliary structures as per the scope specified in Section-I of Volume-II. Bidder shall carry-out complete design and engineering including but not limited to pipe sizing, flexibility analysis, hanger support engineering, tanks, vessels and engineering of thermal insulation etc.

Bidder shall carry-out chemical cleaning of piping systems after complete erection, which also includes complete supply, erection and dismantling of temporary piping, valves and fittings etc.

The Bidder shall supply all standard and non-standard matching pieces as may be needed within the piping system and for connection of piping systems with equipment. Pipe stubs for mounting thermo wells and other instrumentation, including for the instruments supplied by others, along with necessary root valves, reducers/matching pieces and instrument tubing shall be provided.

Thermal insulation and cladding along with all necessary accessories for all piping systems, tanks and vessels, etc. shall be provided by the Bidder.

The Bidder shall design and provide for additional guides/ stops/restraints etc. along with auxiliary steel for control of pipe line vibration within allowable/ acceptable limits. Bidder shall provide all valves, actuators and specialties including expansion joints, orifice plate assemblies, steam traps, strainers, instrument root valves, etc.

The Bidder shall also supply special accessories like floor stands, chain operator, extended spindle etc. as required. Valve, especially for which approach from existing floors are not possible for operation and maintenance, Bidder shall provide appropriate platforms with the access ladders for the same. All pipe supporting elements such as constant load spring hangers, variable spring hangers, supports, guides, restraints, stops, etc. and all associated auxiliary steel and hardware such as beams, channels, insert plates section attachments to pipe supports, pipe and beam clamps, straps, slings, stools, shoes, saddles, devices, rods, turn buckles, graphite/steel plate/ Teflon sheet etc. shall be provided by the Bidder.

Bidder shall provide all erection material such as bolts, nuts, washers, gaskets, electrodes, filler materials, welding gas, consumable inserts and backing rings, accessories and miscellaneous specialties required for the proper installation of piping systems. All temporary piping, supports, valves, tanks, vessels, blanking plates, target plates, spool pieces for valves, flow nozzles & specialties and other accessories required to complete the chemical cleaning operation, Hydro testing and steam blowing & arrangement, temporary connections, supports, blowup valve, target plates and associated piping systems as required shall be provided.

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6.2 Codes & Standards

The Design, manufacture, shop testing, erection, testing and commissioning of piping and valves shall conform to the latest revisions of the following codes and Indian Standards or equivalent international codes, in addition to other standards mentioned in the tender documents subject to any modification and requirement as specified hereinafter.

IS: 778	Gunmetal gate, globe and check valves for general purpose.
IS: 780	Sluice valves for water purpose (50 to 300 mm).
IS: 1239	Mild steel tubes and fittings - Part I & II, ERW pipe upto 8" diameter..
IS: 1536	Centrifugally cast (spun) iron pipes for water, gas and sewage.
IS: 8329	Centrifugally cast (Spun) Ductile Iron Pressure Pipe for water, gas and sewage
IS: 1537	Vertically cast iron pressure pipe for water, gas and sewage.
IS: 1538	Cast iron fittings for pressure pipes for water, gas and sewage.
IS: 1703	Ball valves (horizontal) plunger type including floats for water supply purposes.
IS: 2379	Colour for the identification of pipe line.
IS: 2685	Code of practice for erection, installation, and maintenance of sluice valves.
IS: 2906	Sluice valve for water works purposes (350 to 1200 mm).
IS: 3042	Single faced sluice gates (200 to 1200 mm).
IS: 3589	Electrically welded steel pipes for Water gas & sewage (200 to 2000 mm).
IS: 4038	Foot valve for water works purposes.
IS: 4984	High Density polyethylene pipes.
IS: 4985	Unplasticized PVC Pipes.

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IS: 5312	Swing check type reflux (non-return) valve Part-I.
IS: 458	Concrete pipes (with and without reinforcement).
IS: 3952	Cast Iron butterfly valves for general purposes.
IS: 554	Pipe thread for pressure tight joints.
IS : 1363	Black hexagon bolts, nuts and lock nuts.
IS: 1364	Precision and semi-precision hexagon bolts, screws, nuts and lock nuts.
IS: 2062	Structural steel fusion welding quality.
IS: 4736	Hot dip zinc coating on steel tubes.
IS: 2825	Code of unfired pressure vessels.
IS: 2712	Gaskets.
IS: 4192	Part-I Rubber lining.
IS: 9523	Specification for Ductile Iron fittings for pressure pipes for water, gas and sewage
IS: 3006	Acid resistant SWG Pipe.
IS: 783	Code of practice for laying RCC pipes.
IS: 3114	Code of practice for CI Pipes.
IS:4984 - Class-5	High density polyethylene pipes
IS:4985 - Class-4	PVC Pipes.
ANSI:B 16.5	Steel pipe flanges and flanged fittings.
ANSI:B 31.1	Power Piping code.
ANSI B 16.34	Valves-Flanged, threaded and welding ends
ASME Sec VIII Div 1	Boiler and pressure vessels code

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ASME B 16.21	Non metallic gaskets for flange
ASME B 16.20	Metallic gaskets for flange
ASME B 16.11	Screwed joints
ASME B 16.25	Welded joints
ASTM-A 106	Gr.C Seamless carbon steel pipe.
ASTM 53	Seamless carbon steel.
ASTM A 106, Gr. C	Schedule 80 - Seamless carbon steel pipe
ASTM A 312 Grade TP-316	Schedule 40s - Stainless Steel pipes
ASTM D 3517 / 4024	GRP pipes
ASTM A 105	Standard specification for carbon steel forgings for piping application.
ASTM A 182	Standard specification for forged or rolled alloy and stainless steel, pipe flanges, forged fittings and valves and parts for high temperature service.
ASTM A 216	Standard specification steel casting suitable for fusion welding for high temperature service.
ASTM A 217	Standard specification for steel castings martensitic stainless and alloy for pressure containing parts suitable for high temperature service.
ASTM A 234	Standard specification for pipe fittings of wrought carbon steel and alloy steel for moderate and high temperature service.
ASTM A 312	Standard specification for seamless welded and heavily cold worked austenitic stainless steel pipe.
ASTM A 335	Standard specification for seamless ferritic alloy steel pipe for high temperature service.

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ASTM A 403	Standard specification for wrought austenitic stainless steel pipe fittings.
ASTM A-193-194	Specification of alloy steel and stainless steel bolting material;/ nuts for high temperature services
AWWA-C-504	Standard for butterfly valve.
MSS SP-58	Pipe hangers and supports- Materials, designs and manufacture
MSS SP-69	Pipe hangers and support – Selection and application
API-6D	Specification for pipe line valves
API-607	Fire test for soft seated ball valves
API-598	Valve inspection test
API-594	Standard for dual check valve
BS: 5156	Standard for Diaphragm valve.
BS: 5142	CI globe valve.

Pipe lines carrying water, chemicals, air etc. shall be sized generally on the following velocities. However wherever minimum pipe sizes are defined in the tender drawing /data sheets the selected size shall not be less than the specified size.

Table-6.1

Service	Below 50 mm	50-150 mm	200 mm & above
Pump suction	-	1.2 - 1.5	1.2 - 1.5
Pump discharge and recirculation	1.2 - 1.8	1.8 - 2.4	2.1 - 2.5
Header	-	1.5 - 2.4	2.1 - 2.4
Compressed air	6		

Note – All above velocities are in m/sec

Pipe line under gravity flow shall be restricted to a flow velocity of 1 m/sec generally. Channels under gravity flow shall be sized for a maximum flow velocity of 0.6 m/sec.

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The following "C" Value shall be used in WILLIAM & HAZEN formula for calculating the friction loss in piping systems.

Carbon Steel pipe	-	100
C.I Pipe / Ductile Iron	-	100
Rubber lined steel pipe	-	120
PVC / HDPE / GRP pipes	-	140

For calculating the pump head, at least 10% margin shall be taken over the pipe friction losses.

Material of construction for pipes carrying various fluids shall be as below:-

Table: 6.2

S.No	Service	Recommended Material
1.	Clarified water/Filtered Water	Carbon Steel
2.	Acidic Water	FRP/CPVC/SS
3.	Demineralised Water	SS 316
4.	Passivated Demineralised Water	Carbon Steel
5.	Acid (hydrochloric)	FRP/CPVC/SS
6.	Alkali (Sodium Hydroxide)	FRP/CPVC/SS
a)	Strong (5% & above)	Stainless Steel
b)	Dilute	FRP/CPVC/ SS
7.	Chlorinated Water	Rubber lined Carbon Steel
8.	Sludge	Cast Iron/ Ductile Iron
9.	Instrument Air	Galvanized Steel
10.	Waste effluent	HDPE/ MS Rubber lined

However the portion downstream of the isolation valves of pipe lines conveying flushing water shall be of the material & type as that of the chemical pipelines which is being flushed.

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6.3 Design Basis

- i) Design, fabrication, testing & erection of Power Cycle Piping, valves & specialties for critical piping system under purview of IBR, shall satisfy IBR, and ANSI/ASME B31.1 latest code. The design pressure of the feedwater line and feedwater heater will be in line with the recommendations of Indian Boiler Regulation (IBR), ASME Section-1 and ASME B31.1 as applicable.
- ii) Design, fabrication, testing & erection of Power Cycle Piping, valves & specialties for non-critical piping system which are not purview of IBR, shall satisfy ANSI/ASME B31.1 latest code.
- iii) Sizing, design and installation of safety valves shall conform to IBR and the non-mandatory rules for the design of safety valve installation of ANSI/ASME B31.1.
- iv) Piping Flexibility analysis shall be carried-out for all piping having sizes equal to or above 50 mm NB & design temperature 100 deg C and more, according to ANSI/ASME B-31.1 latest & also satisfying IBR latest.
- v) Design pressure and temperature shall be as per IBR. Wherever not clearly stipulated in IBR, criteria stipulated in ASME/ANSI B31.1 for selecting design pressure & temperature shall be followed.
- vi) Material of construction of piping, valves & specialties shall conform to relevant ASME / ASTM / BS / IS or equivalent codes/standards. In case materials not approved by IBR are used, it is the Bidder's responsibility to obtain IBR approval, without affecting the Construction schedule.
- vii) Type of Hangers, supports etc. shall be selected as per the following criteria:
 - a. Variable spring hangers
 - Where the variation in supporting effort between hot and cold condition does not exceed 20% of the higher of the operating load and cold setting load.
 - The resulting effect of load take-up/ release by a group of hangers in a span does not overstress the piping span or cause overloading at equipment terminals.
 - Thermal deflection between hot & cold conditions does not exceed 40 mm.
 - b. Constant load hangers
When thermal deflection between hot and cold conditions exceeding 40mm, these are used.
 - c. Spring hangers
These should not be loaded more than 80% of the spring travel range.
 - d. Rigid hangers & restraints
To be judiciously selected, without exceeding the stipulated limits of terminal forces & moments and stress level. Struts shall be considered where compressive load is expected.

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viii) Design Requirement of Hangers & Supports:-

In order to minimize any horizontal force components of the dead weight or any binding of the pin or rocker joints used on the hangers, the hanger rods should be as long as possible. In critical piping systems, the length of the hanger assembly capable of swinging shall not be less than 20 times the maximum expected pipe movement in the horizontal plane at the hanger location.

Constant support type of hangers shall be adopted at all locations on critical piping excepting where the smaller of vertical movements of pipe justifies the use of variable spring hangers.

As far as practicable, connections of hangers to supporting structure shall be achieved without welding to structural members. If welding is inevitable, adequate factor of safety shall be considered in the design and specification of the weld.

The attachment of support brackets to brick walls shall be avoided as far as possible and where this is not possible, details of the attachment shall be furnished to the Owner for his approval. Under unavoidable circumstances, when medium or heavy brackets are bolted to walls, back plates of adequate size and thickness shall be furnished to distribute the load against the wall. Where the use of a back plate is not practical, the brackets shall, be fastened to the wall in an approved manner.

Diameter of hanger rods for piping NB 50 mm and smaller shall not be less than 10 mm and for piping with size NB 65 mm and larger shall not be less than 13 mm.

All components for hangers such as turn buckles, clamps, etc. shall be of forged steel.

ix) Snubbers, dampers etc.

To take seismic / dynamic loads, thrust due to safety valve discharge. Effort shall be made to limit its use by judicious placement of rigid hangers. Bottom support spring hangers are to be avoided as far as possible.

x) Design, materials, fabrication, testing and erection of hangers, supports, anchors, guides etc. shall be as per ANSI/ASME B31.1 latest code. Material of support packing used for alloy steel piping shall be same or better than the parent pipe material.

xi) Hanger suspension rods, tie-rods/ struts should have proper arrangement & adequate length, so that thermal movements in direction which are free are not constrained and should not make an angle more than 4 degree with vertical due to horizontal pipe movement.

xii) Pipe Thickness calculations shall be made on the basis of procedure and formula given in ANSI B31.1. Stress values of piping material for calculation shall be selected from tables given in ANSI B31.1. Thickness, thus calculated shall be checked as per the formula of IBR and the more stringent of the two shall then be selected. If it is seen that sizes arrived at for main steam, hot reheat and boiler

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feed pumps discharge pipes are not in the standard range of the manufacturers, ID controlled piping, shall then be selected for these piping systems.

- xiii) Pipe sizing and piping system design shall conform to the requirements of power piping code ANSI B31.1. Statutory requirements as laid down in Indian Boiler Regulations (latest edition) will also be taken care in pipe system designs. Pipe wall thickness as calculated by ANSI Code formula will also be checked for IBR requirements for piping systems falling under IBR purview.
- xiv) Inside diameters of piping shall first be calculated for the flow requirement of various systems. The velocity limits for calculating the inside diameters are listed below used to determine line size if dictated by considerations of pressure drop, NPSH, surges, water hammer, etc.
 - a. Steam
 - Main Steam hot and cold reheat pipes : 75 m/sec.
 - Saturation steam : 40 m/sec
 - Auxiliary steam : 30 m/sec.
 - b. Feed Water :
 - Suction : 2.0 m/sec.
 - Discharge : 5.0m/sec.
 - c. HP bypass :
 - Upstream : 75 m/sec.
 - Downstream : 100 m/sec.
 - d. LP bypass
 - Upstream : 75 m/sec.
 - Downstream : 100 m/sec.
 - e. Extraction steam :
 - Superheated steam : 60 m/sec.
 - Saturated steam : 30 m/sec.
 - HFO & LDO suction : < 1 m/sec
 - HFO & LDO discharge : 2 m/sec
 - f. Condensate :
 - Discharge : 3.4 m/sec.

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- Suction : 1.5 m/sec.
- g. Heater vents : 25m/sec
- h. Heater drains : 1.5m/sec
- xv) Other piping - As per good engineering practice.
- xvi) Drains shall be provided, at all low points and vents at all high points as per actual layout regardless of whether the same have been shown in the flow diagrams or not. Pipelines shall be sloped towards the drain points. For operating temperatures of greater than 400 °C, drip leg with drains, operated by a motor operated valve shall be provided. At all other drain locations (operating temperatures less than 400 °C) traps shall be provided. All traps shall be provided with strainers, isolating, bypass and free blow valves. Traps shall be thermodynamic type.

6.4 Piping Design

- i) Complete design, engineering, etc. for the power cycle piping systems and other piping systems shall be the responsibility of the Bidder. Owner's responsibility/ function in this connection shall be limited to review and approval of Bidder's design/ calculation, engineering, drawings, documents. Bidder's scope of services for complete engineering of the piping systems shall include but not be limited to the following:
- ii) Preparation of engineering piping diagram indicating flow schematic, flow parameter, pipe sizes, line designations and tag nos. of various components etc.
- iii) Design parameter selection, pipe sizing calculation, pipe schedule, valve schedule, insulation schedule, specialties schedule and hanger schedule for the systems.
- iv) Preparation of preliminary as well as final composite piping layout drawings of pipe size 65mm NB & above.
- v) Design in detail all piping supports including restraints, guides, stops etc., after deciding the final location of hangers and supports and based on final stress analysis and hanger/ support load data.
- vi) Prepare separate sketches for each hanger/ support, restraint, anchor, etc. These sketches shall include the location with reference to column co-ordinates, identification number, bills of material, design loads, operating load, spring stiffness, amount of spring pre-compression etc., the method of attachment to the pipe and steel structure. Additionally the sketches shall show a key plan referenced to plant north and centre line elevation of the pipe at the point of attachment for cold and hot conditions.
- vii) Preparation of fabrication and erection isometric (with material take off) drawings for shop fabricated piping which are of size 65 mm NB and above.
- viii) Sizes of Boiler feed pump suction piping shall be selected to meet the NPSH requirements of the pumps under transient conditions prevailing on loss of steam

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supply to feed water tank. Similarly for all pumps, NPSH requirements shall be satisfied in line sizing.

6.5 Stress Analysis

The Bidder shall carryout stress analysis of piping system using proven and validated software and shall submit for Owner's approval.

- i) Following loading conditions shall be considered for stress analysis:
 - Internal pressure
 - Thermal loads due to – (a) Piping thermal expansion and (b) Anchor displacement due to thermal movements of piping anchors.
 - Piping weight consisting of weight of piping, valves, bends, fittings, insulation etc. as well as weight of support components like clamps, shoes, suspension rods, trapeze etc. & weight of contained fluid.
 - Test or cleaning fluid load
 - Equivalent static loads due to discharge of safety valve (SV), Electromatic relief valve (ERV), simultaneous discharge of SV & ERV where applicable.
 - Dynamic load due to steam hammer (if applicable)
 - Seismic loads due to (i) Equivalent static load due to seismic inertia effect and (ii) Equivalent static load due to seismic anchor displacement
 - Wind load where applicable
- ii) Loading combination Design load for supports, restraints, anchors & supporting structures shall be obtained by proper selection of one or combination of two or more of the loads as above based on the possibility of independent or simultaneous occurrence. Loads imposed due to hydrostatic tests shall also be taken into consideration for the design of supports.
- iii) Bidder shall clearly indicate the basis of his judicious selection or loading combination for support, restraints and anchor design. Component of thermal expansion reaction range expected to appear at cold condition, as per equation 9 & 10 of ANSI/ASME B31.1 shall be considered in loading combinations. As overload factor of 1.30 shall be considered over the computed loads except occasional loads before combining them. Bidder shall justify with reasoning in case any one of the specified loads is not considered in analysis.
- iv) Combination of Stresses the computed stress under different loading conditions shall be combined as per equation 11, 12 & 13 of ANSI/ASME B31.1 & the stress shall be within allowable limits.
- v) Allowable stress values for piping materials other than ASME/ASTM materials, values shall be derived as per the criteria defined in Appendix-P of ASME Boiler & Pressure Vessel Code, Section-VIII, and Division 1 while computing pipe wall thickness and flexibility analysis shall be conducted as per ANSI/ASME B31.1.

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However, higher of pipe wall thicknesses derived between IBR regulation & ANSI/ ASME B31.1 code shall be considered.

vi) Factor to be considered in flexibility analysis.

- Cyclic load operation of the Unit. Bidder shall consider value of stress range reduction factor 'f' for cyclic conditions due to temperature reversals equal to 1.
- Stress intensification factor at all transitions, fittings & all branches as per ANSI/ASME B31.1.
- Variation in supporting effort by variable spring due to pipe movements

vii) Piping Flexibility analysis is to be conducted as per the piping layout in case any modification of piping layout is felt essential to maintain stresses & terminal reactions within allowable ranges, same are to be carried out by the Bidder after discussion with Owner.

The following piping systems shall be analyzed:

- Pipelines with a maximum operating temperature equal to or greater than 100°C having size 50NB or above.
- Regardless of their operating temperatures, all pipelines connected to sensitive rotating equipment such as turbines, feed pumps etc. for which limiting values of pipe reaction have been specified by the equipment manufacturer
- Any other pipeline which in the opinion of the Owner requires a formal analysis.
- A write up on the stress analysis including codes used and design conditions considered.
- A copy of the computer print out for input data for the various design conditions considered for stress analysis along with the stress diagram (piping isometric marked with node points marked.)
- A copy of flexibility analysis software soft copy shall also be submitted for Owner's approval.
- Analysis results in tabular form giving calculated and allowable reactions / forces / moments on equipment nozzles/terminals for the various design conditions considered for analysis.
- Allowable and calculated code stresses at various node points in the piping for the design conditions considered based on code requirements for analysis.
- Analysis results giving calculated forces and moments and movements at various hanger / support / restraint / anchor points from the static analysis corresponding to various thermal / operating conditions, sustained load case,

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hydro load case (other than water lines) and occasional loads, as applicable, for each piping system analyzed.

6.6 Statutory Approvals

- i) It is the sole responsibility of the Bidder to identify and obtain all necessary approvals from various Government agencies / statutory authorities including IBR, CCoE, etc., as applicable for the design, manufacture and testing of pipes, valves, fittings, specialties etc.
- ii) The Bidder shall also identify and obtain all necessary approvals from the IBR authority in the state where the plant is being installed, for the erection / testing / commissioning and any other requirement as required by IBR.
- iii) It is also the responsibility of the Bidder to get approval(s) from any other statutory authority in other countries from where the supplies are made, as applicable and acceptable to IBR for the design/manufacture/testing etc. for the piping / fittings / valves / specialties etc.
- iv) In order to obtain the above approvals, all necessary documentation etc. required shall be arranged and furnished by the Bidder to the statutory authorities.

6.7 Installation

- i) Cleaning including chemical cleaning of all systems as specified herein and installation of temporary pipe work for the same. All hot bent, forged formed, fabricated and straight pipes shall be chemically cleaned, pickled or wire brushed and purged with air blast or shot/grit blast to remove all sand and scale from the inner surface as applicable.
- ii) Making temporary closures/ stubs on piping system as required for hydrostatic testing and performing hydrostatic test on all piping. All pipes shall be hydro tested at shops for pressures as per standards and all erected piping shall be tested 1.5 times the design pressure.

The Bidder shall carryout the following cleaning after hydro test.

- a. All piping shall be mass flushed, in addition to the specific cleaning operations as described below, as required.
- b. Extraction steam, condensate, boiler feed suction and discharge, heater drains and vents shall be alkaline flushed.
- c. Compressed air piping shall be blown by air.
- d. Turbine lubricating oil piping shall be pickled
- iii) Making interface piping connections at TP with equipment/piping etc. as applicable.
- iv) Apart from carrying out chemical cleaning, the work shall include neutralization disposal of water, clean up, reinstatement of the cleaned piping system, dismantling and removal all temporary piping, equipment and materials from site.

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- v) Painting of piping system shall be in accordance with the stipulations laid down in Vol 2, Annexure II of this specification.
- vi) Weather hood for pipes crossing ceilings and walls.
- vii) Checks after Installation
In order to ensure that all supporting elements, anchor and restraints have been installed and adjusted in accordance with design documentation, the Bidder shall inspect and log the hanger readings for the hangers associated with the power cycle piping system as follows:
 - a. After hydrostatic test with the piping in the cold position, with all travel stops removed, with the pipe completely insulated and in all respect ready for start-up.
 - b. Piping in hot position (rated parameter condition) after six (6) months of operation.
 - c. Piping in cold position during the first complete shutdown after at least six (6) months of operation.
 - d. After steam blowing, in case steam blowing is applicable for the line.
 - e. At the time of each inspection, the Bidder will determine the necessity for revision, adjustment or replacement of pipe supporting elements, restraints and anchors. Any changes proposed shall be subject to the concurrence of the Owner. The changes shall be incorporated by the Bidder after Owner's concurrence.

6.8 Inspection and Testing

All shop tests as required by the applicable codes, ANSI Standards, IBR and other standards specified.

- i) Obtaining approval from Chief Inspector of Boiler as per latest Indian Boiler Regulations (IBR) is the responsibility of the Bidder. This shall include furnishing all necessary certificates for design, manufacture and testing for pipe, valves, fittings, specialties, certificate of manufacture and test for each erected piping in the relevant formats to the Chief Inspector of Boilers, obtaining his approval and furnishing the same to the Employer.
- ii) The Bidder shall also identify and satisfy all other statutory code requirements as may be required for the piping systems covered in this specification.
- iii) Certified copies of test reports for all tests and examinations specified in the specification and for the mandatory test and analysis required by ASME/ ASTM material specification, for the materials used for piping, shall be furnished to Employer.
- iv) Provide complete interface engineering with the suppliers of other equipment and piping with which the piping systems in the Bidder's scope are connected.
- v) Performing all tests and implementing all quality control procedures as specified herein including provision of testing equipment, stress relieving equipment,

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radiography equipment and any other equipment necessary to meet the requirements of the specification.

6.9 Low Pressure Piping, Valves and Fittings

Low Pressure (LP) piping shall, basically, cover piping systems for the following services:

- a) Circulating water system (Part).
- b) DM water normal make-up system
- c) Condenser normal/emergency make up system / condensate (storage and transfer) system.
- d) Deaerator fill system.
- e) Equipment Cooling Water (ECW) system including its chemical dosing system
- f) Service water system
- g) Instrument Air System.
- h) Service Air System
- i) Lube oil System
- j) Chemical feed lines
- k) Auxiliary cooling water system
- l) Drain & Vents for the piping\equipment etc.
- m) Re-circulation pipes along with valves, break-down orifices etc., wherever required.
- n) Any other piping system required to make the Low Pressure (LP) piping systems complete.

All the piping systems be designed to operate without replacement and with normal maintenance for a plant service life of [20] years, and shall withstand the operating parameter fluctuations and cycling which can be normally expected during this period.

o) Piping Materials and Sizes

All piping system shall be capable of withstanding the maximum pressure and temperature in the corresponding line. The pressure rating of individual piping system component such as valves, flanges etc shall however be not less than that specified. Nominal pipes sizes and pipe outside diameters shall generally be as per ANSI B36.10. In case of deviation BIDDER shall bring it to the specific attention of ENGINEER for prior approval stating reasons for the deviation.

The Steel pipes (Welded type) for the services of water/clarified water/Filtered water shall conform to the following standards or codes.

i)	Pipes upto 150 NB	
a)	IS:1239 Part-I	(Heavy grade-Black)

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b)	ASTM-A-53 Grade B (Welded)	Sch 80 upto 2 inch nominal size(Minimum)
		Sch 40 above 2 inch nominal size (Minimum).
ii)	Pipes 200 NB and above	
a)	IS:3589 Grade 410	
b)	ASTM – A53 Grade B (Welded)	Sch. 40 (Minimum)

i) Wall Thickness

The calculation of wall thickness required for pipelines subject to internal and/or external pressure shall be based on the formulae and recommendations as given in the applicable codes. Adequate allowances shall be made towards thinning due to bending, weakening at branch connections, threading, commercial tolerances on pipe wall thickness, corrosion and erosion, etc. and the same shall be subject to approval by Owner. In any case a minimum corrosion allowance of 1.0 mm shall be considered while selecting the thickness.

In case of carbon steel materials, the nominal wall thickness of pipeline shall be not less than the minimum acceptable values given below:

NB mm (inch)	15 (1/2)	20 (3/4)	25 (1)	32 (1 1/4)	40 (1.5)	50 (2)	65 (2.5)	80 (3)	100 (4)	125 (5)
Min. thickness, mm	3.2	3.2	3.6	3.6	3.6	3.6	3.6	4.0	4.5	5.4
NB mm (inch)	150 (6)	200 (8)	250 (10)	300 (12)	350 (14)	400 (16)	450 (18)	500 (20)	600 (24)	
Min. thickness, mm	5.4	6.35	6.35	6.35	7.1	7.1	7.1	8.0	8.0	

NB 700 mm to NB 800 mm - 10.00 mm

NB 900 mm to NB 1500 mm - 12.00 mm

NB 1600 mm to NB 2000 mm - 14.00 mm

NB 2100 mm to NB 2500 mm - 16.00 mm

NB 2600 mm to NB 3200 mm - 18.00 mm

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6.10 Thermal Insulation

The thermal insulation for the turbine casing shall consist of sprayed insulation produced by projecting specially prepared mineral wool along with a fine liquid spray. This should be covered with prefabricated 'blanket' type insulation. These blankets shall consist of high temperature felted mineral insulation fully enclosed in wire inserted asbestos cloth for temperature exposure to 445 deg C to 595 deg C. A single layer of blanket shall not be more than 75 mm thick. Voids around the blankets should be avoided. However, unavoidable voids shall be filled with loose mineral wool.

- i) Nuts and other exposed portions of the casing and valve flanges shall be suitably insulated for minimum heat loss.
- ii) The density of the mineral fiber felt shall be carefully controlled at about 200 kg/m³ and the thermal conductivity of mineral wool shall be 0.052kCal/mh deg C at mean temperature.
- iii) Suitable stainless steel lugs shall be tack welded on turbine casing to support the insulation. In places where welding is not permitted, suitable alternative arrangement shall be provided by the Bidder. The design of the support shall be so as to involve minimum number of lugs.
- iv) The mineral wool shall be capable of passing standard combustibility test, both immediately after application and also after being subjected to its maximum operating temperature for not less than 100 hours. The mineral wool shall be free from objectionable odour at the ambient conditions in which it is used. The mineral wool shall not contain substances which shall support pests or encourage growth of fungi. The mineral wool shall not suffer permanent deterioration as a result of contact with moisture due to condensation. The mineral wool shall not suffer quality deterioration under the specified conditions of use. In this connection, both hot and cold face temperatures are relevant. The mineral wool shall be capable of being applied to the surface concerned without causing corrosion of the surface being insulated or the cladding on it under normal site conditions.
- v) The thermal insulation designed, furnished and installed by the Bidder shall be such that the following items of performance shall be guaranteed, and the specific design and application features adopted shall be so as not to exceed the stipulated limits in temperature differentials. The Owner shall have the option to have any random check of specimen as per his choice, to establish conformity to following guaranteed particulars:
 - a. The temperature difference between the cold face of finished insulation and ambient shall not be more than 15 deg C. The ambient temperature shall be considered as 50 deg C.
 - b. The difference in temperature between upper and lower metallic parts of H.P. and I.P. casings in the zone of governing stage/ steam admission shall not be more the 40 deg C during cooling of the casing.

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The difference in metallic temperatures of upper and lower halves of both H.P. and I.P. casings, during normal operating conditions shall not be more than 15 °C.

6.11 Fittings

Fittings to be used with carbon steel pipes shall conform to IS: 1239 Part-II (Heavy grade) or ASTM A 234 Gr. WPB. for sizes up to 150 NB.

For sizes 200 NB & above steel fittings shall conform to ASTM A 234 Gr. WPB. However for sizes above 300 NB fabricated fittings (mitre bends etc) may be used.

Wherever regular pipe bends are employed for change of direction the same shall be to a radius of 5 times the pipe diameter. Mitre bends shall be 1.5D radius.

Inside surface of all the fittings used for the rubber lined application shall be de beaded and made suitable for rubber lining.

Galvanized pipe application all the fittings shall be galvanized as per IS: 4736. Fittings to be used in other type of piping shall conform to relevant IS/BS ANSI Standards and in conformity with the parent pipe standard.

Branch connections in piping shall be made by the use of wrought or forged seamless fittings such as tees, laterals and crosses. Small stubs as may be required for instrument, drain and vent connection may be provided in the form of weld outlet fittings or forged couplings. Intersection welds are acceptable only in the event of non-availability of fittings.

6.12 Design and Construction

i) Pipes, valves and Fittings

Following items shall be included for piping:

- Pipes, bends, elbows, tees, branches laterals, crosses, reducing unions, couplings, cap, expansion joints, flanges, blank flanges, saddles, shoes, sampling connections etc. necessary for making a reliable piping system.
- Valve, gates, dampers, etc.
- Strainers and filters.
- Instrument tapping connection, stubs and thermo-wells, root valves.
- Matching flanges, pipe spools and matching pipes to connect to equipment, instruments, etc. as necessary.
- Gaskets, ring joint, bracing rings, jointing material etc. as required.
- Bolts, nuts, fasteners as required for interconnecting piping, valves and fitting as well as for terminal points.
- Pipe supports like pedestals, Anchor blocks (for buried / over ground piping), brackets, hangers, clamps, trestles, etc.

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- Secondary steel for pipe supports and embedded steel. Also pipe supports and necessary embedment required to be embedded in concrete for underground/above ground pipes.
- Painting, anti-corrosive coatings, wrapping and coating, thermal insulation, etc. inside and outside of pipes as necessary.

ii) End connections

Unless otherwise specified, following types of end connections shall be used:

Pipes 50 NB and smaller shall have socket welded joints for chlorine line. For water, air and other services where steel pipes are used, joints of this size range shall be Socket welded/screwed/flanged type (For rubber lined pipes).

All unlined steel pipes 65 NB and above (other than CI pipes and air service pipes) shall be connected by butt welding. All rubber lined pipes shall have flanged joints.

Butt welding edge preparation shall be done as per ANSI B 16.25. The Bidder shall furnish details/specifications for all welding electrodes and welding rods including special ones, if any for approval.

Steel pipe flanges shall be generally slipped on flat face type. Weld neck flanges shall be used when flange follows immediately after a butt welding or where it is required with respect to service conditions. Slip-on type of flanges may be only up to a maximum pressure rating of ANSI 300 lbs. In case of higher pressure ratings, weld-neck type of flanges shall be employed. When weld neck or socket weld flanges are used, their bore must be made the same as that of the pipe being welded to. Socket welded or threaded flanges may be used, with the appropriate piping system for connection of pipe to the flanged equipment.

All the piping flanges and counter flanges shall conform to ANSI B 16.5 Cl. 150 (minimum). However wherever the interferences is involved with the Owner's pipe, the flange/interconnection details shall be designed to match the piping and the details of which will be intimated later.

For easy handling & removal of equipments, valves etc. and for maintenance purpose, break up flanges for 65 NB and above sizes and suitable type of compression flexible coupling for flanged joints of 50 NB and below size shall be provided. The over ground piping wherever routed inside building, shall have a clear head room of minimum 2.2 m from floor in passages/walkways.

6.13 Piping Layout

- Pipes shall be generally routed above ground but where specifically indicated/specified the pipe may be laid in trenches or buried. Buried piping shall be generally installed so that the top of pipe is 1.5 meter below the ground level unless otherwise specifically mentioned. Full length of buried piping shall be provided with 100 mm thick sand bed.
- Complete supporting system for the pipe line shall be designed, fabricated and supplied by the Bidder. Inside the building, the overhead portion of the pipe line may be supported from the building structures. No support shall be taken from

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the brick wall. Outdoor, pipes other than buried pipes shall run on steel trestles. Crossing of the road shall be on a pipe bridge with a clear height of at least 8.0 meters (minimum) over the road surface. All the steel structure for the pipe bridge and the supporting posts/trestles along with all necessary hangers clamps, connecting steel, fixing bolts, nuts etc. shall be supplied and erected by the Bidder. All pipe racks shall be provided with 750 mm (Minimum) clear width walkways.

- iii) Hangers and supports shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipe line movements as necessary. All guides, anchors, braces, dampener, expansion joint and structural steel to be attached to the building/structure, trenches etc. shall be provided.
- iv) Mitre bends will not be accepted for steel pipes of 250 NB and below. For sizes 300 and above, the mitre bends shall conform to BS: 534.
- v) For rubber lined pipe of acid service, lining should be applied in two (2) layers, giving a total thickness not less than 3 mm.
- vi) Pipe coming under purview of IBR should meet its requirements and getting the IBR approval shall be under Bidder's scope.
- vii) Thickness calculation of CW duct/large diameter buried pipes as per AWWA-M-11
- viii) Anti corrosive protection shall be provided for all buried piping including galvanized steel piping. In case of buried pipes of size 1000 mm NB and above, the Bidder shall stiffen them and/or increase the thickness of pipe adequately against ovality formation in use.
- ix) Flexibility analysis for piping systems wherever required. Whenever, straight run of the above ground yard pipes are more than 50 meters, flexibility analysis shall be conducted by the Bidder to identify the requirement of loops, type of supports etc.
- x) The Bidder shall prepare the flow diagrams, detailed dimensional piping layout/ Isometric/ fabrication/ as built drawings of all the systems along with Cross sectional drawings, showing all supports and equipment as required.
- xi) All pipelines with size greater than NB 50 mm are considered as shop fabricated piping and detailed piping layout drawings shall be prepared for all such pipelines. The drawings shall be to scale and shall be prepared as plan & sections and shall carry the following minimum details:
 - a) Fully dimensioned layout with locating dimensions referred to plant axes and coordinates
 - b) Details of all stub connections and other welded attachments as required for anchors, restraints, hangers supports, etc.
 - c) Slope, drains and vents
 - d) Edge preparation details of weld ends

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- e) Mounting and orientation of valves and specialties and maintenance space requirements
 - f) Location and tag numbers of hangers, supports, restraints, anchors, etc.
 - g) Location and magnitude of cold cuts, if any
 - h) Pipe sizes, materials, design parameters, shop and field test requirements
 - i) Insulation details
 - j) Tolerances, if any
 - k) Any specific requirements on shop fabrication and/or field erection
 - l) Any other detail considered necessary by the Owner.
- xii) The piping shall be arranged to provide clearance for the removal of equipment requiring maintenance and for easy access to valves and other piping accessories required for operation and maintenance. Layout drawings shall indicate valve orientations and availability of access to valves and specialties. Layout of all piping shall ensure that all valves including motor operated valves are located as to be accessible conveniently for operation. Valves for operation and maintenance shall have 1.0 m clear approach space. If any of the valves are not accessible, suitable access platform shall be provided by the Bidder.
- xiii) Provision shall be made while preparing piping layout to accept control valves, flow measurement element and any other on-line specialty or equipment. Sufficient upstream and downstream lengths shall be provided for flow measuring devices, control valves, desuperheaters and other specialties as required by the respective equipment manufacturer.

6.14 Valves

- i) All valves shall be suitable for service conditions i.e. flow, temperature and pressure under which they are required. The valves shall be of standard pressure rating as per the relevant code/ standard.
- ii) Either Butterfly type or sluice/gate valves shall be used for isolation purposes in raw water, Clarified & Filtered water application. Butterfly valves shall be of double flanged or lugged wafer type of low leakage rate conforming to AWWA-C-504 class 150 or EN-593 Class 150.
- iii) Manually operated valves shall be provided with reduction gear unit for valves of size 200 NB and above. Valve provided with motorized or pneumatic actuator shall be provided with a hand wheel for manual operation.
- iv) All the valves shall be equipped with adjustable mechanical stop-limiting devices to prevent over travel of the valve disc in the open and closed positions. The valve operators (Hand wheel or Gear reduction unit or Motor actuator etc.) shall be designed as per relevant International Standard.
- v) Ball valves or Globe Valves may also be provided for the application of Raw/ Clarified / Filtered water services for sizes 50 NB and below.

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- vi) Butterfly valves or proven patented diaphragm valves shall be used for the services of demineralised water application for isolation purposes.
- vii) Sluice valve/knife edge type slide valves shall be used in the sludge and drain pipe line.
- viii) For Air services, globe valves or Ball valves may be used for sizes 50 NB and below. For sizes higher than 50 NB, either Butterfly valve or Ball valves shall be used.
- ix) Check valves for Raw / Clarified / Filtered water may be offered in Gun metal construction and with threaded ends for sizes 50 NB and below conforming to IS:778 or Equivalent.
- x) For Chlorine gas and Chlorinated water application check valve of Lift Ball type may be used in PVC construction (in case of PVC pipes). In case of rubber-lined pipes, the check valves of swing check type shall be lined construction.
- xi) The safety valves / relief valves at the down stream of positive displacement type metering pumps shall be of the standard type manufactured by the pump manufacturer and the material of construction shall suit to the fluid handled.
- xii) Safety valve
- xiii) The butterfly valves for DM water application shall conform to the following requirements:
- xiv) Body shall be lined (minimum 3 mm) with natural rubber, ebonite, polypropylene or PVDF.
- xv) Disc shall be lined with PVDF, polypropylene, or natural rubber.
- xvi) Seat rings shall be of Nitrile rubber or Hypalon
- xvii) Valves for Acid & Alkali Services shall be proven patented diaphragm type. Diaphragm shall be of reinforced teflon, EPDM/Black Butile/appd. eqv. For acid services and reinforced Neoprene/Hypalon/app eqv for alkali services.
- xviii) For air application, Body material of Ball valves shall be leaded Tin Bronze (IS: 318 Gr.2) or stainless steel (AISI: 304/316). Body & Disc of Butterfly valves shall be either cast iron lined with elastomer such as PVDF or PTFE or stainless steel construction (AISI 304/316).
- xix) For the application of alum, lime, coagulant aid solution, DM water and air, the body, cover & Disc of Non return valves shall be lined with natural Rubber, PTFE or Viton.

6.14.1 Design and Construction Features

The following design and construction features of valves shall be complied with.

- i) All gate and globe valves shall be of rising stem, outside screw and yoke type. The design of valves shall ensure a streamlined passage and gate valves shall have low pressure drop. The seats and discs shall be easily renewable and/or shall be suitable for easy refacing and grinding. Valve discs shall be of such design as to keep the seats tight when the valve body is subjected to pressure, temperature variations and piping stresses. Gate valves shall close in both flow directions.

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- ii) All globe valves shall be capable of being closed against pressure.
- iii) In the case of all end-welded valves, the stub ends of the valves shall project from the valve body a sufficient amount to ensure that the welding process will not distort the valve body and internal parts.
- iv) Valves for regulating duties shall be of the globe type with tapered plug type disc.
- v) Hardness of seating surfaces shall be a minimum of 350 BHN and a minimum differential hardness of 50 BHN shall be provided between seats to prevent galling. This is not applicable for stellited seats.
- vi) Check valves of sizes 400 mm NB and larger shall have dash pot arrangement.
- vii) All gate and globe valves shall have back-seating arrangement to facilitate easy replacement of packing with the valve in service.
- viii) All valves shall be so designed that the hand-wheel moves in a clockwise direction to close the valve. The face of the hand-wheel shall be clearly marked with the words 'OPEN' and 'CLOSE' and an arrow to indicate the direction for opening. All hand-wheels shall be fitted with name plate. All globe valves shall be provided with position indicator.
- ix) Piston lift check valves shall have accurately guided pistons so that the pistons are cushioned in their cylinders as they move up.
- x) All gate, globe, Y-type and angle valves intended for manual operation and falling under the following categories shall be equipped with a gear operator for ease of operation and to ensure fast and tight closure:

ANSI Pressure Rating Valve Sizes for which Gear Operator is required

Class 300 and below	350 mm and larger
Class 600 and above	200 mm and larger

- xi) All gate valves falling in the following categories shall be provided with integral bypass valve. Bypass size shall conform to MSS-SP-45 as a minimum standard. The bypass valve shall be hand operated unless specified otherwise. Pipe for bypass shall be of at least schedule 80 seamless and of a material of the same nominal chemical composition and physical properties as that used for the main line. Orientation of bypass arrangement shall be subject to the approval of Owner.

ANSI Pressure Rating Valve Sizes for which Bypass is required

Class 600 and over	200 mm and larger
Class 300 & 150	350 mm and larger

- xii) All gate valves of ANSI pressure rating class 150 and 300 shall have solid or flexible wedge and ANSI pressure rating class 600 and above shall have flexible or parallel slide type of wedge.

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- xiii) Valves with flexible wedge shall have provision for relieving the pressure in the neck of the valve when the valve is in the closed position.
- xiv) All valves of ANSI pressure rating up to class 600 shall have bolted bonnet construction and class 900 and above shall have bonnet construction of the pressure seal type. Pressure seal valves shall have stainless steel inlay in the gasket area and silver-plated gaskets or other acceptable proven features.
All carbon steel valves of ANSI pressure rating up to class 150 and 300 shall have stainless steel trim (13% Cr) and ANSI pressure rating class 600 and above shall have stellited trim.
- xv) All alloy steel valves shall have stellited seats.
- xvi) All valves of ANSI pressure rating up to class 900 and higher shall have yoke with anti-friction bearing arrangement.
- xvii) Valves that are to be kept in full 'OPEN'/'CLOSE' position shall be provided with a non-detachable locking arrangement. The locking arrangement provided shall be subject to approval by the Owner.
- xviii) All gate, and globe valves of size 50 mm and below in vacuum service shall have extra deep gland packing without requiring water gland sealing. All gate and globe valves of size 65 mm NB and above in vacuum services shall have adequately deep gland packing and shall be equipped with lantern rings to admit pressurized water for gland sealing. The inlet and outlet connections shall be NB 15mm. The BIDDER shall indicate the maximum and minimum sealing water pressure and the required flow rate.
- xix) Motor actuators for motor operated valves shall meet requirements mentioned in the specification.

6.15 Cleaning

Prior to factory inspection, all manufacturing waste, such as metal chips and filings, welding rods and stubs, rags, debris and all other foreign matter shall be removed from the interior of each valve. All mill scale, rust, oil, grease, chalk, crayon, paint marks and other deleterious material shall be removed from the interior and exterior surfaces. At the time of shipment, valves shall be clean inside and outside.

6.16 Inspection and Tests

Inspection and tests shall be as per the Data Sheet given below.

Defects in excess of acceptance standards shall be removed by suitable means. If removal of surface defects does not result in reduction in wall thickness below 5% of intended thickness of metal at that location, the area shall be blended smoothly into the surrounding surface. Where defect removal results in a wall thickness less than the above resultant cavity may be repaired by welding. The procedure and operator shall be qualified as per applicable standards. Major weld repairs shall be stress relieved or heat treated in accordance with ASME Section VIII Division I-UCS 56.

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The required area shall be re-examined and the acceptance standards shall be as in the original examination.

Weld repairs made as a result of radiographic examination shall be radiographed after welding. Repairing a particular area more than 2 times is not permitted and the component shall be rejected. The acceptance standards for welds shall be as per ASME Boiler and Pressure Vessel Code, Section VIII, Division I, UW - 51.

Prior approval shall be obtained from the Owner before taking up major weld repairs (major weld repair - when depth of repair exceeds 20% of thickness or 1 inch whichever is smaller). Mapping of major weld repairs is also required.

All valves shall be tested hydrostatically for strength, tightness of seats and tightness of back seating at the pressures, in accordance with MSS-SP 61, "Hydrostatic Testing of Steel Valves". Water used for hydrostatic testing of valves with stainless steel components shall not have chloride content exceeding 20 ppm. Clean potable water may be used for testing of all other valves.

All valves except check valves shall be tested for seat tightness by air at a pressure of 6 bar (g) on both sides of seat.

All check valves shall also be hydro tested at 125% of the seat hydro test pressure.

All valves shall be checked for correctness in respect of specified end details as per applicable standards.

6.17 Painting and Corrosion Protection

Two coats of primer of thickness 35 microns for each coat shall be applied to all steel and cast iron exposed surfaces as required to prevent corrosion, after release has been given for painting and before dispatch. The use of grease or oil, other than light grade mineral oil, for corrosion protection is prohibited. Bores of all valves shall be covered immediately after testing, draining and drying with suitable plastic end covers to avoid ingress of foreign materials.

All pipe lines, piping components shall be adequately protected against corrosion during manufacture, fabrication, shipment and storage by appropriate protective paint. For details, refer Section on Painting.

6.18 Specific Requirement For Valves

SERVICE	SIZE	BODY/ BONNET	DISC	STEM	HAND WHEEL	VALVE ENDS
Steam lines (temp > 400 °C) except for main steam and hot-reheat	> 65NB	ASTM A217 WC- 6/WC-9	ASTM A217 WC- 6/WC-9	ASTM A182 Gr. F6a	ASTM A47 Gr. 32510	Butt welded.
	< 50 NB	ASTM A182 Gr.F-	ASTM A182	ASTM A182	ASTM A97	Socket Weld

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SERVICE	SIZE	BODY/ BONNET	DISC	STEM	HAND WHEEL	VALVE ENDS
		11/Gr.F-22	Gr.F-11/Gr.F-22	Gr.F6a	Gr.32510	
Steam lines (temp < 400 °C), feed water, Condensate blow down, steam tracing	>65NB	ASTM A216 Gr WCB	ASTM A216 Gr WCB	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Butt welded
	< 50 NB	ASTMA105	ASTM A182 Gr F6a	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Socket welded
Boiler feed system	65NB	ASTM A216 Gr. WCB/WCC	ASTM A216 Gr. WCB/WCC	ASTM A182 Gr. F6a	ASTM 417 Gr. 32510	BW
	<50NB	A105	ASTM A182 Gr.F6a	ASTM A182 Gr.F6a	ASTM 417 Gr. 32510	SW
Cooling water system	BFV	AWWA C-504; flanged or long body wafer type; Body A 216 WCB; SHAFT A 182 304; seal & O ring: EPT/ BUNA – N / Neoprene				FL
Instrument air system, potable water system (ball valves)	>65NB	ASTM A216 Gr WCB	ASTM A216 Gr WCB	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Flanged
	< 50 NB	ASTMB62 / IS318 Gr.2	ASTM B62 / IS:318 Gr.2	ASTM B312 Gr A / IS320 HT2	ASTM A47 Gr 32510	Screw type
Service air system, (ball valves)	>65NB	ASTM A216 Gr WCB	ASTM A216 Gr WCB	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Butt welded
	< 50 NB	ASTM A105	ASTM A182 Gr F6a	ASTM A182 Gr F6a	ASTM A47 Gr 32510	Socket welded

Note:

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- i. Testing of body, seat and back seat shall be as per ANSI B16.34
- ii. For water system with sizes greater than NB200 butterfly valves shall be used and shall conform to AWWA C-504.
- iii. All valves of size 400 NB and above shall be provided with electrical actuators.

6.19 Gates

Design standard for gates shall be IS: 3042 or equivalent. The gates shall be rectangular or square sluice, rising spindle type conforming to class-1 of IS: 3042. The Material of Construction shall be as follows:

i)	Frame and Door	:	Cast Iron IS:210 Gr. 260
ii)	Spindles, bolts & nuts	:	ASTM A 182 Gr. F6A
iii)	Face & seat rings	:	Gun metal (as per IS:3042).

All the parts of gates shall be applied with the coats of heavy duty bitumastic paint.

Each of the gates shall be provided with hand wheel, and a position indicator. The gates for DM plant drains shall be rubber lined to a minimum thickness of 4.5 mm.

6.20 Strainers

i) Basket Type Strainers

Basket strainers of simplex design shall have the following materials of construction for raw/clarified/filtered water application.

a)	Body	:	Fabricated mild steel : IS:2062 (Tested quality)
b)	Strainers	:	Wire shall be stainless steel (AISI: 316, 30 mesh suitably reinforced. Reinforcement material shall also be of stainless steel construction)
c)	Drain Plug/Nuts	:	Gun metal

Screen (strainer) flow area shall be at least four times pipe sectional area. Flow area in any portion of Basket strainer assembly shall not be less than the pipe cross sectional area. Pressure drop in clean condition shall not be more than 1.0 MWC.

Basket Strainer shall be provided with lifting lugs and suitable mounting arrangement. Suitable Vent and drain valves shall be provided for the strainers.

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For DM water service, body shall be rubber lined to minimum 4.5 mm thickness (soft rubber of shore Hardness $65 \pm 5^{\circ}\text{A}$).

ii) Y-Type Strainers

Y-Type strainer for water application shall be constructed of following materials

a)	Body	:	Cast Iron IS: 210 Gr. FG 260
b)	Strainers	:	Wires of stainless steel AISI-316, 30 mesh suitably reinforced. Reinforcement material shall also be of stainless steel construction.
c)	Drain Plugs	:	Gun metal (threaded construction)

Body of the Y-type strainers of alkali, and demineralised water shall be of Cast Iron (IS: 210, Gr.FG 260) and lined with soft or hard rubber to a thickness of 4.5 mm.

For acid services, apart from the rubber lined body material, the screen material shall be Polypropylene or HDPE wire cloth of suitable mesh and thickness.

6.21

Steam Traps

- i) The steam traps shall be inverted bucket or thermodynamic type complete with integral or separate strainers.
- ii) The internal components of traps shall be of AISI-316 stainless steel construction. Material of construction of the body shall be selected by the Bidder based on the service conditions stipulated.
- iii) All Y-type strainers, wherever provided with steam traps or otherwise, shall have AISI-316 stainless steel screen of not more than 20 mesh size. Screen open area shall be at least three (4) times the pipe internal cross-sectional area. The strainer shall have a screwed blow-off connection with a removable plug. Material of construction of the body shall be selected by the Bidder based on the duty conditions specified.
- iv) All traps and strainers shall have socket weld ends as per ANSI B16.11 for size NB 50 mm and smaller and butt weld ends as per B 16.25 for size NB 65 mm and above.

Steam drain traps shall be provided with strainers, inlet and discharge valves and by-passes and test cocks as schematically indicated in the enclosed drawing. Materials and other details of these valves shall meet the specified requirement.

General:

Note: The specification furnished above shall be considered as broad requirement. The Bidder shall consider compatible material and specification for all piping components as well as specialties for the corresponding service applications.

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6.22 Instrument Connections

Unless otherwise called for by Owner all thermo well stubs shall have an internal threading to M33 x 2.

All stubs for pressure or flow measurement for pipelines with a maximum working pressure equal to or above 42 bar(g) or with a maximum working temperature equal to or above 350°C shall be NPS 25 mm and double root valves shall be used.

Stubs, which are used for pressure or flow measurement on pipelines, with a maximum working pressure less than 42 bar (g) and a maximum working temperature less than 350°C shall be of NPS 15 mm size and single root valves can be used.

Measurement stubs on fuel oil lines shall be of NPS 25 mm size and provided with two root valves.

6.23 Drain and Vent Connections

Drain and vent connections on pipelines shall be at least of NPS 25 mm size. All systems having pressure greater than 6.2 MPA shall have double isolating valves on drain, vent lines and instrument connections. For pressure conditions other than as mentioned above single isolating valves are considered adequate. Where with single root valve, instrument and root valve are not accessible, double root valve shall be provided with one root valve near the tap off and the second root valve with instrument at accessible point. For fuel oil drain and vent lines double isolation valves shall be provided irrespective of the pressure and temperature.

6.24 Welding and Heat Treatment

All heat treatment, welding, post and pre weld temperatures shall be as per the code ASME B31.1.

6.25 Underground Protection

Where pipelines are buried, underground protection shall be provided for the piping system as indicated any one of the methods given below:

- i) Coal tar primer, coal tar enamel, inner wrap of fiber glass, final outer wrap of enamel impregnated fiber glass. Total thickness of coating shall not be less than 4.0 mm.
- ii) With anti-corrosive tape of 4 mm thick conforming to IS-10221 and AWWA C 203-93.
- iii) Pipe surfaces shall be cleaned by shot or sand blasting before application. Slag blasting may also be considered.
- iv) Tests to be carried out after application
- v) Bond/Adhesion test
- vi) Holiday test

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6.26 Non-Destructive Examination

Mandatory as per ASME B31.1 & Regulation 360(d) of IBR.

Special requirements:

- i) 100% UT/RT & MPI and 3% hardness testing on butt welds of P12, and P11 materials.
- ii) 100% UT/RT & MPI and 100% hardness testing on butt welds of P91, P92 and X20 materials .
- iii) 100% MPI on butt welds of carbon steel materials.
- iv) 100% UT/RT for fittings of 200NB & above for X20 & P91, P92 material.
- v) 100% UT/RT for fittings of all other piping of size OD 508mm & above.

6.27 Hydrostatic Test Pressure

- i) Piping system under IBR purview:
 - a) At Shop: All piping including fabricated piping shall be hydro tested at 1.5 times the design pressure subject to regulation 374 of IBR. However, non-destructive testing in lieu of hydro test is also acceptable subject to regulation 343 (3) of IBR
 - b) After Erection all piping systems shall be hydro tested at 1.5 times the design pressure subject to regulation of 374 IBR. However, for such systems where it is practically not possible to do hydro tests, the tests as called for in ANSI B31.1& IBR in lieu of hydro test shall also be acceptable.
- ii) Non-IBR Piping Systems:-
 - a) At Shop All piping including fabricated piping shall be hydro tested at 1.5 times the design pressure.
 - b) After Erection All piping systems shall be hydro tested at 1.5 times the design pressure. However, for such systems where it is practically not possible to do hydro tests, the tests as called for in ANSI B31.1 in lieu of hydro test shall also be acceptable.

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7 QUALITY ASSURANCE

7.1 Quality Assurance, Inspection & Testing

The Bidder shall adopt Quality Assurance Programmes as per relevant standards subject to Owner's approval, to ensure that the equipment and services under the scope of contract, whether manufactured or performed within the Bidder's works or at his sub-vendor's premises or at the Owner's site or at any other place of work, are in accordance with the specifications. Such programmes shall be outlined by the Bidder and shall be finally accepted by the Owner/Owner's authorized representative after discussions before the award of the contract. The QA programme shall be generally in line with IS/ISO-9001. The Quality Assurance Programme of the Bidder shall generally cover the following:

- i) Organization structure for the management and implementation of the proposed Quality Assurance Programme.
- ii) Quality System Manual.
- iii) Design Control System.
- iv) Documentation and Data Control System.
- v) Qualification data for Bidder's key personnel.
- vi) The procedure for purchase of materials, parts, components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
- vii) System for shop manufacturing and site erection controls including process, fabrication and assembly.
- viii) Control of non-conforming items and system for corrective actions and resolution of deviations.
- ix) Inspection and test procedure both for manufacture and field activities.
- x) Control of calibration and testing of measuring testing equipment.
- xi) System for Quality Audits.
- xii) System for identification and appraisal of inspection status.
- xiii) System for authorizing release of manufactured product to the Owner.
- xiv) System for handling, storage and delivery.
- xv) System for maintenance of records, and
- xvi) Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

7.2 General Requirements - Quality Assurance

- i) All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. This is, however, not intended to form a comprehensive programme as it is the Bidder's responsibility to draw up and implement such programme duly approved by the Owner. The

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detailed Quality Plans for manufacturing and field activities shall be drawn up by the Bidder and will be submitted to Owner for approval.

- ii) Manufacturing Quality Plan (MQP) will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Bidder's/ Sub-vendor's Quality Control Organization, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted to the Owner for review and approval.
- iii) Field Quality Plans (FQP) will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Bidder's "Site Quality Control Organization", during various stages of site activities starting from receipt of materials/equipment at site.
- iv) The Bidder indicate in the QP the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., These Quality Plans and reference documents/standards etc. will be subject to Owner's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Owner shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Owner or his authorized representative and beyond which the work will not proceed without consent of Owner in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to the Owner along with technical justification for approval and dispositioning.
- v) The material shall be dispatched from the manufacturer's works before the same is accepted by the Purchaser/Consultant.
- vi) All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.
- vii) The Bidder shall submit to the Owner Field Welding Schedule for field welding activities in the format enclosed at acceptable to owner. The field welding schedule shall be submitted to the Owner along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least *[ninety days]* before schedule start of erection work at site.
- viii) All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Owner.
- ix) The welding/brazing procedures shall be submitted to the Owner for approval prior to carrying out the welding/brazing.

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- x) All brazers, welders and welding operators employed on any part of the contract either in Bidder's/sub-vendor works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Owner.
- xi) Welding procedure qualification & Welder qualification test results shall be furnished to the Owner for approval. However, where required by the Owner, tests shall be conducted in presence of Owner/Owner's authorized representative.
- xii) For all pressure parts and high pressure piping welding, the latest applicable requirements of the IBR (Indian Boiler Regulations) shall also be essentially complied with. Similarly, any other statutory requirements for the equipment/systems shall also be complied with.
- xiii) On all back-gauged welds MPI/LPI shall be carried before seal welding.
- xiv) Unless otherwise proven and specifically agreed with the Owner, welding of dissimilar materials and high alloy materials shall be carried out at shop only.
- xv) No welding shall be carried out on cast iron components for fabrication or repair.
- xvi) All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.
- xvii) All non-destructive examination shall be performed in accordance with written procedures as per International Standards but qualified operator. NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.
- xviii) All plates of thickness above 40mm and all bars stock/Forging above 40mm dia shall be ultrasonically tested. For pressure parts, plate of thickness equal to or above 25mm shall be ultrasonically tested.
- xix) The Bidder shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-Bidders (BOI).
- xx) For components/equipment procured by the Bidders for the purpose of the contract, after obtaining the written approval of the Owner, the Bidder's purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-vendor shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the vendor's quality control organization, the relevant reference documents/ standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful vendors shall be finalized with the Owner.
- xxi) Owner reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Bidder's or their sub-vendor's quality management and control activities. The Bidder shall provide all necessary assistance to enable the Owner carry out such audit and surveillance. The Bidder shall also take requisite corrective measures for restoring/ improving the system in line with the outcome of such quality surveillance and audits.

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- xxii) The Bidder shall carry out an inspection and testing programme during manufacture in his work and that of his sub-vendor's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identity and acceptability of all materials, parts and equipment. Bidder shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.
- xxiii) Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Purchaser to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Bidder in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.
- xxiv) For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.
- xxv) Repair/rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Owner.
- xxvi) In case any deviation is observed with respect to relevant document or good engineering practices, and the same is considered by the Bidder to be acceptable, as it is or with certain rectifications/ modifications, based on his detailed technical analysis, then the Bidder shall refer the same to Owner along with reason for deviation, proposed corrective action, technical justification for suitability of the proposal and preventive measures for avoiding recurrence of similar deviations. Based on his evaluation, the Owner may accept the proposal as it is or with modifications or may reject the same. Such proposals shall be raised in suitable No-conformity report format (NCR). The NCR can be raised irrespective of the CHP stages in the QP.
- xxvii) Burn in and Elevated Temperature Test Requirement for Electronics Solid State Equipment:
- xxviii) All solid state electronic systems/equipment shall be tested as a complete system/equipment with all devices connected for a minimum of 168 hours (7 Days) continuously under energized conditions prior to shipment from manufacturing works, as per the following cycle.

Elevated Temperature Test Cycle

During the elevated temperature test which shall be for 48 hours of the total 168 hours of testing, the ambient temperature shall be maintained at **[50 °C]**. The equipment shall be interconnected with devices which will cause it to repeatedly perform all operations it is expected to perform in actual service with load on various components being equal to those which will be experienced in actual service.

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During the elevated temperature test the cubicle doors shall be closed (or shall be in the position same as they are supposed to be in the field) and inside temperature in the zone of highest heat dissipating components/modules shall be monitored. The temperature rise inside the cubicle should not exceed **[10 °C]** above the ambient temp at **[50 °C]**.

Burn in Test Cycle

The 48 hours elevated temperature test shall be followed by 120 hours of burn in test as above except that the temperature shall be reduced to the ambient temperature prevalent at that time.

During the above tests, the process I/O and other load on the system shall be simulated by simulated inputs and in the case of control systems; the process which is to be controlled shall also be simulated. Testing of individual components or modules alone shall not be acceptable.

In case the Bidder/ sub-vendor is having any alternate established procedure of eliminating infant mortality of components, the detail procedures followed by the Bidder/ sub- vendor along with the statistical figures to validate the alternate procedure may be submitted to the Owner for his consideration.

The Bidder/Sub-vendor shall carry out routine test on 100% item at Bidder/sub-vendor's works. The quantum of check/test for routine and acceptance test by Owner shall be generally as per criteria/sampling plan defined in referred standards. Wherever standards have not been mentioned quantum of check/test for routine / acceptance test shall be as agreed during detailed engineering stage.

7.3 QA Documentation Package

The Bidder shall submit the QA Documentation in **[two hard copies]** and **[two CD ROMs]**, as identified in respective quality plan with tick (√) mark.

Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Bidder/ sub-vendor and the same shall be submitted to the Owner in **[2 hard copies]** and **[2 CD-ROMs]**, within **[two weeks]** of dispatch of the equipment.

7.3.1 Typical contents of QA Documentation is as below:-

- i) Approved Quality Plan.
- ii) Material mill test reports on components as specified by the specification and approved Quality Plans.
- iii) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
- iv) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.

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- v) Heat Treatment Certificate/Record (Time-temperature Chart).
 - vi) All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).
 - vii) Inspection reports duly signed by the Inspector of the Owner and Bidder for the agreed Customer Hold Points.
 - viii) Certificate of Conformance (COC) wherever applicable.
- Similarly, the Bidder shall be required to submit *[two sets (two hard copies and two CD ROMs)]*, containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.

7.4 Inspection, Testing and Inspection Certificates

- i) The word 'Inspector' shall mean the Owner's Inspection engineer and/or Owner's authorized representative acting on behalf of the Owner to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- ii) The Owner's Inspection Engineer and/or Owner's authorized representative acting on behalf of the Owner shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Bidder shall obtain for the Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, permission to inspect as if the works were manufactured or assembled on the Bidder's own premises or works.
- iii) The Bidder shall give the Owner fifteen *[(15) days]* written notice of any material being ready for inspection/testing. Such tests shall be to the Bidder's account except for the expenses of the Inspector's. The Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within *[fifteen (15)]* days of the date on which the equipment is noticed as being ready for test/inspection failing which the Bidder may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the Purchaser duly certified copies of test reports in *[two (2) copies]* for his review and approval.
- iv) The Owner's Inspection Engineer and/or Owner's authorized representative acting on behalf of the Purchaser shall within *[fifteen (15) days]* from the date of inspection as defined herein give notice in writing to the Bidder, on any objection to any drawings and all or any equipment and workmanship which is in his opinion is not in accordance with the contract. The Bidder shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Owner's Inspection Engineer and/or Consultant's inspection agency acting on behalf of the Owner, giving reasons therein, that no modifications are necessary to comply with the contract. After due consideration, Owner may accept or reject the same.

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- v) When the factory tests have been completed satisfactorily at the Bidder's or sub-vendor's works, the Owner shall issue a certificate to this effect within **[fifteen (15)]** days of completion of tests. The completion of these tests or the issue of the certificates shall not bind the Owner to accept the equipment should it, on further tests after erection be found not to comply with the contract.
- vi) In all cases where the contract provides for tests whether at the premises or works of the Bidder or any sub-vendor, the Bidder, except where otherwise specified, shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Owner's Inspection Engineer and/or Owner's authorized representative acting on behalf of the Owner, to carry out effectively such tests on the equipment in accordance with the Contract and shall provide the facilities to accomplish testing.
- vii) The inspection by the Owner's Inspection Engineer and/or Owner's authorized representative acting on behalf of the Purchaser and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Bidder in respect of the contract.
- viii) To facilitate advance planning of inspection in addition to giving inspection notice, the Bidder shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.
- ix) All inspection, measuring and test equipment used by Bidder shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Bidder shall maintain all the relevant records of periodic calibration and instrument identification, and shall produce the same for inspection by Owner. Wherever asked specifically, the Bidder shall re-calibrate the measuring/test equipment in the presence of Owner's Inspection Engineer and/or Owner's authorized representative acting on behalf of the Purchaser.

7.5 Shop and Site Tests:

- i) Shop tests will include all tests to be carried out at Bidder's works, at works of his sub-vendor and at works where raw material supplied for manufacture of equipment is manufactured.
- ii) All materials will be of tested quality supported with correlated test certificates. Whenever tested quality material is specified and wherever called upon by Indian Boilers Regulations or by design code, the test pieces are to be prepared and tested to Owner's satisfaction. The results of the tests will be certified.
- iii) Shop and Site tests will include electrical, mechanical, performance and hydraulic tests in accordance with relevant IS, IBR or any other approved standard or any other tests called for by the Owner under these specifications to ensure that the plant being supplied fulfills the requirements of the specifications. For equipment not covered by any IS or other approved standards, the tests to

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be carried out will be in accordance with the quality plan to be agreed to between the Bidder and the Owner.

General Notes

- a. For IBR items, stamping on the components, inspection and certification will be carried out by the IBR as per the IBR procedures. However; the Bidder will also be identified the same to which project they are meant by stamping/ stenciling.
- b. For non IBR items inspection will be as per mutually agreed QAP. The QAP will be submitted for major items and will be finalized during detail engineering. Joint protocol and dispatch clearance will be based on the agreed QAP.
- c. Major items for which the QAP are to be furnished will be mutually discussed and agreed during detail engineering.
- d. For items/ components not covered in the QAP, Bidder will furnish the certificate of compliance.

7.6

Turbine

- i) The following shop tests will be conducted as applicable on the various components such as rotor, casings, blades, diaphragms, valves, pipes, flanges, etc. All such tests will be documented and forwarded to the Owner for his review.
 - a) Material analysis.
 - b) Boro-scope test.
 - c) Ultrasonic test.
 - d) Magnetic particle test for crack detection.
 - e) Radiographic test at welds.
 - f) Heat stability test.
 - g) Hydrostatic pressure test.
 - h) Resonant vibration tests.
 - i) Examination of threading tolerances etc.
 - j) Overall mechanical inspection.
 - k) Molybdenum content test on blades (moving).
- ii) After the shop assembly of the various components of the turbine, the following tests will be conducted at shop:-
 - a) Verification of fits and operating clearances and dimensions.
 - b) Test at 120% over speed for 2 minutes.
 - c) Tests for checking the proper operation of Governors, control valves and auxiliaries.
 - d) All motor driven oil pumps will be operated at normal speed and checked for proper alignment, smoothness in operation, head and capacity. Oil tanks will be tested at operating temperatures for leaks.
- iii) After completion of erection the following test will be conducted at site:

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- a) Running test with steam. Running test with steam will include but not be limited to:-
 - Barring gear operation
 - Steam turbine performance to be proved by running at operating speed and maintaining this speed for at least one hour.
 - Governor speeder range to be checked and recorded.
 - Trip and reset speed of emergency governor.
 - Operation of HP turbine stop valves and control valves and IP turbine stop valves and control valves to be checked for tripping.
 - All testing devices (Protective devices) to be checked for satisfactory operation.
- b) Tests for checking the proper operation of governors, control valves and auxiliaries.
- c) All motor driven oil pumps will be operated at normal speed and checked for proper alignment, smoothness in operation, head and capacity. Oil tanks will be tested at operating temperatures for leaks.
- d) Bearing and shaft vibration, shaft eccentricity, bearing oil pressure and return oil temperature will be recorded at increment of speed up to over speed.
- e) Certified copies of casing level records, rotor alignment checks including sling & concentric checks and alignments in cylinder, rotor clearance giving all axial, radial clearance between moving and fixed blades, glands etc. will be furnished.
- f) Tightening strains on high temperature bolts will be recorded.

7.7 Tests on Auxiliaries

The following shop tests will be conducted as applicable on the various auxiliaries:

- i) All the pressure vessels/heat exchangers will be tested at a hydrostatic test pressure of 1.5 times the maximum working pressure or 1.3 times the design pressure whichever is higher or as required by IBR.
- ii) Radiography tests at welds as per requirements of IBR as applicable.
- iii) Functional tests of equipment wherever applicable.
- iv) Overall mechanical inspection.
- v) Complete performance tests of all pumps to establish flow vs head, power input, efficiency and NPSH. Performance curves corrected for site condition will be provided.

7.8 Condenser

- i) All materials used for the manufacture of the equipment covered under this Specification will be of tested quality. Relevant test certificates will be made available to the Owner.

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- ii) All welded joints will be tested by liquid penetrant examinations according to the method outlined in ASME Boiler and Pressure Vessel code. Radiography and ultrasonic testing will be employed wherever necessary. At least 10% of all butt welding joints will be radiographed.
- iii) The water box and shell will be hydrostatically tested as per Heat Exchange Institute Standards. Gaskets will be replaced with new ones after shop test.
- iv) All condenser tubes will be hydraulically tested at [70.0] kg/cm² (g) internal pressure and carefully inspected (ultrasonically or by eddy current testing) as per ASTM E213-68 and ASTM E243-67T respectively prior to shipment. All other parts subjected to pressure will be hydrostatically tested as per relevant ASME Standard.
- v) The completely assembled condenser will be hydrostatically tested at site after erection, according to the standards of Heat Exchange Institute.
- vi) Condenser shell will be tested for tube leakage by filling the steam space with water in which a fluorescent will be added.
- vii) A field performance test will be conducted in conjunction with approved Acceptance Tests Procedure. It will be based on ASME Power Test Code PTC-12.2, or equivalent and include all tests necessary to demonstrate the performance guarantees.
- viii) Performance of the air removing equipment will be tested at the manufacturer's shop in accordance to the applicable ASME Power Test Code.
- ix) Condenser on load tube cleaning system will be tested for increase in pressure drop in cooling water system due to the installation of the same. The various controls provided will also be checked for satisfactory performance. Also, the recovery rate of the balls will be demonstrated at site.

7.9

L.P. & H.P. Heaters

- i) At Manufacturer's Works:
 - a) All heaters will be subjected to manufacturer's standard shop inspection and all inspection and tests called for elsewhere in this specification. Mill certificates for the material for heater shell, tube support plates, tube sheets, water boxes, flash tanks etc. will be submitted to the Owner for review.
 - b) Heat exchanger tubes and water boxes will be tested by one of the following methods for cracks, imperfections etc.
 - Black light
 - Magnetic particles
 - Dye penetrant
 - c) Each tube will be "Eddy Current" tested to detect any imperfection. The following tests will be performed on each lot of Heat Exchanger tubes.
 - Microscopic
 - Chemical Analysis

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- Yield strength
- Flattening
- Flanging

d) Hydrostatic testing of the heat exchangers will be done in accordance with ASME TEST CODE for unfired Pressure Vessels Section VIII and I.B.R. as applicable. The LPH-1 will be hydraulically tested at 1.3 times the design pressure.

ii) At site:

The feed water heat exchangers will be field tested along with the TG set as per applicable code to determine the following. :-

- a) Temperature rise of the feed water/condensate at guaranteed capacity points.
- b) Pressure drop in the water circuit.

The Bidder will furnish all instruments necessary to perform the above tests.

7.10

Deaerator

i) At Manufacturer's Works

Each deaerating heater and storage tank will be shop inspected during fabrication in accordance with applicable provisions of ASME "Code for unfired pressure vessel" Section VIII Div 1. Hydrostatic testing will be carried out as per the above code. Mill certificates for all the materials used will be submitted to the Owner's for review. However hydro test for FST will be conducted at site.

ii) At site

The Bidder will conduct field tests on the deaerating feed water heater. Tests will cover the determination of dissolved oxygen and free carbon dioxide in Deaerator outlet water along with thermal and hydraulic performance of the Deaerator.

All performance tests will be done and evaluated as per applicable code..

7.11

Condensate extraction Pump (CEP)

i) All tests will be conducted by the Bidder to demonstrate the capability, guarantees, performance and compliance with the specification. The Bidder will provide all instruments and temporary equipment including their installation for all test requirements. Prior to testing, the detailed test procedure will be submitted for the Owner's approval. After the test, the copies of final report including the performance calculations shall be submitted for Owner's approval. Following Tests shall be conducted.

ii) Tests at Shop

- a) Material analysis and testing.
- b) Radiographic and Magnetic Particle Examination of material and welds.

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- c) All pressure parts will be subjected to hydraulic testing at a pressure of 150% of shut-off head or 200% of rated head (effective head), whichever is higher, for a period not less than half an hour.
- d) Static and dynamic balancing tests of rotating parts at specified over speeds to determine the mass centre and vibration level.
- e) Performance tests are to be conducted to cover the entire range of operation of the pumps. These will be carried out in the range from 125% of rated capacity to pump shut-off condition. The tests will be conducted as per hydraulic institute standards of USA. Overall performance of the Pump will be tested for the following:
 - Total head developed by the pump at rated capacity.
 - Horsepower required of the pump under rated condition.
 - Efficiency at rated condition.
 - NPSH requirement at rated condition In any of the pump
 - To establish the pump characteristic curves for capacity Vs Head, power NSPH and efficiency.

iii) Tests at Site :

The pumps with its drives will operate satisfactorily at site for the whole range of rated operating condition as specified. The controls such as auto starting of pumps, speed, recirculation, etc. will also be tested for satisfactory performance. Parallel operation of pumps with different combinations will also be tested. During entire range of operation the vibration level will conform to VDI 2056.

7.12

Boiler Feed Pump & Booster pump of BFP

- i) All tests will be conducted by the Bidder to demonstrate the capability, guarantees, performance and compliance with the specification. The Bidder will provide all special instruments and temporary equipment including their installation for all test requirements and performance calculations and submit copies of final report for approval. Prior to testing the detailed test procedure will be submitted for the Owner's approval.
- ii) Tests at Shop
 - a) Material analysis and testing.
 - b) Hydrostatic pressure test of all pressure parts and piping at 1.5 times the maximum operating pressure at closed discharge valve.
 - c) Static and dynamic balancing tests of rotating parts at specified over speeds to determine the mass centre and vibration level.
 - d) Radiographic and Magnetic particle examination of material and welds.
 - e) Calibration tests of instruments.
 - f) Gear box testing at full load for transmission efficiency and smooth operation.

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- g) Overall performance of the boiler feed pumps and its booster pumps will be tested in accordance with ASME power test code PTC 8.2 latest edition or equivalent to obtain the following characteristics. At least one of the pumps BFPs will be tested with water at actual temperature.
- Total head developed by the pump at rated capacity.
 - Horsepower required of the pump under rated condition.
 - Efficiency at rated condition.
 - NPSH requirement for each pump at rated speed and temperature, over the entire operating flow range both for 1% and 3% head drop. NPSH testing shall be governed by ASME PTC and Hydraulic Institute Standards.
 - To establish the pump characteristic curves for capacity Vs Head, power NSPH and efficiency.
 - Gear box testing at full load for transmission efficiency and smooth operation. Noise level to be measured.
 - Hydraulic coupling speed vs. output and efficiency tests.
 - Vibration at bearings and noise level shall be checked during performance tests.
 - Tests for drive motors shall be as specified in the Standard specification for A.C. Electric Motors.

iii) Tests at Site :

The pumps with its drives will operate satisfactorily at site for the whole range of rated operating condition as specified. The controls such as auto starting of pumps, speed, recirculation, etc. will also be tested for satisfactory performance. Parallel operation of pumps with different combinations will also be tested. During entire range of operation the vibration level will conform to VDI 2056.

7.13 Other Major Pumps (More than 75 kW)

- i) Raw material for casing, shaft and impeller will be tested for chemical and physical properties.
- ii) All forgings and castings will be subjected to 100% UT/RT and MPI/DP check respectively.
- iii) Static and dynamic balancing of the rotary parts will be carried out.
- iv) Hydraulic pressure tests will be conducted on pumps casing.
- v) Interchangeability will be maintained and checked.
- vi) Each pump will be subjected to a performance test at the manufacturer's works as per the approved procedure.
- vii) Type Test:
 - a) NPSH test

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- b) Under voltage test
- c) Tests to establish unit functioning of pumps at temp. and pressure
- d) Hot standstill and start up tests
- viii) Routine Test:
 - a) Hydraulic test of complete unit
 - b) Over speed test
 - c) Pumps performance
 - d) Unit run at rated voltage
 - e) Cold start up test
 - f) Noise level

7.14 Minor Pumps & Fans (Less than 75 kW):

- i) Impeller and rotor will be dynamically balanced.
- ii) Pumps assemblies will subject to hydraulic test.
- iii) Functional test will be carried out at Manufacturer's works
- iv) Performance tests as applicable will be carried out on first pump/fan of each type and capacity to verify its output against total head, power input, efficiency, vibration, noise level. Capacity Vs Head, efficiency and power input curves corrected for site conditions will be furnished.

7.15 Turbine Oil Purification System

- i) Tests at Shop
 - a) The manufacturer will conduct all tests required to ensure that the equipment supplied will conform to the requirements of this specification and in compliance with the requirements of the applicable codes.
 - b) The test procedures for tests will be submitted to the Owner for approval before conducting the tests.
 - c) All materials and castings used for the equipment will be of tested quality. The test certificate will be made available to the purchaser for review.
 - d) The pressure parts of pumps, heaters, strainers etc. will be subjected to hydrostatic testing as per applicable codes.
 - e) All pumps will be tested for capacity, head, efficiency and brake horsepower. The tests will be performed in accordance with standards of 'Hydraulic Institute' USA.
 - f) Static and dynamic balance tests will be carried out on rotating parts of the centrifuge and pumps to determine vibration level.
- ii) Tests at site

Tests will be conducted at site to prove the performance requirement as specified.

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7.16 Acceptance Tests for STG

After erection of the TG equipment at site acceptance test will be conducted in accordance with ASME power test code PTC 6 or equivalent. A detailed test procedure will be prepared and submitted to the purchaser for approval at least [3 months] prior to testing. All instruments and accessories for the test will be arranged by the Bidder.

The tests will include but not limited to the following:

- (i) Maximum continuous electrical output, in MW, at Generator terminals of each unit at rated parameters under VWO Condition.
- (ii) Turbine Cycle Gross Heat rate in kCal/kWh at rated steam conditions at 76 mm Hg (abs) design condenser pressure with 3% make up at 100% TMCR load.
- (iii) Condenser Pressure with Unit Operating at VWO Condition.
- (iv) Unit Auxiliary Power Consumption at 100% TMCR unit load at condenser pressure of [76] mm Hg (abs)] with 3% make-up and with design ambient air condition.

Note: Power consumption of each of the pump/fan/compressors etc. wherever mentioned shall be measured with its own drive.

For performance guarantee test, Clause No. 8 of Section-I, Volume-II is also to be referred to.

7.17 Piping & Fittings:

- i) Raw materials for pipes are tested by UT/ECT at mill as follows
 - 100% ECT for thickness <3.6 mm
 - 100% UT for thickness ≥3.6 mm
- ii) All bent pipe will be checked for ovality and thinning by U.T. on first off and on random samples for subsequent pieces.
- iii) Butt welds will be subjected to NDT after stress relieving as follows

For IBR Class I piping

ID ≤ 102 mm: 10%RT

ID >102 mm: 100% RT

MT/ PT is carried out on butt welds after PWHT as follows

P91:100%

For Class II piping: 10% RT
- iv) All load bearing attachment welds will be subjected to MPI after stress relief.
- v) All forged/formed fittings will be checked by UT and / or MPI after forming as follows
- vi) MPI on the parting lines of tees and alloy steel elbows and UT on tees of bore size 508 mm and above.
- vii) Completed pipe work will be subjected to hydraulic pressure test at site.

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7.18 Valves

- i) Pressure retaining parts of valves will be subjected to NDT as per the table given below:

Table: 7.1

Valve Size NB in mm	ANSI class up to 300	ANSI class above 300 up to 600	ANSI class above 600 below 900	ANSI class 900 & above & below 4500
Less than 50	Visual	Visual	Visual	MPI
50 & above but below 100	Visual	Visual	MPI	MPI , RT (on 10% of valves on 100% area)
100 & above but less than 300	Visual	MPI	MPI RT(on 10% of valves on change of section and weld ends)	MPI, RT (on 100% area)
300 and above	MPI	MPI	MPI, RT (on change of sections and weld ends)	MPI, RT (on 100% area)

NOTE: For body and bonnet forgings UT may be adopted in place of RT. for austenitic steel MPI may be replaced by LPI.

- ii) Bar stock/forging above 50 mm diameter for valve trim will be subjected to UT.
- iii) Hardened / stellitted valve disc and seat are to be subjected to LPI and hardness check.
- iv) Colour matching of valve disc / plug and seat will be carried out to ensure contact.
- v) Hydraulic pressure tests and seat leak test will be carried out as per ANSI 16.34.
- vi) Air seat leak test will be carried out as per applicable standards/codes.
- vii) Functional testing will be carried out on each valve to check the following as per the approved valve data sheet:
- smooth operation

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- valve travel, closing and opening time
 - current drawn by actuators
- viii) Spring for safety valves will be tested with suitable NDT and for spring rate.
- ix) Safety and safety relief valves will be tested for performance.
- x) Weld preparations on suction and discharge side of the valves will be examined as per relevant code as applicable.

7.19 Heat Exchangers

- i) Tested quality materials will be used for tubes, shell and tube plate etc. for heat exchanger. Welds on pressure parts will be tested with non-destructive testing like RT/UT.
- ii) For Plate heat exchangers, at least 10% plates will be randomly tested by dye-penetrant test.

7.20 Lube Oil Systems / Hydraulic Power Pack

Lube oil system / hydraulic power packs will be tested for performance.

7.21 Motors

Motors will be subjected to the routine and type tests as indicated in Electrical Part of the Tender Specification

7.22 Control & Instrumentation:

C&I inspection and testing will be done as indicated in C&I Part of the Tender Specification

7.23 Site Tests

The successful Bidder will prepare and submit detailed quality plans in the format prescribed by Owner setting out the quality practice and procedures to be adopted by him for assuring quality for each equipment under this specification from the receipt of material at site, during storage, erection, pre-commissioning to final commissioning of the plant. These procedures will necessarily include all checks/tests conducted at site for preservation, assembly, alignment, positioning of the equipment, foundation preparation, welding/bolting, heat treatment, non-destructive examination, hydraulic test, running test, performance test etc. The above will be discussed and finalized by the Bidder with the Owner.

The Bidder will also furnish detailed quality procedure proposed by him for storage, preservation, painting, acid cleaning, alkali boil out, steam blowing, hydraulic test, air/gas tightness test etc. to the Owner. The same will be discussed and finalized by the Bidder with the Owner.

7.24 System Checking / Reliability Trials:

- i) Successful Bidder will carry out tests at site to prove to the Owner that each equipment of the supply complies with requirements stipulated and is erected in accordance with requirements specified. Before the plant is put into trial

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operation the Successful Bidder will be required to conduct tests to demonstrate to the Owner that each item of the plant is capable of correctly performing the functions for which it was specified and its performance, parameters etc. are as per the specified/approved values. These tests may be conducted concurrently with those required under commissioning sequence.

- ii) The tests required will specifically include the following :
- Checks on operation of all fans to ascertain level of noise and vibration.
 - Test running of pumps
 - Calibration test of orifice, flow nozzles, instruments and control equipment to the extent included in these specifications.
 - Tests on C&I Equipment - The Bidder will demonstrate the performance of all C&I equipment.
- iii) The plant after completion of the above test will be put on trial run.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBOGENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-II, PART-B, DETAILED TECHNICAL
SPECIFICATION- ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
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MASTER INDEX (ALL VOLUMES)

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TURBO GENERATOR & AUXILIARIES (PACKAGE NUMBER: R&M-SP-02)

VOLUME-II, SECTION-II, PART-B DETAILED TECHNICAL SPECIFICATION- ELECTRICAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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1. GENERATOR & AUXILIARIES**1.1 General**

This specification is intended to cover the *[design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of Generator complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]. The renovated Turbo Generator shall be capable of producing the output of [210/215/220/250] MW.

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code	Name of Standard
IS 3231	Electrical relays for power system protection
IS 8686	Specification for static protective relays
IS: 13947	Degree of Protection
IEC 60034	Rotating Electrical Machines
IEEE:32	Neutral Grounding Devices
IEEE-STD-4298	Standard for high potential test requirement for excitation system for synchronous machines
IEEE-STD-67	Guide for operation, maintenance of turbine generator
IEEE-STD-1115	Guide for testing synchronous machines
C37.102-1995 (R2001)	IEEE Guide for AC Generator Protection
C37.91-2000	IEEE Guide for Protective Relay Applications to Power Transformers
C37.101-1993 (R2000)	IEEE Guide for Generator Ground Protection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) For the purpose of design of equipment/systems, an ambient temperature of [50] deg. Centigrade and relative humidity of [95%] shall be considered. The equipment shall operate in a highly polluted environment.
- b) All equipments are suitable for rated frequency of 50Hz with a variation of [+3% & -5%] and [5%] combined variation of voltage and frequency unless specifically brought out in the specification.
- c) Bidder to provide fully compatible electrical system, equipment, accessories and services.
- d) Paint shade of Generator shall be as per Turbine and shall be finalized during engineering.
- e) Excitation system shall be either of static or brushless and same shall be finalized during detail engineering.
- f) Rated voltage of generator shall be selected in such a way that it should match with existing generator voltage.
- g) Efficiency of generator shall be greater than 98%.

1.4 Specific Requirements

1.4.1 Type and Rating

- a) Type: Three phases, horizontal mounted, indoor installed, two-pole cylindrical rotor type directly driven by steam turbine, class F winding insulation with completely H₂ cooled or Hydrogen cooled rotor and stator core, DM water cooled stator winding.
- b) Generator and its excitation system will have a capability at least matching the declared maximum continuous rated output of the associated steam turbine (for the hydrogen cooler, the secondary cooling water temperature of [39] deg C) at all power factors between 0.85 lagging and 0.95 leading with [+3% to -5%] frequency variation, terminal voltage variation of $\pm 5\%$ and combined voltage & frequency variation of [5] %. It is ensured that when the Generator is working at this capability and cooling water temperature is [39] deg C, no part of the Generator will attain a temperature in excess of the class-B temperature limits as per IEC-60034.
- c) The generator and its excitation system will be capable of continuous

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stable operation at the peak output of the associated steam turbine under VWO & HP heater out condition, etc. as available for secondary cooling water temperature [39] deg, at power factors 0.85 lagging with [+3% to -5%] frequency variation, terminal voltage variation of $\pm 5\%$ and combined voltage & frequency variation of [5] % absolute. *[Temperature of different parts may exceed those permissible for class B under such operating conditions, but shall be lower than those permissible for class F insulation as per IEC-60034].*

d) Rated Parameters:

General	
1. Active output	[210/215/220/250MW or as per plant requirement } per unit
2. Apparent output	[247/253/259/294 or as per plant requirement]/MVA
3. Power Factor	[0.85] (lagging)
4. Terminal voltage	[as per plant requirement] KV
5. Frequency	50 Hz
6. Speed	3000 rpm
7. Short circuit ratio	As per existing plant data or mutually agreed between purchaser and manufacturer.
System of cooling	
8. Stator winding	Closed loop system using demineralised water flowing through the hollow conductors.
9. Rotor winding	Directly cooled by hydrogen
10. Stator core	By hydrogen flowing through suitable ventilating ducts.
11. Configuration for Hydrogen	Shaft driven Hydrogen blower. Machine Cooling mounted Hydrogen to water heat exchanger. Secondary cooling water details as indicated elsewhere in technical specification.
12. Capacity with one Hydrogen Cooler out	Capable of delivering at least two third of the rated MVA with ten (10) percent of tubes in each cooler plugged without exceeding the temperature limits of Class B

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e) Operational Requirements

1	Voltage Variation	$\pm 5\%$ continuously at rated power factor.
2	Frequency Variation	The generator will be capable of continuous operation, at the range of $[-5\%$ to $+3\%$ i.e. [47.5 HZ to 51.5] Hz.
3	Combined voltage and frequency variation	[5%]
4	Power factor variation	0.85 (lag) to 0.95 (lead)
5	Generator Neutral Earthing	Non-effectively earthed through a distribution transformer, loaded with a resistor. Core design to permit the flow of earth fault current for at least [15] amperes for one second without any major core damage.
6	Short time overload	As specified in IEC 60034-1
7	Over speed	10%
8	Operation under unbalanced load	As specified in IEC 60034-1
9	Operation under unsymmetrical short circuit	Negative sequence current I_2 expressed in per unit of rated current for a duration of 't' second such that the value of $I_2^2 t$ comply to IEC 60034-1
10	Voltage Wave form	The telephone harmonic factor (T.H.F) is within the limit specified in IEC 60034-1.
11	Short Circuit withstanding Capacity as specified in IEC 34-3	Capable of withstanding of 3 phase short circuit at the generator terminals when operating at rated MVA and power factor with 5 % over voltage for a period of not less than 3 seconds.
12	Special operating conditions	Capable of withstanding the electrical,

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		mechanical and thermal stresses developed during i) Single-phase fast reclosing of high voltage line, transmission line switching faults, ii) Out of step operation, as per the operation curve furnished by Manufacturer. iii) Out of phase synchronization permissible times:
13	Line Charging Capability	Not less than 40% of its rated MVA at zero PF
14	Impulse level & Surge Protection	To be suitable for test voltage of $4U + 5$ KV (where U is rated voltage in kV).
15	Stator over current requirement	Machines shall be able to carry stator over current without damage, of the order of 1.5 p.u for 30 secs
16	Degree of Protection	IP54
17	Maximum continuous negative phase sequence current	8%

1.5 Constructional Features

All components of the generator will be designed to avoid resonance at any of the frequency in the operating range and their multiples. All components requiring inspection and maintenance shall be designed for easy access and replacement.

1.5.1 Stator

1. Stator frame To withstand without any residual deformation, in case of any internal hydrogen explosion. All leads including power, control and instrumentation will be brought out of the generator through gas tight seals.

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2. Handling

Considering the non-availability of suitable crane for lifting the stator, suitable jacks are to be provided for the same. Four numbers of trunions also to be provided for handling the stator. Contractor may detail out his proposal for handling the stator.

3. Transportation

The dimensions of the generator stator body to be within the maximum permissible rail/road transportation dimensions within the country taking into account special wagons available/being made available for transporting such heavy oversize consignment.

4. Manholes

At suitable locations with proper sealing arrangement etc. to facilitate the inspection of back of the core, end winding area and terminal connections.

1.5.2 Stator Core

1. Material

High permeability, low loss, cold rolled silicon sheet steel segmental punching

2. Core assembly

Assemble on core bars in an interleaved manner, To rest on flexible support system such that radial and tangential magnetic vibration of the stator core due to electromagnetic loading transmitted to the outer frame is minimum

3. End packets:

To be adequately strengthened to minimize the magnetic vibration due to end leakage flux.

1.5.3 Stator Winding

1. Winding Configuration

The stator winding will consist of three phase, double layer, short chorded, bar type winding having two parallel paths. The elementary conductors are Roebel transposed in the slot portion.

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2. Insulation Epoxy thermo-setting type and rated for class 'F' insulation. Adequate protection will be provided on the winding and slots for avoiding the corona and other surface discharges.
3. Ripple springs To be provided in stator slots.

1.5.4 Stator water Distillate Headers (manifold)

1. Inlet and outlet water headers Preferably of stainless steel
2. Insulation The headers and header connections will be suitably insulated from the stator body. It is possible to measure the insulation resistance of the stator winding after simply removing the outside water pipe connection. It is also possible to measure the insulation resistance between the water header and stator body after disconnecting the header grounding.
3. Connection of bars High quality heat resistant and high strength teflon (P.T.F.E) hoses. Single pass cooling arrangement will be preferred.

1.5.5 Winding Connection and Terminal Bushings

1. Winding Star connected, Three (3) phase and the three (3) neutral terminals. In case the stator winding is double-star, a machine with six (6) terminals will be acceptable. All stator terminal lead connections inside the generator will be suitably supported to contain vibration.
2. Overhang portion of winding The overhang portion of the winding will be suitably braced and supported so as to withstand - 3 phase short circuit at its terminals as stipulated in IEC-34 when the machine is operating at rated MVA, power factor and permissible maximum over voltage (105% of rated voltage).
3. Bushing housing Bushing to be housed in lower part of stator frame in a non magnetic steel terminal box.

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4. Bushing
Porcelain or epoxy based material with non-hygroscopic property. The terminal bushing is cooled by suitable arrangement with cooling water
5. Terminal connector
Silver coated copper having octagonal configuration or any other configuration suitable for connection to the bus duct through flexible for which the operating conductor temperature is 105deg C

1.5.6 Rotor

Machined from single alloy steel forging to give the required mechanical, metallurgical and magnetic characteristics. To have an adequate margin between critical speed and the running speed to ensure smooth running.

1. Rotor Winding

- a) Conductor
Coils made of hard drawn silver bearing copper.
- b) Insulation
Epoxy glass based material rated for class F insulation.

2. Retaining Rings and Nuts

- a) Retaining rings
Machined from high strength, non-magnetic alloy steel forging, with the material specification 18Mn-18Cr resistant to stress corrosion. Floating type shrunk on the rotor body.
- b) Snap rings
High strength non-magnetic alloy steel forging will be provided on the retaining rings to prevent any axial movement.
- c) Centering rings
To be mounted at the end of the retaining rings to support it and prevent the movement of rotor winding in the axial direction due to thermal stresses.

1.5.7 Bearings

Self aligning type bearings mounted on the end shields. The bearing housings as well as bearing shells will be of split construction. The bearing shells will be lined with Tin based Babbitt metal.

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- a) Seal Labyrinth oil seal for bearing will be provided.
- b) Jacking Arrangement The hydrostatic jacking arrangement in line with turbine bearings
- c) Bearing insulation The bearings are insulated from the generator ground to prevent current flow through the bearing. At the collector end, these components are double insulation. With this arrangement, the insulation of generator bearing can be monitored during generator operation. Insulating material used for the purpose will be non-hygroscopic epoxy glass laminate.
- d) Bearing instrumentation Redundant pick-ups/ transducers for bearing metal temperature and bearing drain oil temperature shall be supplied.

1.5.8 Shaft Seals

- a) Type Double flow ring type, to be provided at both ends and designed in such a way that minimum oil comes in contact with hydrogen during operation to minimize contamination.
- b) Gland sealing ring The inner surface of the gland seal ring will be lined with babbitt metal.
- c) Insulation The shaft seals and associated piping will be adequately insulated to prevent circulation of shaft current.

1.5.9 Collector rings, Brush gears and Brushes

- a) Enclosure For static excitation system, a suitable brush holding arrangement with brush assembly, in a well ventilated enclosure will be provided.
- b) Collector rings Insulated helically grooved, alloy steel collector rings shrunk on the rotor, For cooling the slip rings, , suitable fans will be provided on the rotor shaft adjacent to it.

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|--|--|
| c) Brush position | Located on the upper two third periphery of collector rings. The brushes will be arranged along the length of collector ring to avoid any non-uniform ring wear. |
| d) Access doors and Inspection windows | To be provided to enable replacement and inspection of brushes while the machine is in operation |
| e) Brush holder | Constant pressure type which can be adjusted as per requirement. Suitable insulation will be provided to prevent passage of current through pressure device. |
| f) Rotor winding Insulation and Voltage monitoring shaft | Through a brush, suitably mounted and sliding on an oil free surface shall be provided. |
| g) Earthing brushes | To be provided at the turbine end bearing pedestal. It shall be possible to increase the brush pressure while generator is working. |

1.5.10 Hydrogen Coolers

To be provided with 10% excess tubes. Cooler will be designed for at least 10 Kg/sq.cm. Gauge pressure on the gas side irrespective of a lower normal operating casing pressure.

- | | |
|-------------------------------|---|
| a) Cooler tubes | Corrosion resistant with integral fins and arranged on the top of the stator frame, a tray under cooler avoid water fall during leakage, if any, on the winding insulation |
| b) Water pressure in coolers: | It will be maintained below the operating hydrogen pressure in the generator frame |
| c) Temperature control | Necessary control system including temperature sensing elements, control valves and devices will be provided. Adequate number of temperature and pressure gauges will also be provided on inlet and outlet of cooling water, in case water cooled machine is offered. |

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1.5.11 Generator drying arrangement

The drying arrangement shall be provided as per standard & proven practice of manufacturer/supplier.

1.5.12 Generator Instrumentation

The following minimum instruments will be provided for each generator.

I. Resistance temperature detectors (RTD)

a) Temperature Detectors

Resistance temperature detectors (RTD) To be duplex three wire type 100 ohms platinum, calibrated as per DIN standard or other equal international standard and located at points where highest temperature is likely to occur during operation. Manufacturer may also offer thermo-couple (TC) or duplex RTDs. In case simplex RTDs are provided they will be double of those specified as below. All the below thermocouples detector, the thermocouple is simple type detector, Pt100 R.T.D is duplex type.

b) Number and location

i) {Forty-two (42)} duplex PT100 RTDs:

1. 4 numbers of RTDs for each phase of stator winding.
2. 12 numbers of RTDs for stator core.
3. 2 numbers of RTDs for each gas section.
4. 2 numbers of RTDs for each H2 section
5. 2 numbers of RTDs for each bearing.

Detectors for monitoring water temperature of each winding bar in case of water cooled machine. One thermo-couple is installed at each water outlet of stator bar.

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- ii) {Twenty-four(24)} detectors for stator core out of which {sixteen (16) }will be located in the end zones where maximum temperatures are expected.
- iii) Two (2) duplex detectors per gas cooler section for measurement of inlet and outlet gas temperature.
- iv) Two (2) duplex detectors per H2 cooler section for measurement of inlet and outlet water temperature.
- v) Two (2) detectors per bearing for measurement of babbitt metal and drain oil temperature.
- vi) Sets of detectors for generator shaft sealing, Hydrogen gas and stator water systems required for monitoring the temperature of oil, water and Hydrogen at different salient locations in the system.

- c) Termination of RTD leads At terminal box
- d) Location Terminal box will be at an easily accessible position so as to enable maintenance/testing of the devices when the machine is under operation.
- e) Terminal box construction Dust and vermin proof (IP54)
- f) Interface All the above temperature measurement devices shall be connected to Junction boxes mounted on generator.

II. Rotor winding Temperature Monitoring

Rotor winding temperature shall be calculated by rotor current in the excitation system. Once the calculated rotor temperature is higher than the alarm temperature, the excitation system shall send alarm signal to the DDCMIS.

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III. On line water temperature monitoring for Individual stator winding bars

Complete with all software and hardware required to detect any abnormalities in the temperature at any given generator operating point and shall be sensitive to generator loads, header flows, pressure, etc. This shall be realised in TG C&I part of DDCMIS.

IV. Vibration monitoring System

Manufacturer informed that their end winding design is of rigid flex structure of cone type and in view of this they do not provided vibration sensors and monitoring system in the end winding.

V. Liquid leakage detector

It will be provided at all the low level points inside the generator frame including end shields along with provisions of indication and alarm during leakage of liquid in generator in case of water cooled machine.

1.5.13 Gas System (For Hydrogen & Water Cooled Machines)

1) Description

Each generator will be furnished with hydrogen and carbon dioxide supply system including hydrogen and CO₂ gas manifold, CO₂ heating system, hydrogen pressure regulator, interconnecting piping, fittings, valves, gauges, thermometers, pressure transmitters and other instruments, panels, etc.

Contractor may indicate the number of cylinders during detail engineering with supporting calculation. Cylinders will be supplied till completion of trial operation getting necessary approval from chief controller of explosives is also in the scope of the Contractor. The contractor will also furnish the necessary test certificates and filling certificates. The cylinders to be supplied under this specification will conform to IS: 8198. Each gas cylinder will be complete with cap and valve as per IS: 3224. Volumetric (water) capacity of each cylinder will be 45.0 litres. Each cylinder will be hydro tested at pressure of 250 Kg/cm² (min).

2) Purity

Purity of hydrogen is from 97 - 99%.

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- 3) Piping & Valves Seamless steel tubes will be used for valve piping. Valves are of Bellows blocking type, wherever possible.
- 4) Purging During purging, filling and emergency operating conditions, the gases will be expelled to the atmosphere (outside the TG hall) through a manually operated vent valve.
- 5) Hydrogen Safety relief valve to be provided at hydrogen manifold
- 6) Driers 2x100% duty to maintain the hydrogen inside the machine dry with zero deg C dew point at operating pressure.
- Type: Refrigeration type Gas circulation at Standstill
- To run the gas system for short time shut down of generator for which gas circulation arrangement through drier with blower, piping valves and accessories along with required control equipment shall be provided. However Bidder's standard and proven system of generator drying arrangement at standstill is also acceptable. A suitable hot air blowing system complete with blower, heater and thermostatic control etc. will be provided to prevent condensation during long shut down.
- 7) Valve interlocking Three way valve used along with the drier for interconnecting the hydrogen and air line (as applicable) preferably have mechanical interlocking such that closing of the hydrogen side port is positively ensured before opening of the air side port.
- 8) Online dew point measurement On line dew point monitoring system will be provided across the inlet and outlet lines to the drying system along with alarm/annunciation in case of high moisture content in the generator casing hydrogen.
- 9) Nitrogen capping During the transportation and storage the machine will be kept under nitrogen atmosphere. Manufacturer informed that as per their standard and proven design nitrogen capping is not required in stator water tank

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10) Gas Analyzer

Thermal conductivity type and continuously analyses the gas discharged from casing during purging and will also analyses samples of the casing hydrogen during normal operation. The analyzer will measure the gas purity under the following three Conditions

- a). Normal % of purity of Hydrogen in air in the generator casing. Purity range will include a low purity alarm.
- b). % of Hydrogen in CO₂ leaving the casing when Hydrogen is being admitted expelled.
- c). % of air in CO₂ leaving the casing when CO₂ is being admitted or expelled.

11) The local control panel will be complete with all switches, lamps, indicators, power Supplies etc. Further following instruments will be provided.

- i) Pressure indicator for the pressure of hydrogen in the hydrogen manifold.
- ii) Dial type thermometer for CO₂ vaporizer and gas drier,
- iii) Gas flow meter
- iii) Pressure guage for hydrogen gas cylinder pressure.
- ii) Pressure indicator / local gauge for gas pressure inside the generator.
- iii) Gas purity indicator.
- iv) Temperature indicator for hot and cold hydrogen inside casing.
- v) Dew point indicator for casing hydrogen across drier inlet and outlet lines

12) Alarms in TG MMI and annunciation contacts for use in station DDCMIS will be provided for these conditions (List is indicative only)

- i). Hydrogen pressure in generator casing Low/High.
- ii). Pressure of cooling water hydrogen coolers Low/High.
- iii). Purity of hydrogen in generator casing-Low.
- iv). Liquid level in the generator casing - High.
- v). Temperature of cold/hot gas in the generator - High.

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vi). Dew point level, in hydrogen gas across the drier inlet and outlet lines High.

vii). Hydrogen leakage into cooling water.

14) Portable gas analyzer Similar as detailed above under clause "Gas Analyser" will be provided for supervision of the gas purging operation

15) Hydrogen pressure and purity to be monitored and annunciated in TG MMI.

1.5.14 Seal Oil System (For H2 / Water Cooled Machines)

- | | |
|-----------------------------|--|
| a). General | A complete seal oil supply and control system including AC and DC motor operated pump sets, cooler, filters, pressure regulators, oil tanks, de-gassification tanks, regulating and control valves, gauges, thermometers and other instruments, interconnecting piping including hangers and supports, valves and control panel complete with all interlocking relays will be provided. Blowers for venting out Hydrogen gas liberated from oil will be provided suitably mounted at places where such gas accumulation is likely to occur |
| b). Number of pumps | 2X100% AC motor driven pump. 1 no DC motor driven pump. |
| c). Pump starting interlock | The auto starting of standby seal oil pumps shall be interlocked with seal oil pressure. |
| d). Emergency condition | During short time emergency which may arise due to non availability of both AC & DC pumps, unit may be tripped and seal oil supply for such coasting down period will be from a suitable arrangement from lubrication oil system |
| e) Pipes | Carbon steel seamless piping shall be used in the system. |

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- f). Seal oil pressure The seal oil pressure will be maintained at a pressure suitably in excess of the generator casing hydrogen pressure. The differential pressure is kept constant, once set at the time of commissioning, at all hydrogen pressures and all regimes of generator operation. The pressure regulator or the regulating valve used for the purpose is adjustable type. The seal oil system will be so designed that it is possible to run the machine at no load in air medium at a slightly positive air pressure without any modification in the system.
- g). Oil level gauge To be provided in the different tanks. To give alarm/annunciation for high and low levels, switches will be fitted in the tank and adequate contacts will be provided for annunciation. Necessary hydraulic sealing arrangement will be provided in H2 side oil discharge line to prevent circulation of gas due to any possible difference of heads developed by fans mounted at the end of the generator rotor.
- h). Coolers Two (2) number 100% duty seal oil coolers along with necessary valves for isolating or bringing one cooler in service, will be provided. These coolers are shell and tube type suitable for using D.M. water of condensate quality.
- i) Cooler tube redundancy Seal oil coolers will be designed to have 15% excess tube surface area over and above designed tube surface area required for the rated load conditions while maintaining the design pressure drop on cooling water side.
- j) Water pressure The oil pressure in the cooler is greater than water pressure under all operating conditions.
- k). Filters Suitable filters of 2x100% duty will be provided. It is possible to carry out cleaning and maintenance of any cooler and filter when the machine is in operation.
- l). Temperature/Flow measurements Temperature gauges and flow meters will be provided at all appropriate locations
- m). Pressure gauges and

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switches

Pressure gauges and switches will be provided at least at the following locations

- i). At the inlet and outlet of pumps.
- ii). At the outlet of the cooler.
- iii). At the inlet and outlet of the pressure regulators and filters.
- iv). At the oil supply header.

n). Control

The system is controlled as part of turbine control system at CCR. In addition to the remote control and monitoring, local control and monitoring for this system are realised in the local panel mounted near these systems as per Manufacturer's standard. At least the following instruments will be provided on the local panel :

- Indicators for seal oil pressure at the seal (for both hydrogen and air side stream).
- Indicators for seal oil-hydrogen differential pressure.
- Indicators for temp. of seal oil at the seals.
- Indicators for thrust oil pressure.
- Seal oil pump discharge pressure
- Control & status indications for seal oil pumps
- Seal oil tank oil level indication
- Seal oil flow meter
- Seal oil filter-choked
- Seal oil cooler water pressure-High/Low
- Seal oil cooler water temperature-High/Low"

o). Alarms in TG MMI & Annunciation contacts for use in station DDCMIS will be provided for these conditions.(List is indicative only)

- 1 Pressure of seal oil-Low.
- 2 Pressure of thrust oil-Low will be provided for these conditions
- 3 Oil level in damper tank-Low (if applicable)
- 4 Oil level in damper tank-(if applicable Emergency)
- 5 Automatic switching on of AC standby oil pump.
- 6 Automatic switching on of DC emergency oil pump.

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- 7 Differential pressure between oil and hydrogen-Low.
- 8 AC seal oil motor power supply failure.
- 9 DC seal oil motor power supply failure.
- 10 AC/DC seal oil motor control faulty
- 11 Seal oil temperature -high.
- 12 Seal oil pump discharge pressure
- 13 Control & status indications for seal oil pumps
- 14 Seal oil tank oil level indication
- 15 Seal oil flow meter
- 16 Seal oil filter-choked
- 17 Seal oil cooler water pressure-High/Low
- 18 Seal oil cooler water temperature-High/Low"

1.5.15 Generator synchronization panel

- a) Synchroscope panel with synchroscope, running and incoming voltmeters and frequency meters and indicating lights shall be provided.
- b) Synchronizing shall be possible through Manual or Auto mode. In manual mode, the synchronizing shall be done using synchroscope and synchrocheck relay. In Auto mode, the synchronizing shall be via the synchronizer which shall adjust the frequency and voltage at the generator terminal to match with that of the grid.

1.5.16 Generator Neutral Grounding

- a) The transformer and resistor shall be located in cubicles/compartments adjacent to each other. The cubicles shall have hinged access doors capable of being pad locked. The Neutral Grounding Transformer and resistor shall be of required rating and rated for 1 minutes duty. Rating for continuous duty shall also be indicated.
- b) The transformer cubicle shall be made of angle frame steel construction with formed sheet sides. The resistor cubicle shall be made of angle frame steel construction with hot dip galvanized screen sides. Alternatively it can be painted with heat resistant paint suitable for 250 deg. C. Neutral grounding equipment shall be completely assembled, wired and connected to the neutral bus tap through seal-off bushings.

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- c) The neutral grounding transformer shall be cast epoxy resin type natural air-cooled single phase connected between generator neutral and ground.
- d) The loading resistor shall be formed of non-aging, corrosion resistant punched stainless steel grid element provided with necessary insulation and designed for indoor service for a temperature rise not exceeding 300 deg. C.
- e) All alarm, protection and indication leads shall be wired up to terminal blocks that shall be mounted in a IP: 52 enclosure suitable for flush mounting and having a fully hinged cover with lock.

1.5.17 Generator Disturbance Recorder (DR)

- a) One no. microprocessor based Disturbance Recorder (DR) shall be provided for each generator to record graphic form of instantaneous values of voltage and current in all three phases and neutral, open and closed positions of relay contacts and breaker during disturbances.
- b) It shall have the facility for slow and fast scan to record transient and dynamic performance of the system.
- c) Both slow and fast scan facility shall have atleast 8 analog and 16 digital inputs.
- d) The slow scan facility shall be provide with the following minimum features:
 - The input shall be MW, MVAR, field voltage, frequency and generator terminal voltage etc. Any transducers, if required for interfacing, shall be provided.
 - It shall be suitable to record the frequency excursions and response of generator field and governor control on system fluctuations.
 - It shall have options to select the scan rate in the range having a min. of 10Hz suitable to facilitate capture of low frequency waveforms in the range of 0.5 - 3Hz.
 - The non-volatile memory shall be suitable for recording for a minimum of 15minute at scan rate corresponding to selected pre-fault zone of recording.
- e) The fast scan facility shall be provide with the following minimum features:
 - The input shall be voltages and current etc. Any transducers, if required for interfacing, shall be provided.
 - It shall have scan rate of 1000Hz or better for sampling each of the analog channel having fundamental frequency of 50Hz. The frequency response for these channels shall be DC on the lower side to 500Hz or better on the upper side. Any interposing devices provided shall be suitable for this frequency response.

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- The pre and post fault recording time shall be at least 200 ms and 5s respectively.
- f) All external and internal faults in the DR equipment such as power supply fail, printer faults, paper exhausting, processor failure, memory failure etc. are to be indicated by means of light emitting diodes on the front of the panel of restitution unit. The DR shall be provided with a MMI (man machine interface) through a PC with VDU, keyboard and printer.
- g) The internal clock of the system shall be synchronized through the GPS. The output shall be in IEEE/ COMTRADE format. The format shall be compatible for dynamic protection Relay Test Kit Necessary interfacing and software for analysis shall also be provided.
- h) The amplitude resolution of the analog channels shall not be less than 16 bit and event resolution for digital channels shall be 1ms or better.

1.5.18 Stator Water Cooling System

Cooling will be provided with a closed loop stator water cooling system. The system generally includes but not be limited to the following.

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|----------------------|---|
| a) Stator water tank | One (1) number to be provided. Bidder shall indicate and provide devices to detect, trap, monitor and release the hydrogen that leaks in to the stator water cooling system, to a safe place outside the building through suitable safety valves. |
| b) Make up water | Make-up water for primary water system is tapped off from condensate extraction pump discharge header (before and after the condensate polisher) and from DM water make-up line to the condenser. The level in the tank is maintained by means of suitable valves in the makeup line. |
| c) Water to water | Two (2) 100% capacity the water to water heat |

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Heat exchangers

Exchanger will be designed to accept secondary D.M.Water (condensate- quality). The system is so designed that the pressure of primary DM water inside the cooler is always greater than that of secondary DM water (condensate quality) The exchanger is designed to have 10% excess tube surface area over and above the designed surface area required for the rated load condition while maintaining the design pressure drop on cooling water side.

d) Filters

Two (2) 100% capacity fine wire mesh filters with magnet bars of unlimited life for removal of all magnetic particles. The permanent magnet bars will be protected by sleeves of stainless steel. It is possible to clean easily the ferromagnetic particles adhering to the magnet bars during capital Maintenance.

e) Circulating

Two (2) 100% capacity A.C. motor driven. Standby

Water pumps:

pump will cut in automatically in case the working pump fails or the pressure of circulating water drops below a certain preset value.

f) Demineraliser

One (1) mixed bed demineraliser (MBD) of adequate capacity to maintain the required quality of water. The MBD remains continuously in service in order to retain high purity of stator cooling water with its associated electrical resistivity. The Bidder will indicate in the proposal the capacity of MBD necessary to maintain the quality of water at the desired level for time duration of six months or more. It will be designed that the MBD could be taken out of service for refilling without untoward effect on the system which could necessitate load reduction/rejection.

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g) Piping Set of stainless steel piping including hangers and supports, valves and other fittings for the complete water system.

h) Instrumentation

The following minimum instrumentation will be provided

- i) Set of conductivity meters in the main water circuit and after the demineraliser.
- ii) Set of flow switches (at least two nos.) to monitor low distillate condition and flow transmitters/meters for primary water to stator winding and main bushing, make up water etc.
- iii) Sets of pressure gauges at the inlet and outlet of stator water filters, differential pressure switches for the filters, differential pressure gauge across stator winding and pressure transmitters as required.
- iv) Sets of resistance temperature detectors, local indicators for primary water before and after the generator winding, bushing and cooler. Vapour filled temperature detectors also be provided to give signals for high temperatures.
- v) Set of dial type thermometers for cooling water at the inlet and outlet of the cooler.
- vi) Water level gauge, transmitters, level switches for high and low level alarms and other accessories for primary water tank.

i) Control system

The control system is as specified for seal oil system. At least the following Instruments will be provided on the local panel :

- i) Indicator for primary water flow in the stator winding.
- ii) Indicators for primary water conductivity at the inlet of winding and after the demineraliser.
- iii) Indicator for stator winding differential pressure.
- iv) Indicators for primary water temp. at the inlet and outlet of stator winding.
- v) Indicator for primary water pressure at the inlet of stator winding.

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Alarms in TG MMI & Annunciation contacts for use in station DDCMIS will provide for these conditions (List is indicative only)

- Water level in the stator water tank-low.
- Water level in the Stator water tank-high
- Temp of primary cooling water at the outlet of stator winding high.
- Temp of primary cooling water at the inlet of stator winding - high.
- Flow of primary cooling water to the stator winding - Low.
- Conductivity of primary cooling water at the winding inlet - high.
- Flow of primary cooling water to the stator winding - very low.
- Conductivity of primary cooling water at the winding outlet-high.
- Pressure of primary cooling at the inlet of winding - Low.
- Differential pressure across the primary water strainer - high.
- Stator water cooling pumps tripped on overload.
- Reserve control supply failure for stator water cooling.
- Differential pressure across stator winding - high.
- Leakage of hydrogen into primary water.

Primary stator bar water temperature - high.

i) Alkaliser

Alkaliser unit required for ensuring a corrosion free operation be provided along with stator water system.

j) On line oxygen monitoring system

To be provided, if the Manufacturer recommends continuous monitoring of dissolved oxygen content in the stator water, to prevent copper corrosion

k) Stator coolant flow

Generator auxiliary system valves, piping, tanks and coolers etc. will be designed for at least 10 Kg/sq.cm gauge pressure irrespective of a lower operating pressure. The maximum continuous rating of the pump and motor at specified ambient temperature will be at least the maximum load demand of the driven equipment in its entire range of operation including run out flow condition when operating at frequency variations from 47.5 Hz to 51.5 Hz.

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The turbine generator control VDU in the central control room will have graphical display of various generator subsystems, process/flow diagrams such as stator cooling water, seal oil, hydrogen, lube oil, generator stator and rotor parameters along with display of generator capability curves and operating point, generator stator & rotor temperatures and vibration parameter etc. These will have limit values alarm/trips tag numbers etc. clearly displayed on VDUs. In addition operator help features for control of these systems and historical and reference data also be made available for efficient operator guidance of these systems.

1.6 Generator Excitation System

1.6.1 General

- a) The Generator shall be provided with complete excitation system with voltage regulation system. The excitation system is either a completely static excitation system or brushless excitation system to meet the requirement specified herein. The excitation system offered is of proven design and has a satisfactory field service record on machines of similar size and construction incorporating the type of excitation. The AVR shall be digital type.
- b) The excitation system has matching characteristics suitable for satisfactory parallel operation with other generators in the plant.
- c) The various change over relays and other equipment associated with supply system other than AVR control supply, electronic circuits of either channel etc. is such that the loss of their control supply does not lead to the excitation system outage.
- d) The necessary inputs and interface equipment will be provided with Generator Excitation and Automatic Voltage Regulator for connecting with DDCMIS.
- e) Stability studies both dynamic (Long duration, transient) and steady state shall be carried out to evaluate various parameters of the excitation system, e.g response time, response ratio, ceiling voltage, loop gains, PSS parameters etc so as to meet the operational requirements of the grid particularly on loading side as the power station is connected to the grid by long transmission lines.

1.6.2 Equipment Design & Sizing Criteria

a) General

When the generator is subjected to a sudden loss of rated output at rated power factor, the system is capable of restoring the voltage of within 2% of the nominal preset value within negligible time, so as not to initiate the protection equipment.

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b) Redundancy

The excitation system has two (2) 100% channels including independent AVRs, power converters and controls. Each is equipped for 'Auto Operation' with the facility for selecting either channel in 'Auto' or 'Manual' mode.

c) Margin

Each excitation system channel is designed to continuously carry currents of at least 10% above the field current requirement at generator MCR condition and higher currents for short time duty. Short time duty as mentioned above is on MCR base as per clause 1.14 of part III in VDE 530.

d) Excitation system

Response time sec as per IEEE 421 A < 0.5 sec

Excitation response ratio > 2

Excitation system ceiling voltage Equal to 2.0 times rated load excitation voltage.

e) Field forcing capability

Each excitation system channel is capable of supplying without damage to any of the components, the field forcing voltage and current of the system for a period of 20 seconds without exceeding the limits of temperature for rectifier junction and heat sink, when the equipment starts at normal operating temperature.

1.6.3

Voltage regulator

a) The excitation system is designed in such a manner that due to any fault in AVR firing circuit pulse transformer, rectifying elements in any channel etc. excitation system is available with its full capacity. All rectifying elements have over voltage and short circuit protection.

b) Two numbers fully equipped automatic channels. Either channel is capable of being the main or standby. Either channel is capable of being selected as manual also.

c) Automatic voltage regulators is either of solid state type or microprocessor/PLC based as per Manufacturer's standard and having negligible dead band suitable for a large interconnected system.

d) Inputs to AVR

Current transformer secondary 5A, potential transformer secondary 110V phase to phase.

e) Characteristics

- Auto control range +/- 10% of rated terminal voltage in all modes for voltage level adjustments of generator operation.

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- Frequency range of 47.5 to 51.5 Hz Operation
- Accuracy at which generator voltage to be held better than 0.5% of the set value over the whole load range of the machine
- Range of transformer 0 to 15% drop compensation
- Max. Change in generator less than 0.5% voltage when AVR is transferred from auto to manual under all conditions of excitation.
- Manual control range 70% of no load to 110% full load excitation.

Voltage regulator will have the following provisions.

- a) Maximum and minimum excitation limiter.
- b) Channel reference control either solid state or microprocessor control.
- c) Ramp generation circuit: To enable gradual rise of reference signal applied to the circuit to avoid sudden voltage build up.
- d) Rotor earth fault detection: Two stage rotor earth fault unit for continuous monitoring along with alarm & trip contacts.
- e) Transformer drop Suitable feedback proportional to compensation transformer drop to be provided for compensation.

- f) Power system Stabilizer (PSS) - PSS will be suitable for damping the
The excitation system shall be provided with power system stabilizer for achieving the dynamic stability of the system under the most stringent conditions of operation in the phase of disturbance created by short circuit conditions, load rejections, switching on/off of transmission lines as per manufacturer's practice.
- g). Rotor angle limiter (P/Q) A rotor angle limiter (P/Q limiter) will be incorporated in the system. This will enable to keep the angle between the direct axis of the machine and network vector within the set reference value as determined by stability, by adjusting the excitation.
- h). Stator current limiter The stator current limiter will act immediately in under-excited range. The time delay in overexcited range will enable a temporary overloading of the machine.

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- i). Rotor Current limiter The regulator will act with time delay, so that the regulation dynamics are not impaired in case of a fault.
- j) Voltage/frequency(V/Hz) To limit the ratio of generator voltage and frequency limiter at all operating conditions to such a value that the maximum generator transformer core flux density does not exceed the value specified.
- .k). Follow up In order to avoid a sudden change in generator voltage when voltage regulation is transferred from 'Main' to 'Standby', or 'Auto' to 'Manual', a suitable arrangement will be provided to follow up changes in 'Auto' mode along with follow up indication in UCB. An alarm and visual indication will be provided to indicate change over from Auto channel-1 to Auto channel-2 or 'Auto' to 'Manual'.
- l). Automatic changeover from Auto-1 to Auto-2 or vice versa: Will be possible in case of trouble in the running channel.
- m). Automatic changeover from Auto to manual: Automatic change over will be possible from 'Auto' to 'Manual' in case of:
- Generator protection circuit operation i.e. after field forcing and over excitation condition with a time delay.
 - Loss of terminal voltage feedback by way of any of the PT fuses blowing up Faulty over excitation condition.
 - Loss of automatic channel reference signal
 - Power supply failure in the automatic channel
 - Manual intervention
 - Any other condition as considered necessary by Bidder.

All the above conditions and the conditions of limiter operations will be annunciated in local panel as well as in TG MMI. Local regulator panel will be complete with necessary facia window sequence logic, power supplies, accept reset test push buttons, indicating lamps, control switches, local/remote switches, auxiliary relays and programmable logic controllers, etc.

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At least following signals will be provided on local control panel. Further, it will be possible to exchange information with station DDCMIS.

- Generator field current
- Rotor winding temperature
- Auto channel-1 to Auto channel-2 & auto/manual changeover
- Generator field breaker/excitor field breaker control
- PSS control
- Auto and manual channel control of excitation level.
- Rotor Earth fault
- Limiter indication
- Field flashing (for Static Excitation System) and field forcing condition indications.

1.6.4 Static Excitation system

a) General

The static excitation system shall be provided with the following:

- Rectifier transformer
- Thyristor converter
- Voltage regulator
- Field flashing system
- Field circuit breaker

b) Rectifier Transformer

Type Indoor, epoxy moulded dry type, 3 phase step down transformer with class F insulation complete with flanges and terminal lugs for connection to the generator terminals through isolated phase bus ducts. The transformer will conform to IS: 11171/Relevant IEC

Temperature rise: 70 deg.C over an ambient temperature of 50 deg.C.

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Fault rating: Withstand through fault current for the time duration equal to de-excitation time of the generator field current for such faults under AVR/manual operation.

Housing Sheet steel cubicle

Protection A set of CTs to be provided in the primary of rectifier transformer for overload protection.

Hot spot temperature measurement in each limb of the transformer along with indication as well as alarm and trip contacts will be provided.

c) Power Thyristor Convertor

Type Fully controlled three phase, full wave bridge type facilitating fast and high ceiling performance. Suitable to ensure trouble free service of the cells under all fault conditions. The convertor has redundancy features as mentioned in clause "Equipment Design & Sizing Criteria".

Protection The thyristors will be selectively protected against over- loads by ultra high speed fuses. Suitable lamps indication will also be provided to indicate the defective 'thyristors'.

Location To be installed in air conditioned room near turbine floor.

d) Gate Firing Circuit

The firing circuit will have the following essential features:

- It produces a gate pulse for every thyristor once in a cycle.
- It is able to shift the gate pulse in the time over a range of about 150 electrical degrees under a signal from the regulator.
- It provides a linear relationship between the regulating inputs volts and rectifier output.
- The firing circuit has negligible time lag. e) It shall fire the thyristors correctly for any situation of input voltage, depression or unbalance coupled with high or low field currents

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e) Pulse Transformer

There will be a pulse transformer between the individual gates of the parallel connected thyristors and between the main current circuit and the control circuit. Their amplitudes will depend upon the trigger characteristics, approximately +3 to +20V peak against cathode.

f) Field Flashing

The initial field flashing will be taken from station's 415 V AC auxiliary supply. Suitable rectifier filters, etc. required for converting this ac supply to the required DC supply will be housed in the excitation system cubicle. Suitable protection interlock with desired time delay will be provided so that when the AC terminal voltage of the generator is built up to the required level for the main excitation rectifier system to take over, the field flashing circuit is switched off. In case the main excitation system fails to take over after a predetermined time of field flashing, the field breaker will trip automatically. An annunciation for field flashing failure/main field breaker trip due to field flashing failure will be incorporated. All the components of field flashing system will be continuously rated irrespective of its short time duty requirement so as to guard against any failure in case of its prolonged mal-operation.

g) Field Application & Suppression Arrangement

- The generator field breaker will be of DC, double pole / single pole air break type, suitable for operation from local panel as well as from UCB. The breaker has arc quenching arrangement for the discharge contacts. Breaker will be designed to carry currents for continuous as well as short time duty of the excitation system. Breaking current capacity of the breaker will match with the fault level at the output DC bus. Discharge contacts will be rated to discharge the field energy corresponding to the highest field current which may come during its entire operating range. The breaker completes with control switches, indication lamps, local/remote selector switch, etc.
- Non-inductive for quick discharge of inductive energy and thereby controlling the voltage across the field.
- Separate breaker for field application and suppression is not applicable.

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- Suitable interlock will be provided to prevent closing of the field breaker unless the regulator reference signal is at/near the minimum setting and minimum machine speed of 95% is attained. Adequate number of normally open and normally closed field circuit breaker auxiliary contact for remote position indication and interlocking with generator and field flashing circuit will be provided. The static excitation panels will be located near turbine floor in an air conditioned room.

1.6.5 Brushless Excitation System (If Applicable)

A complete generator Brushless excitation and automatic voltage regulating system will be furnished with the generator comprising of the following:

- a. One (1) Pilot Exciter consists of Permanent Magnet Generator (PMG).
- b. One Main AC Exciter consisting of brushless synchronous generator with rotating armature.
- c. One Rotating Rectifier.
- d. Field Discharging Resistors.
- e. One Automatic Voltage Regulators with associated complete instrumentation and protection system.

A. Permanent Magnet Generator (PMG)

The pilot exciter shall be revolving field, salient pole, permanent magnet high frequency type. The armature shall be stationary 3 phases feeding current to static rectifier assembly and excitation control equipment. The rotor shall be magnetized and stabilized by the Manufacturer to give stable magnetization characteristic during operation.

The stator winding shall be of Thermal Class 155 (F) insulation or better, suitable for operation at ambient temperature. The machine shall be fitted with fans for self ventilation.

B. Convertor Assembly

Converter assembly of pilot excitation system, thyristor gate firing system & pulse transformer shall have 2x100% redundancy.

One (1) Thyristor-controlled dual channel digital automatic voltage regulator.

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Necessary interface circuits for galvanic separation of exchanged signals including signals exchanged with DDCMIS/MMI system.

Protection and logic systems.

C. Brushless Main Exciter

Armature: This shall be of rotating armature, 3-phases, star connected, feeding current to the rotating diodes mounted on the exciter shaft.

Armature core: The armature core shall be made from silicon sheet lamination to reduce eddy losses and shall be suitably varnished on both sides.

Exciter enclosure and Support: The exciter shall be totally enclosed, self ventilated, frame supported on the generator foundation having journal bearings.

D. Rotating Rectifier Assembly

The rectifier assembly made of silicon diodes shall be arranged as two distinct Rings with opposite polarity diodes on respective rings.

The diodes shall be connected in a conventional three arm full wave rectifier bridge. Rectifier assembly shall have one complete bridge as redundant. Alternatively a single three phase rectifier bridge having at least one redundant parallel branch in each of the six arms of the bridge may also be considered. Rectifier assembly shall have same requirements as regards the component features and rating as detailed out for the thyristor assembly.

Diodes shall be cooled by forced air circulation by means of fans mounted on the main exciter.

Each diode shall be provided with a fuse together with visual indication in the event of diode failure.

The output from the rectifier shall be fed to the generator field through the bore of the rotor shaft and necessary plug in type of shaft connection. The axial copper connector shall be designed such that it shall be possible to disconnect this connector at the point where the exciter shaft couples to the generator so that, if necessary, the generator and exciter can be tested individually.

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E. Instrumentation and Protection

The system will generally include, but not be limited to, the following:

- Suitable twin resistance temperature detectors for measuring hot and cold air temperature of exciter with necessary provisions for protection tripping/interlocks.
- Dial type thermometer for measuring the inlet and outlet temperature of water to the air coolers.
- Pressure gauges at the inlet and outlet of water to air coolers.
- Instruments and devices for the measurement of rotor winding temperature measurement and monitoring (using quadrature axis coil for brush excitation system).
- Stroboscope or suitable alternative device for detection of faulty rotating diode element.
- Suitable arrangement for exciter field suppression.
- A pair of auxiliary slip rings will be provided to give access to the rotor circuit allowing an earth fault detector circuit to be connected.
- For all alarms in the system, contact will be taken from the pressure switches temperature switches etc. provided at suitable points. The system will be provided with transmitters for the above indicators/ recorders.
- For unit interlock and protection system two out of three protection systems will be adopted. To comply with this Contractor will furnish two or three separate sets of sensors/switches etc. for parameters associated with unit interlock and protection will be provided.

1.7 Tests on Generator and Excitation System

- a. The turbine generator and accessories covered against this specification will be subjected to tests by the contractor during manufacture, as also during erection and commissioning. The successful passing of any such test will not, however, prejudice the right of the purchaser to reject the plant if it does not comply with the specification when erected or give complete satisfaction in service. The cost of all tests, packing, freight and insurance charges of any transportation including any repeat tests will be borne by the contractor. This also applies to tests and inspections carried out at the Sub-vendor's works.
- b. Before any equipment/plant is packed or dispatched from the vendor's work's all tests called for will be carried out in the presence

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of the purchaser's representative.

- c. Adequate notice, to be mutually agreed upon, will be given when the equipment/plant is ready for inspection or test and every facility will be provided by the contractor and his Sub-vendors to enable the purchaser's representative to carry out the necessary inspection and witness the test at the works.
- d. The works tests will include electrical, mechanical and hydraulic tests in accordance with relevant standards as well as the regulations of the purchaser's and in addition any test called for by the purchaser's representative to ensure that the plant being supplied fulfils the requirements of the specification. For plants not covered by the relevant standards, the tests are to be agreed upon with the purchaser's representative. If considered necessary by the purchaser, any multipart assemblies are not to be fully erected at the works prior to packing and dispatching to site.

1.7.1

Tests on Generator

a. General

The tests listed below are to be carried out on each and every generator to be supplied against this specification. If possible, running trials are to be conducted for the generator, exciter and automatic voltage regulator equipment combined as a unit on the test bed, and the contractor will clearly indicate/confirm these requirements.

The data recorded during the electrical tests, the result noted, and the calculations made are to be included in a test report which will include, inter-alia description of the test method, equipment used and any limitations of the test plant.

b. Shop Tests

1) Routine electrical tests to be performed on each generator :

- Measurement of insulation resistance of the following before high voltage test
 - * Terminal Bushing
 - * Stator windings including tan delta measurement.
 - * Rotor windings.
 - * Embedded resistance thermometers.
 - * Exciter side bearings and oil pipe connections

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- Measurement of polarisation index for stator windings.
- Partial discharge test on stator windings
- Measurement of the DC resistance of the following :
 - * Stator winding
 - * Rotor winding
 - * Embedded resistance thermometers.
- Determination of generator open circuit characteristics.
- Stator phase sequence checking.
- Measurement of mechanical losses.
- Determination of short circuit characteristics.
- Measurement of core losses at the rated voltage and frequency.
- Determination of direct axis synchronous reactance.
- Determination of short circuit ratio.
- Determination of potier reactance.
- Equivalent heat runs to determine temperature rises comprising an open circuit run at 100% of the rated stator voltage (however, while taking OCC, voltage will be varied up to 110% of rated voltage) followed by a short circuit run at the rated stator current. A zero excitation heat run may be conducted at the contractor's option but in the absence of such a test no correction for the inclusion of zero excitation losses in both the open circuit and short circuit heat runs will be allowed in the calculation of temperature rises of the stator and rotor windings.
- Determination of generator efficiency by the separation of losses at 100%, 80% and 60% load.
- AC high voltage test of stator winding and stator terminal bushings after heat run test.
- Measurement of rotor winding impedance with the rotor revolving at 3000 rpm and also with the stationary rotor. This is to be done during balancing of rotor and in assembled condition also at works as well as at site.
- AC high voltage testing of the field windings after the heat run test.
- High voltage testing of resistance temperature detectors after the heat run test.
- Measurement of the insulation resistance of the items listed under (i) above after the high voltage test.

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- Calculation of the temperature rise of the stator and the rotor.
- Measurement of shaft voltage.
- Measurement of individual phase to earth and all three phase to earth capacitance of the stator and calculation of the equivalent generator capacitance as viewed from the generator terminals ; also the measurement of the capacitance between the complete winding and the body and the dissipation factor.
- Waveform analysis on no load and Harmonic analysis of line and phase voltage, balanced and residual TIF, THF.
- Hydrogen leakage test.
- Type test on one generator ("Type test certificates for the following type tests carried out on identical generator will be furnished") :
- Sudden 3-phase short circuit withstand test at 50% of the rated voltage and measurement of all reactances and time constants, SCR and synchronous reactance.
- A single phase short circuit test at reduced excitation to determine the zero and negative phase reactances.
- Telephone influence factor and harmonic analysis of the voltage wave form.
- Impulse withstand voltage test on the terminal bushings (Type test certificate will be furnished).
- Mechanical tests on each generator :
 - Mechanical inspection
 - Measurement of bearing vibrations.
 - Over speed test.
 - Hydraulic tests on coolers.
 - Hydraulic tests on machine housings.
 - Rotor balance
 - Air leakage test on hydrogen cooled stator frame.
 - Resistance temperature detector test.
 - Flow continuity for armature winding.
 - GD 2 value determination.
 - Noise measurement.

c. Site Tests On Each Generator

The site tests to be conducted will include but not be limited to those listed below. Any other test considered necessary by the purchaser will also be carried out.

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i) Electrical

- Measurement of the insulation resistance of the stator and rotor windings to the frame and between phases, after drying out the machine, and measurement of the polarisation index.
- Measurement of the DC resistance of all windings and embedded temperature detectors.
- High voltage test at 80% rated voltage.
- Measurement of the insulation resistance of bearings & bearing pedestal.
- Capacitance measurement and dissipation factor between the winding and body.
- Phase sequence & shaft voltage measurement.
- Open circuit and short circuit tests.
- Measurement of temperature rise at the rated load.
- Performance capability of the machine.
- Line charging capacity.
- Short circuit test on the generator HV end and the generator transformer HV end to check the stability and operation of the generator and the overall (i.e. generator and generator transformer) differential protections and negative phase sequence protection.
- Operational tests on auxiliary seal oil & Hydrogen gas system.
- Operational tests on all interlocks protection & alarms.
- During Generator short circuit testing at site, suitable external power supply will be arranged by the contractor for feeding the Excitation Transformer(if applicable)
- Measurement of rotor winding impedance

ii. Mechanical

- Hydrogen leakage test
- Vibration test.
- Over speed test measurement of vibration levels before and after over speed test.
- Hydraulic tests on coolers.
- Bearing and shaft current test.

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- iii. Load throw - off test

1.7.2 Tests on AVR

a Electrical Tests On AVR

- i) The tests to be conducted, at manufacturer's works on the AVR will include, but not be limited, to those listed below.
- ii) Accuracy test.
- iii) Sensitivity test.
- iv) Response ratio test
- v) High voltage test
- vi) Performance test at reduced supply voltage
- vii) Performance test of all limiters
- viii) Impulse input response test
- ix) Manual channel followed by auto channel test
- x) Range of voltage adjustment test for both auto and manual channels
- xi) Output test
- xii) IR test.

b Site tests on AVR

All the tests listed above at works will also be carried out at site.

c Electrical Tests On Excitation Equipment

All components of the excitation system will be tested in accordance with the relevant standards and type and routine test certificates will be furnished. The tests have been listed for different equipment in electrical column.

1.8 Drawings, Data and Manuals

The following minimum Drawings, data & manuals for the Generator and its auxiliaries shall be submitted as indicated below:

- a) [Dimensional GA drawing of generator and excitation system.
- b) Data sheets of generator and excitation system.
- c) Generator capability curves.
- d) Typical calculation for arriving at the size of conductor and the insulator spacing.

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- e) Type test report (short circuit, temperature rise test) for similar rating of equipment manufactured by the proposed manufacturer.*
- f) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]*

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2. GENERATOR PROTECTION PANEL & METERING PANEL

2.1 General

This specification is intended to cover the *[design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of Generator , GT and UT Protection and Metering panel complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

2.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code	Name of Standard
IS 3231	Electrical relays for power system protection
IS 8686	Specification for static protective relays
C37.102-1995 (R2001)	IEEE Guide for AC Generator Protection
C37.91-2000	IEEE Guide for Protective Relay Applications to Power Transformers
C37.101-1993 (R2000)	IEEE Guide for Generator Ground Protection
IS: 13947	Degree of Protection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed

2.3 Design Criteria

- a) Protection & Metering panel shall covers protection and metering of Generator, Generator Transformer and Unit Transformer. Number of

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panels shall be decided depends on space requirement or as per manufacturer design.

b) [Protection and metering of Station Transformer is covered under Electrical Balance of plant package (eBOP) and hence same is not covered in the scope of this specification].

c) All protection and metering panels shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.

d) All equipments shall be suitable for following voltage & frequency variations as follows:

a Voltage Variation : (±) 10%

b Frequency Variation : (+) 3% to (-)5%

c Combined Variation of Voltage & Frequency : 10% (absolute sum)

e) Relay and metering panel shall be floor mounted, free standing with degree of protection of IP 54.

2.4 Specific Requirements

2.4.1 Protection Philosophy

a) Protective relay system shall be provided to protect the electrical equipments from faults, overloading and abnormal conditions.

b) The protection of Generator and Transformers shall be divided into two main protection groups as per the protection listed out elsewhere in the specification. Complete protection of the respective equipment shall be fully available even if either of the groups is not available. Hence, both of them shall be mechanically, physically and electrically separated into two separate and independent systems i.e. mounted in two separate panels. These two groups shall derive DC supply from two separate feeders. However, the relays in both groups shall be tripping the respective circuit breaker through both trip coils.

c) Two numbers of dc supplies shall be arranged for the relay panel. Auto changer over and dc supply supervision relay shall be considered. Normally, group-1 & 2 protection systems will be fed by source 1 & 2 respectively and the common services from any one of the sources. In case of failure of any one source (say source 1), supply shall be change over to source 2 (i.e. healthy source) automatically. White colour supervision lamps of clustered LED type shall be provided on Relay panel to indicate availability of DC supply.

d) Each protection system shall be utilizing separate DC source, separate CT/VT cores, separate cables and hand reset lock out relays to obtain 100% reliability.

e) Each group of protection shall be of different make.

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- f) Trip or lock out relays for each group of protection shall be separate and shall have sufficient number of contacts for all functions.

2.4.2 Generator Protections

Two numbers of identical numerical relays shall be provided for generator protection. They shall receive all AC signals from two different sources. Each of the generator protection relays shall comprise of the following minimum protections unless noted otherwise. If any other protection deemed necessary by manufacturer, same shall be considered.

- a. Generator differential protection (87G)
- b. 100% Generator stator earth fault protection(64G1)
- c. 95% Generator stator earth fault protection(64G2)
- d. Generator back-up stator earth fault protection (64G3)
- e. Rotor earth fault protection (2 stages)
 - First Stage (64F1) for alarm.
 - Second stage (64F2) for trip.
- f. Generator negative phase sequence protection (46G1 and 46G2)
- g. Generator reverse power protection (Preferably 3 phase power relay) (32G1 and 32G2)
- h. Generator loss of excitation protection (40G).
- i. Generator pole slipping protection (98G)
- j. Generator under frequency protection (81G1 and 81G2) (one alarm stage and two trip stages)
- k. Generator over-voltage protection (59G1 and 59G2) (One instantaneous stage and one definite time stage)
- l. Generator backup impedance protection (21G)
- m. Generator Voltage balance scheme for blocking voltage dependent protection in case of VT fuse failure (60G)
- n. Inadvertent energization (27/50)
- o. Generator over-fluxing protection (99G)
- p. Generator field over-voltage protection (can be a part of excitation system) (59F)
- q. Generator definite time over current Protection (51 G1)
- r. Generator Low Forward Power.(37 G1 & 37G2)
- s. Overheating (winding and or bearing) for alarm.
- t. Inter turn fault protection (where spilt winding in stator is provided) if six neutral terminals are available (87TG).

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In case of digital multifunctional generator protection system (MGPS) is provided, the protections shall be duplicated. Each MGPS shall be preferably provided with individual inputs from CTs and VTs and connected to the independent set of hand reset trip relays, such that one set is always available in case of testing and mal operation of other set. Any protection which is not part of MGPS, separate discrete protection shall be provided as per the above protection list. The MGPS shall preferably have continuous self monitoring and testing facilities.

2.4.3 Generator Transformer Protections

The Generator Transformer shall be provided with the following protections

- a. Overall differential protection covering GT, UT and Generator (87OA)
- b. Generator transformer differential protection (87GT).
- c. Generator transformer HV side IDMT phase over current protection (51GT).
- d. IDMT type back-up non-directional over current protection in all 3 phases (51GT).
- e. Generator transformer restricted earth fault protection (64GT).
- f. Generator transformer backup earth fault protection (51NGT).
- g. GT over fluxing protection (99GT).
- h. Buchholz protection (63) for alarm and trip.
- i. Winding temperature high (49T) for alarm and trip
- j. Oil temperature high (49Q) for alarm and trip.
- k. OLTC oil surge relay
- l. Pressure relief valve trip (PRV)
- m. Pole discrepancy protection of breaker (EHV) if single pole breakers are used (Covered in eBoP package under chapter of switchyard) (162).
- n. Breaker (EHV) back up protection (Protection against breaker failure) (Covered in eBoP package under chapter of switchyard) (50Z)

2.4.4 Unit Transformer Protections

The Unit Transformer shall be provided with the following protections

- a. Unit transformer differential protection (87UT).
- b. Unit transformer restricted earth fault protection (if applicable) (64UT).
- c. Unit transformer HV side instantaneous over current protection (50UT).
- d. Unit transformer HV side IDMT phase over current protection (51UT).

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- e. Unit transformer backup earth fault protection for low/high resistance grounding (LV side)(51NUT).
- f. Buchholz protection (63) for alarm and trip.
- g. Winding temperature high(49T) for alarm and trip
- h. Oil temperature high (49Q) for alarm and trip.
- i. Pressure relief valve trip(PRV)

2.4.5

Metering

- a. Each metering panel shall house the following meters. The construction of these panels shall be similar to that of the relay panel and shall be as per details given in this specification.
 - Generator : 3 phase current, 3 phase voltage, MW, MVAR, MWH, MVARH, power factor and frequency and also exciter field voltage and exciter field current meters
 - Unit Transformers : MWH, MW, MVARH
 - Station Transformer: MWH, MW, MVARH
- b. The meters shall be suitable for flush mounting or semi-flush mounting on vertical panels. Watt-hour and var-hour measurements shall be suitable for un-balanced loads. The meters shall comply with the following requirements
 - Accuracy class 0.2S
 - Suitable for operation with 1A/5A CT secondary and 110V VT supply.
 - EMC compliant.
 - Shall have RS-485 communication port suitable for MODBUS protocol.
 - LCD display.
 - Degree of protection IP-52.
 - Non-volatile memory
- c. The energy meters mentioned above shall be used for energy accounting and audit purposes and shall be located at a point after the generator stator terminals and before the tap off to UTs and shall comply with the requirements of CEA regulations on Metering.
- d. All Meters shall be of flush mounted type, direct reading, back connected, dust proof and switchboard type, having removable transparent dust tight window cover. The enclosed cases shall be finished in dull black. They shall be fitted with non-reflecting glass and anti parallax scales.
- e. The meters cases shall be flush mounted and draw out type. This draw out feature shall permit the meters to be withdrawn from the cases

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without opening current transformer secondary circuits, disturbing service or requiring disconnection of leads.

- f. The digital power demand meters shall have a minimum life of 10 years. The meters shall be shock resistant, dust protected and weather proof. The display character shall be minimum 5 mm wide and 8 mm high. The resolution shall be minimum 0.1 %.
- g. All meters and instruments shall be calibrated for 50 Hz operation and according to the CT & PT ratio and accuracy ratings. All meters shall indicate the test calibration values used for full scale deflection.
- h. The maximum current and voltage of the meters and instruments shall match the rated extended secondary current and voltage of the relevant instrument transformers.
- i. The nominal current and voltage ratings of meters and instruments (used with CTs and PTs) shall be 1A or 5A.
- j. All meters and instruments (including the associated circuitry) shall be capable of withstanding the following overloads:
 - Long duration overloads up to 120% of the rated electrical input quantity without affecting calibration. The duration of each overload shall be per applicable IEC or ANSI standards.
 - In case of wattmeters and varmeters, this continuous overload up to 120% of the rated input quantities, that is current and voltage shall however be applied sequentially; the other value being maintained at its rated value.
 - All meters and instruments shall also withstand overloads of short duration per applicable IEC or ANSI standards.

2.4.6 Relay

- a. Relays shall be furnished in rectangular /square dust tight, draw out or rugged plug in type, flush /semi flush mounting cases.
- b. The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on microprocessor technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- c. All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in contractor's scope of supply.
- d. All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 A/5A CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall

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operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

- e. All protection relays shall be numerical type with communication interface compliant to IEC-61850 protocol. It is proposed to fully utilize the metering, protection and control features of the numerical relays. They shall have programmable logic facility with built-in timers. Apart from the status of operation of the protection functions inbuilt in the relay, it is proposed to utilize the binary inputs of the relay for taking the operation of other non communicable relays (if any) in the protection panel to DDCMIS. The numerical relays shall be selected with suitable number of binary/analog inputs and outputs. Static relays have to be provided for any other protections not adequately afforded by the multifunction numerical relays.
- f. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme. Contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.
- g. Timers shall be of solid state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.
- h. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- i. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- j. Any alternative / additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative / additional equipment shall lie with the purchaser.
- k. The design of the integrated generator protection shall be based on numerical techniques. 2x100% integrated numerical protection along with other standard protections shall be provided. All the analogue

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signals will be converted into digital data, using analogue-to- digital conversion circuit. The data will be processed by a microprocessor, which will perform digital signal processing and executes various protection algorithms.

- l. The relay shall be provided with one number Laptop-PC of latest generation, for user interfaces, monitoring, testing facility etc. In addition to above a unitized PC based with 21" colour monitor shall be provided for configuration and diagnostics of all the numerical relays.
- m. Such Station shall be complete with licensed version of all software for analysis and retrieval of disturbances occurred in the system/equipment. Data/signal from numerical relays will go to station DDCMIS through communication protocol and shall be time synchronized through the same.
- n. The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- o. Relay characteristics shall be coordinated for proper functioning in conjunction with associated relays. The Contractor shall co ordinate the characteristics of all relays to suit the system and equipment parameters. Relay ranges and settings shall be selected accordingly. Some of the relays for generator protection may be back-up for switchyard relays and the settings of these relays shall be properly coordinated with the settings of the later.
- p. The relays shall function satisfactorily being located in non AC physical environment.
- q. All protections shall be furnished compete with necessary auxiliary, supervisory, lock out etc, relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- r. Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- s. D.C circuits shall be supervised by relays.
- t. Tripping shall be done through high speed lock out relays.
- u. Tripping relays shall be offered with sufficient redundancy. Operating of these relays shall be continuously monitored through supervising relays.
- v. The generator protection system relays shall be classified into three categories viz., class-A trip [Generator Faults). Class- B trip [Turbine Faults] and Class C trip (Grid faults].Accordingly all the relays shall be divided into these three modes of tripping.

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- w. All protective relays and meters shall be provided with test terminal blocks for secondary injection testing of protection relays and meters.
- x. Relay shall be provided with self reset contacts except trip, lock out relays and interlock relays which shall be manual reset type.
- y. High speed trip relays: Adequate number of high speed trip relays for each category tripping for both the groups will be provided for the protection of the unit. The quantity of the trip relays will also consider the requirement due to the following:
 - Contact requirements from these relays to various systems covered under the scope of this contract.
 - Contacts from each category of tripping relay for annunciation, data acquisition, sequential event recorder and fault disturbance recorder.
 - Contacts for control, protection and interlock in system viz. [400kV] circuit breakers/transfer breaker tripping / close permissive, [6.6] kV aux. Supply breakers trip / close permissive, transformer cooler circuit interlocks, LBB protection etc.
 - 10% spare contacts (both NO and NC).
- z. All protective relays and meters shall be provided with test terminal blocks for secondary injection testing of protection relays and meters.
- aa. All alarm and trip conditions of Generator Transformer and Unit Transformer shall be made available in the DDCMIS.

2.4.7

Panel

- a. The Relay Panels shall be totally enclosed, floor mounted, free standing, dead front assemblies conforming to IP-54 degree of protection.
- b. Design, material selection, and workmanship shall be such as to present a neat appearance outside and inside with no welds, rivets, screws or bolt heads apparent from the exterior surface of the Boards. The boards shall have a smooth and uniform matt finish, free from scratches, dents and other imperfections.
- c. The panels shall be liberally sized so as to provide spacious layout of equipment and devices with sufficient working space in between.
- d. Each board may consist of a number of panels mounted side-by-side, in which case, these shall be bolted together to form a compact unit. Where two panels meet, the joints shall be smooth and close-fitting.
- e. The boards shall be of folded sheet steel construction, assembled on channel/angle base plates with ant vibration mountings.
- f. The boards shall be fabricated of minimum 2 mm thick sheet steel, free from all surface defects. The boards shall have sufficient structural

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reinforcement to ensure a plane surface, to limit vibration, and to provide rigidity during shipment and installation.

- g. All doors and removable covers shall be provided with neoprene gaskets all around and latches sufficiently strong to hold them in alignment when closed. The door operating handle shall have locking arrangement.
- h. All panels shall have rear door with concealed type hinges and pad locking arrangement. Doors shall be grounded by flexible copper braid.
- i. The boards shall be complete with vibration damping pads, stainless steel kick plates, floor channel sills, anchor bolts, and other necessary hardware for mounting.
- j. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel / station through a flexible braided copper conductor rigidly.
- k. The panels shall be provided with removable gland plates with glands made of brass suitable for armoured cables. Cable glands shall be double compression type. Cable gland support plate shall be 3 mm thick and mounted not less than 200 mm above floor level
- l. The panels shall have provision of cable entry from the bottom. Bottom plate shall be provided to make entry dust-tight.

2.4.8

Panel Internal Wiring

- a. All wiring shall be carried out with 650/1100 V grade, single core, and stranded copper conductor wires with FRLS PVC insulation and shall be vermin, rodent proof. The minimum size of the stranded copper conductor used for panel wiring shall be as follows
 - All circuits except CT & PT circuits : 2.5 mm² per lead
 - CT & PT circuits : 4 mm² per lead
- b. All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- c. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.
- d. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

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2.4.9 Terminal Block

- a. Terminals shall be box clamps and clip-on type, suitable for terminating up to two wires of 4 sq. mm. cross section and provided with marking strips. Terminals for CT secondary leads shall have built-in disconnecting links with facility for shorting. Terminals for CT leads should have adequate cross section for terminating associated CT leads.
- b. Not more than two wires shall be connected to one terminal. If necessary, a number of terminals shall be shorted together to provide wiring points.
- c. Each terminal shall be identified with designation as per approved schematic. At least 20% of the total number of active terminals shall be furnished as spare in each panel.
- d. The wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.
- e. The terminal blocks shall be located to allow easy access and also to suit floor openings for cable entry.
- f. Terminal blocks shall generally be mounted vertically with adequate spacing (not less than 100 mm) between adjacent rows.
- g. The bottom of the terminal blocks shall be at least 200 mm above the incoming cable gland plate.
- h. There shall be a minimum clearness of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearances between two rows of terminal blocks edges shall be minimum of 150mm.
- i. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included the scope of supply.

2.4.10 Equipment Mounting

- a. All instruments, relays, switches, etc. mounted on the front face of the panels shall be flush or semi flush type.
- b. No equipment shall be mounted on panel door.
- c. All equipment shall be so mounted that removal and replacement may be accomplished individually without interruption of service to others.
- d. All equipment inside the panels shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.
- e. In case cut-outs are provided on any panel for future mounting of equipment, the same shall be properly blanked off.

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- f. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections.
- g. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawing.
- h. The centre lines of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be no less than 450mm from the bottom of the panel.
- i. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

2.4.11 Illumination, Space Heating and Receptacles

- a. Each panel shall be provided with interior fluorescent tube with door switch, space heater with thermostat and switch and 240V, 5A, 3 pin receptacles with plug. Third pin of the socket shall be effectively grounded through the metallic structure.
- b. Lamp, heater and receptacle circuits shall be suitable for available 240V A.C. supply and furnished with individual ON-OFF switch.
- c. The tube shall be located at the ceiling and guarded with protective cage. Space heater shall be located near the floor so as not to pose any hazard to service personnel.

2.4.12 AC/DC Power Supply

- a. Necessary A.C and D.C supplies to each panel as required for control and service shall be arranged by the Contractor. Single feeder shall be arranged for A.C supply but redundant feeders shall be arranged for D.C supply by purchaser.
- b. Indication lamps and audible alarms shall be provided to annunciate failure of main incoming D.C supplies in each panel. Flag relay shall be provided for A.C. supply failure.
- c. MCCB/MCB shall be provided for the incoming AC/DC power supplies. Bus wires shall be run for power distribution to different panels. Power supply isolation switches shall be 4-pole, single throw, for A.C. (considering single feeder) and 2-pole, double throw with OFF, for D.C.

2.4.13 Name Plate

- a. Nameplates shall be provided on each panel and on each instrument or device mounted in the panel.

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- b. The material of the nameplates shall be plastic, 3 mm thick, with white letters on black background.
- c. The nameplates shall be held by self tapping screws. The size of nameplate shall be approx. 20 mm x 75 mm for equipment and 40 mm x 150 mm for panels.
- d. Nameplates for panels shall be provided both on the front and the rear. Nameplates for all devices shall be located below the respective devices.
- e. Instrument and devices mounted on the face of the control boards shall also be identified on the rear with the instrument or device number. The number may be painted on or adjacent to the instrument or device case.
- f. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

2.4.14

Grounding

- a. Tinned copper ground bus of adequate size shall be provided in each panel, extending along the entire length of the assembly.
- b. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of isolators and breakers.
- c. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractors. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.
- d. Provision shall be made on each bus bar of the end panels for connecting Substation earthing gird. Necessary terminal clams and connectors for this purpose shall be included in the scope of supply of Contractors.
- e. Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. Earthing may be done in such a manner that no circulating current shall flow in the panel.
- f. VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.
- g. An electrostatic discharge point shall be provided in each panel connected to earth bus via 1 Mega Ohm resistor.
- h. The ground bus shall have two-bolt drilling with GI bolts and nuts at each end and shall be suitable for connection to 50 x 6 mm G.S. flat.

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- i. The ground bus shall be bolted to the panel structure and effectively ground the entire assembly. The cases of meters, relays and switching devices shall be grounded through the steel structure.
- j. Whenever a circuit is grounded, a single wire from the circuit shall be run independently to the ground bus and connected to it.

2.5

Tests

I) Type Test

For each type of relays and equipments, Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted at manufacturer work/site are as follows:

- a) Wiring continuity tests
- b) Insulation tests before and after high voltage test
- c) Functional tests to ensure operation of the control/protection/metering schemes and individual equipment.
- d) All switches, meters, relays and other devices shall be tested and calibrated in accordance with relevant IEC/IS standards.
- e) HV test on control circuits
- f) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- g) Secondary injection of all metering circuits.
- h) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting

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the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

2.6 Drawing & Documents

Drawings, data & manuals for the Protection panel and metering panel shall be submitted as indicated below

- a) [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening of panels.
- b) Bill of Materials.
- c) Technical Data sheet and Catalogue.
- d) Heat loss of panels
- e) Foundation drawing details with bottom view of Panels.
- f) Descriptive write-ups and literature for the main equipment offered i.e relays, meters, etc.
- g) Control Schematics & Wiring diagram.
- h) Inspection and Test Plan (ITP).
- i) Suggestive list of protective relays.
- j) Transport/shipping dimensions and weights].

2.7 Ratings & Requirements

Protection relay panels and meters shall comply with the particulars indicated in the following tables.

S. No.	Technical Particulars	Unit	Parameters
1.0	General		
1.1	Type (simplex / duplex / panel cum desk)		Simplex type
1.2	Make		[By bidder]
1.3	Maximum dimensions width	mm	[800 x 800 x 2300]/[as per

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S. No.	Technical Particulars	Unit	Parameters
	x depth x height		existing panels]
1.4	Weight of each panel		[By bidder]
1.5	Degree of protection		IP 52
1.6	Colour shade		[RAL 5012]
1.7	Cold rolled sheet steel thickness		
	(a) Load bearing members	mm	2.0
	(b) Non-loading members	mm	1.6
1.8	Cable entry top / bottom		Bottom
1.9	Control cable glands to be supplied		[As per specification/Project specific]
1.10	Purchaser's external cable sizes		2.5 mm ² (control) 4 sqmm (for CT) Cu, PVC Multicore 1kV grade Any other sizes will be informed during detail engg stage
1.11	Any special interconnecting cable between panels to be provided by vendor.		Inter-panel wiring between adjacent panels to be done inside the panels.
1.12	Special requirements:		
a)	Matching with existing / new panels of others	Yes/No	Yes
b)	Coordination with other suppliers		By Bidder
c)	Hardware and accessories for protocol converter and		Shall match with existing system. {Scope of work regarding

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S. No.	Technical Particulars	Unit	Parameters
	connection to DDCMIS		<i>connection and protocol converter if required shall be finalized during detail engg}</i>
1.13	Earth bus material & size inside the panel		Copper bus
1.14	Equipment list for each panel		Main relays shall be listed in BOQ by vendor. Auxiliary relays required for control and protection interlock schemes should be worked out and provided by the vendor.
1.15	Auxiliary voltages		
a)	A.C.	V	230 V, AC 1 phase, 50 Hz, +/- 10% voltage variation
b)	DC	V	220 V, ungrounded, + 10% and - 15% voltage variation
			24V + 10%, -20% for interposing relays
2.0	Particulars of Protective relays		
2.1	Relay type required		Numerical
2.2	Mounting		Pre engineered panels, flush mounted / swing door mounted
2.3	Communication protocol		Compliance to IEC 61850. {Exact protocol will be decided during detail engg}
2.4	Wiring arrangement		Between panels wiring could be from terminal block to terminal block in internal raceways

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S. No.	Technical Particulars	Unit	Parameters
2.5	Testing facility		Yes
2.6	Minimum rating of contacts for auxiliary and output relays :		[By bidder]
	(a)Voltage	V, DC	
	(b) Continuous current	A, DC	
	(c)Make & carry for 1 sec.	A, DC	
	(d)Breaking capacity (i) Resistive (ii) Inductive	Watts Watts	
2.7	Relay type and protection [For Generator] (List out all protection and relay type used)		[By bidder]
2.8	Relay type and protection [For Generator Transformer] (List out all protection and relay type used)		[By bidder]
2.9	Relay type and protection [For Unit Transformer] (List out all protection and relay type used)		[By bidder]
2.10	Tripping Relays		[By bidder]
	(a)Make / designation		

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S. No.	Technical Particulars	Unit	Parameters
	(b)Static / Electromagnetic		
	(c) Rated voltage	V, DC	
2.11	Trip circuit Super Vision Relays		[By bidder]
	(a)Make / designation		
	(b)Static / Electromagnetic		
	(c) Rated voltage	V, DC	
2.12	Indicating Lamps		
a	Type		Clustered LED
b	Ratings		
c	Voltage	V	[By bidder]
d	Wattage	W	[By bidder]
3.0	Meters		By bidder]
3.1	Make		
3.2	Type of measurement		
3.3	Measuring range in primary watts.		

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S. No.	Technical Particulars	Unit	Parameters
3.4	CT ratio		
3.5	VT ratio		
3.6	Accuracy class		
3.7	Burden		
	(a)Current coil	VA	
	(b)Voltage coil	VA	
3.8	Transducers		
a	Output	4-20mA	
b	Accuracy		
c	Burden	VA	
4.0	Timers		[By bidder]
4.1	Make		
4.2	Type designation		
4.3	Range of time delay		
	(a)On energization	m sec.	
	(b)On de-energization	m sec.	

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3. ISOLATED PHASE BUS DUCT

3.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of Isolated Phase Bus duct (IBPD), Surge Protection and VT (SPVT) cubicle complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

3.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code	Name of Standard
IS 2099	Bushings for alternating voltage above 1000V.
IS 2544	Porcelain post insulator for voltages above 1000V.
IS 2633	Method of testing uniformity of coating on zinc coated articles.
IS 2705	Current Transformer
IS 3070	Lightning Arresters
IS 3156	Voltage Transformers
IS 8084	Interconnecting Bus bar for AC Voltage above 1kV up to and Including 36kV
IS 9431	Specifications for indoor post insulators of organic material for systems with nominal voltages greater than 1000 volts up to including 300kV.
IEEE C37.23	IEEE Standard for Metal-Enclosed Bus.
ANSI/IEEE C37.20	Switchgear assemblies including metal enclosed bus.
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear.
IEC 60947	Low Voltage Switchgear and Control gear.
IEC 60439	Low-voltage switchgear and control gear assemblies.

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BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

3.3

Design Criteria

- a) The main run of IPBD shall connect generator phase side terminals to Generator Transformer (GT) LV terminals. Tap off bus ducts from IPBD for Unit Transformer (UT) and Static Excitation Transformer (SET) shall be provided. The neutral side bus duct shall be terminated at the Neutral Grounding (NG) cubicle after formation of the neutral point, which shall house a neutral grounding transformer and loading resistor.
- b) Busduct shall be isolated phase, continuous bonded type and shall be installed indoor/Outdoor in a hot, humid and tropical atmosphere. It shall be natural cooled and positive pressure type.
- c) Cubicle for neutral grounding, Voltage transformers and surge protection equipments shall be installed indoor.
- d) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- e) The portion of bus duct at the transformer/generator end will be subject to vibration normally prevalent for this type of installation in a power generating station. Suitable means shall be provided to isolate the transformer/Generator vibration from rest of the bus structure / bus duct.
- f) The busduct shall be of a Manufacturer's proven design and shall meet or exceed the requirements of this specification in all respects.
- g) The busduct shall be designed to operate and perform satisfactorily at all service conditions without exceeding the hot spot temperature limits specified in relevant standards.
- h) The busduct shall be an integrally designed assembly of rigid busbar conductors, insulators, bus conductor supports, associated connections,

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joints and wall frames and all other accessory items necessary to assure a complete coordinated design.

- i) The continuous rating of the Isolated phase bus duct (generator bus ducts) main run shall be arrived considering the maximum continuous output of the Generator at the rated power factor and minimum operating voltage and rounded off to the next Standard rating. The generator busduct shall be such that the continuous rating can be delivered at site ambient conditions without exceeding the allowable temperatures considering site ambient and duly considering the effect of solar radiation.
- j) The continuous rating of the Isolated phase bus duct (generator bus ducts) tap-off shall be arrived considering the rating of Unit transformer.
- k) The main run of the busduct shall be designed to withstand the maximum fault current from following at least for 1 second.
 - i) Fault current contribution from the Generator and from the motors through Unit transformer (as applicable) OR
 - ii) Fault current contribution from the Grid system and from the motors through Unit Transformer (UT).
- l) The tap off run of the busduct to UT shall be designed to withstand at least for 1 second, the total fault current contribution from Generator, grid system and from motors via UT.
- m) Bidder shall provide the IPBD between Generator and GT LV side, tap off to UT and SET & Generator neutral busduct.
- n) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the short-circuit currents.
- o) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- p) Wall frame assembly for IPBD if required and floor frame assembly for IPB tapping wherever it penetrates the floor shall be provided.
- q) Air pressurizing system, air compressor, drier, piping, valves etc. for pressurizing the IPB section if required shall be provided.
- r) Required supporting galvanized steel structures and necessary hardware need to be provided.
- s) Following calculation to be furnished
 - i. Temperature rise calculation at rated current considering solar radiation

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- ii. Calculation for conductor size
- iii. Calculation of enclosure size
- iv. Guaranteed kW losses
- v. Short circuit withstand current & force capability for specified time duration
- vi. Supporting span
- vii. Dynamic and static forces transmitted to TG foundation
- t) For generator busduct, adapter box of aluminium sheets with seal-off bushing near Generator ends (both Phase and Neutral) and wherever required shall be provided. All contact surfaces shall be silver-plated to ensure an efficient and trouble free connection.
- u) The busduct shall be designed to withstand the internal or external forces resulting from the following:
 - 1. Normal operating condition
 - 2. Momentary short circuit currents
 - 3. Rigorous / adverse weather conditions as detailed in the technical specification.
- v) Isolated phase busduct shall be supplied in maximum practical lengths easily transportable to site, to suit layout and minimize number of field joints. The standard shipping section length should be of the order of 6 meters for IPBD's.
- w) Equipments shall be arranged to ensure same phase disposition throughout the run of the bus duct. Phase cross over units, if required, shall also be provided.
- x) Isolated phase busduct terminations shall be complete with flexible connectors of copper for all connected equipments along with flanges, gaskets, bolts, nuts and washers and adequate supports, as required. These shall be able to absorb movement of equipment terminals.
- y) The spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the momentary short circuit assigned for the bus duct.
- z) For the portion of the bus duct installed outdoor and exposed to direct sun-rays, the effect of the solar heat shall be considered in the determination of the design ambient temperature. In addition, the outdoor section shall also withstand the wind loading.
- aa) Generator transformers and unit transformers shall be placed on the rail track. The busduct and supporting structure shall be designed in such a

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way so as to permit transformer removal, after opening the terminations, but without dismantling busduct run or supporting structure.

- bb) The bus duct near the generator terminals shall allow for removal of the generator bushing current transformers without extensive disassembly of the bus structure or any welding during re-assembly.

3.4 Specific Requirements

3.4.1 General

- a) Isolated phase busduct shall have continuous bonded non-magnetic metallic enclosure and rated for the highest possible system voltage / continuous terminal voltage of the generator (if used as Generator busduct). The Bus ducts shall be naturally cooled, dust tight and weather proof type, provided with positive pressurization arrangement using clean air. The leakage rate of air shall not exceed 5% of the total volume per hour after installation.
- b) Busduct shall be isolated phase, continuous bonded type and shall be installed indoor/Outdoor in a hot, humid and tropical atmosphere. It shall be natural cooled and positive pressure type.
- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) All supporting steel structures shall be hot dip galvanized.
- e) Wall frame assembly and seal off bushing shall be provided whenever busduct passing through the wall.
- f) For the purpose of protection and metering of the UTs, required current transformers shall be provided along the tap off run of the IPBD on the phase side if CT is not considered on the Bushing of UT.

3.4.2 Bus Conductor

- a) The material of the conductor shall be high conductivity, aluminium alloy. The bus conductor shall be designed to carry the rated current under normal site operating conditions without exceeding the temperature rise as stipulated in IS 8084
- b) The temperature rise of conductor shall be as per IS: 8084. Also the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.
- c) The bus conductor shall be given a coat of matt black paint to facilitate heat dissipation. The bare conductor with above painting shall be

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designed to carry the normal rated current without exceeding temperature rise as specified in IS: 8084. However, the sizing of the bus conductor shall consider the conductor as bare.

- d) The section of the bus conductors used may be rectangular, tubular, hollow square, hollow rectangular, double channel or hollow hexagonal/octagonal type. However, tubular shape is preferred.
- e) The bus conductor shall be designed for welded connections except at equipment terminations and bolted disconnect links.
- f) Flexible braided copper connections shall be provided at the terminals of generator, GT, UT, SET, SPVT and neutral earthing cubicle. Bimetallic connectors shall be provided between the bus-bars and the copper flexible. The flexible connectors shall comprise a number of small braids woven out of copper wires in order to obtain flexibility in all the directions
- g) The bus conductors shall be designed to carry rated current under normal site operating conditions without exceeding hot spot temperature.
- h) Flexible connections shall be provided between bus sections to allow expansion and contraction of the conductor. Flexible connection shall also be provided at all equipment terminations.
- i) All contact surfaces shall be silver plated to ensure an efficient and trouble free connection. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- j) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.

3.4.3 Enclosures

- a) The bus enclosure shall be of continuous bonded type. The cross section of the bus enclosure shall be circular. The material of bus enclosure shall be of aluminum alloy grade [63401] as per IS-5082. The entire bus duct shall be designed for indoor/outdoor installation, with dust, vermin and weather-proof construction. The degree of protection shall be IP-55 and shall meet the requirements of water and air tightness test specified in IS 8084.
- b) Each phase shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminum alloy) enclosure.
- c) The inside of the bus enclosure shall be given a matt finish of black colour paint to facilitate heat dissipation. The paint shall not deteriorate

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at specified maximum temperature of the bus conductor and enclosure. The outside of the bus enclosure shall be painted with RAL [5012].

- d) The outdoor portion of the bus duct shall be provided with rain hood. This hood shall be mounted on the bus duct supporting structures or on the busduct and all hardware and accessories required for mounting the hood shall be furnished by the bidder.
- e) For continuous type of design, successive sections of enclosures shall be connected by providing circular bonding enclosures with adequate overlap and welding the same to the main enclosure at site. All gaskets used shall be of EPDM / Neoprene rubber with good ageing, compression and oil resistance characteristics suitable for busduct application.
- f) The enclosure cross-section, connecting members between enclosure section, flexible and rigid joints and shorting links between phase enclosures shall be adequate to allow the flow of longitudinal current required for the rated continuous currents of the bus without overheating.
- g) The enclosure shall be insulated at the connections to the generator, transformers and other equipment so that the longitudinal current will not flow through or be transmitted to any connecting equipment.
- h) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion/ contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.
- i) Inspection opening/split covers shall be provided to allow easy access for installation, inspection, replacement or repairs of the insulators, disconnects, bus connections and terminations. The inspection/split covers shall have reliable sealing arrangements with neoprene/rubber gaskets in grooves.
- j) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent exchange of air between indoor and outdoor portions of the busduct.
- k) The enclosure shall be furnished with suitable connections for a dry air pressurization system, to prevent / remove condensation. Filtered drains

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for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.

- l) The enclosures of all three phases shall be rigidly supported by cross members to maintain parallel alignment.
- m) Shipping length of the bus duct shall be as long as practicable within transport limitation to reduce field assembly work.
- n) The enclosure design shall ensure grounding continuity capable of carrying the rated momentary current of the bus throughout the length of each run.
- o) Phase enclosure shorting links rated for continuous current shall be provided at bus duct termination on generator, generator transformer, and unit tap off. All such links shall be same material as of bus bar.
- p) Drain plugs shall be installed at low points along the run of the bus duct. The drain plugs shall be fitted with porous filter elements. The filter elements shall be easily removable for cleaning purposes.

3.4.4 Disconnect Link

- a) Disconnecting links with rating same as that of the bus conductor shall be provided in the run of the bus duct to facilitate disconnection of the bus conductor during maintenance.
- b) The separation between the bus conductors sections with the bolted links removed shall be sufficient to withstand the rated voltage of the bus duct.
- c) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- d) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- e) A minimum clearance of 300 mm. (12") shall be provided between the disconnected bus sections with the link removed.
- f) Disconnect links shall be plainly marked to be removable only when bus is de-energized.

3.4.5 Insulators

- a) Within the bus duct the bus shall be mounted and supported on insulators. The insulators shall be mounted on resilient pads provided in the bus enclosure. The insulators shall be either porcelain or resin cast.

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- b) Bus support insulators shall be interchangeable, high creep, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.
- c) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- d) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator. The conductor shall be fastened on the set of 3 insulators, 120° apart.
- e) All ferrous metal part of the insulator shall be hot-dipped galvanized.
- f) Additional insulators shall be provided at bends, tap-off etc.

3.4.6 Wall Frame Assembly

Wherever the bus duct passes through the plant building wall, from indoors to outdoors, a wall frame assembly with seal-off bushings shall be provided to prevent any leakage of rain water, infiltration of dust and air temperature variations from indoors to outdoors. The wall frame shall be fabricated out of aluminium angles and sheet and shall be suitable for grouting in the wall. It shall be provided with flanges on both sides to receive the bus duct flanges. A suitable size breather shall be provided for the two sections of the busduct separated by the wall frame assembly.

3.4.7 Seal-off Bushings

- a) The bus duct shall be equipped wherever necessary with seal-off bushings to prevent interchange of air at different temperatures. The seal-off bushings shall be flanged type.
- b) The seal-off bushings shall be made of porcelain / cast epoxy. The mechanical and electrical properties of the bushings shall be as specified for bus support insulators.
- c) Seal off bushings shall be provided at the following locations:
 - i. Entry of tap-off bus duct to the static excitation transformer, neutral grounding cubicle, etc.
 - ii. Between indoor and outdoor portions of the bus duct on turbine building outer wall.
 - iii. At GT and UTs.

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- iv. One set of seal-off bushings shall be provided in the bus duct after the generator bushings to prevent hydrogen leakage into the bus duct. Arrangement shall be provided to vent the trapped hydrogen in the portion between generator bushings and seal-off bushings.
- d) The insulator for wall frame assembly and seal-off bushings shall be of porcelain. Also the bushings shall be designed for thermal expansion/contraction due to temperature differential for outdoor/indoor use.

3.4.8 Air Pressurization system for IPBD

- a) The entire bus duct shall be kept constantly pressurized while in service, for the purpose of dehumidification after the installation of bus duct is complete in all respects. For this purpose the Bidder shall make available dry instrument air provided by purchaser at indoor location inside the TG building near the bus ducts. From this point, the Bidder shall supply all necessary equipment to maintain the pressure inside the entire bus duct. The equipment supplied shall include all necessary piping including delivery, exhaust and interconnecting piping, pressure reducing device, all necessary valves and associated instrumentation to maintain pressures and scavenging rates as specified. A pressure relief valve shall be provided to relieve the excess pressure in case the pressure goes beyond the pre set value. Air pressurization system shall be 2x 100% redundancy.
- b) A wall mounted control cabinet shall be provided to house the pressure reducing device. The control cabinet shall also have indicating lamps for low pressure and high pressure inside bus duct, inlet air supply failure and system fault indications. Degree of Protection of control panel shall be IP 52.
- c) Two potential free shall be provided for remote annunciation of each of the following conditions:
 - i. Low pressure inside bus duct
 - ii. High pressure inside bus duct
 - iii. Inlet air supply failure
 - iv. System fault.
- d) At least one RTD shall be provided for temperature measurement of ambient air inside each of the bus duct. The same shall be hooked up to Distributed Control System (DDCMIS) by the Bidder.

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3.4.9 Hot air blowing system for IPBD

- a) Facilities shall also be provided to blow out the busbars with dry filtered air and so facilitate rapid cleaning and drying of the installation following maintenance or a period of shutdown.
- b) It shall be of portable type. System shall have the capability to blow out the entire length of the bus duct within 2 hours. Necessary opening shall be provided on IPBD at different locations.

3.4.10 Connections & Terminations

- a) All matching flanges/adaptor boxes, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the Generator, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the Generator and transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.
- e) If the material of bus conductor and that of the equipment terminal connectors are different then suitable bimetallic connectors shall be furnished.

3.4.11 Shorting Link

- a) Pre-fabricated shorting links rated same as the continuous amperage of bus duct main run shall be furnished complete with all hardware for connections.
- b) The links shall be suitable for shorting bus conductors-enclosures of three (3) phases after generator phase current transformers.
- c) The links shall be so designed with flexible connections that the bus insulators will not be unduly stressed due to expansion/ contraction during dry out or short circuit tests.

3.4.12 Grounding

- a) The electrically continuous bus enclosure shall be used as the ground bus. All parts of the bus enclosure, supporting structures and equipment frames shall be grounded.

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- b) Grounding system design shall meet the requirements of ANSI/IEEE C37.23, Sections 7.2 and 7.3. Reliance on the air gaps only between the bus and equipment enclosures for avoiding the circulating currents is not acceptable. An isolating bellows shall be provided; e.g., between the generator terminal enclosure and the bus enclosure; such that electrical clearance between equipment and bus enclosures shall not be less than two (2) and in no way shall thermal expansion and/or movement compromise the isolation between generator terminal enclosure and bus enclosure.
- c) The ground circuit shall be capable of carrying two times the line-to-ground fault current for 1 second, without exceeding temperature limitations.
- d) Duplicate bolted type ground pads shall be provided to accommodate galvanized steel flats, wherever isolated phase busduct terminates.
- e) The metal enclosure of the bus shall be grounded at only one end of the bus run. All gasketed connections shall be bridged by grounding conductor. The contact assemblies shall be sized for the ground fault current.

3.4.13 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) Indoor portion of the bus duct may be supported from the floor or ceiling beams. Outdoor portion of the bus duct shall be supported from ground below on suitable foundation in the ground. The foundations and structures in outdoor area shall clear the transformers, transformer foundations, cable trenches.
- c) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- d) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- e) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.

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- f) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.
- g) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

3.4.14 Current Transformers (if applicable)

- a) The current transformers shall be cast-resin, ring type confirming to IS 2705, mounted within the busduct enclosures and suitable for operation at an ambient temperature equal to rated busbar temperature.
- b) The bus design shall permit removal or replacement of C.T.s without dismantling the bus run or supports.
- c) The C.T.s shall have polarity markings indelibly marked on them.
- d) C.T. secondary leads will be brought out to separate terminal box mounted on or adjacent to C.T. enclosure. From phase terminal boxes, C.T. secondary leads shall be brought out through non- magnetic metallic conduits to a master terminal box for field cable connections.
- e) The terminal boxes shall be dust-tight, weather-proof, fabricated from aluminium alloy and complete with screwed cover for access to terminals and removable cable gland plate.

3.4.15 Surge Protection and Voltage Transformer (SPVT) Cubicles

- a) The V.T. & S.P. cubicles, one for each phase, shall be metal-clad, dust and vermin proof, free standing dead front assemblies.
- b) Each phase cubicle shall house three (3) voltage transformers, one (1) lightning arrestor and one (1) surge capacitor, in separate compartments. Seal-off bushings shall be used between the bus tap and cubicle and between compartments.
- c) Lightning arrestor shall be station class, hermetically sealed type, connected between line and ground, specifically suitable for generator protection.
- d) The characteristic of the lightning arrestor shall be carefully chosen to provide a low protective ratio for generator BIL.
- e) A discharge counter shall be provided for each lightning arrestor. The discharge counter register shall be visible without having to open the compartment door.
- f) The surge capacitor shall be non-inflammable and non-toxic type, single pole, connected between line to ground.

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- g) The voltage transformer shall be cast-resin type, suitable for nominal operation connected from line to ground, and for 1.73 times rated line to ground voltage under sustained emergency condition.
- h) The voltage transformer shall be mounted on draw out type carriage. Suitable guide slots and stops shall be provided to ensure easy withdrawal and positioning.
- i) In the disconnected position, the voltage transformer primary and secondary circuits shall be automatically disconnected and the primary fuse shall be visibly grounded. The draw out frame shall be grounded at all times.
- j) The high voltage winding of the voltage transformer shall be protected by current limiting fuse mounted on top of the primary bushing. The fuse will be accessible only in fully drawn out position.
- k) The secondary leads from the voltage transformer shall be extended to a fuse/MCB and terminal cabinet flush mounted on the compartment.
- l) From phase cabinets the V.T. secondary leads shall be brought to a marshalling box having sufficient number of terminals to accommodate all V.T. leads, facility for making star points and removable plates with knockouts for cable connections.

3.4.16 Cubicle and Control Panel / Cabinet

- a) All cubicles, control panels and control cabinets shall be fabricated from sheet steel of minimum 2 mm thickness suitably reinforced to ensure structural rigidity.
- b) The degree of protection for all indoor cubicles shall be IP 54.
- c) Each cubicle shall be equipped with space heater, internal illumination lamp and ground bus.
- d) Space heater and lamp shall be provided with individual ON-OFF switches. The space heater shall be provided with thermostat.
- e) The ground bus shall have provision for receiving field ground connections two numbers [65 x 10] galvanized steel flats.

3.4.17 Wiring

- a) All wiring shall be done with insulated stranded copper conductor of not less than 2.5 Sq.mm cross-section. Each wire shall be identified at both ends with wire designation as per contractor's wiring diagram and shall be brought out to a terminal box outside the bus duct.

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- b) Terminal blocks shall be box-clamp type suitable for minimum 10 sq.mm with marking strips.
- c) At least 20% spare terminals shall be furnished in the terminal block.
- d) Heat resistant type wires suitable to withstand specified bus duct inside temperature shall be used for wiring between CT secondary terminals to the terminal box.
- e) Terminal for C.T. secondary leads shall have provision for shorting and grounding.

3.4.18 Name plate

Name plates shall be furnished at each disconnect link, voltage transformer compartment, surge protection compartment and fuse block etc.

Materials for name plate shall be plastic, 3 mm thick, using white letters on black background.

3.4.19 Painting and Finish

- f) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint
- g) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- h) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- i) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].
- j) The interior surface finish shall be as per manufacturer's standard.
- k) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- l) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.

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- m) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- n) The paint shade shall be subject to owner's approval.

3.5 Tests

V) Type Test

For each type & rating of Isolated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

VI) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test
- d) Insulation resistance measurement.

3.6 Drawings, Data and Manuals

Drawings, data & manuals for the Isolated phase bud duct shall be submitted as indicated below:

- g) *Dimensional GA drawing*
- h) *Data sheets*
- i) *Typical calculation for arriving at the size of conductor and the insulator spacing.*
- j) *SPVT cubicle GA and Wiring drawing*
- k) *Type test report (short circuit, temperature rise test) for similar bus duct manufactured by the proposed manufacturer.*
- l) *The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other*

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necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

3.7

Ratings & Requirements

Major technical parameters of Isolated Phase Bus Duct are listed below.

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.0	General			
1.1	System nominal voltage	kV	[15kV or As Generator Voltage]	All values are given as per 15kV. However same shall be suitable modified.
1.2	System maximum voltage	kV	[17.5]	
1.3	Number of phases		3	
1.4	Rated Frequency	Hz	50	
1.5	Neutral Grounding		High resistance grounded for generator	
1.6	Insulation level			
a	1 min power frequency withstand voltage	kV	[38]	
b	Impulse withstand voltage	kVp	[95]	
1.7	Short Circuit Level			
a	Symmetrical short circuit capacity	kA	As per Clause 1.3(k). [As per requirement]	
b	Dynamic capacity	kAp	[By bidder]	
1.8	Auxiliary Voltage			
a	Air Pressurization/Hot Air blowing	V	415V + /-10%, 50Hz + 3% to -5%, 3phase, 4 wire.	
b	Space heating voltage	V	240V ± 10%, 1ph, 50 Hz, 2 wires.	
1.9	Reference standard		IS 8084/ IEEE C37.23	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
2.0	Busduct			
2.1	Make		[By Bidder]	
2.2	Type of bus duct		Isolated phase bus duct	
2.3	Service		Indoor/Outdoor	
2.4	Type of cooling		Natural air cooled	
2.5	Nominal service voltage/rated frequency		[As generator Voltage/15kV], 50Hz	
2.6	Busduct length		a) Between Generator and GT, b) Tap off to UT and SET	
2.7	Rated voltage class		[17.5] kV	
2.8	Continuous current rating of bus duct under site conditions between			
	a) Main run between Generator and GT	Amps	[As per Project specific]	
	b) Tap off to UT and SET	Amps	[As per Project specific]	
2.9	Basic impulse withstand level (1.2 x 50 micro sec wave)	kVp	[95]	
2.10	One minute power frequency dry withstand voltage	kV	[38]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
2.11	Short time current for one second /Dynamic withstand current a) Main run b) Tap off	KA /KAp	As per Clause 1.3(k). [As per requirement]	
2.12	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
2.13	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
2.14	Maximum temperature rise of conductor over 50° C ambient when carrying short circuit current for 1 sec	°C	200	
3.0	Bus conductor			
3.1	Bus conductor Material		Aluminium alloy Grade [63401] as per IS-5082	
3.2	Bus conductor size for			
	a) Main run between Generator and GT	mmxm m	[By Bidder]	
	b) Tap off run for UT and SET	mmxm m	[By Bidder]	
3.3	Bus conductor shape		[By Bidder]	
3.4	Busbar Dimension		[By Bidder]	
3.5	Method of joining adjacent sections		Welded	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
3.6	Parameters	ohms	[By Bidder]	
a	Resistance/meter/Phase at 20°C		[By Bidder]	
b	Inductive reactance per phase at 20 deg.C at 50 Hz (main/tap-offs)		[By Bidder]	
c	Capacitive reactance per phase at 20deg.C at 50 Hz (main/tap-offs)		[By Bidder]	
4.0	Bus enclosure			
4.1	Bus Enclosure Material		Aluminium alloy Grade [63401] as per IS-5082	
4.2	Shape of Enclosure		Circular	
4.3	Inner diameter and thickness	mm	[By Bidder]	
4.3	Cross section of enclosure	mmxm m	[By Bidder] { It shall be provided for each rating of busduct}	
4.4	Method of joining adjacent sections		[By Bidder]	
4.5	Parameters			
a	Resistance/meter/Phase at 20°C		[By Bidder]	
b	Inductive reactance per phase at 20 deg.C at 50 Hz (main/tap-offs)		[By Bidder]	
c	Capacitive reactance per phase at 20deg.C at 50 Hz (main/tap-offs)		[By Bidder]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
4.6	Power loss			
a	Power loss in the isolated phase bus duct at full load		Main/Tap off	
b	Middle phase	kW/m	[By Bidder]	
c	Each outer phase	kW/m	[By Bidder]	
d	Total	kW/m	[By Bidder]	
e	Power loss in bus conductor when carrying rated current	kW/3 ph. Metre run	[By Bidder]	
f	Power loss in bus enclosure when carrying rated current	kW/3 ph. Metre run	[By Bidder]	
g	Total power loss(Conductor and enclosure)	KW	[By Bidder]	
5.0	Bellows			
5.1	Manufacturer		[By Bidder]	
5.2	Material and grade		[By Bidder]	
5.3	Maximum permissible expansion		[By Bidder]	
6.0	Phase to phase spacing			
a	Main run	mm	[By Bidder]	
b	Tap off	mm	[By Bidder]	
c	Minimum phase to earth clearance	mm	[By Bidder]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
7.0	Material of gasket for inspection window		[By Bidder]	
8.0	Disconnecting links			
a	Quantity/Location		[By bidder]	
b	Rated current under site conditions		[To suit corresponding bus rating]	
9.0	Insulators and seal off bushings			
9.1	Make		[By Bidder]	
9.2	Rated Voltage	kV	[17.5]	
9.3	One minute Power Frequency Withstand Voltage	kVrms	[38]	
9.4	Impulse Withstand Voltage (1.2 x 50 micro-second Wave)	kVp	[95]	
9.5	Minimum Creepage Distance	mm/kV	25	
9.6	Insulators			
	a) Material of Insulators		[By Bidder]	
	b) Cantilever strength		[By Bidder]	
	c) Weight of insulator	kg	[By Bidder]	
	d) No of supports and insulator span		[By Bidder]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
10.0	Seal-off bushings			
10.1	Make		[By Bidder]	
10.2	Current rating of Seal of Bushings	Amps	[By Bidder]	
10.3	Material of Seal Off Bushings		[By Bidder]	
10.4	Type		[By Bidder]	
10.5	Mechanical Strength		[By Bidder]	
10.6	Weight of each bushing	kg	[By Bidder]	
11.0	Pressurization equipment			
11.1	Pressure of supply air	Kg/cm ²	[5 to 7]	
11.2	Pressure to be maintained inside bus ducts		[20 to 100]mm water column above atmosphere	
11.3	Scavenging rate	l/hr	[By Bidder]	
11.4	Guaranteed leakage rate (through bus ducts)	l/hr	[By Bidder]	
11.5	Quantity of air required		[By Bidder]	
12.0	Hot air blowing system	Yes/No	[Yes]	
13.0	Current transformer			
13.1	Type		Cast resin, indoor	
13.2	Rated voltage class	kV	[17.5]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
13.3	One second thermal rating	kA	[By Bidder]	
13.4	Dynamic rating	kA	[By Bidder]	
13.5	Insulation class		Class E	
13.6	Accuracy class		[0.2] for protection [0.5] for metering	
14.0	Voltage Transformer			
14.1	Type		Cast resin, draw out	
14.2	Service		Indoor	
14.3	Rated Voltage			
a	Primary	V	[Generator Voltage]/sqrt(3)	
b	Secondary Voltage	V	110/sqrt(3)	
14.4	Winding connection			
a	Primary		Grounded Wye	
b	Secondary		Grounded Wye	
c	Insulation class		[17.5]	
14.5	Over voltage factor			
a	Continuous		1.2	
b	30 second		1.9	
14.6	Accuracy class		3P for protection	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
			0.5 for measurement	
15.0	Surge protection			
15.1	Type		Station class	
15.2	Service		Indoor	
15.3	Rated voltage class	kV	[17.5]	
15.4	Nominal Discharge current		[10]kA	
15.5	Power frequency withstand voltage	kV	[38]	
15.6	Lightning impulse withstand voltage	kVp	[95]	
16	Earthing Material		GS	
117	Finish of Bus Enclosure		[RAL5012]	
18	Rain hood required Yes/No		Yes, for outdoor portion	
19	Degree of protection for enclosure		IP 55	

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4. LIST OF ATTACHMENTS

The following List of attachments is enclosed along with this specification.

[Note: List of attachments is depends on specific project scope of work. R & M consultant may attach the attachments as per project specific scope of work. For reference all attachments are considered in this package as per scope of work considered]

Legend: O: USE, X: NOT USE

TABLE-4.1

Sl.No	Attachment Number	Description	Rev No	Application
1	E1	Motor	R1	O
2	E2	Motorized Actuators	R1	O
3	E3	LV Transformers(Dry type/Oil type)	R1	O
4	E4	415V Switchgear,MCC and DBs	R1	O
5	E5	415V Non Segregated Bus Duct	R1	O
6	E6	220V DC system	R1	O
7	E7	HV Cables	R1	O
8	E8	LV Cables	R1	O
9	E9	Illumination system	R1	O
10	E10	Cable Carrier System	R1	O
11	E11	Earthing and Lightning Protection system	R1	O
12	E12	MV Switchgear	R1	O
13	E13	Variable Frequency Drives	R1	O
14	E14	6.6kV Segregated Phase Bus Duct	R1	O

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E1
TECHNICAL SPECIFICATION FOR MOTORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E1

1.0 MOTOR

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Electric Motor complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS : 325	:	Specification for three phase induction motor.
IS : 900	:	Code of Practice for installation and maintenance of induction motors
IS : 996	:	Single phase AC motors
IS : 1231	:	Dimensions of three-phase foot-mounted induction motors
IS : 1271	:	Thermal evaluation and classification of electrical insulation.
IS : 2223	:	Dimensions of flange mounted ac induction motors.
IS : 2254	:	Dimensions of vertical shaft motors for pumps
IS : 3177	:	Crane duty motors
IS : 4029	:	Guide for testing three phase induction motors.
IS : 4691	:	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	:	Specification for rotating electrical machinery.

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IS : 4728	:	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	:	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	:	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	:	Designation of Method of Cooling of Rotating electrical machines.
IS : 8223	:	Dimensions and output ratings for foot mounted rotating electrical machines with frame numbers 355 to 1000.
IS : 8789	:	Values of performance characteristics for three phase induction motors.
IS : 12065	:	Noise level of motors.
IS : 12075	:	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	:	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	:	Temperature rise measurement of rotating electrical machines
IS : 12824	:	Type of duty and classes of rating assigned.
IS : 14222	:	Requirements and method of Impulse withstand test
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IEC: 60034	:	Rotating electrical machines.
NEMA, MG-1	:	Motors and Generators
ISO : 1940-1	:	Mechanical vibration – Determination of permissible residual unbalance

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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All motors shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment.
- b. AC Motors shall be of [constant speed, squirrel cage, three/ single phase, induction type.] Motors shall be rated for [continuous duty/intermittent duty]. They shall also be suitable for long period of inactivity. They shall also be suitable for direct online starting (DOL starting).
- c. DC motors provided for emergency service shall be shunt / compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.
- d. Power supply for AC motors shall be as follows:

Table: 2.0

1.	[Below 0.22 kW]	:	240V, 1 Phase, 50Hz
2.	[From 0.22 kW up to & including 160 kW]	:	415V, 3 Phase, 50Hz
3.	[Above 160 kW]	:	6.6kV, 3 Phase, 50Hz

- e. All AC motors shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

- f. DC motors shall be rated for 220V DC supply with voltage variation of -15% to +10%.
- g. The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, break down and full load torques are available for the intended service.

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- h. Moreover, motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
- i. Motors shall be capable of developing the rated full load torque even if the supply drops to 70% of the rated voltage.
- j. For 6.6kV motors, locked rotor current not to exceed [600%] of full load current, including positive tolerance, except for BFP. For BFP the starting current shall be [450%] of FLC. For 415 V motors Locked rotor current not to exceed [600%] of full load current with IS tolerance.]
- k. For DC motors, the starters shall be provided to limit the starting current to [2] times of the full load current.
- l. Maximum continuous motor ratings shall be at least [10%] above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.
- m. Accelerating torque at any speed with the lowest permissible starting voltage shall be at least [10%] motor full load torque. Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.
- n. The motors shall be suitable for bus transfer schemes provided on the 6.6kV and 415V systems without any injurious effect on its life. If motors are connected to an automatic bus transfer system, they may be subjected to 150% of the nominal voltage during changeover of buses due to the phase difference between the incoming voltage and motor residual voltage. In such cases, motors shall be capable of restarting under full load after momentary loss of voltage.
- o. Motors shall be of [energy efficient of type Eff-2] as per IS: 12615/equivalent IEC/ International Standards.
- p. Motor shall be designed to keep torsional and rotational natural frequencies of vibration of the motor and driven equipment at least 25% above the motor operating speed range.

1.3.1 System Grounding

Table: 3.0

(a)	6.6 kV	:	Low Resistance Grounded to limit the earth fault current to [300 Amps]
(b)	415 V	:	Solidly Grounded
(c)	220V DC	:	Ungrounded

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1.3.2 Fault Level

Table: 4.0

(a)	6.6 kV	:	[40 kA for 1 second]
(b)	415 V	:	[50 kA for 1 second]
(c)	220V DC	:	[25 kA for 1 second]

1.3.3 Degree of Protection

Table: 5.0

(a)	Indoor Motors	:	[IP 54]
(b)	Outdoor Motors	:	[IPW 55]
(c)	Cable Box located in Indoor Area	:	[IP 54]
(d)	Cable Box located in Outdoor Area	:	[IPW 55]

1.3.4 Winding Insulation

Table: 6.0

(a)	For 6.6 kV AC Motors	:	[Class – F]
(b)	For 415V AC Motors	:	[Class – B]
(c)	For 220V DC Motors	:	[Class – B]

1.3.5 Winding Conductor Material

Table: 7.0

(a)	For 6.6 kV AC Motors	:	Copper
(b)	For 415V AC Motors	:	Copper
(c)	For 220V DC Motors	:	Copper

1.3.6 Bearing

Table: 8.0

(a)	For Drive End	:	[Roller]
(b)	For Non Drive End	:	[Roller / Ball]

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1.3.7 Temperature Rise

Table: 9.0

(a)	For Air Cooled Motors	:	[70 °C] over ambient temperature [Class B]
(b)	For Water Cooled Motors	:	[80 °C] over inlet cooling water temperature [Class B]

1.3.8 Motor Earthing

Table: 10.0

(a)	Motors above 90 kW	:	[50 x 6 mm GI Flat]
(b)	Motors above 30 kW and up to 90 kW	:	[25 x 6 mm GI Flat]
(c)	Motors above 5 kW and up to 30 kW	:	[25 x 3 mm GI Flat]
(d)	Motors up to 5 kW	:	[8 SWG GI Wire]
(e)	Terminal Box	:	[8 SWG GI Wire]

1.3.9 Space Heater

Table: 11

(a)	For Motors 30 kW rating and above	:	Space heater suitable for 1Phase, 240V AC, 50 Hz supply
(b)	For Motors below 30 kW rating	:	No Space heater provided.

1.3.10 Painting

Table: 12

a)	Paint Type	:	Epoxy based with approved class
b)	Paint Thickness	:	[Within 100 to 150 micron.]
c)	Paint Shade	:	[RAL5012 BLUE]

1.4 Specific Requirements

1.4.1 Locked Rotor Withstand Time

- The starting time of the motor shall be at the minimum permissible voltage.
- For motors with starting time up to 20 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot

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condition at highest voltage limit shall be at least 2.5 second more than starting time.

- c) For motors with starting time more than 20 second and up to 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 second more than starting time.
- d) For motors with starting time more than 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- e) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.

1.4.2 Starting Voltage Requirement

I.	All motors (except mill motors):
a)	[85% of rated voltage for motors up to 4000 kW]
b)	[75% of voltage for motors above 4000 kW]

II.	For mill motors:
a)	[85% of rated voltage for motors above 1000 kW]
b)	[90% of rated voltage for motors below 1000 kW]

The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at [125%] rated speed in reverse direction.

The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

1.4.3 Winding and Insulation

a)	6.6 kV AC motors	:	Winding material shall be of copper. Insulation shall be of [Class F with winding temperature rise limited to Class B]. They shall withstand 1.2/50 microsecond switching surges of "4U + 5 KV" (U=Line voltage in KV). The coil inter-turn insulation shall be suitable for 0.3/3 micro second surge of 32 / 12 KV followed by 1 min
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			power frequency high voltage test of appropriate voltage on inter turn insulation.
b)	415V AC & 220V DC motors	:	Winding material shall be of copper. Insulation shall be of [Class B with temperature rise limited to Class B.]
c)	Conveyor motors		Short circuit rings of conveyor motors shall be either joint less or welded type. Brazed joint is not acceptable.

1.4.4 Motor Control

a) For HV Motors

- i. Motors of rating above [160 kW] shall be suitable for 6.6 KV voltage
- ii. Frequent starting motors of rating above [160 kW] shall be suitable to be controlled by vacuum contactors

(b) For LV Motors

- i. Motors of rating less than [132 kW] shall be operated by Contactor from respective MCCs. Motors of rating up to [18.5 kW] shall be provided with MPCBs and Electronic overload relays. Motors of rating above [18.5 kW] and below [45 kW] shall be provided with MCCBs and Electronic overload relays. Motors of rating [45 kW] and above but less than [132 kW] shall be provided with MCCBs and CT operated Electronic over load relays.
- ii. Motors of rating [132 kW] and up to [160 kW] shall be suitable to be controlled by Air circuit breakers from switchgear, PMCCs and shall be provided with comprehensive numerical motor protection relays.
- iii. Only for firefighting system, motor rated [upto 200kW] shall be fed from 415V switch board.

1.4.5 Starting duty

Motors shall be suitable for [3 nos. consecutive Cold starts ups and 2 nos. consecutive Hot starts ups.] Motors shall be suitable for three equally spread starts per hour when the motor is under normal service condition.

1.4.6 Bearings

- a) Anti-friction type radial and thrust bearings (ball, roller) and sleeve bearing shall be rated for minimum standard life of 40,000 hours taking bearing and driven equipment loads (in case the drive is not having

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separate thrust bearing) into account. If bearings are lubricated, loss of grease shall be scarce and it shall not creep along shaft into motor housing. Facility of removal of excess grease shall also be provided for grease lubricated bearings.

- b) Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if Anti-friction bearings can take vertical thrust, thrust & guide bearings are not required.
- c) Bearing shall be effectively sealed against dust ingress and shall be pressure grease gun lubricated. The bearing and housing shall be so designed that greasing shall be possible while the motor is running, without removal of covers.
- d) Where bearing supports are attached to the motor casing, adequate bracing shall be provided on these supports to reduce vibrations and ensure life of bearings.
- e) If the bearings are oil lubricated, a drain plug shall be provided for draining residual oil and oil level gauge shall be provided to show precisely oil level required under standstill and running conditions.
- f) Unless otherwise approved, bearing lubricating system shall be such that no external forced oil or water is necessary to maintain required oil supply to keep bearing temperature within design limits.
- g) Lubricants shall be selected for prolonged storage and normal use of motors in tropical climate and shall contain corrosion and oxidation inhibitors. Greases shall have suitable bleeding characteristics to minimize setting. The selected lubricants shall be indigenously available.
- h) Motors rated above 1000 kW shall have insulated bearings to prevent flow of shaft currents.

1.4.7 Temperature Rise

- a) For Air Cooled Motors, temperature rise of insulation should be limited to [70 °C] over ambient temperature by resistance method.
- b) For Water Cooled Motors, temperature rise of insulation should be limited to [80 °C] over inlet cooling water temperature mentioned elsewhere, by resistance method.

1.4.8 Cooling

[All motors shall be either Totally Enclosed Fan Cooled (TEFC) or Totally Enclosed Tube Ventilated (TETV) or Closed Air Circuit Air Cooled (CACA) type. However, motors rated 3000 kW or above can be Closed Air Circuit Water Cooled (CACW)]

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1.4.9 Enclosure

- a) All motor enclosures shall conform to the degree of protection of [IP54] for indoor and IPW-55 for outdoor installation unless otherwise specified. Motor for outdoor or semi outdoor service shall be of weather proof construction. Motors of large output rating located indoor could have screen protected drip proof (SPDP) enclosure conforming to [IP-23.]
- b) For motors located in outdoor & corrosive locations, FRP canopy shall be provided. In case steel canopy is provided, the same shall be epoxy painted to meet the surrounding atmosphere. Motors located in hazardous areas such as Hydrogen plant shall have flame proof enclosures of Group – IIB conforming to IS: 2148.
- c) For hazardous locations such as fuel oil facilities area, the enclosure of motor shall have flame proof construction conforming to IS 2148.

1.4.10 Noise Level and Vibration

Noise level shall be limited to 85 dB (A) at 1.5 meters from the motor. However the same shall be as per IS: 12065 unless otherwise specified. The peak amplitude of vibration shall be within the specified limits laid down in IS: 12075. Motors shall withstand vibrations produced by driven equipment. HV motor bearing housings shall have flats in both X and Y directions suitable for mounting 80mmX80mm vibration pads. Vibration pads with screwed holes for mounting vibration probes shall be provided at both DE and NDE.

1.4.11 Temperature Monitoring

[In HV motors, at least four numbers simplex/ two numbers duplex platinum resistance type temperature detectors shall be provided for each phase of stator winding]. Each bearing shall be provided with dial type thermometer with adjustable alarm contact and two numbers duplex Platinum resistance type temperature detector (3 wire, 100 ohm at zero °C). In case of CACA and CACW motors dial type temperature indicator shall be provided (one each for hot and cold air temperature monitoring for CACA and CACW and one each for inlet and outlet water temperature monitoring for CACW). If alarm and trip are required for cooling air temperature, temperature switch shall be provided. The contact rating shall be minimum 0.5A at 220V DC and 5A at 240V AC. Flow switches shall be provided for monitoring cooling water flow of CACW motor and oil flow of forced lubrication bearing. Low voltage motors rated 100 kW and above shall be provided with two PT100 RTDs per phase of winding.

1.4.12 Earthing

Motor body shall have two earthing points on opposite sides. Motor terminal boxes shall also have separate grounding terminals.

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1.4.13 Termination

- a) HV motors can be offered with either Elastimold termination or dust tight phase segregated double walled (metallic as well as with insulated barrier) cable boxes. In case Elastimold terminations are offered, then protective cover and trifurcating sleeves shall also be provided. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided in case of cable boxes. The main cable box / terminal box shall withstand *[a fault current up to 40 kA for 0.25 seconds for HV motors and 50 kA for 0.25 seconds for LV motors]*. Separate terminal boxes shall be provided for space heaters and RTDs and NCT (if applicable).
- b) *[All terminal boxes shall be capable of being turned through 360 degrees in steps of 90 degrees unless otherwise specified.]*
- c) For HV motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

1.4.14 Differential Protection

For motors rated 6.6kV, *[2000 KW & above,]* neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box for differential protection.

1.4.15 Tropical Protection

- (a) All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- (b) All fittings and hardware shall be corrosion resistant.
- (c) Space Heater
- (d) Suitable single phase space heaters operated at 240V, 50Hz, 1Phase AC supply shall be provided on motors rated for 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided.
- (e) The space heater shall be sized to maintain the motor internal temperature above dew point when the motor is in idle condition.

1.4.16 Rating Plate

Motor shall have Stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / NEMA-MG-1 and following additional information:

- (a) Type of bearing and recommended lubricants along with location of insulated bearing.
- (b) Temperature rise under normal/abnormal conditions.

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(c) In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.

(d) Year of Manufacture

1.4.17 Drain Plug

Motor shall have drain plugs so located that they shall drain the water, resulting from the condensation or other causes from all pockets of the motor casing.

1.4.18 Dowel Pins

Motor shall be designed to permit easy access for drilling holes through motor feet or mounting flange for installation of dowel pins after assembling the motor and driven equipment.

1.4.19 Painting

The complete motor assembly including fan shall be painted with corrosion proof paints of approved class.

1.4.20 Lifting provision

Motor weighing 25 Kg or more shall be provided with eyebolt or other adequate provision of lifting.

1.4.21 Local Push Button Station (LPBS)

- a) Each motor shall be provided with push button station as per process requirement i.e. Start/Stop or Emergency Stop.
- b) The degree of protection of LPBs shall be IPW 55 for outdoor and IP 54 for indoor applications.
- c) All Push Buttons shall be push to actuate type and stop Push Button shall be lockable in off position as per the scheme requirement.
- d) The Emergency local stop push button of Stay put type shall be provided with Press to lock & turn to release keyless mechanism.
- e) All PBs shall be provided with 2 numbers NO and 2 numbers NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to switchgear module for direct tripping and another contact to control system.
- f) Terminals to be suitable for 2 cores of 2.5 Sq.mm. cable with 20% spare terminals.
- g) All LPBS shall be of Poly Carbonate /FRP / Die Cast Aluminium material.

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I) TestsType Test

For each type & rating of HV and LV motors of rating above [50 kW], the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last[five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- (a) Visual and dimensional check
- (b) Winding resistance measurement
- (c) No load test
- (d) Mechanical vibration
- (e) Direction of rotation versus phase sequence
- (f) Insulation resistance measurement
- (g) High potential test
- (h) Locked rotor test
- (i) Speed/torque test
- (j) Over speed test
- (k) Temperature rise test
- (l) Determination of characteristic
- (m) Degree of protection test for the enclosure.
- (n) Noise level
- (o) Shaft current and bearing insulation test (Applicable for HV motors)

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

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IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.5 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

Dimensional General Arrangement drawing

- a) [Motor sizing calculation
- b) Foundation Plan & Loading
- c) Cable end box details
- d) Space requirement for rotor removal
- e) Thermal withstand curves hot & cold
- f) Starting and speed torque characteristics at 80% & 100% voltage
- g) Complete motor data
- h) Erection & Maintenance Manual
- i) Test reports
- j) QAP]

1.6 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	Technical Particulars	Unit	Parameters	Remarks
1	Motor application		[As per requirement]	
2	Rated Output, kW	kW	[As per requirement]	
3	Maximum continuous kW obtainable without exceeding specified temperature rise	kW	[By Bidder]	
4	Motor type		Squirrel cage induction motor	
5	Duty Cycle (IEC 60034-1)		[S1]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
6	Rated voltage	kV	6.6 kV for HV motors 415 V for LV motors 220V DC for DC motors	
7	Phase/frequency	Hz	50	
8	Allowable variation in supply conditions			
a)	Voltage		6.6 kV	
b)	Frequency		50	
c)	Combined			
9	Method of starting		DOL	
10	CT details for differential protection	Yes/No	For motors of rating > 2000kW	
11	Full load amperes	A	[By Bidder]	
12	Locked rotor current amperes	A	HV(Except BFP): 6 times without tolerance BFP: 4.5 times without tolerance LV: 6 times with IS specified tolerance DC : 2 times with no positive tolerance at rated terminal voltage.	
13	Method of Cooling (IC code)		[As per requirement]	
14	Enclosure (IP Code)		Indoor : IP54 Outdoor : IPW55	
15	Construction (horizontal or vertical)		[As per requirement]	
16	Max. temperature, by resistance method	Deg C	120 deg (Class B)	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
17	Insulation class		HV: Class F LV: Class B	
18	Motor insulation system (describe material used)		[By Bidder]	
19	Bearings		[By Bidder]	
a)	Type			
b)	Quantity			
c)	Lubrication system pressure and flow			
20	Temperature detector (type & quantity)			
a)	Winding		[As per requirement]	
b)	Bearing		[As per requirement]	
21	Space heaters		30 kW and above	
a	Watts (Rating/Operating)	W	[By Bidder]	
b	Volts (Rating/Operating)	V	[By Bidder]	
22	GD ² of motor		[By Bidder]	
23	Power factor		[By Bidder]	
a)	Full load	p.u		
b)	3/4 load	p.u		
c)	1/2 load	p.u		
d)	No load	p.u		
24	Efficiency		[By Bidder]	
a)	Full load	%		
b)	3/4 load	%		
c)	1/2 load	%		
25	Impedance data		[By Bidder]	
a)	locked rotor reactance per phase	Ohm		
b)	Rotor resistance per phase	Ohm		

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S. No.	Technical Particulars	Unit	Parameters	Remarks
c)	stator resistance per phase	Ohm		
26	Net motor weight	Kg	[By Bidder]	
27	Terminal box dimensions H/W/D	Mm	[By Bidder]	
28	Rotor removal clearance	mm	[By Bidder]	
29	Winding connection (star or delta)		HV: Star LV: Delta	
30	Noise Level	dB(A)	[As per requirement]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E2

**TECHNICAL SPECIFICATION FOR MOTORIZED
ACTUATORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E2

1.0 MOTORIZED ACTUATORS

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Motor Operated Actuator complete with all accessories for efficient and trouble-free operation of valves, dampers and gates for R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS : 325	Specification for three phase induction motor.
IS : 900	Code of Practice for installation and maintenance of induction motors
IS : 996	Single phase AC motors
IS : 1271	Thermal evaluation and classification of electrical insulation.
IS : 2223	Dimensions of flange mounted ac induction motors.
IS : 4029	Guide for testing three phase induction motors.
IS : 4691	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	Specification for rotating electrical machinery.
IS : 4728	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	Designation of Method of Cooling of Rotating electrical machines.

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IS : 8789	Values of performance characteristics for three phase induction motors.
IS : 9334	Electrical Motor Operated Actuators.
IS : 12065	Noise level of motors.
IS : 12075	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	Temperature rise measurement of rotating electrical machines
IS : 12824	Type of duty and classes of rating assigned.
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package
IEC: 60034-1	Rotating electrical machines.
NEMA, MG-1	Motors and Generators

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All motor operated actuators shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.
- Depending on the required type of services, the rating of motor operated actuators shall be selected. For isolating service, the actuator shall be [rated for three successive open-close operations of the valve/ damper or 15 minutes continuous operation whichever is higher.] Whereas for regulating service, the actuator shall be suitably [time rated for required number of duty cycle or 150 start per hour whichever is higher].
- The actuator shall be accompanied with constant speed, squirrel cage, three/ single phase, induction motor. The motor shall be designed for high

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torque and reversing service. They shall also be suitable for direct online starting (DOL starting).

- d. Motors of actuators shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- e. The motor operated actuator shall be sized for performing open / close operation at rated speed against designed differential pressure at [90%] of rated voltage. The motor shall have [10%] design margin on the shaft design power.

The actuator shall meet the following performance requirements:

- i. Open & Close the valve completely and make leak tight valve closure without jamming.
- ii. Attain full speed of operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- iii. The motor reduction gearing shall be sufficient to lock the shaft when the motor gets de energized and prevent drift from torque switch spring pressure.
- iv. The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.
- v. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

1.4 Specific Requirements

1.4.1 Construction

- a) The actuator shall essentially comprise of drive motor, limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, space heater and internal wiring.
- b) The actuator enclosure shall be totally enclosed, dust tight, weather proof with [IPW 55] degree of protection.
- c) All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

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- d) Gear train shall be made of metal (fiber gears are not acceptable). Self locking feature shall be provided to prevent drift under torque switch (wherever applicable) spring pressure when motor is de energized.
- e) Manual wheel shall disengage automatically during motor operation.

1.4.2 Type

- a) The actuators shall have integral starters along with overload relays with built-in single phase preventer.
- b) A 415 V, 3 phase, 3 wire, 50 Hz power supply will be provided from power plant 415 V switchgear through MCCB. Control voltage of the starter circuit shall be 110 V AC or depending on manufacturer's practice. But the same shall be derived from incoming 415 V, 3 phase, 3 wire supply.

1.4.3 Motors

- a) Type: The drive motor shall be three phase, squirrel cage induction motor suitable for direct on line starting with starting current limited to six times the rated current
- b) Enclosure: The motor shall be totally enclosed, self ventilated with [IPW 65] degree of protection.
- c) Insulation: The motor winding shall be insulated with [Class – B] insulation having temperature rise limited to [Class – B].
- d) Bearing: The motor bearing shall be [double shielded, grease lubricated and antifriction type].
- e) Earthing: At least two earthing terminals shall be provided for the motor body. Separate earthing terminal should be provided for terminal box.
- f) Protection: The following electrical protections should be provided for the motor:
 - i. Single Phasing Protection
 - ii. Overload Protection
 - iii. Overheating Protection through thermostat
 - iv. Wrong Phase Sequence Protection
- g) Limit Switches: Each actuator shall be accompanied with following switches:
 - i. Four nos. positional limit switches (2 for open & 2 for close), each adjustable at any position from fully open to fully closed positions of the valve / damper.
 - ii. Two torque limit switches, one for each direction of travel, self blocking & adjustable torque type.

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- iii. Four nos. end travel limit switches, two for each direction of travel.
 - iv. A single shaft shall actuate all contacts of limit switches at each position.
- h) Interface: Open/close command termination logic with position and torque limit switches, positioned circuit shall be suitably built in the PCB inside the actuator.
 - i. For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided. Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the DCS shall be energized to initiate opening and closing, by 24V DC signal from the external control system. Potential free contact provided by the IPR shall be utilized in the control circuit of the contactor of motorized actuators.
 - ii. For modulating drive, the command to actuator shall be in form of 4- 20mA signal. The necessary positioning circuit and motor protection shall be provided.
 - iii. Open/close command termination logic shall be suitably built inside actuator.
- i) Hand Wheel: Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall disengage automatically when the motor is energized.
- j) Position Indicator / Transmitter: The actuator shall have
 - i. One built in local position indicator for 0 – 100% travel.
 - ii. One position transmitter of modulating / inching type for remote indication suitable to stabilize 4-20mA signal and operated with [24V DC].
- k) Space Heater: Space heater of suitable rating shall be provided. The power supply shall be derived from main power supply available in the actuator.

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- l) Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be done with [2.5 sqmm] copper wires. All wiring shall be well identified at both ends with ferrules.
- m) Terminal Box:
 - i. The terminal box shall be weather proof with removable front cover and cable glands suitable for cable connection. The terminals shall be suitable for connection of [2.5 sq.mm copper] conductor.
 - ii. Necessary double compression cable glands with nickel coating and tinned copper lugs for cables shall be provided.
 - iii. The terminal block shall be suitable for 650V grade power cable.
- n) Rating Plate : Motor and actuator shall have Stainless steel nameplate(s) showing all particulars as per relevant IS/ IEC and following additional information:
 - i. Type of bearing and recommended lubricants.
 - ii. Temperature rise under normal/abnormal conditions.
 - iii. Degree of Protection
 - iv. In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.
 - v. Year of Manufacture

1.5 Tests

The actuator and all components thereof shall be subject to routine factory tests as per relevant IS standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

1.5.1 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum [7] days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc.]

1.5.2 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished with requisite no. of copies for approval of the Owner.

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- b) The equipment shall be dispatched from works only after receipt of owner's written approval of shop test reports.

1.6 Drawings Data and Manuals

The drawings, data & manuals for the motorized actuators shall be submitted as indicated below:

1. [Actuator Data Sheet]
2. General arrangement drawing
3. Internal wiring Diagram and Control Schematic.
4. Torque switch and Limit switch contacts development.
5. QAP for Test Reports
6. Manufacturer's Catalogue.
7. Instruction manuals on Installation methods.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		Integral
2.	Application		[As per project specific]
3.	Motor type		Squirrel Cage
4.	Supply voltage	V	415 V, 3 ph, 3 wire.
5.	Phase, frequency	Hz	3ph, 50 Hz
6.	Motor rated voltage	V	415V/230 V
7.	Control Voltage	V	[110 V AC]
8.	Voltage and its variation	V	± 10%
9.	Frequency and its variation	Hz	+ 3 to -5%
10.	Combined V & f variation	%	10%

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S. NO.	DESCRIPTION	UNIT	DATA
11.	Degree of Protection		IPW 65
12.	Winding Insulation		Class B
13.	Temperature Rise (over ambient temperature)	°C	Class B
14.	Painting		[RAL 5012]
15.	Motor Starting		
a)	Method		DOL
b)	Starting Current		6 times

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

TURBO GENERATOR & AUXILIARIES

(PACKAGE NUMBER: R&M-SP-02)

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E3

TECHNICAL SPECIFICATION FOR LV TRANSFORMERS

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E3

1.0 LV TRANSFORMER (DRY TYPE/OIL TYPE)

1.1 General

This specification is intended to cover [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV Transformers (Dry type/Oil type) complete with all accessories for efficient and trouble free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

CODE	NAME OF STANDARD
IS:334	Dimensions for porcelain Transformer bushing
IS:335	New insulating oil for transformers and switchgears
IS:1271	Classification of insulating materials for Electrical Machinery and apparatus in relation to their stability in service.
IS 2026	Specification for power Transformer (all parts)
IS:2071	Method of high voltage testing
IS:2099	High voltage porcelain bushings
IS:2147	Degree of protection.
IS:2705	Current transformers
IS:3202	Code of practice for Climate proofing of electrical equipment
IS:3637	Gas operated relays
IS:3639	Fittings and accessories for power Transformers
IS:5561	Electric Power connectors
IS:6600	Guide for loading of oil immersed transformers

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CODE	NAME OF STANDARD
IS: 11171	Dry type transformers
IS:10028	Code of practice for selection, Installation and maintenance of transformers Part I, II and III
CBIP	Manual on transformers
IEC60076	Power Transformer
IEC 60214	Tappings
IEC 60726	Dry-type power transformers
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
ANSI C57.12.51	Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160 Volts
ANSI C57.12.55	Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard
ANSI/IEEE C57.98	Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
ANSI/NFPA 70	National Electrical Code
IEEE C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.94	Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers

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CODE	NAME OF STANDARD
NEMA ST 20	Dry Type Transformers for General Applications
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The transformers shall be dry type (AN) for indoor location and shall be oil type (ONAN) for outdoor location.
- b) The oil type transformer shall be installed in hot, humid and tropical atmosphere with ambient temperature equal to 50°C. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- c) The transformer shall be capable of continuous operation at specified rating under the following condition:
 - i) Voltage variation - $\pm 10\%$
 - ii) Frequency variation - $[+3\%, -5\%]$
 - iii) Combined voltage and frequency variation (absolute sum) - $[10\%]$
- d) The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.
- e) The noise level shall be limited to the value specified by NEMA Standard Publication No. TR-1-1993 when measured in accordance with conditions outlines in ANSI/IEEE C57.12.90-1999/IS13964/CBIP publication.
- f) The design shall be such as not to cause any undesirable interference with radio or communication circuits.
- g) Transformers shall accept without injurious heating, combined voltage and frequency variation which produce an over fluxing condition of 120% for one (1) minute.

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- h) Each transformer shall be sized based on actual load with 10% margin and considering voltage regulation factor. It shall be sized by considering 100% load connected on the bus considering other transformer outage. An appropriate load factor of 0.9 for continuous and 0.2 for intermittent shall be considered.
- i) The impedance of the transformers shall be chosen such that the fault level on the LV switchgear does not exceed 50kA including the motor contributions and also voltage dip while starting the motor does not exceed 15% at motor terminal.

1.4 Specific Requirements of Transformers

1.4.1 Enclosure (for dry type)

- a) The encapsulated cast resin transformer shall be housed in naturally ventilated floor mounted cold rolled sheet steel cubicle with louvers backed by fine brass wire mesh. The enclosure shall be of bolted type fabrication and degree of protection shall be at least IP32. The minimum sheet steel thickness shall be 2 mm.
- b) Enclosure shall be provided with lifting lugs and grounding terminals at both ends. Further the enclosure door shall have pad locking provision.
- c) The enclosure door shall be interlocked with service transformer incoming breaker such that.
 - The door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position.
 - [6.6] kV side circuit breaker can be closed only when the doors are closed.
- d) Necessary illumination with controls shall be provided in the enclosure.
- e) Thermostatically controlled space heater inside the enclosure of suitable rating shall be provided if necessary.

1.4.2 Tank (for oil type)

- a) For LV transformers, the tank shall be of conventional type.
- b) Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.
- c) Tank shall be designed to permit lifting, by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.
- d) Tank together with radiators, coolers, conservator, bushings vessel and other fittings, shall be designed to withstand full vacuum without permanent distortion.
- e) The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

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- f) The material used for gaskets shall be cork-neoprene or approved equivalent. Gasketed joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather. Spare gaskets shall be provided for all openings as shipping gaskets will not be reused.
- g) Tank shall be provided with all necessary valves.
- h) Tank shall be provided with a pressure release device which shall operate at a pressure below the test pressure for the tank and radiators. This device shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall be rain proof after blowing and shall be provided with a device visible from ground to indicate operation. An equaliser pipe connecting the pressure relief device to the conservator shall be supplied. This device shall be provided for all transformers. Pressure relief device shall be equipped with remote monitoring/alarm contacts

1.4.3 Core

- a) The transformers shall be three phase core type. The core shall be built up with high grade, non-ageing, low loss, high permeability grain oriented cold rolled silicon steel laminations especially suitable for core material. Laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.
- b) CRGO sheets shall be coated with insulation varnish. Insulation shall be able to withstand the curing temperature and shall reduce eddy current to minimum. The core shall be protected from corrosion with a rust-resistant coating.
- c) The core clamping brackets shall be designed to provide an even distribution of clamping forces to the core, yokes and legs and shall be rigidly braced to reduce sound levels and losses.

1.4.4 Winding

- a) The coils shall be manufactured from electrolytic copper conductor with sufficient number of radial supports and fully insulated for rated voltage.
- b) The insulating material shall conform to Class F. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and shall withstand even the severest of temperature fluctuations.
- c) Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. The windings shall be arranged to ensure a free circulation of the air and to reduce the hot spots in the winding.

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- d) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.
- e) The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer, under short circuit stresses, switching or other transients.
- f) All coils rated 1200V or higher shall be subjected to partial discharge tests to ensure a properly cured and void free casting.

1.4.5 Encapsulation (for dry type)

- a) HV and LV coils shall be separately cast under vacuum in fibre glass reinforced epoxy resin compound. The insulation shall be fire resistant, non-inflammable, non-hygroscopic and resistant to temperature fluctuations.
- b) The epoxy shall contain filler material providing characteristics superior to unfilled epoxy including higher temperature rating, better heat conductivity, better arc resistance and adhesion to the conductor, plus a coefficient of expansion closer to that of the conductor material. The epoxy resin shall be self extinguishing.
- c) Encapsulated winding shall be free of internal voids, surface irregularities, etc. No surface finishing of encapsulated winding shall be undertaken after the process of encapsulation.

1.4.6 Insulating Oil (for oil type)

- a) The transformer shall be filled with mineral insulating oil suitably inhibited to prevent sludging.
- b) The quality of oil to be supplied for the transformer shall conform to the parameter specified in IS: 335 with latest amendments. No inhibitors shall be used in oil. Prior to filling oil shall be tested as per IS: 335 for tan delta, specific resistivity, breakdown voltage, moisture content etc.
- c) Transformer shall be dispatched oil filled. 10% excess oil for topping up shall be supplied in non-returnable container suitable for outdoor storage.
- d) Oil preservation shall be by means of conservator tank complete with silica gel breather and oil seal.
- e) Oil preservation shall be by means of bellows/ diaphragm sealed conservator tank with silica gel breather to avoid direct connection between atmosphere and transformer oil. It shall be complete with level gauges, pipes, drain valve etc. The level gauges shall be so placed that same can be readable standing from ground.
- f) Necessary device shall be kept to provide annunciation in the event of rupturing of bellow.

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1.4.7 Tappings (OCTC)

- a) Off-circuit taps as specified shall be provided on the high voltage winding.
- b) The transformer shall be capable of operation at its rated KVA on any tap provided the voltage does not vary by more than $\pm 10\%$ of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be provided.
- e) Off circuit tap changer switch where provided shall be 3 phase, hand operated, by an external handle with position markings and pad locking facility and mechanical stops to prevent over cranking beyond extreme positions.
- f) Arrangement shall be such that switch can be operated at standing height from ground level.
- g) The operating handle can be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator with pad locking facility.

1.4.8 Fittings and Accessories:

The following fittings and accessories shall be provided :

- a) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the purchaser's earthing conductors. Suitable earthing terminals on cable boxes shall also be provided.
- b) Terminal marking and rating plates shall be as per the specified standard.
- c) In case of oil type, the conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of -5°C up to an oil temperature of 100°C , with oil level varying within the minimum and maximum visible levels with necessary accessories.
- d) In case of oil filled type, Valves shall be supplied on the transformer tank and radiators.
- e) Pressure relief device: Pressure relief device shall be provided for transformers rated 2 MVA and above which shall be of sufficient size for rapid release of any pressure that may be generated within the tank and which may result in damage of the equipment
- f) Gas and Oil Actuated Relay (Magnetic Reed Type Gas & Oil Relay):

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A double float type magnetic reed type gas and oil relay as per applicable standard shall be provided for all oil filled transformers. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. These contacts shall be wired up to the transformer marshalling box. The relay shall be provided with shut off valves on the conservator side as well as the tank side.

g) Temperature Indicators

i Oil temperature indicator (OTI)

All oil type transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device. The contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC.

ii Winding Temperature Indicator (WTI):

A device for measuring the hot spot temperature of the winding shall be provided. The accuracy class of winding temperature indicator shall be $\pm 20^{\circ}\text{C}$ or better.

iii Oil Level Indicator:

A magnetic type oil level indicator shall be provided to indicate oil level in the tank.

iv RTD/transducers for remote annunciation:

In addition to the above mentioned indicators, the Oil and winding temperature measurement, RTDs / transducers shall be provided for remote indication in the DCS. RTDs shall be duplex platinum type with nominal resistance of 100 ohms at zero degree centigrade.

h) Bushing Current Transformers for stand by earth fault protection shall be provided in the neutral bushing and lead shall be brought to Marshalling box.

i) Radiator (oil filled type): Tank mounted radiators banks shall have bolted flanged connections and pipe extensions to permit withdrawal of

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transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes (unless otherwise approved) to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. The interconnecting pipes shall be provided with drain plug and air release vents.

- j) Conservator (For oil filled type): The transformers rated below 7.5MVA shall be provided with conventional single compartment conservator with dry air filling the space above the oil.

1.4.9 Bushings

- a) The bushing shall conform to the requirements of IS:2099 and IS:3347.
b) All transformer bushings shall be of porcelain (for oil filled)/ epoxy (for dry type).
c) The neutral terminal of 433V winding shall be brought out on a bushing along with the 433V phase terminal to form a 4 wire system for the 433V. Neutral CTs shall be located in the lead coming out of the winding and location of these CTs shall not be inside the tank.
d) The neutral terminal of secondary shall be brought out through an outdoor. Further this neutral terminal shall be connected by a copper flat of size [50 mm x 6] mm, which shall be brought down upto 100 mm above ground. The copper flat shall be insulated and supported from the tank body.

1.4.10 Terminal arrangement

- a) Cable boxes
i. Wherever cable connections are specified, suitable cable boxes shall be provided and shall be air insulated.
ii. Cable boxes shall have drilled gland plate of adequate size to receive cables and to allow easy termination.
iii. Removable drilled gland planes shall be provided in the cable boxes.
iv. The additional supports for the cable boxes shall be galvanised iron.
v. The contractor shall provide earthing terminals on the cable box, to suit [50mmx6] mm GI flat.
b) Bus duct
i. Wherever Bus duct termination is specified a flanged throat or equivalent connection shall be provided for termination of bus duct enclosure. The winding termination shall be outdoor type bushing. The material of the bus duct termination arrangement of the transformer shall be nonmagnetic. The bus duct may be either phase-segregated or non-segregated.

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- ii. Tolerance permissible for the height of terminals and bus duct flange location specified for bus duct termination over ground level is $\pm 5\text{mm}$. Contractor has to ensure that radiator, conservator and explosion vent do not obstruct the path of the bus-ducts.

1.4.11 Marshalling box

- a) A sheet steel weather, vermin and dust proof marshalling box shall be furnished. The sheet steel used shall be at least 2.0 mm (CRCA) thick. The box shall be free standing floor mounted/tank mounted type and have a sloping roof. The degree of protection shall be IP-55 in accordance with IS:2147.
- b) The marshalling box shall have a glazed door of suitable size for convenience of temperature indicators reading.
- c) All incoming cables shall enter the marshalling box from the bottom.

1.4.12 Wiring

- a) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- b) Wiring shall be done with 650V PVC wires in conduit or PVC armored cable. *[Minimum wire size shall be 1.5 sq.mm stranded copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.]*
- c) Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. *[Terminals shall be stud type, suitable for terminating 2 nos. 2.5 mm2 stranded copper conductor and provided with acrylic insulating cover.]*
- d) All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- e) Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

1.4.13 Painting

- a) All steel surfaces shall be thoroughly cleaned by sand blasting and / or by chemical agents, as required to produce a smooth surface free of scales, grease and rust.
- b) The external surfaces, after cleaning, shall be given a coat of high quality red oxide or yellow chromate primer followed by filler coats.
- c) The transformer finished with two coats of epoxy based powder coated paint. The paints shall be carefully selected to withstand tropical heat,

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rain etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

- d) Painting shade shall be subject to owner's approval.
- e) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.14 Name Plate

Nameplates of approved design shall be furnished at each cubicle (one no. each at front as well as at backside of cubicle) and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black background. Self-tapping screws shall hold the nameplate. *[Nameplate size shall be minimum 20 x 75mm for instrument/device and 40 x 150mm for panels. Caution notice on suitable metal plate shall be affixed at the back of terminal Box.]*

1.5 Tests

1.5.1 Type Tests

For each type & rating of LV Transformers, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within *[last five]* years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within *[last five]* years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- a) Temperature rise test
- b) Dielectric test

1.5.2 Routine Tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The following tests shall be performed on each transformer as a minimum:

- a) After assembly, each core shall be pressure tested for one minute at 2KV (r.m.s.) A.C. between all bolts, side plates, structural steel works and the core.

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- b) The wiring for auxiliary power and control circuitry shall be subjected to withstand one minute power frequency test with 2.0KV (r.m.s.) to earth
- c) Measurement of winding resistance
- d) Measurement of voltage ratio and check of phase displacement
- e) Measurement of short circuit impedance and load loss
- f) Measurement of no load loss and current
- g) Dielectric routine tests
- h) Excitation loss and current measurements shall be made at 90%, 100% and 110% of the rated voltage as routine test.
- i) Partial discharge test
- j) Tan delta test

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings/ Data and Manuals

Drawings, data, and manuals for the transformers shall be submitted as indicated below:

- a) *[General Arrangement Drawing]*
- b) *Dimensioned general arrangement drawing showing enclosure, core coil assembly, terminal arrangement, marshalling box and various fittings.*
- c) *Transport/shipping dimensions with weights, wheel base detail etc.*
- d) *Foundation plan & loading.*
- e) *Bus duct/cable termination arrangement.*
- f) *Control schematics and wiring diagrams.*
- g) *Test reports and QAP*
- h) *Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.*
- i) *Instruction manuals on Transformer and its various fittings The manual shall clearly indicate method of installation, checkups and tests to be carried out before commissioning of the equipment.]*

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Note: The drawings, data and manuals listed are minimum requirement only. The Bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted.

1.7 Ratings and Requirements

Table 2.0

6.6/0.420 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Application	[As per project requirement]	[As per project requirement]
2.	Location	Indoor	Outdoor
3.	Type	[Dry Type: epoxy cast resin transformer]	[Oil type transformer]
4.	Reference standard	IS 11171	IS 2026
5.	Rated power (indicative)	[As per project requirement]	[As per project requirement]
6.	Rated winding voltage ratio (line to line)	6.6/0.433 kV	6.6/0.433 kV
7.	Number of phases	3	3
8.	Winding	2	2
9.	Rated frequency	50 Hz	50 Hz
10.	Type of cooling	AN	ONAN
11.	Insulation Class	Class F or Better	Class F or Better
12.	Temperature rise Over ambient temperature of 50°C		
a.	For Winding by	90°C or lower as permissible for class	55°C

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	resistance method	of insulation offered	
b.	For Oil by Thermometer method	Not Applicable	50 °C
13.	Insulation level (LI/AC)		
a.	HV- (LI/AC)	60 KVp/20 kVrms	60 KVp/20 kVrms
b.	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
14.	Vector group	[Dyn11]	[Dyn11]
15.	Short-circuit impedance on principal tap	[As per project requirement]	[As per project requirement]
16.	Parallel operation of transformer	Momentarily	Momentarily
17.	Type of taps provided	OCTC, full capacity	OCTC, full capacity
18.	Taps provided on	H.V. winding	H.V. winding
19.	Range of taps	[+/- 5 % in steps of 2.5%]	[+/- 5 % in steps of 2.5%]
20.	Method of Tap charge control-		
a.	Manual local	Yes	Yes
b.	Electrical local	No	No
c.	Electrical remote	No	No
d.	Automatic	No	No
21.	System earthing		

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a.	H.V.	Non-effectively earthed			Non-effectively earthed
b.	L.V.	Effectively earthed			Effectively earthed
22.	Terminal arrangement				
a.	H.V.	6.6kV(UE) Cable/ busduct			6.6kV(UE) Cable/ busduct
b.	L.V.	Non-segregated phase bus duct			Non-segregated phase bus duct
23.	Neutral for earthing	GS flat connector			GS flat connector
24.	Transformer bushing	HV	LV	LV - N	Same as Dry type transformer
25.	Voltage class KV(r.m.s.)	7.2	1.1	1.1	
26.	Creepage distance mm	[As 25mm/kV]			[As 25mm/kV]
27.	Min. Ph-Ph/ Ph-E clearance mm	As per Standard			As per standard
28.	System fault Level				
a.	HV Side	40 KA (r.m.s.)			40 KA (r.m.s.)
b.	LV Side	50KA (r.m.s.)			50KA (r.m.s.)
29.	Max. Noise level	As per NEMA std. TR-1			As per NEMA std. TR-1
30.	Auxiliary supply	415 V, 3 ph, 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)			415 V, 3 ph 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)
31.	LV neutral side	[As per project]			[As per project]

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	current transformer for standby earth fault protection	requirement]	requirement]
32.	Guaranteed no load loss (kW)	[By Bidder]	[By Bidder]
33.	Guaranteed load loss (kW)	[By Bidder]	[By Bidder]
34.	Efficiency		
a	At full load	[By Bidder]	[By Bidder]
b	At 75% load	[By Bidder]	[By Bidder]
c	At 50% load	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

TURBO GENERATOR & AUXILIARIES

(PACKAGE NUMBER: R&M-SP-02)

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E4

**TECHNICAL SPECIFICATION FOR 415V SWITCHGEAR,
MCC & DBs**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E4**1.0 415V SWITCHGEAR, MCC AND DB****1.1 General**

This specification is intended to cover the *[design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning]* of 415V Switchgear MCC and DBs, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2551	Danger notice plates
IS :2705	Current transformers-specification
IS :3156	Voltage transformer specification
IS :3231	Specification for electrical relays for power system protection
IS: 8084	Specification for interconnection busbars for AC voltages above 1kV up to and including 36kV.
IS :8623	Specification for low-voltage switchgear and control gear assemblies
IS :8686	Specification for static protective relays
IS :10118	Code-of practice for selection installation and maintenance of switchgear and control gear
IS :12021	Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 v ac
IS : 13947 (Part 1)	Specification for low-voltage switchgear and control gear
IS : 13947 (Part 2)	Specification for low-voltage switchgear and control gear –part 2: circuit breakers
IS : 13947 (Part 4)	Specification for low-voltage switchgear and control gear -part 4 : contactors and motor feeders

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Codes	Name of Standard
IS : 13947 (Part 5)	Low-voltage switchgear and control gear specification Part 5 : control circuit devices and switching elements
IEC 61439	Low voltage switchgear and control gear assemblies.
CEA	CEA regulations for installation and operation of meters 2006.
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All 415V Switchgear, MCC and DB shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- All 415V Switchgear, MCC and DB shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-) 5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC system	:	-15% to +10%

- 415 V switchgear & MCCs shall be of indoor /outdoor, double front/single front [Preferably single front] and fully draw out type. ACB feeder may be of single tier/two tier configuration depending upon rating. DBs (ACDB / DCDB) shall be of single / double front [Preferably single front] and fixed type. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration shall be provided.
- All AC motor starters shall be suitable for Direct on Line (DOL) starting. Motors rated below [132]kW shall be provided with combination starters consists of MCCB/MPCB, contactors and electronic over load relay and

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the motor starter shall comply with Type – 2 coordination conforming to relevant code and standards. Motors rated [132] kW and above shall be breaker controlled and shall be provided with comprehensive motor protection relay. Motors rated above [160]kW shall be fed from MV Switchgear [Only for firefighting system Motor rated up to 200kW shall be fed from 415V switch board].

- e) For 415 V switchgear & MCCs Feeders rated [630A] and above shall be equipped with Air Circuit Breaker (ACB). Outgoing/Incoming feeders rating below [630] A shall be MCCBs.
- f) For DBs Incomer rated 630A and above shall be ACB. Incomer below 630A shall be MCCB. Outgoing feeder may be MCCB/MCB depending upon the bus fault level.
- g) All ACB shall be draw out type & should have Service, test and disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- h) Local/remote selection shall be provided for all incoming/Outgoing ACB module. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local(Switchgear).
- i) Two out of three breaker logic shall be considered for switchgear/MCC. However mechanical interlock shall be considered for income of MCCB operated DBs.
- j) Also, Local/remote selection switch shall be provided for all motor modules for control from Remote(DCS). Also for breaker operated motor, breaker shall be closed in Test position from local(Switchgear).
- k) All motors shall be provided with Emergency stop push button.
- l) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary MCCB/MCB shall be provided for each MCC, 2 x 100% per section. However breaker shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from bus bars. This control supplies shall be monitored.
- m) All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 415V switchgear, MCC and DBs shall have following minimum features.

- a) All 415V switchgear, MCC and DBs shall be metal enclosed, indoor, floor mounted and free standing type. The panels shall be suitable for cable entry at bottom and busduct connection at top.

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- b) Between 415V Switchgear and dry type transformers, non segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with busduct manufacturer in this regards is covered in this specification.
- c) All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d) Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels
- e) Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f) The switchgear enclosure shall confirm to the degree of protection IP-54 (for outdoor). For indoor, enclosure shall confirm to IP52, however for Busbar chamber of switchboards rated above 1600A, degree of protection shall be IP-42.
- g) Paint shade for complete panels excluding end covers shall be [RAL 9002] and [RAL 5012] for extreme end covers for all board.
- h) The switchgear assembly shall comprise a continuous, line-up of single / multi tier cubicles. The installations of circuit breakers however shall be limited to the bottom two tiers only. Working height shall be limited to [250 mm to 1800 mm] from the floor level.
- i) Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc
- j) A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgears having more than one bus section.
- k) Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable

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terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.

- l) For MCC/DB a full height vertical cable chamber with cable supports shall be provided in each section to facilitate unit wiring.
- m) 2x100%, 415V/110V AC control transformer shall be provided for control, Indication and annunciation supply for contactor operated motor feeder. All the necessary auxiliary and main contactor shall be provided suitable for this control supply.
- n) Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module.
- o) Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- p) Supplier shall provide total 20% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- q) Motors of rating 30 kW and above shall be provided with anti-condensation heaters. Necessary provision for supply of motor space heating shall be considered in the switchgear.
- r) The incoming connection to transformer of more than 1000kVA and inter-connecting sections between switchboards shall preferably be of bus ducts.
- s) It should be possible to carryout maintenance on a feeder with adjacent feeders alive.

1.4.2

Bus and Bus taps

- a) The main buses and connections shall be of high [conductivity Aluminum / Copper] alloy sized for specified current ratings with temperature rise limited [to 40°C over ambient temperature of 50°C].
- b) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminum contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance. Adequate contact pressure shall be ensured by means of two bolts connection with plain & spring washers and locknuts. Temperature rise shall not exceed 105 degree for silver plated joints over an ambient temperature of 50 degree.
- c) Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- d) Bus insulators shall be flame-retardant, track resistant type with high creepage surface. All buses and connections shall be supported and braced to withstand the stresses due to maximum short-circuit current and also to take care of thermal expansion.

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- e) Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f) Power shall be distributed to each module or compartment by a set of vertical bus bars. The vertical bus bars shall run behind the modules. Necessary tee off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.
- g) The clearance between the individual bare phase power bus bars and between the phase and earth bus bars in air shall be not less than [25.4] mm.
- h) Three phase, neutral (with at least [50] % rating of main Bus bar and continuous earth bus shall be provided. Bus bar and tapping shall be provided with color coded PVC sleeves.

1.4.3

Air Circuit Breaker

- a) All Circuit Breakers for incoming feeders and Bus couplers shall be [four] poles; single throw, motor operated and air break type. Circuit breaker for outgoing feeders shall be triple pole, single throw and air break type. However for supply feeders it shall be [four] pole.
- b) Circuit Breakers shall be [draw out type] having Service, Test & Disconnected positions with positive indication for each position.
- c) Circuit breakers of identical rating shall be physically and electrically interchangeable.
- d) Bolted disconnected links shall be provided for all outgoing feeders for isolation of neutral, if necessary.
- e) For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open – close – open operation of the circuit breaker shall be possible after failure of power supply to the motor when the spring is charged after a closing operation.
- f) Mechanical safety interlock shall be provided to prevent the circuit breaker from being racked in or out of the service position when the breaker is closed.
- g) Automatic safety shutters shall be provided to fully cover the female primary disconnects when the breaker is withdrawn.
- h) Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indicator, an operational counter and mechanism to indicate spring charge / discharge condition.
- i) In addition to the auxiliary contacts required for normal breaker operation and indication, each breaker shall be provided with followings for interlocking purpose:-
 - i. Position / cell switch with 4 No + 4 NC contacts.

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- ii. Limit / auxiliary switches shall be convertible type that is facility for changing N.O. contact to N.C. and vice-versa.
- iii. Mechanical stopper to prevent accidental falling while withdrawing.
- j) Breaker cannot be racked in from 'isolated' to 'test' position with the door open together with provision for defeat of this interlocking, however, the door can be closed only when the breaker is brought back to 'isolated' position. Insertion of breaker into 'Service' position not possible if the shutters are not free.
- k) Door can be opened only when breaker is OFF and is in 'Isolated' position. Remote closing of breaker not permitted with door open.
- l) Anti pumping relay / device to ensure that there can be only one closing operation for each closing command.
- m) Suitable trolley arrangement shall be provided for breaker/starter modules. Two trolleys per switchgear room shall be provided so that top most breaker module of all types, sizes and rating can be withdrawn on trolley and lowered for maintenance purpose.
- n) Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage.

1.4.4 Contactors, MCCB and MPCB

- a) Incomers for MCCs and DBs rated below 630A shall be MCCB.
- b) Incomer and bus coupler rated below 630A shall be mechanically Interlocked.
- c) Motor starter contactors shall be of air break, electromagnetic type. Suitable for DOL starting of motor, and shall be of utilization category AC-3 for ordinary and AC-4 for reversing starters. DC contactor shall be of DC-3 utilization category.
- d) The contactors shall be three pole, air break type designed for [duty class III category A.C. –3 with non-bouncing silver / silver alloy.]
- e) Each contactor shall be provided with two (2) normally open and two (2) normally closed auxiliary contacts unless otherwise specifically stated. Rating shall be decided by the bidder.
- f) Reversing contacts shall be electrically and mechanically interlocked.
- g) Contactors with delayed dropout feature shall be provided for some essential auxiliaries. These contactors shall not dropout on power failure if the voltage is restored within 3 seconds.

1.4.5 Electronic over load relays

- a) Electronic overload relays shall conform to IEC:292-1 and shall be triple pole, ambient temperature compensated with adjustable setting, inverse time lag, built in single phase preventer and hand/auto reset type

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provided as per requirement along with necessary command, feedback cable, coupling relays etc.

- b) Provided with 1 NO and 1NC contact of rating same as the auxiliary contact of the contactors.
- c) The relay shall be able to withstand prospective short circuit current without damage or injurious heating till the motor protection MCCB/MPCB clears the fault.
- d) Relays may be direct acting or CT operated, depending on current rating. CTs shall be included in the scope of supply.

1.4.6 Bus Transfer scheme:

Each switchgear of two incomer and bus coupler shall be provided with the following provisions.

- i) Dead bus closing.
- ii) Manual live change over (Momentary paralleling)
- iii) Automatic bus transfer scheme.

1.4.7 Current Transformer

- a) Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made.
- b) CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c) CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d) All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e) CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Voltage Transformer

- a) Voltage transformers(VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b) VTs shall be of the single-phase type. VTs shall be protected on their primary side by MCCBs with interrupting ratings corresponding to breaker rating and by MCB (with auxiliary contacts) on the secondary sides.

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- c) VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d) It shall be possible to replace VTs without having to de-energise the main busbars.
- e) VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.9 Transducer

For all the incoming and the outgoing of 415V Switchgear / MCC/ DB Feeders requiring remote metering and/or current monitoring shall be provided with multi-functional transducers. The output shall be 4-20 mA DC which shall correspond to the normal range.

1.4.10 Secondary Wiring

- a) The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b) Fuse /MCB and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c) Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d) Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with [stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring.]
- e) Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.11 Terminal Blocks

- a) Terminal blocks shall be 660V grade box-clamp type with marking strips, similar to 10 mm² or equal. Terminals for C.T. secondary leads shall have provision for shorting.
- b) Not more than two wires shall be connected to any terminal. If more than two wires at one terminal are required, separate terminals with function wise shorting links shall be provided. [Spare terminal equal in number to 20% of active terminals shall be furnished.]
- c) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged so that individual wires of an external cable can be connected to consecutive terminals.

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1.4.12 Ground bus

- a) A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b) Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c) C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.13 Space Heater

- a) Each vertical section shall be provided with thermostat controlled space heater 5A, 3 pin socket plug.
- b) In addition, motor feeders rated [30 KW and above] shall be wired up for feeding the motor space heater through suitably rated breaker auxiliary NC contact and/or contactor.
- c) Cubicle heater, Motor heater, and Plug socket circuit shall have individual switch fuse units/MCB.

1.4.14 AC Distribution Boards (ACDBs)

- a) AC Distribution Boards shall have MCCB/MCB at incomer depending upon the short circuit rating. Distribution Boards may be fed from switchgear and shall have two incomers. AC distribution Boards shall be of two types - one with 415V, 4-wire, triple pole and neutral (TPN) outgoing feeders and the other with 240V, 2-wire, single pole and neutral (SPN) outgoing feeders.
- b) For small loads, MCB boards with TPN MCB as incomer and TPN/SP MCBs for outgoing may be considered. The feeder rating and quantity shall be as per requirement.
- c) Board shall be single/double front [preferably single front], metal clad, front matched, dust and vermin proof, fixed type, compartmentalized and extensible on both sides.
- d) Bus bars shall have same cross section throughout the length. Rating of the neutral bus bar shall be 50% of the main bus bar. Earth bus bar shall run in bottom chamber throughout the length of the Board.

1.4.15 DC Distribution Boards

DCDBs shall have two incomers and a bus coupler. Incomers and outgoing feeders of DCDBs shall be MCB/MCCB modules. They shall be fixed type and floor mounted. Other constructional features shall be similar to ACDB.

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The feeder rating and quantity shall be as per requirement.

1.4.16 Control & Indication

The circuit breaker shall be wired up for local & remote operation. Each breaker cubicle shall be equipped with following:

- a) Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In switchgear position, the breaker shall be operated from switchgear only in test position with only protection (no interlock).
- b) Two (2) heavy duty, oil-tight, push buttons for Trip & Close.
- c) Circuit breaker shall be indicated electrically. The following indication colour shall be used.

Breaker open - GREEN

Breaker closed - RED

Spring Charged - WHITE

Breaker Auto Trip- AMBER

- d) However, any other indication shall be provided as per owner's requirement.
- e) Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.
- f) For all MCCB feeders, trip indication lamp shall be provided on front of the compartment.
- g) For all starters, ON, OFF and trip indication lamps shall be provided on front of the compartment.

1.4.17 Relays, Protection & Metering

- a) The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- b) All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner.
- c) All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.

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- d) All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- e) Energy meters shall be provided for incomer of 415V Switchgear and MCC and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than 1.0S.
- f) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- g) All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- h) The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- i) All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- j) Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- k) D.C supply shall be supervised by DC supervision relays.
- l) Trip circuit shall be supervised by Trip circuit supervision.
- m) Tripping shall be done through high speed lock out relays.
- n) All meters/ instrument shall be flush mounted on front panel, at least 96mm² size with 90° linear scales and accuracy class of 2.0.
- o) Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- p) For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- q) Metering and protection shall be as per below table

a)	Incomers	
	Protections	Metering
i	Time graded short circuit protection	Local Current (single phase) indication and remote indication through transducer.

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ii	Over current protection	Voltage Measurement for all three phases and remote indication through transducer.
iii	Earth fault protection	KW, Kwhr
b)	Bus coupler	
	Protections	Metering
i	Over current protection(51)	Local Current (single phase) indication.
ii	IDMT Earth fault protection(51N)	
c)	Contactor controlled motor feeders [90kW and above motor only]	
	Protections	Metering
i	Time graded short circuit protection	Local Current indication and remote indication through transducer.
ii	Over current protection	
c)	[Motor Feeders [of 132KW and above only]]	
	Protections	Metering
	Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload etc.	Local Current indication and remote indication through transducer.
[Other feeders]		
a)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection	[Voltage – phase to phase,]
	Fuse failure protection	
b)	Motor feeders (MPCB/MCCB with Contractors)	
	Protections	Metering
	Electronic Overload relay (with single phase preventor), short circuit protection (through fuse/MCCB/MPCB as specified)	
c)	Incoming feeders for ACDB/DCDB	
	Protections	Metering

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	Short circuit protection (if MCCB)	[Voltage (single phase and, Phase Current (1 Phase))] Local indication only.
d)	Outgoing feeders of ACDB/DCDB	
	Protections	Metering
	Short circuit protection (through fuse/MCCB)	

1.5

Tests

I) Type Test

For each type & rating of 415V Switchgear, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted are as follows:

- Measurement of insulation resistance of Circuit Breaker in closed and open positions.
- Measurement of milli-volt drop across Circuit Breaker main contacts and other joints.
- Measurement of Circuit Breaker/Contactor operating time for close & open at nominal voltage and 80% of rated voltage.
- Measurement of resistance, IR value and drop-off/pick-up voltage of close and trip coils.
- Healthiness of limit switch contacts.
- Spring charging motor functional checks.
- Verification of phase sequence and checking of clearances of busbars between phase to phase and phase to earth.
- Measurement of milli-volt drop across busbar joints

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- i) Torque tightness test.
- j) High voltage test on busbar.
- k) Measurement of CT/PT polarity, ratio and knee point voltage.
- l) Electrical and mechanical interlock checks.
- m) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- n) Secondary injection of all metering circuits.
- o) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below

- a) [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening.
- b) Bill of Materials.
- c) Technical Data sheet and Catalogue.
- d) Foundation drawing details with bottom view of switchgear.
- e) Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f) Control Schematics & Wiring diagram.
- g) Inspection and Test Plan (ITP).
- h) Suggestive list of protective relays.
- i) Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

415V switchgears, MCC and DB shall comply with the particulars indicated in the following tables.

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Table- 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		415 Volts, 3 Phase, 4 wire 50 Hz.
2.2	System neutral earthing		Solidly earthed
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		a) 2.5kV b) 1.5kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		90°C for busbars having non-silver plated joints 105°C for busbars having silver plated joints
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	50
b	Dynamic Rating	kA (peak)	105
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		Cu/Al
2.14	Fully draw out (FD)/ Fixed (F)		FD for Switchgear/MCC; F for DBs.
2.15	Entry –Top (T)/Bottom (B)		Top for busduct, bottom for cables
2.16	Degree of protection		IP 52
2.17	Colour finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	GS
2.19	Minimum clearances in air of live parts	mm	As per standard
3.0	Starters		
3.1	Type	DOL	DOL
3.2	Contactor rated duty		AC3 for DOL
3.3	Single phasing preventer required.	Yes / no	Yes
3.4	Thermal overload relay reset	Manual / Auto	Settable for either to Manual or Auto
4.0	Circuit breakers		
4.1	Maker's name		[By bidder]
4.2	Voltage, frequency & no.of phases , poles		415 V, 50 Hz, 3 Ph, 4 Pole
4.3	Rated operating duty		O-3min-CO- 3min -CO
4.4	Circuit breakers type		ACB
4.5	Short circuit withstand current for 1 sec. Duration	kA	50
4.6	Rated making current	kAp	105
4.7	Rated current at site reference ambient temp	A °C	[By bidder]

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S. No.	DESCRIPTION	UNIT	DATA
4.8	Type of operating mechanism		Spring charged motor and manual
4.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
4.10	Control voltage		
a	Spring charging motor	V AC/DC	[220V DC/240V AC]
b	For closing/tripping	V AC/DC	220V DC
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	As per IS
b	Closing at normal voltage	%	As per IS
c	Trip coil	%	As per IS
4.12	Power required for closing at normal voltage	W	[By bidder]
4.13	Power required for tripping at normal voltage	W	[By bidder]
4.14	Spring charging motor details:		
a	Rating	kW	[By bidder]
b	Rated voltage	V, AC/DC	[By bidder]
c	Spring charging	Sec.	[By bidder]
	Electrical and mechanical anti-pumping features been provided	Yes/No	Required
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		415 V, 50 Hz & 3 P for outgoing, 4P for incoming and supply feeders
5.2	Rated operating duty		As per IS
5.3	Rated breaking capacity	kA (rms)	50

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S. No.	DESCRIPTION	UNIT	DATA
5.4	Rated making current	kA (Peak)	105
5.5	On/off operation		
5.6	Manual	Yes/No	Yes
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	Yes
5.8	Auxiliary contacts required	Yes/No	[As per project specific]
6.0	Contactors		
6.1	Make		[By Bidder]
6.2	Rated duty	AC3/A C4	AC3 for DOL AC4 for RDOL
6.3	No of poles		3
6.4	Utilization category		[By Bidder]
6.5	Rated voltage of auxiliary contacts	V	[By Bidder]
6.6	Rated voltage of coil	V	[By Bidder]
6.7	Rated breaking capacity	Factor of rated current	[By Bidder]
6.8	Rated making capacity	Factor of rated current	[By Bidder]
6.9	Limits of operation		As per IS/IEC
a	Supply voltage variation		[By Bidder]
b	Supply frequency variation for closing		[By Bidder]
c	Drop out voltage		[By Bidder]
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		

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S. No.	DESCRIPTION	UNIT	DATA
7.1	Voltage Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
7.2	CT Ratio		Primary current/1A or 5A
7.3	Measuring CTs		CI - 1.0 instrument safety factor 5.0
7.4	Protection CTs		CI 5P20
7.5	Measuring VTs		(min)/phase CI1.0
7.6	Protection VTs		CI 3P
8.0	Control transformers		
8.1	Make		[By Bidder]
8.2	Type		Dry Type
8.3	Applicable standards		As specified in the specification
8.4	Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
8.5	Class of insulation		Class-B or Better
8.6	Rated output	VA	[As per project specific]
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		[By Bidder]
10.2	Make		[By Bidder]
10.3	Type designation		[By Bidder]
10.4	Setting range		[By Bidder]
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		[By Bidder]
11.2	Make		[By Bidder]
11.3	Type		[By Bidder]
11.4	Current setting range		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	[By Bidder]
12.0	Under voltage relay		
12.1	Make		[By Bidder]
12.2	Type		[By Bidder]
12.3	Voltage rating	V	[By Bidder]
12.4	Setting range	V	[By Bidder]
13.0	Auxiliary relays and timers		
13.1	Make		[By Bidder]
13.2	Type		[By Bidder]
13.3	Coil voltage	V	[By Bidder]
14.0	Control/selector switch		
14.1	Make		[By Bidder]
14.2	Type designation		[By Bidder]
15.0	Meters		
15.1	Applicable Standards		As specified in the specification.
15.3	Accuracy Class		Class 1.0 or Better
15.4	Make		[By Bidder]
15.5	Type		Multi function with RS 485 connectivity
16.0	Voltmeter		
16.1	Make		*[By Bidder]
16.2	Type		Moving coil
16.3	Applicable standards		As specified in the specification.
16.4	Accuracy class		Class 1.0
17.0	Ammeter		

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S. No.	DESCRIPTION	UNIT	DATA
17.1	Make		As specified in the specification.
17.2	Type		Moving coil
17.3	Applicable standards		As specified in the specification.
17.4	Accuracy class		Class 1.0
18.0	Indicating lamps		
18.1	Make		As specified in the specification.
18.2	Type		Clustered Led
18.3	Voltage	V	As specified in the specification.
18.4	Wattage of lamp	W	As specified in the specification.
19.0	Push buttons		
19.1	Make		As specified in the specification.
19.2	Type designation		As specified in the specification.
19.3	Contact rating	A	As specified in the specification.
20.0	Space heater		
20.1	Make		As specified in the specification.
20.2	Type		As specified in the specification.
20.3	Rated voltage	V	As specified in the specification.
21.0	Wiring and terminal blocks		
21.1	Voltage grade		1.1 kV
21.2	Insulation		[By Bidder]
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	2.5 for CT & PT 1.5 for Others
b	Control wiring	Sq.mm	1.5 for Others

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S. No.	DESCRIPTION	UNIT	DATA
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		Sliding type
	II) For Fixed Type		Stud & nut type
21.5	Minimum current rating of terminal blocks	A	10

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E5

**TECHNICAL SPECIFICATION FOR 415V NON
SEGREGATED PHASE BUS DUCTS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E5**1.0 415V NON SEGREGATED PHASE BUS DUCT****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Non Segregated Phase Busduct, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS 8084	Interconnecting Bus bar for AC Voltage above 1KV up to and Including 36kV
IEC 60947	Low Voltage Switchgear and Control gear
ANSI/IEEE C37.20	Metal-Clad and Station-Type Cubicle Switchgear
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear
IEC 60439	Low-voltage switchgear and control gear assemblies.
BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) The 415V Non-segregated phase bus duct shall serve as an interconnection between the 415V Switchgear and 11/0.433kV LV Transformer. The Non-segregated phase bus duct shall be installed

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indoor/Outdoor in a hot, humid and tropical atmosphere. All panels associated with Non-segregated phase bus duct shall be located indoors/Outdoors.

- b) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- c) For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be as specified in Clause 1.7 Rating and requirements.
- d) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the required short-circuit currents.
- e) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- f) The bus ducts shall be self cooled and shall not be equipped with blower or any other type of forced ventilation.
- g) The equipment rating shall be based on an ambient temperature. Same phase disposition shall be maintained throughout the run of the bus duct. Phase crossover units, if required, shall also be provided inside the Busduct itself.
- h) Bus ducts shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current.

1.4 Specific Requirements

1.4.1 General

- a) 415V Non Segregated Phase Busduct is provided for connection between low voltage side of 11/0.433kV cast resin dry type /oil type transformers and associated 415V Switchgears shall be of TPN (3 phase and neutral) along with necessary bends, flexible at both transformer & switchgear ends, flanges, phase crossover chambers (if required), support structures & accessories including terminations at the equipment ends.
- b) The 415V bus duct shall be metal enclosed, non-phase segregated enclosure type, self cooled and insulated for 1.1kV voltage. The cooling medium inside the duct shall be air.

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- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) The 415V non-segregated phase bus duct will be installed indoor or partially indoor & outdoor depending upon the location of equipment being interconnected in a hot, humid and tropical atmosphere. All panels associated with LV non-segregated phase bus duct will be located indoors.
- e) The continuous current rating and momentary peak withstand current rating of the Busduct between transformers & their associated switchgears shall be same as that of the associated switchgears and as indicated in the specification.
- f) All supporting steel structures shall be hot dip galvanized.
- g) The bus ducts shall be provided with space heaters to control moisture. Slicagel breather if required same shall be provided.

1.4.2 Enclosures

- a) The enclosure shall be rectangular and shall be made of [aluminium alloy/Mild steel] of grade [19000H2] as per IS-5082. The entire bus duct shall be designed with dust, weather and vermin-proof construction. The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- b) *[Phases shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminum alloy) of 3mm for bus rating including and above 3000A whereas enclosures for normal bus current rating (<3000 A) shall be sheet steel fabricated type of 2.5mm thick].*
- c) Enclosures shall be provided with flange ends with drilled dimensions to suit the flanges at the switchgear and transformer ends.
- d) Circumferential neoprene rubber gaskets shall be provided for dust tight joints with adjacent enclosure section.
- h) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion / contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.

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- i) All outdoor bus-enclosures shall be so designed & constructed as to prevent accumulation of rain water on top sheet. Similarly all Gasketed flanged joints shall be suitably protected against direct splashing of rain water in case of outdoor runs. The connection flanges shall be sufficiently stiffened so as not to bend while tightening the bolts.
- j) Outdoor portions of the bus duct, if any, shall have continuous rain hood of non magnetic material or with suitable arrangement for rainwater prevention.
- k) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, switch gear terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets.
- l) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between indoor and outdoor portions of the bus duct.
- m) In case, the bus duct penetrates the firewall, the wall frame assembly and the seal shall be designed for the same fire rating as the firewall.
- n) Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct. Space Heaters shall be provided in the bus duct.
- o) Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- p) Shipping length of the Busduct shall be not more than three (3) meters in length.
- q) Minimum Degree of protection of Busduct enclosure shall be IP-52 for indoor and IPW-55 for outdoor section of the Busduct.

1.4.3 Bus Conductor

- a) The bus conductor shall be of high conductivity, [Aluminium alloy / Aluminium].
- b) The bus conductors shall be given a coat of matt black paint to facilitate heat dissipation. However the sizing of the bus conductor shall consider the conductor as bare.
- c) The bus conductor shall be designed for bolted connections throughout the run.
- d) Flexible connection shall ensure an efficient and trouble-free connection.

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- e) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminium contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- f) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.
- g) The bus bar shall be sleeved with FRLS heat shrinkable, colour coded PVC sleeves at intermittent points for phase identification.
- h) The material of the conductor shall be aluminium alloy of grade [63401WP] as per IS: 5082. The temperature rise of conductor shall be 40 degree over design ambient temperature of 50 degree. Also, the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.

1.4.4 Disconnect Link

- a) Removable bolted disconnected link shall be provided in the bus for the purpose of isolation.
- b) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- c) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- d) A minimum clearance of [300 mm. (12")] shall be provided between the disconnected bus sections with the link removed.

1.4.5 Insulators

- a) The bus conductor supporting insulators shall be flame retardant, non-hygroscopic, high impact and high dielectric strength material with an anti tracking contour.
- b) Material of insulator shall be [Epoxy SMC moulded /FRP].
- c) Spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the short circuit current assigned to the bus duct.
- d) Bus support insulators shall be interchangeable, high creepage, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.

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- e) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- f) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator.
- g) Space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus duct.

1.4.6 Connections & Terminations

- a) All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the switchgear, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the switchgear and auxiliary transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.

1.4.7 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- c) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- d) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.
- e) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.

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- f) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

1.4.8 Ground bus

- a) The ground bus of two numbers of separately run [50x10 mm] minimum GS flat shall be provided along the run of the bus duct. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.
- b) Ground bus shall be finally to connected to power plant earth grid at one end.

1.4.9 Wiring

All wiring for space heaters shall be done with insulated stranded copper conductor of not less than [2.5 mm² cross-section]. Each wire shall be identified at both ends with wire designation as per bidder's wiring diagram and shall be brought out to a terminal box outside the bus duct.

Terminal blocks shall be box-clamp type minimum 10 mm² with marking strips.

At [least 20% spare terminals] shall be furnished in the terminal block.

1.4.10 Name Plate

Suitable name plate shall be furnished with each piece of equipment.

[Materials for name plate shall be plastic / lamicoid, 3 mm thick, using white letters on black background.]

1.4.11 Space Heater

Thermostatically controlled Space heaters shall be provided in the bus ducts, wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation. At least one number space heater with thermostat shall be provided at each transformer and switchgear end.

The space heaters shall be suitable for continuous operation on single phase supply, and shall be automatically controlled by thermostats. Necessary wiring up to junction boxes mounted on bus duct and from junction boxes to switchboards shall be provided.

1.4.12 Painting and Finish

- a) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as

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possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint

- b) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- c) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- d) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].
- e) The interior surface finish shall be as per manufacturer's standard.
- f) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- g) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.
- h) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- i) The paint shade shall be subject to owner's approval.

1.5 Tests

l) Type Test

For each type & rating of 415V Non segregated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test

1.6 Drawings and Documents

Drawings, data & manuals for the 415V Non segregated phase bus duct shall be submitted as indicated below:

- a) [Dimensional GA drawing
- b) Data sheets
- c) Typical calculation for arriving at the size of conductor and the insulator spacing.
- d) Type test report (short circuit, temperature rise test) for similar bus duct manufactured by the proposed manufacturer.
- e) Foundation layout and requirements
- f) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

1.7 Ratings and Requirements

Major technical parameters of 415V non segregated Bus Duct are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table: 2.0

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.	Type of bus duct		Non segregated phase bus duct	
2.	Rated voltage and No. of phase	V	415V, Triple Pole , Neutral(3Phase & 4 Wire)	
3.	Applicable standard		IS 8084	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
4.	System Frequency	Hz	50	
5.	Design ambient temperature	Degree	50	
6.	Rated Current	A	[As per project Requirement]	
7.	Designation (from & to)		[As per project Requirement]	
8.	Type of cooling (NSPBD)		Natural air	
9.	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
10.	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
11.	One minute power frequency voltage withstand	KV (RMS)	2.5	
12.	Continuous current rating at 50°C design ambient air temperature	A	[As per project Requirement]	
13.	Material a) Bus bar b) Enclosure		a) [Aluminum] b) [Aluminum alloy/MS]	
14.	One second short circuit withstand rating	KA (RMS)	50	
15.	Momentary short circuit withstand current	KA (Peak)	105	
16.	Bus bar Support		[FRP/ SMC]	
17.	Degree of protection		IP 52 for indoor IP W55 for outdoor	
18.	Earthing Conductor Material		GS	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
19.	Heating		Thermostat controlled space heater	
20.	Fittings of silica gel breather and drain plug		Required	
21.	Finish of Bus Enclosure		a) Inside: Matt Black b) Outside [RAL 5012]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E6

TECHNICAL SPECIFICATION FOR 220V DC SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E6**1.0 220 V DC SYSTEM****1.1 General**

This specification is intended to cover the *[design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of 220V DC system with its all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS- 266	:	Specification for Sulfuric Acid
IS- 1069	:	Specification for Water for Storage battery
IS- 1146	:	Specification for rubber and Plastic Containers for Lead Acid Storage Batteries
IS-1652-1991	:	Stationary Cells and Batteries, lead acid type (with Plante positive plates) – Specification
IS- 3116	:	Specification for Sealing Compound For Lead Acid Batteries
IS- 8320	:	General requirements and methods of tests for lead acid storage batteries.
IS- 6071	:	Specification for synthetic separators of lead acid storage batteries.
IS-10918-1984	:	Specification For Vented Type Nickel-Cadmium Batteries.
IS-14782-2000	:	Code of Practice for maintenance and testing of large Lead Acid Batteries in Generating Station and Substation.
ANSI-C-	:	Guide for surge withstand capability test.

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37.90a		
IEC - 60623	:	Secondary Cells and Batteries Containing Other Non-Acid Electrolytes – Vented Nickel- Cadmium Prismatic Rechargeable Single Cells.
IEEE-1115-2000	:	Recommended Practice For Sizing Nickel-Cadmium Battery For Stationary Application.
IEEE-485-1997	:	Recommended Practice For Lead Acid Battery For Stationary Application.
IEEE-946-1992	:	Recommended Practice For The Design Of DC Auxiliary Power Systems For Generating Station.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IS:5	:	Colours for ready mix paints.
IS : 694	:	PVC Insulated Cable for working voltages upto and including 1100V
IS : 1248	:	Specification for Direct acting indicating analogue electrical measuring instruments.
IS:13947 Pt-1	:	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS : 13947	:	Specification for low voltage switch gear and control gear
IS : 3231	:	Electrical relays for power system protection.
IS : 3842	:	Application guide for Electrical relays for AC System
IS : 3895	:	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	:	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	:	Code of practice for phosphating of Iron and Steel
IS:6619	:	Safety Code for Semi-conductor Rectifier Equipment.
IS:6875	:	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 VAC or 1200VDC

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IS : 9000	:	Basic environmental testing procedures for electronic and electrical items.
IS:13703	:	Low voltage fuses for voltages not exceeding 1000 V AC, 1500VDC.
EEUA-45D	:	Performance requirements for electrical Alarm Annunciation system

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity (IE) Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) 220 V DC Systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The system shall be suitable for operation in a highly polluted environment.
- b) The permissible voltage variation for 220V battery shall be from -15% to +10%.
- c) The battery shall be of storage type [Lead Acid Plante Positive Plate/Ni-Cd] Type. The Battery shall be of high discharge performance type. The plates shall be designed for maximum durability during all service conditions including high rate of discharge & rapid fluctuation of load.
- d) While estimating the battery size, temperature correction factor [based on lowest expected temperature 5 Deg C], margin on capacity [10%] and aging factor [1.0 for Lead Acid Plante and 1.2 for Ni-Cd] shall be considered.
- e) Cell Voltages for Lead Acid batteries:

i.	Nominal Discharge Voltage/cell	2.0 V
ii.	Float Voltage/cell	2.2 V
iii.	Boost Voltage/cell	2.7 V
iv.	Capacity for ten(10) hour rate at 27°C any time during the entire duty	1.85 V/Cell

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	cycle	
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f) Cell Voltages for Ni-Cd Batteries

i.	Nominal Discharge Voltage/cell	1.2 V
ii.	Float Voltage/cell	1.42 V
iii.	Boost Voltage/cell	1.7 V
iv.	Capacity for five(5) hour rate at 27°C any time during the entire duty cycle	1.14 V/ Cell

- g) 2x100% sets, 220V of either Lead-Acid Plante Type or Nickel-Cadmium battery banks with 2 x100% float cum boost charger catering to 100% of unit as well as station loads shall be provided.
- h) Permissible voltage variation for 220V battery shall be from 190V to 240V.
- i) The Ampere-Hour capacity of DC Storage Battery shall be based on [Three] hours' continuous DC supply at rated voltage to essential auxiliaries.
- j) Batteries shall be suitable for being boost charged to fully charged condition from fully discharged condition within 10 hours.
- k) Lead acid batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.2V/cell.
- l) Ni-Cd batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42V/cell.
- m) The float-cum-boost charger shall be rated to cater to the following:
- Trickle charging current of the battery
 - Equalizing charging of the Battery
 - Boost charging of the Battery
 - Continuous load on the DC system
 - 25% spare capacity over above loads.

1.4 Specific Requirements

1.4.1 Constructional requirements of battery

a) Containers

Container shall be made of transparent glass for lead acid and polypropylene for Ni-Cd batteries. It shall be robust, heat resistance, leak

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proof, non-absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container. The marking for the electrolyte level should be for the upper and lower limits. Container shall be closed / sealed lid type.

The pole sealing arrangement should be such that no acid particle gets entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

b) Vent Plugs

Vent plug shall be provided in each cell. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the spring type hydrometer can be inserted into the vent to take electrolyte sample.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuation of load. The construction of plates shall conform to latest revisions of standards as applicable for type of battery.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative posts shall be clearly marked.

The plante positive plates shall be supported from the ledges of the SAN container. They should not be supported at the bottom of container. Sufficient space shall allowed to allow the creepage of the plates.

d) Sediment Space

Sufficient sediment space shall be provided so that the cells shall not have to be cleaned out during normal life and prevent shorts within the cells.

e) Cell Insulators

Each cell shall be separately supported on PVC / Porcelain / Hard rubber insulators fixed on the racks with adequate clearances between adjacent cells. Minimum distance between adjacent cell shall be more than the bulge allowed for two cells in accordance with relevant IS standard.

f) Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS: 266 and distilled water conforming to IS: 1069 for lead

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acid batteries and battery grade potassium hydroxide for Ni-Cd batteries. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately in a separate non-returnable container. 10% extra electrolyte shall be furnished to cover spillage in transit or during erection.

g) Connectors and Fasteners

Lead or Lead coated copper connectors (For Lead acid Plante Type batteries) and Nickel coated copper connectors (for Ni-Cd batteries) shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated/Nickel coated to prevent corrosion. The thickness of lead coating of connectors should not be less than 0.025 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulated shrouds. End take-off connections from positive and negative poles of battery shall be made by single core cables having stranded aluminum conductors and XLPE insulation. Necessary supports and lugs for termination of these cables on battery shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 30 minutes discharge current of the respective battery and through fault short circuit current which the battery can produce and withstand for the period declared. Suitable number of inter rack connectors shall be supplied by the bidder to suit the battery room layout during the detail engineering.

h) Battery Racks

Steel racks with anti-corrosive epoxy paint for all the battery shall be provided. They shall be free standing type mounted on porcelain / hard rubber / PVC pads insulators. Battery shall be located in the single tier arrangement. However battery having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The battery rack and support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

i) Manufacturer's Identification Systems

The following information shall be indelibly marked on outside of each cell:

- i. Manufacturer's name and trade marks
- ii. Country and year of manufacture
- iii. Manufacturer type of designation
- iv. AH capacity at 10 hour discharge rate
- v. Serial number

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1.4.2 Constructional Requirements of battery charger

- a) The Charger shall be indoor, floor mounted, self supporting sheet metal enclosed cubicle type. All necessary base frames, anchor bolts and hardware shall be supplied. The charger shall be fabricated using cold rolled sheet steel shall not less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied. The lugs for cables shall be made of electrolytic copper with tin coat. The chargers shall be tropicalised and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The chargers shall have hinged double leaf doors provided on front / or backside for adequate access to the charger internals. All the charger cubicle doors shall be properly earthed. The degree of protection of charger enclosure shall be at least IP-42.
- b) All indicating instruments, control and selector switches and indicating lamps shall be mounted on the front side of the charger.
- c) Electronic equipments shall be of modular design consisting of plug in modules in standard 19 inches metallic racks with metallic card guides. The cards should be provided with proper handles. Card to card wiring should be preferably through a motherboard. Unplanned jumpering and track modifications are not permitted and track modifications are not permitted. Mechanical interlocks to prevent wrong insertion of cards should be provided. Each card shall have its junction and test points identified. Maintenance aids such as extension printed wiring boards and jumper leads shall be provided.
- d) The layout of charger equipment shall be such that their heat losses do not give rise to excessive temperature within the charger panel surface. Location of the electronic modules shall be such that temperature rises of the location, in no case, shall exceed 10°C over ambient air temperature outside the charger.
- e) Printed Circuit Boards (PCB)
PCB shall be made of glass epoxy of 1.6 mm thick, fire resistant, bonded with 99.8% pure copper foil, free of wrinkles, blisters, scratches and pinholes. The contact surface of the edge connectors of the PCBs shall be plated with hard gold to a minimum thickness of 5 microns. Component identification shall be printed on PCB by silk screen method. All PCBs shall be tropicalised and masked.
- f) Contactors

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All battery chargers shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. The operating coil shall be rated for 415 Volts AC.

g) Thermal Overload Relay

A thermal overload relay incorporating a distinct single phase protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

h) Rectifier-Transformer and Chokes

The rectifier-transformer and chokes shall be dry and air cooled (AN) type. The rating of the rectifier transformers and chokes shall correspond to the rating of the associated rectifier assembly. The rectifier-transformers and chokes shall have class-B insulation with temperature rise limited to class A insulation value.

i) Rectifier Assembly

The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective charger. The rectifier cells shall be provided with their own heat dissipation arrangement with natural air cooling. The rectifier shall utilize diodes / thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink shall not be permitted to exceed 85 °C absolute duly considering the maximum charger panel inside temperature. Calculations to show what maximum junction temperature shall be and what the heat sink temperature shall be when operating at 200% and 100% load current continuously duly considering the maximum surrounding air temperature of 50°C outside the panel have to be submitted. Necessary surge protection devices and rectifier type fast acting fuses shall be provided in each arm of the rectifier connections.

1.4.3 System Concept for 220 V DC system

- a) First float cum boost charger shall be normally ON in float mode, supplying the D.C. load and at the same time trickle charging the battery and shall (a) provide occasional equalizing charge (b) boost charge the battery up to 2.7/1.7 Volts per cell as required.
- b) The characteristics shall be such that if load is high and exceeds the charger capacity, the excess load shall be supplied by the battery.
- c) The second float-cum-boost charger shall be normally in stand-by (auto float/charge) mode and shall come into the circuit automatically (a) to take over the functions of first float cum boost charger in case of its failure (b) to provide occasional equalizing charge as required, (c) boosting charge the battery up to 2.7/1.7 Volts per cell.

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- d) The float-cum-boost charger shall also have provision for float, equalizing, and boost charging the battery through manual selection. On failure of station A.C. supply, float-cum-boost charger shall go out of service and battery shall take over to supply emergency loads.

1.4.4 Operational requirements of charger

- a) The float-cum-boost charger shall be sized to restore the fully discharged battery to full charge condition in ten (10) hours with 10% margin over maximum charging rate and also to operate as a float charger.
- b) The batteries & chargers shall be so designed that the maximum fault level on DC DB is limited to 15KA (Indicative only; the actual value shall be decided by the contractor after substantiating the same by calculation.)
- c) The battery shall be trickle charged at 2.15 to 2.25 V per cell and 1.4 to 1.42V per cell for lead acid and Ni-Cd battery respectively. All chargers shall also be capable of boost charging the associated battery at 2.0 to 2.7 V per cell for lead acid and 1.53 to 1.7V for Ni Cd at the desired rate. The chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50 °C.
- d) Necessary interlocks shall also be provided to avoid accidental boost mode operation when loads are connected to the bus.
- e) The battery chargers as well as their automatic regulators shall be of static type. Battery chargers shall be capable of continuous operation at the respective rated load in trickle mode i.e. trickle charging the associated lead acid battery/Ni-Cd battery while supplying the DC loads.
- f) Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle / float or Boost charging.
- g) All battery chargers shall be provided with facility both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage / current control, whether automatic or manual. Means shall be provided to avoid current / voltage surges of harmful magnitude/ nature which may arise during changeover from Auto to Manual mode or vice versa under normal operating condition.
- h) Soft start feature shall be provided to build up the voltage to the set value slowly within fifteen (15) seconds. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the charger nor shall it cause blowing of

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any of the charger fuses. The charger shall not trip on overload or external short circuit. After clearance of fault, the charger voltage shall build up automatically when working in automatic mode.

- i) When on automatic control mode, during trickle / float charging, the charger output voltage shall remain within (\pm) 1% of the set value for AC input voltage variation of (\pm) 10%, frequency variation of (+) 3 / (-) 5%, a combined voltage and frequency variation of 10% (absolute sum) and a continuous DC load variation from zero to full load. Uniform and step less adjustment of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire trickle / float charging output range specified. Step less adjustment of the load limiter setting shall be possible from 80% to 100% of the rated output current for trickle / float charging mode.
- j) During boost charging, the battery chargers shall operate on constant current mode (when automatic voltage regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50% to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be vernier type.
- k) Energizing the chargers with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere shall be less than fifteen (15) seconds.
- l) Momentary output voltage of the charger, with the battery connected shall be within 94% to 106% of the voltage setting during sudden load change from 100% to 20% of full load or vice versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above mentioned change.
- m) The charger manufacturer may offer an arrangement in which the voltage setting device for trickle/ float charging mode is also used as output voltage limit setting device for Boost charging mode, and the load limiter of the trickle / float charging mode is also used as Boost charging current setting device.
- n) Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.

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1.4.5 Auxiliary Equipment

- a) DC Voltmeter, DC ammeter and AC voltmeter in 96 mm square shall be provided for each charger. The instruments shall be 240 scale, antiglare glass, flush mounted type, dust proof and moisture resistant. The instrument shall have easily accessible means from zero adjustments. The instruments shall be of 1.5 accuracy class.
- b) In addition to above, following metering provision shall be given for remote metering / recording at PLC/DCS
 - i. Battery Voltage
 - ii. DC voltage of float & Boost charger
 - iii. DC current of float & Boost charger
 - iv. DC load voltage
 - v. DC load current
 - vi. DC Voltage and Current at FCBC
 - vii. Centre Zero Ammeter with Shunt to read Discharge/Charge current
 - viii. Ammeter for Battery Trickle Charge current
 - ix. DC Bus Voltmeter indicating - +ve to Earth, -ve to Earth and +ve to -ve with Selector switch.

The following indications shall be provided

- i. AC Supply – R,Y,B Healthy
- ii. DC supply – Available
- iii. Charger in Float Mode
- iv. Charger in Equalising mode
- v. Charger in Boost mode
- vi. Charger tripped on fault
- vii. D.C Earth fault sensing & alarm

Suitable soft link to be provided for interfacing with DDCMIS.

c) Air Break Switches

All chargers shall have AC input and DC output switches of air break, single throw, load break and fault make type. The contacts of the switches shall open and close with a snap action. Switches shall be rated for 120% of maximum continuous load. 'ON' and 'OFF' position of the switch shall be clearly indicated.

d) Control and Selector Switches

Control and selector switches shall be rotary, stay put type with escutcheon plates showing the functions and positions. The switches shall be of sturdy construction and suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred. The contact ratings shall be at least the following:

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- i. Make and carry continuously - 10 Amps
- ii. Breaking current at 220V DC - 0.5 Amp (inductive)
- iii. Breaking current at 240V AC - 5 Amp. at 0.3 p.f.

e) Fuses

Fuses shall be of HRC cartridge fuse link type. Fuses shall be mounted on fuse carriers which are mounted on fuse bases. Wherever it is not possible to mount fuses on fuse carriers, fuses shall be directly mounted on plug in type bases. In such cases one insulated fuse pulling handle shall be supplied for each charger. Kick-off fuses (trip fuses) with alarm contacts shall be provided for all DC fuses.

f) Indicating Lamps

Three (3) indicating lamps shall be provided to indicate AC supply availability. The indicating lamp shall be of panel mounting, LEDs and capable of clear status indication under the normal room illumination. The lamps shall be replaceable from front. The lamp covers shall be preferably screwed type, unbreakable and moulded from heat resistant material.

g) Blocking Diode

Blocking diode shall be provided in the output circuit of each charger to prevent current flow from the Battery into the charger.

h) Annunciation System

Following annunciation shall be provided for local and remote indications in all chargers(List is indicative only)

- i. AC supply failure
- ii. Rectifier fuse failure
- iii. Surge circuit fuse failure
- iv. Filter capacitor fuse failure
- v. Load limiter operated
- vi. Charger fail / trip
- vii. Battery on Boost
- viii. Battery on Trickle
- ix. DC output fuse failure
- x. Positive grounded
- xi. Negative grounded
- xii. Battery fully discharged
- xiii. AC input under voltage
- xiv. DC voltage low
- xv. DC voltage high
- xvi. DC system earth fault

The annunciation system shall have audio-visual arrangement and shall incorporate acknowledge, reset and test push buttons. On occurrence of fault, the corresponding window lights up and shall stay in lighted

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condition till the fault is cleared and the reset push button is pressed. At least 20% spare annunciation windows with accessories shall be provided.

i) Lamp / Space Heaters / Receptacles

The charger panels shall be provided with:

- i. Internal illumination lamp with door switch.
- ii. Space heater with thermostat control.
- iii. 3-pin 5A receptacle with plug.
- iv. Lamp, heater and receptacle circuits shall have individual switch fuse units/MCB.

1.4.6 Battery Accessories

Each battery shall be furnished complete with following:

- a) First charge of electrolyte plus 10% extra.
- b) Teak wood racks with 3 coats of anti-acid paints.
- c) Stand insulators 5% extra.
- d) Cell inter-connectors 5% extra and one extra end take-off.
- e) Lead-coated connection hardware 5% extra
- f) Cell numbering tag with fixing arrangements
- g) Insulated cable clamps with hardware
- h) Six (6) extra cell with all accessories but without acid
- i) In addition to the above each battery shall be furnished with a set of following accessories.
- j) One (1) Interconnector bolt wrench
- k) One (1) Hydrometer syringe
- l) One (1) Thermometer with specific gravity correction scale.
- m) One (1) Cell testing voltmeter with leads.
- n) One (1) Pocket thermometer
- o) One (1) set of Acid resisting funnels
- p) One (1) set of Acid resisting jugs of adequate capacity
- q) One (1) set of Rubber aprons
- r) One (1) set of Rubber gloves
- s) PVC spill trays under the battery cells
- t) Spanner for cells

Catalogues and Instruction manuals of battery and battery charger to be furnished.

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1.4.7 Painting

- a) All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.
- b) After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality lead oxide primer and stoved after each coat.
- c) The equipment shall be finished in Siemens Gray RAL: 9002 color with two coats of epoxy based powder coated paint except end covers and RAL 5012 for end covers. The coating shall be done electro statically followed by stoving.
- d) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.8 Installation

- a) The battery room floor shall be acid resistant type and walls shall have acid resistant tiles up to a suitable height. Alternatively acid resistant paints are also acceptable. Adequate ventilation shall be provided in the battery room for the removal of hydrogen.
- b) The Battery charger along with D.C. distribution board shall be located in separate rooms.
- c) After erection and connection of the Battery Charger, the contractor shall complete the charging discharging cycles recommended by the manufacturer. The contractor shall rig up a suitable discharge resistor for this purpose.
- d) Connection from Battery terminals shall be made by means of cables. Lead coated terminal connector shall be furnished for this purpose.

1.5 Tests

1) Type Test

For each type of Battery and battery charger, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

All Battery, Battery chargers, Inverters and its components thereof shall be subject to shop tests as per relevant IS/IEC standards. The tests on Battery chargers shall include but not limited to the following:

- a) Voltage regulation check from 0 to 100% loads with $\pm 10\%$ input voltage variation.
- b) Ripple content measurement.
- c) D.C short circuit test to prove ability of current limit.
- d) Measurements of transient overshoot/undershoot during switching ON/load throw-off.
- e) Current limiter operation.
- f) Special tests for electrical equipment, when specified in relevant Indian / International standard shall be carried out on at least one item of each rating.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports. Drawings, Data & Manuals:

1.6

Drawings, Data & Manuals

1. Following drawings/ data and Manuals to be submitted for approval:

- a) [Dimensional battery layout diagram and plan & section.
- b) Connection details of take-off terminals.
- c) Dimensional general arrangement drawings of battery charger clearly showing device dispositions, cable entry, space requirement, etc.

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- d) Sectional views of battery charger.
- e) Charger foundation plan and loading.
- f) Charger schematics and wiring diagrams.
- g) Test reports
- h) Detailed bill of materials
- i) Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.
- j) Instruction manuals of battery and battery Charger. The manual shall clearly indicate method of installation, check-ups, and tests to be carried out before commissioning of the equipment.
- k) Bidders shall note that the drawings, data and manuals listed herein are minimum requirements only. The Bidders shall ensure that other necessary write-ups, curves and information required to fully describe the equipment are submitted with their bids].

1.7 Rating and Requirement

S.No	Technical Particulars	Unit	Parameters	Remarks
1.0	General			
1.1	Bidder's Name			
1.2	Make			
1.3	Application		[For Main plant/BOP]	
2.0	Battery			
2.1	Make and country	:	[By bidder]	
2.2	Type	:	Lead acid(Plante)/Ni Cd	
2.3	Reference standard		As specified in specification	
2.4	Rated system voltage	: (Volts)	220V DC	
2.5	Rated capacity for one hour discharge at 27°C	: (Ah)	[As per project specific]	
2.6	Rated capacity for 10 hour discharge rate at 27°C	: (Ah)	[As per project specific]	
2.7	Nominal voltage per cell	: (V)	2.2V /1.42V	
2.8	End cell voltage	: (V)	1.85/1.14V	
2.9	Number of cells per battery	:	Based on type of battery.	
2.10	Short circuit current	: (kA)	[By bidder]	
2.11	Mounting type	:	[By bidder]	

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S.No	Technical Particulars	Unit	Parameters	Remarks
2.12	AH efficiency at rated load	: (%)	[By bidder]	
2.13	Watt hour efficiency	: (%)	[By bidder]	
3.0	Constructional details		[By bidder]	
3.1	Container			
a	Material			
b	Thickness	Mm		
3.2	Separator			
a	Type			
b	Material			
c	Thickness	Mm		
3.3	Electrolyte			
3.4	Quantity for first filling plus 10% extra			
3.5	Specific gravity at twenty seven (27) degree Centigrade			
a	With all cells fully charged			
b	At the end of discharge			
3.6	Method of supporting elements		[By bidder]	
a	Edges of plates and Inner surfaces of container	Mm		
b	Bottom of negative plates	Mm		
c	Top of plates	Mm		
d	Sediment space	Mm		
3.7	Weather explosion-proof cent plugs are provided		[By bidder]	
3.8	Distance between centre's of cells when erected	mm	[By bidder]	
3.9	Expected life span of battery	Year	[By bidder]	
3.10	Proposed Layout (attach layout)		[By bidder]	
4.0	Battery Charger			
4.1	Number of rectifiers	:	[By bidder]	
4.2	Reference standard	:		
4.3	Make and country			
4.4	Type	:		

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S.No	Technical Particulars	Unit	Parameters	Remarks
4.5	Rectifiers with thyristors Y/N	:	[By bidder]	
4.6	Rated input AC voltage	: (V)	415V, 3ph, 4 wire	
4.7	Frequency	: (Hz)	50	
4.8	Output DC current	: (A)	[By bidder]	
4.9	Rectifier efficiency	: (%)	[By bidder]	
4.10	DC voltage setting adjustment of AVR for float charging		[By bidder]	
4.11	Boost mode:		[By bidder]	
a	Starting rate	: (V)		
b	Finishing rate	: (V)		
4.12	Protection class of cubicles	:		
4.13	Residual ripple	: (%)	[By bidder]	
4.14	Current limiting feather provided	: (Yes/No)	[By bidder]	
4.15	Soft starting feather provided	: (Yes/No)	[By bidder]	
4.17	Voltage and current setter in different mode provided	: (Yes/No)	[By bidder]	
4.18	Type of cooling	:	Natural	
4.19	Paint shade: Indoor and outdoor		[RAL 5012]	
5.0	Constructional details		[By bidder]	
5.1	List of major accessories			
5.2	Diode			
a	Make			
b	Type			
c	Rating			
d	Voltage	V		
e	Current	A		
5.3	Rectifier Transformer			
a	Make			
b	Rating	kVA		
c	Connection			
	Primary Winding			
	Secondary Winding			

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S.No	Technical Particulars	Unit	Parameters	Remarks
d	Voltage			
	Primary Winding	V		
	Secondary Winding	V		
e	Percentage of tap provided			
	Primary Winding	%		
	Secondary Winding	%		
5.4	Control/ Selector switch			
a	Make			
b	Type designation			
c	Voltage Grade	V		
d	Current rating	A		
e	Make and carry			
f	Brake			
g	Spring return or stay out			
h	Type of handle			
i	No. of positions			
j	No. of poles/ ways			
k	Angular Movement			
m	Special features if any			
5.5	Indicating Lamp			
a	Make			
b	Type			
c	Voltage	V		
d	Series resistor value	Ohm		
6	Thickness of battery charger panel sheet steel;	Mm		
5.6	Weight & dimensions		[By bidder]	
a	Length	Mm		
b	Depth	Mm		
c	Height	Mm		
d	Weight	Kg		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E7

TECHNICAL SPECIFICATION FOR HV CABLES

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E7

1.0 HV CABLEs

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of HV cables complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part II)	:	XLPE insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques
IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the

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		cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All HV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The HV power cables shall be 6600V unearthed grade, single/multi core stranded Aluminum conductor, extruded XLPE insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-2). These cables shall conform to IS 7098 (Part II).
- d) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- e) HV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- f) HV cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)
 - v. Installation conditions.
 - vi. Voltage drop under normal running and starting condition
 - vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
 - viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
 - ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.

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1.4 Specific Requirements

1.4.1 Type of Cable

- a) HV cables shall be 6600V unearthed grade, heavy duty, stranded aluminium conductor, XLPE insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-2) cables conforming to IS: 7098 part II.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum to form compact conductor having a resistance within the limits specified.

1.4.3 Conductor Shield

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be provided over the conductor by applying non metallic semi conducting tape or by extrusion of semi conducting tape or by extrusion of semi-conducting compound or a combination of the two. The semi conducting polymer shall be cross linked for XLPE cables.

1.4.4 Insulation

The insulation of the HV cables shall be XLPE type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

1.4.5 Insulation Shield

A non magnetic semi conducting shield shall be put over the insulation to confine electrical field to the insulation. The XLPE cable insulation shield shall be strippable.

The metallic layer of the insulation shield shall be grounded at least at one location in the cable's run. In the case of single conductor cable, care should be taken with regard to ampacity when grounding at more than one point.

For all the cables having insulation shield, it shall have some form of stress relief measure at every splice at termination. This can be stress cones, moulded devices, heat shrink or cold shrink kits. All kits must be suitable for the voltage class and cable size.

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1.4.6 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.7 Armour

HV cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.8 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.9 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than 500m or as per required length.

1.4.10 Identification of cores:

HV power cables shall be identified by color code.

1.4.11 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers

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shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.

b) Workmanship shall be neat, clean and of the highest grade.

c) Special Properties:

All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:

- i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
- ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
- iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
- iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
- v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
- vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
- vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.12 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.13 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]
- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.

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f. ISI marks

g. Nominal cross sectional area of the conductor & no of cores

h. Sequential marking

i. Owner's identification mark]

1.4.14 Fire Proof sealing system

i) General

- a) Fire proof sealing system shall consist of Fire-stops/fire-seals for sealing of cable/cable tray and conduit/pipe penetrations, both horizontal and vertical, through brick or RCC walls/floors, to prevent the spread of fire from one area, which is separated from others by fire-resistant barriers.
- b) 'Fire-breaks' provided on long runs of cable racks/trays to prevent the propagation of fire along the cable rack, within a single fire-area or fire- zone.
- c) The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop/fire-break.
- d) The FPS system shall comply in all respects with the requirements of the codes and standards listed below

IEEE-634 ASTM-E-814

ANSI-IEEE-383 IEC-331 IEC-332

ii) Fire stop/ seal

The FPS system adopted for cables or cable trays penetrating through walls and floor constitute a openings, or cables passing through embedded conduits / pipes / pipe- sleeves, fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

iii) Fire Break

The fire proofing system, other than fire-stops, adopted to retard flame propagation long runs of horizontal or vertical cable trays in the same fire zone or area, in an event of a fire, shall constitute a 'fire-break' and shall be provided by applying a suitable fire –resistance coating on cables and cable trays for the required length, with or without a fire resistant panel, at the point of the fire break to obtain the fire-rating specified.

iv) Application of fire proof sealing system

Fire stops shall be provided for cable penetration openings listed below

The passage of cables/cable trays pipe sleeves/embedded conduits through walls / floors.

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Vertical raceways, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

Cable entry through openings in floor slabs below HT/LT switchgear, MCCs, various Control and relay panels and other bottom entry panels, shall be effectively sealed by fire stop

Location of fire breaks

Firebreaks shall be provided on both cable rack and trenches at all cable tray Intersections and tee-offs.

On linear runs of cable trays between fire stops or fire breaks, fire breaks shall be provided at intervals of 15 metres on horizontal cable runs and 5 m on vertical cable runs.

Fire breaks in linear runs of cable trenches between intersections and tee-offs shall be provided at intervals of 30 metres.

Bidder shall furnish the test certificates for the fire stops and fire breaks after award of contract for Owner/Owner's Representative review. If the certificates are not satisfactory all the tests shall be conducted free of cost. The offered system i.e. fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Owner / Owner's Representative.

v) Test on fire stops

The fire stops shall be subjected to the following type tests:

- a. Fire Rating Test
- b. Hose Stream Test

Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

Preconditioning of fire stop test specimens before conducting the fire rating and hose stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the fire rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable

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penetration fire stop, with a maximum temperature limit on the unexposed surface of 200°C.

Tests on fire breaks

Firebreaks shall undergo the following tests as per ANSI-IEEE-383:

- Ampacity test
- Flame test

1.5 Tests

1.5.1 Type Test

For each type & rating of HV cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 H.V. Power cable, 6600V unearthed grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		6.6 V	
2.	Voltage Grade		6.6/6.6kV Unearthed	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE cables		90°C	
5.	Maximum conductor temperature for		250°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE cables			
6.	Conductor		Aluminum	
7.	Insulation		XLPE	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		Armoured	
11.	System Grounding		Resistance Grounded	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		40 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E8

TECHNICAL SPECIFICATION FOR LV CABLES

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E8**1.0 LV CABLES****1.1 General**

This specification is intended to cover the *[design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning]* of LV cables for power & control applications complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS:1554(Part I)	:	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100V
IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part I)	:	XLPE insulated PVC sheathed cables for working voltage up to 1.1kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques

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IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All LV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The LV power cables shall be 1100V grade, single/multi core stranded Aluminum conductor, extruded XLPE/PVC insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1). These cables shall conform to IS 7098 (Part I) for XLPE and 1554(part 1) for PVC insulation.
- d) The control cables shall be 1100 V grade, multi core, stranded annealed high conductivity copper with extruded PVC insulated inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1).
- e) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- f) The continuous and short time current carrying capacity of PVC insulated cables shall be based on maximum operating temperature of 70°C and 160°C respectively.
- g) LV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- h) Power cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)

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- v. Installation conditions.
- vi. Voltage drop under normal running and starting condition
- vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
- viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
- ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.
- x. The minimum size of cables to be used shall be as follow :
 - Aluminium conductor : 6 Sq. mm.
 - Copper conductor : 2.5 Sq. mm

1.4 Specific Requirements

1.4.1 Type of Cable

- a) LV power cables shall be 1100V grade, heavy duty, stranded aluminium conductor, XLPE/ PVC insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS: 1554(Part 1) for PVC insulation and IS 7098(Part 1) for XLPE insulation.
- b) Control Cables shall be 1100 V grade, heavy duty with annealed high conductivity stranded copper conductor, PVC insulated, FRLS PVC inner sheathed, armoured and FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS : 1554.
- c) LV power cables of size above 35 sq. mm may be provided with XLPE insulation. Bidder shall clearly indicate the type of insulation provided in the technical bid.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum for LV Power cables and Copper for control cables to form compact conductor having a resistance within the limits specified. All the cables of size 25mm² and above shall have sector shaped conductors.

1.4.3 Insulation

The insulation of the LV power and control cables shall be [XLPE/PVC] type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

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1.4.4 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.5 Armour

LV power and control cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.6 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.7 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than the following:

- a) Power cables: 500m
- b) Control cables: 1000m

1.4.8 Identification of cores and spares:

LV power cables shall be identified by color code. However LV control cables shall be identified by the number of its cores.

[Multi-core control cables shall have 20% spare core, minimum one spare.]

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1.4.9 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.
- b) Workmanship shall be neat, clean and of the highest grade.
- c) Special Properties:
All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:
 - i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
 - ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
 - iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
 - iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
 - v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
 - vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
 - vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.10 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.11 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]

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- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.
- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.5 Tests

1.5.1 Type Test

For each type & rating of LV power and control cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 L.V. Power and control cables, 1100 V grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		415 V	
2.	Voltage Grade		1.1 kV	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE/PVC cables		For XLPE: 90°C For PVC: 70°C	
5.	Maximum conductor temperature for		For XLPE: 250°C For PVC: 160°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE/PVC cables			
6.	Conductor		For power cable: Aluminum	
			For Control Cable: Copper	
7.	Insulation		For power cable: XLPE/PVC	
			For Control Cable: PVC	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		For power cable: Armoured	
			For Control Cable: Armoured	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
11.	System Grounding		415 V system is solidly grounded.	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		50 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E9

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E9

1.0 ILLUMINATION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Illumination System complete with luminaries and all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS 1913	:	Electrical lighting fittings- General and safety requirements
IS 2418 - Part I	:	Tubular fluorescent Lamp
IS 3480	:	Flexible steel conduits for electrical wiring
IS 3646 (Part I to III)	:	Code of Practice For Interior Illumination
IS 4012	:	Dust proof electric lighting fittings
IS4013	:	Flame proof enclosure
IS 6665	:	Code of practice for industrial lighting
IS 5077	:	Decorative light fittings
IS 9537 - Part II	:	Rigid steel conduits for electrical installations

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IS 9583	:	Emergency lighting units
IS 9900	:	High pressure mercury vapor lamp
IS 9974	:	High pressure sodium vapor lamp
IS 10322	:	Luminaries for street lighting
CBIP Manual	:	Substation Equipment, Illumination and Layouts
IES (Illuminating Engineering Society of North America)	:	Application and Reference Volume
IEC 60598	:	Luminaries
CEA	:	CEA regulations and standard technical specification.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All illumination systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The illumination systems shall be suitable for operation in a highly polluted environment.
- b. Lighting fixtures shall be suited for the following range of frequency and voltage variations:
 - i. Voltage Variation : $\pm 10\%$
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

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- c. All emergency DC lighting systems shall be suited for voltage variation from -15% to + 10% of rated voltage.
- d. The design of the lighting systems shall be such that it shall ensure average lux levels specified for different areas.
- e. The illumination system shall comprise of the following:
 - i. Normal AC lighting
 - ii. Normal cum emergency lighting system
 - iii. 220V DC Emergency lighting system
 - iv. Maintenance 24V AC lighting system
 - v. Portable emergency lights with self contained battery packs.

1.4 Specific Requirements

1.4.1 Scope of work

The scope of work shall include design, preparation of Lighting design and manufacture, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with Lighting system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Switchgear room and cable gallery.
- iv) All roads within battery limit.
- v) Perimeter and boundary illumination of the above premises.
- vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room and cable gallery.
- v) FOPH area.
- vi) Transfer towers & Conveyor galleries.
- vii) All roads within battery limit.
- viii) Perimeter and boundary illumination of the above premises.

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- ix) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- c) Balance of plant Area:
 - i) Lighting system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- e) AHP Area:
 - i) Switchgear rooms.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard control room
 - ii) GIS building (if applicable)
 - iii) Transformer area
 - iv) All roads within battery limit.
 - v) Perimeter and boundary illumination of the above premises.
 - vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

1.4.2 Illumination System Description

The plant illumination system shall comprise of the following categories:

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a. Normal AC lighting

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply from the normal lighting distribution boards (LDB). All the lighting fixtures connected to this system shall be available as long as the 415V station / unit auxiliary service supply is available.

b. Normal cum emergency lighting system

Certain lighting fixtures considered essential shall be connected to this system. In this system the lighting circuits shall be fed from lighting distribution board connected to 415V Normal cum Emergency Switchgear. The lighting fixtures connected to this system shall be available whenever normal supply is available in the plant and also whenever DG set supplies the power to 415V Normal emergency switchgear.

These lighting fixtures will go off for a few seconds when normal supply fails but will be automatically restored when the emergency AC bus is re-energized by automatic transfer to standby DG supply.

[20% of the total fittings shall be fed from Emergency lighting for areas such as Switchgear room and control rooms etc.]

c. Emergency 220 V D.C. Lighting

The Emergency DC Lighting System shall be located strategically in critical operating areas and at emergency exits. Emergency DC lighting shall also be provided in the Control rooms, Switchgear/ MCC rooms and other strategically important areas. These fixtures shall be fed from respective Emergency DC Lighting Panels. The Emergency DC Lighting Panels (DC ELLP) shall be fed from 220V DC Distribution Boards (DCDB).

These lights shall remain normally OFF but on failure of AC supply these lights shall be automatically ON. Tube lights with Electronic choke suitable for 230 V, AC / DC operation or other Energy Efficient Lamps may be used for DC emergency lighting.

d. Maintenance 24 V AC Lighting System

For lighting facilities comprising portable hand lamps and/or connection of portable hand tools etc., required during the routine maintenance work, 24V single phase 3 pin sockets with switches shall be provided at selected points in the areas listed below. Such sockets for routine maintenance shall be clearly identified by colour coding in order to distinguish them from the normal 240V power outlets. Necessary outlets shall be made on the inside walls of the building near equipments.

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- i. Boiler area: Near inspection manholes on the boiler platforms and near boiler drum at different levels on all four sides.
- ii. TG building: Near HP & LP heaters, turbine flash tank, blow down tank, near condenser water box and near bus duct termination of generator end.
- iii. ESP columns: Near inspection manholes
- iv. Near de-aerator.
- v. Cable galleries.

Any other areas considered necessary identified during detailed engineering.

e. Portable Emergency Lights

This system shall be provided by portable self-contained battery / automatic charger / inverter fed compact fluorescent lamps in isolated buildings / areas where station D.C. supply is not available. These portable emergency light units shall be switched on automatically on loss of normal AC supply. *[Battery packs for portable emergency lights shall be rated for minimum 3 hours duty and the battery shall be of Ni-Cd.]*

f. Exit lights

Emergency escape signs shall be provided at the exit doors, escape routes, intersection corridors, at different floor levels/directions, windowless rooms, toilets, firefighting equipment, lifts, control rooms, switchgear rooms and the areas considered necessary by bidder. *[9W CFL]* lamp shall be used for exit lamps.

The contractor shall design emergency exit lighting system based on plant layouts and install escape lights at suitable locations considering the various escape routes. Emergency exit lights will be fed from normal-cum-emergency lighting panel, wherever available, *[and will be with in-built battery (Ni-Cd) back up of 3 hours operation.]*

1.4.3

Illumination Calculation

- a. Standard Lumen method shall be adopted for interior and exterior lighting in order to determine the number of lighting fixtures for obtaining the desired average level of illumination.
- b. The coefficient of utilization shall be considered to take care of Lumen loss due to:

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- i. Effect of room dimensions.
 - ii. Absorption of light in luminaries.
 - iii. Absorption of light at various room surfaces i.e. ceiling wall etc.
 - iv. Floor cavity, ceiling cavity.
 - v. Mounting height.
- c. Moreover a maintenance factor shall also be considered to account for the fall of illumination due to aging, pollution like dust deposits etc.
 - d. Voltage drop at the fixture terminals from the MLDB shall [not exceed 3%]. Circuit loading of each lighting Panel shall be done in such a way that almost balanced loading in all the phases i.e. R, Y and B is achieved. At least two sub circuits shall be used for illumination of a particular area. Sub circuit loading of each lighting panel shall be restricted to 2000 Watts.
 - e. Design of lighting system shall be such that the average lux level as specified is achieved. The Bidder shall submit illumination calculation/layout for the purchaser's review.

1.4.4 Lighting Distribution System

- a. Separate lighting transformers shall be provided inside the lighting distribution boards located at required location. Lighting distribution system shall be distinct and separate from the LV main distribution. Lighting transformers shall be encapsulated cast resin dry type.
- b. AC lighting panels shall have 240V single-phase, 2 wire incomer controlled by earth leakage circuit breaker and number of single phase outgoing circuits controlled by MCBs. The lights connected to a circuit or few circuits shall be 'ON' automatically through photocell for outdoor lighting. Provision shall be made for switching 'ON' the rest of the lights. Lighting fixtures in indoor areas shall be controlled from the respective lighting panels
- c. Normal 240 V AC Lighting System
For this system, lighting points shall be supplied at 240 V AC through 415 V, 3-phase, 4-wire, 50 Hz, LDB. The supply shall be derived from 415 V, 3-phase, 4-wire, 50 Hz switchgear through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant. Different circuits shall be used from different source. The whole lighting network shall be balanced as far as possible.
- d. Normal/Emergency 240V AC System
For these systems, the distribution shall be by 415V, 3-phase, 4-wire, 50 Hz supply. This supply shall be derived from 415 V, 3-phase, 4-wire, 50

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Hz normal emergency switchgear for NE & lighting through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant.

e. Emergency 220 V DC Lighting System

The power supply shall be obtained from the nearest 220 V DC switchboard. DC lighting panel will have one (1) incomer controlled by double pole MCB, Outgoing circuits will be controlled by DP MCB. Upon failure of the normal-cum-emergency AC supply, emergency DC lighting fixtures will be made automatically ON. The change over in the reverse direction shall also be automatic.

f. Maintenance 24V AC Lighting System

24 V AC supply for maintenance purposes (for hand lamps and/or hand operated tools) shall be supplied from 24 V AC distribution panel, which receives 240 V power supply from 415 V/240V transformer modules of N/E switchgear. 24 V AC distribution panel consists of one incomer controlled by MCB, one 240/26.5 V dry type transformer of adequate rating and number of outgoing circuits controlled by MCB.

1.4.5 Illumination levels and choice of lighting fixtures

The area-wise distribution of average illumination levels and type of luminaries shall be as indicated below:

[Note: These are indicative only. However as per specific Existing project, Bidder may refer section I of this specification for exact details of type of fixtures.]

Table 2.0

Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
A - TURBINE GENERATOR BUILDING				
1.1	General (auxiliary equipment areas)	200	Industrial well glass fixture, dust & jet proof, die cast aluminium body, stove enamel finish, vitreous enamel reflector integral mounted control gear/industrial bulk head with integral mounted control gear.	1x70 W/ 1x150 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.2	Cable vault	100	Industrial type FTL with vitreous enamel reflector	Energy Efficient FTL
1.3	All switchgear room area (including off-site building control room)	250	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.4	TG Building operating floor	250	Industrial high bay with anodized aluminium reflector with all accessories including control gear	1x400 W Metal Halide lamp
1.5	Unit control room and Switchyard control room	400	Decorative recessed with wide angle mirror optic antiglare type	Energy Efficient FTL
1.6	Battery rooms	150	Corrosion-proof	Energy Efficient FTL
1.7	TG building ground, mezzanine floor and misc. floors	200	Industrial well glass with integral control gear	1x150 W/ 1x250W Metal Halide lamp
1.8	Air washer room and A/C plant room	200	Totally enclosed vapor proof with clear acrylic cover	Energy Efficient FTL
1.9	Unloading and maintenance bay	300	Industrial high bay with anodised aluminium reflector	250 W HPSV lamp (for mounting height > 9m)

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.10	Electrical laboratory, chemical laboratory etc. (air-conditioned)	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
B -	BOILER AREA			
1.1	Boiler area and platforms, ESP area and platforms	100	Dust proof / dust tight well glass fixture	70 W Metal Halide lamp
1.2	Feeder floor areas	150	Dust proof / dust tight increased safety well glass	70 W Metal Halide lamp
1.3	ESP control room	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
C -	VARIOUS OFF-SITE BUILDING			
1.1	Equipment room (pump house)	200	Industrial type with vitreous enamel reflector upto mounting height of 8 M	150 / 250 W HPSV lamp
1.2	Switchgear room	250	Industrial high bay for mounting heights above 8M	Energy Efficient FTL
1.3	Outside working areas	70	Flood light medium beam	250 W HPSV lamp
1.4	Stores	100	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.5	Fuel Oil Tank Farm	50	General Purpose flood light with weatherproof fixture	250 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.6	Fuel oil decanting pump house, Hydrogen storage area, Coal conveyor areas	150	Flame-proof well glass	1 x 70 W HPMV lamp
D -	GENERAL			
1.1	Corridors, walkways, staircase, etc.	100	Industrial type with vitreous enamel reflectors/channel mounted box type	Energy Efficient FTL/1 x 70 W HPMV lamp
1.2	Lockers, toilets, wash rooms, etc.	100	Channel mounted box type	Energy Efficient FTL
1.3	Elevator well	50	Industrial bulk head	1 x 100 W incandescent lamp
1.4	Building periphery lighting	50	Industrial well glass with integral mounted control gear/industrial bulk head with integral mounted control gear/flood light fittings with timer control	70 W HPSV lamp / 400 W HPSV lamp
1.5	Office Rooms	300	Decorative recessed type FTL	Energy Efficient FTL
1.6	Transformer yard and Switchyard	50 on equipment, 20 general	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
1.7	Street lighting	20	Street weatherproof fixture with timer control	150 / 250 W HPSV lamp
1.8	Parking area	70	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
E	DC LIGHT FITTINGS			

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.1	Control room	400	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp
1.2	Other areas	250	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp

1.4.6 Area wise distribution of Lighting system in plant

Area wise lighting distribution shall be as below:

Table: 3.0

Area/building	Percentage Distribution of Lighting		
	Normal	Normal & Emergency	220V DC
Turbine Generator Building (all the bays)	80%	20%	10%
Control rooms	80%	20%	10%
Boiler Area (Grade level & Platforms)	80%	20%	5%
Service building	90%	10%	5%
Various pump houses and electrical switchgear rooms such as AHP, CHP, FOPH switchgear room, etc.	90%	10%	5%
Electro static precipitator	90%	10%	5%
Switchyard and Transformer yard	80%	20%	5%

1.4.7 Lighting System Design

The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of

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lighting specified in following paragraph. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

a. Indoor Lighting

The recommended values of illumination level for various areas in the plant are indicated in the table above. Lighting layouts shall be designed such that the ratio of minimum to average illumination shall not be less than [0.6]. Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/buildings in the plant.

i. Maintenance Factor:

- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Industrial areas with normal interiors such as workshops, stores : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors such a crusher house and junction towers : 0.5

ii. Reflection factor for wall/ceiling

- White and very light colors : 0.7
- Light colors : 0.5
- Middle tints : 0.3
- Dark colors : 0.1

iii. The working plane shall be considered at 0.85 m from the floor level.

iv. The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1 meter.

b. Outdoor Lighting

- i) The recommended illumination levels for outdoor areas are indicated in the above table.
- ii) Mounting height, spacing of flood lights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.05.

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- iii) Maintenance factor shall be generally 0.6 under average conditions.
- iv) Flood lights for area lighting shall be mounted on building structures. For outdoor lighting i.e. around the power plant building and transformer yard provision to be made with 400W outdoor type lamps mounted on wall/structures.
- v) Automatic switching ON/OFF shall be shall be provided through timers/photo cells.
- vi) For road illumination inside the boundary limit lighting poles shall be provided and the distance between the poles shall not exceed 30m.
- vii) Aviation obstruction lights shall be provided on tall installations (Chimney, Cooling Towers etc) as per Airports Authority and international standards. Aviation warning lights shall be high intensity type-A flashing LED type with varying intensity for day and night.
- viii) In an area, the lighting fixtures shall be arranged in different phase / LPs such that even in case one lighting panel is faulty complete lighting is not affected. In any location the lighting shall be arranged from two phases.
- c. The circuit loading on each circuit shall be restricted to 80% of the MCB rating.
- d. The voltage drop from LDB and any fixture shall not exceed 3%.
- e. All lighting design calculations, layouts, conduit wiring diagrams, LDBs and LPs drawings and technical data sheets etc shall be furnished for Owner/ Owner's consultant's approval.

1.4.8 Lighting system equipment

- a. Lighting Distribution Boards (LDB) & Lighting Panels (LP)
 - i. The Lighting Distribution board shall be fed through 415V/433V lighting transformers with off circuit taps $\pm 5\%$ in steps of 2.5%. The lighting transformer shall be cast resin dry type , vector group of [Dy1], class F insulation with temperature rise limited to class F and shall be housed in a suitable enclosure. In general, the transformers shall conform to the specification covered under 'Service transformers. The lighting distribution boards shall consist of MCCB incomer and required number of double pole MCB controlled out going feeders to LPs. The LDB shall be designed for the required short circuit level of [20] kA. All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-52. Outdoor panels shall be weather proof type with IPW-55 protection. The

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thickness of sheet steel enclosures shall be CRCA, 2 mm minimum for load bearing and 1.6 mm for other members.

- ii. Number of outgoing feeders in each LDB shall be provided as per requirement including the minimum 3 nos spare feeders for "Purchaser use". Each outgoing MCB in LDB's shall be of 15 A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB
- iii. Individual control in office buildings shall be through single pole flush type switches/MCBs. In those areas where group controls are required, rotary switches shall be provided
- iv. External area lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers/photo cell.
- v. In high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder / platform / approach shall be provided for maintaining / replacement of light fittings.
- vi. Each of the LDBs shall be provided with voltmeter and ammeter along with selector switches, "SUPPLY ON" indicating lamps, etc. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.
- vii. Two ground pads with bolts and nuts shall be provided on each board for connection to 50x6/25x3 mm GS flat.

b. Lighting Fixtures and Lamps

- i) Fluorescent fixtures with electronic ballast shall be generally provided for a room height upto 5m. Type of fixture shall be industrial type with gasket, clear acrylic cover and enamelled reflector or decorative type to suit the aesthetics. For areas with false ceiling, recessed mounted decorative fixtures with mirror optic louvres shall be used. In control room / computer rooms, decorative mirror optic fluorescent light fittings with antiglare features shall be provided. The surface finish shall be smooth, unobtrusive and scratch resistant.
- ii) Reflector shall be of sheet steel or aluminium, minimum 20 SWG thick and securely fixed by fastening device of captive type.
- iii) Fixture shall be suitable for 19 mm conduit entry and 16 SWG GI earth wire connection.
- iv) Fixture shall be furnished complete with lamps and integrally mounted accessories. These shall include holders, ballast, capacitor, starter, ignitors (separate type) etc.

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- v) For corrosive areas, corrosion proof lighting fixture shall be provided. For hazardous areas, light fittings, conduits, junction boxes etc. shall have to meet the corresponding area classification requirement.
- vi) Medium bay or high bay type of lighting fixtures with HPMV/HPSV lamps shall be used depending on the mounting heights for indoor areas having room height more than 5m. Medium/ High bay fixtures shall be provided with vibration damper wherever required.
- vii) For areas like boiler and outdoor areas such as roads, street, transformer areas and open yards, weatherproof HPSV flood/ street lighting fixtures shall be used. For areas like boiler platforms, weatherproof well glass type HPSV fixtures with wire guards shall be used.
- viii) All type of fluorescent lamps including Compact Fluorescent Lamp (CFL) shall be bi-pin rotary type and either cool daylight or white.
- ix) Mercury / Sodium vapour lamp shall be colour corrected type with screwed cap.
- x) Lamps shall be suitable for use in position and capable of withstanding small vibrations.
- xi) Ballasts shall be of heavy duty, low loss and polyester-filled type with copper winding.
- xii) Ballasts for Mercury / Sodium vapour lamps shall be provided with suitable tappings to set the voltage within range specified.
- xiii) Ballasts shall be free from hum. Ballasts which produce humming sound shall be replaced, free of cost.
- xiv) In multi-lamp fixture, each lamp shall be provided with individual ballast.

c. Switches, Receptacles

- i. In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms, etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided
- ii. 240V, 50 Hz, 3 pin Power Receptacles (5A, 15A) shall be provided in all building/areas of the plant. Inside a building, receptacles shall be provided at interval of 30m or part thereof for hand tools, water coolers, exhaust fans etc. Inside each cabins at

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least two receptacles shall be provided and the same shall be indoor/outdoor/flameproof as per the location. Minimum 2 nos of 5A and 1 no 15A receptacles shall be provided in each room. Receptacles shall be heavy duty, complete with individual plug and switch as described below:

Table: 4.0

S.No.	Type	Description
1	RA	5A, 240V, 2 Pole, 3 Pin with third pin earthed - Suitable for flush mounting in office areas and control room. The switch shall also be flush mounting piano type.
2	RB	15A, 240V, 2 Pole, 3 Pin with third pin earthed - Wall/column mounted, metal clad gasketed construction, suitable for 19 mm conduit entry, screwed metal cover tied with metal chain, weatherproof construction suitable for indoor/outdoor installation. This shall be provided at an interval of 30m, or minimum one in each room.
3	RC	63A, 415V, 3 Phase, 5 pin interlocked plug and switch with fifth pin earthed. Wall/column mounted, metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 4 Core 35 sq.mm AYWY cable. These receptacles shall be provided at an interval of 50m throughout the Plant Area.
4	RD	100A, 415V, 3 phase, 5 Pin interlocked plug and switch with fifth pin earthed Wall/column mounted metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 3.5 Core, 95 sq.mm AYWY cable.

d. Cables and Wiring

- i. Wiring from lighting DBs/panels to individual fixtures, plug points, fans, etc. shall be of single core, 2.5sq.mm, 1100 V grade PVC stranded copper conductors through surface mounted or concealed medium duty GI conduits confirming to IS 1239 with earth wire. The wires in the conduits shall not exceed 60% of the conduit area.
- ii. 1100V grade stranded copper conductor, PVC insulated, colour coded, wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, outdoor areas like transformer yard and road lighting, cabling shall be adopted. The

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specification of cable shall conform to the details indicated in "Cabling System" section.

- iii. Minimum size of wires in case of conduit wiring shall be 2.5sq.mm copper in case of lighting and 4sq.mm copper in case of receptacle wiring
- iv. Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits. Wires of AC and DC lighting system shall be carried out in separate conduits
- v. For outdoor lighting, the cable shall be buried at a minimum depth of 750 mm from ground level or run in cable trays. The buried cables shall have suitable bedding, protective covers and markers
- vi. Material used for saddles, clamps, JBs, etc. shall be galvanized
- vii. Office buildings, laboratory buildings shall have concealed wiring with 2.5sq.mm wires using PVC conduits. In heat zones, i.e. in the areas where ambient temperature is 600 C and above, heat resistant control cables shall be used in hot dip galvanised rigid steel surface mounted conduits

e. Fans and Regulators

- i. The fans shall have three well balanced blades, double ball bearings and shall be reasonably free from noise. Fan motor shall be totally enclosed type with copper winding and class-E insulation. Sweep shall be given as 1200 /1400 mm.
- ii. Regulators shall have minimum five steps. Electronic Regulators with smooth control shall be provided.

f. Flame-Proof Equipment

- i. The enclosure of all flameproof equipment for use in hazardous areas where gases/vapors of Group I, IIA, IIB are present, shall be of cast iron/cast aluminum, stove enamel finished. Chemical corrosion resistant epoxy finish shall be provided in corrosive areas. The construction shall comply with relevant applicable standards
- ii. If the enclosures are additionally required to be weather proof, neoprene gaskets shall be provided to make the enclosure dust and weather proof providing a degree of protection of IPW 55.
- iii. All ferrous parts, exposed to atmosphere shall be suitably plated/galvanized

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- iv. All internal wiring shall be connected to terminal blocks provided in terminal enclosure on incoming side.
- v. Flameproof cable gland entries shall be provided suitable for the cable sizes. The number of required cable entries for junction/terminal boxes as required for branching, terminating of cables for lighting distribution shall be provided. All unused cable entries shall be closed by flameproof plugs.
- vi. Flameproof receptacle unit (socket with associated switch/MCB and plug) shall have interlocking feature such that plug cannot be inserted or taken out with switch/MCB in "ON" position.
- vii. Adequate mounting lugs with necessary hardware shall be provided for mounting the equipment on wall/structure.
- viii. These enclosures shall have inscription warning against opening the enclosure unless the circuit is isolated. Equipment rating and ON/OFF positions of switches/MCBs shall also be designated.
- ix. The BIDDER shall indicate that the enclosures have been tested and certified by relevant statutory authorities for use in hazardous areas.

g. Lighting poles and towers

- i. Lighting poles for street lights and flood lights shall be of swaged and welded steel, pole of height 9M/11M and shall conform to relevant standard. Poles shall be hot dip galvanized internally and externally after fabrication as per IS 2629 / IS 2633 / IS 4759 standards. The Poles shall be designed to withstand the maximum wind speed as per IS 875. The steel sheet used to manufacture steel poles shall be of minimum thickness of 3 mm and shall conform to relevant standard . Junction boxes shall be provided with weather proof flush doors and locking facility. Bidder shall design and furnish the foundation drawings for the poles to withstand basic wind speed of minimum [50]meter/sec.
- ii. The supply of poles/Towers shall be complete with base plate, foundation bolts, hot dip galvanized brackets / necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
- iii. Towers for mounting flood lights shall be e of continuously tapered poly gonol cross section and shall be supplied with all acesssories. Steel structure for towers shall be made of hot dip galvanized steel. A steel ladder and platform at the top shall be provided. The length of each step of the ladder shall be at least

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300 mm and spacing between two adjacent steps not more than 300 mm. The structure shall be suitable for mounting the required number of flood lights, weights of maintenance crew and specified wind pressure. The factor of safety shall be [2] for each part and section. The Contractor's structural design drawings shall be approved by the Purchaser before fabrication.

1.4.9 Name Plate

Name plates shall be furnished for identification of devices and circuits. All switches, controls and indications shall be permanently and legibly marked in English regarding the functions.

1.4.10 Painting

All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.

After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoved after each coat.

The equipment shall be finished in approved color shade by owner with two coats of epoxy based powder coated paint. The coating shall be done electro statically followed by stoving.

Sufficient quantity of touch-up paint shall be furnished for application at site.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

Tests on Lighting Distribution Boards / Panels shall include:

- a. Wiring continuity tests.

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- b. High voltage and insulation tests.
- c. Operational tests.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *Lighting panels & distribution boards.*
- b) *Receptacles & Junction boxes.*
- c) *Street light poles & towers.*
- d) *Lighting fixture complete with lamps and accessories.*
- e) *Non-integral/separate type control gear box for lighting fixtures, as applicable.*
- f) *Lux level calculations for each area.*
- g) *Data sheets for lighting fixture, lamps, accessories with light distribution curves, co-efficient of utilization charts etc. Type and routine test certificates of transformer and cables.*
- h) *Control schematic and wiring diagram of 415V AC/220V DC lighting panel with automatic changeover from AC to DC and vice-versa, 415V normal AC Street/area lighting panel with automatic ON/OFF feature.*
- i) *Technical leaflets and data sheet on each piece of equipment/ device such as MCB, switch, fuse, receptacle etc. Type and routine test certificates of transformer and cables.*
- j) *QAP and relevant test certificates*

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- k) Lighting layouts showing the disposition of fixtures, lighting panels/boards, circuit distributions, conduit & wire routing.
- l) Key Single Line Diagram for lighting distribution, board wise single line diagram with feeder loading, cable schedule and interconnection chart, design calculation for lighting.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC DC	240V, 1Ph, 50Hz 220V DC
1.2	Variation in Supply		
	a) Voltage	%	±10
	b) Frequency	%	±5
	c) Combined voltage & frequency	%	10
1.3	Design Ambient Air Temperature	°C	50
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	50KA for 1 sec
	b) At 220V DC (For DC LP)	kA(DC)	[10] kA for 1 sec
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		G.I
b	Conductor size	SWG	12
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		[By bidder]
2.2	Rated Voltage, phase and Frequency	AC	415V, 3phase, 4 wire, 50Hz
2.3	One Minute Withstand Voltage	V	2500
2.4	Mounting Type		

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S. No.	DESCRIPTION	UNIT	DATA
	a) LDBs		Floor Mounted
	b) Single Phase LP		Wall/Structure mounted
2.5	Type and no of circuits & feeder rating		[As per project requirement]
2.6	Colour shade		[RAL 5012]
2.7	Lighting Transformer		
	a) Type		Epoxy cast resin dry type
	b) Voltage Ratio	V	415/415V
	c) Taps	%	+/-5%
	d) Vector Group		[Dyn1]
	e) Impedance	%	[5%]
	f) Rating	KVA	[As per project requirement]
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		[By Bidder]
3.2	Luminaries		[By Bidder]
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		[By bidder]
	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		[By bidder]
	a) Luminaires		
	b) Accessories		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Schedule of fitting and Accessories		[As per project requirement]
5.0	Technical details of luminaries		[By bidder]
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumen s	
	ii) After 1000 burning hours	Lumen s	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		[By bidder]
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		[By bidder]
a	Power factor		
5.4	Luminaries		[By bidder]
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		G.I
	ii) Suitable upto conductor size	SWG	12
c	Internal wiring size	Sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		[By bidder]
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		[By bidder]
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		CTs VTs
8.1	Make		[By bidder]
8.2	Type		[By bidder]
8.3	Output	VA	[By bidder]
8.4	Accuracy Class		[By bidder]
8.5	Literature enclosed	Yes/No	[By bidder]
9.0	Meters		VOLTMETER AMMETER WATTMETER
9.1	Make		[By bidder]
9.2	Type		[By bidder]
9.3	Accuracy Class		[By bidder]
9.4	Literature enclosed	Yes/No	[By bidder]
10.0	Relays (if any provided)		[By bidder]
10.1	Make		

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S. No.	DESCRIPTION	UNIT	DATA
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a)Normally open		
	b)Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		[By bidder]
11.2	Suitable for use in hazardous area		
	a)Area classification		[Fuel oil pump house, Main oil tank area]
	b)Gases/Vapor group		[By bidder]
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	[By bidder]
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	[By bidder]
12.0	Lighting Control Switches		[By Bidder]
12.1	Make		
12.2	Decorative		
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		[By Bidder]
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	

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S. No.	DESCRIPTION	UNIT	DATA
14.0	Lighting wires		[By Bidder]
14.1	Make		[Point wiring with respect to different length shall be furnished]
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	Conduits		[By bidder]
15.1	Make		
15.2	Rigid Steel		Galvanized
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		[By bidder]
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		Yes
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		[By bidder]
17.1	Make		
17.2	Type of Poles/Towers		

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S. No.	DESCRIPTION	UNIT	DATA
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		[By bidder]
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E10
TECHNICAL SPECIFICATION FOR CABLE CARRIER
SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E10**1.0 CABLE CARRIER SYSTEM****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Cable Carrier system complete with all accessories for efficient and trouble free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS 800	Code of Practice for structural Steel
IS 1646	Code of Practice for Fire Safety of buildings
IS2667	Fittings for Rigid steel Conduits
IS 3419	Fittings for Rigid Non – Metallic Conduits
IS 3837	Accessories for Rigid Steel Conduits
IS 4649	Adaptors for Flexible Steel Conduits
IS 5216	Guide for Safety Procedures and Practices in electrical Work

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Cable and cable trays shall be installed in an ambient temperature of 50 °C and relative humidity of 95%.
- b) The cable carrier system shall be designed considering the following:
 1. Facility for easy laying of cables.
 2. Access to maintenance.
 3. Neat and aesthetic appearance.
 4. Safety of equipment & personnel.
 5. Ground water seepage.
- c) Cables shall be laid in prefabricated ladder/perforated type trays and in conduits. Direct burial of cable shall be mostly avoided.
- d) Upper cable trays and all vertical cable trays shall be provided with tray covers.
- e) Cable filling in the trays or racks shall not exceed 80%. Conduits if used, the wires in the conduits shall not exceed 40% of the conduit area.
- f) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V cables shall be laid in top trays and cables of subsequent voltage grade in lower tier of trays. Instrumentation cables shall be laid at bottom most tray.
- g) At least 300mm clearance shall be provided between HV and LV cables & LV and control/Instrumentation cables.
- h) Support system for cables shall be prefabricated type.
- i) Single core cables shall be laid in trefoil touching formation. Trefoil clamp shall be provided in a staggered manner.
- j) 1100V grade power cables of [120] mm² size and above shall normally be laid in single layer in trays/on racks.
- k) 1100V grade power cables below [120] mm² may be run in double layers in case of space restrictions.
- l) Control and instrumentation cables can be laid up to a maximum of three layers in each tray/rack.

1.4 Specific Requirements

1.4.1 Scope of work:

The scope of work shall include Design, Preparation of Cable Tray, Trench/Duct bank/Conduit Layout, supply of Cable tray and its Accessories, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the Cable Carrier System

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for following package. The below list indicates area where cable carrier system to be provided but not limited to:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- iv) Laying and Termination of power & control cables for all the equipments of TG package.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room.
- v) FOPH area.
- vi) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- vii) Laying and Termination of power & control cables for all the equipments of Boiler package.

c) Balance of Plant Area:

- i) Cable Carrier System for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
- ii) Laying and Termination of power & control cables for all the equipments of BOP package.

d) CHP Area:

- i) CHP Switchgear room
- ii) Conveyor.
- iii) Crusher House
- iv) Stacker and Reclaimer
- v) Any other area covered in this package.
- vi) Laying and Termination of power & control cables for all the equipments of CHP package.

e) AHP Area:

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- i) AHP Switchgear room.
- ii) Silo Area.
- iii) Any other area covered in this package.
- iv) Laying and Termination of power & control cables for all the equipments of AHP package.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard
 - ii) Transformer yard
 - iii) Inter plant cabling.
 - iv) Any other area covered in this package.
 - v) Laying and Termination of power & control cables for all the equipments of eBOP package.
- g) All civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification. Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Bidder.
- h) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work.
- i) For Terminal Points and Exclusions of Cable Carrier system and Specific scope of work Bidder may refer section I of this specification.

1.4.2 General Installation Requirements:

- a) Cable trays shall be fabricated from 14 gauge mild steel sheets. Cable trays shall be of hot dip galvanized Steel of ladder/perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings to be submitted by Bidder. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanized.
- b) Constructional details, supporting arrangement and installation details for cable trays shall be furnished by Bidder.
- c) Each 2.5 meter section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.
- d) Cable tray covers shall be fabricated from 16 gauge MS sheets. Cable tray covers shall be hot dip galvanized and same shall be provided for all outdoor cable trays and vertical raceways/trays. Covers for vertical raceways shall be in individual, easily removable sections to facilitate cable maintenance.

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- e) Cable Tray of Standard width of 600mm shall be followed. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.
- f) Cable trays shall be ladder type with maximum rung spacing 250 mm depth 100 mm and rung width not less than 50 mm.
- g) Cable trays in areas subjected to excessive coal dust, or mechanical damage shall have hot-dip galvanized sheet metal tray cover installed on front tray in vertical run and inverted 'V' type on upper tray in horizontal run. Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.
- h) Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal / vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.
- i) Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/termination kits, lugs, glands, ferrules, tapes etc. and other accessories, grounding of cable armor. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.
- j) Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.

1.4.3 Cable Routing/Laying

- a) Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some

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cases cables may have to be laid underground and for short runs in conduits for protection while crossing roads and other facilities.

- b) For interplant connections, the cables may be routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.
- c) For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.
- d) In boiler area, trench shall be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.
- e) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.
- f) Cables for redundant equipment/system shall be run in separate trays in separate route.
- g) Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.
- h) Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).
- i) The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall and fire proof doors.
- j) The floor of the cable spreader rooms shall have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably planned to avoid water entry through this place.
- k) Cables shall generally be laid on cable trays either in concrete trenches or overhead supported from building steel/structures. Cables shall be run in concrete trenches in those electrical rooms at ground level, which are without any spreader room below. In mechanical equipment areas (Indoor), overhead cable trays shall generally be used.

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- l) For inter plant connections, the cables shall be routed through an overhead cable bridge pipe cum Cable Bridge. For isolated but long outdoor cable route with very few cables of 3/4 nos., the cables may be directly buried with prior permission from the purchaser.

1.4.4 Installation of Cables

- a) The Bidder shall install, terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.
- b) The HV power cables of 6.6kV shall be laid in trays or racks as follows:
- In single layer only.
 - 3 core cables to be laid in touching formation.
 - Cables in trefoil groups of the same circuit shall be laid as indicated below so as to ensure balanced current distribution:

Y Y Y Y

R B B R R B B R and so on.

- c) 1100V grade power cables shall be laid in single layer in trays depends on size of cables. Cable of up to 120 sqmm shall be laid in two layers. Beyond this size single layer will be followed.
- d) Control and Instrumentation cables can be laid up to a maximum of three layers in each tray.
- e) The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.
- f) Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there shall not be more than 2 nos. 90 Deg. Bends between pull points.
- g) Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension, minimum bending radius and no. of bends.

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- h) All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :
- Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.
 - Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.
 - For all HV, LV, Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.
- i) All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.
- j) The portion of galvanized steel, which, if required, undergoes any welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.

1.4.5 Cable Termination and Joints (if applicable and not covered in cable specification)

- a) The Bidder shall supply cable termination and jointing kits in requisite quantity for HV. Power Cables, LV. Power, Control Cables, etc. along with all accessories & consumables required for making termination and joints complete . All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/joints are intended.
- b) The straight through joints of HV. cables shall be heat shrinkable and pre moulded push on type. The end termination kits for HV. cables shall be of {Raychem/3M/Elastimold} type. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.
- c) Glands and lugs required for termination of HV, LV. shall be supplied by the Bidder in required quantity.
- d) Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer etc. Cable glands shall match with the sizes of different HV/LV/Control cables.

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- e) Cable lugs shall be suitable for termination of different cross-sections of L.V./Control cables and shall be of following types:
 - i. Aluminium tubular terminal end for solderless crimping to aluminium conductors.
 - ii. Copper tubular terminal end for solderless crimping to copper conductors.
 - iii. Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.
 - iv. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.
 - v. The terminations shall with tinned copper only.
 - vi. For mill area, the cable shall be routed through GI pipes embedded in Ground.
 - vii. In heat zone areas as far as possible the cables shall be taken away from the area to avoid heat. If cabling in the heat zones can not be avoided, the cables shall be terminated in junction box of IP 67 protection class away from the heat zones and small length of cables may be laid from junction box to the respective equipment to facilitate easier replacement in case of fire. Bunching of cables in the heat zones and boiler areas shall be avoided and laid in separate groups.

1.4.6 Identification

- a) The complete cabling system shall be properly identified. Methods for identification of cabling system will be furnished to the Bidder and the Bidder shall strictly adhere to the said methods.
- b) Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- c) Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate, projected above ground level.
- d) Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) meters in cable tray/trench runs. Cable tags shall also be provided

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inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant / purchaser or his representative.

- a) Checking of continuity / phasing and IR values for all the cables before and after HV test
- b) Checking of continuity / phasing and IR values for all the cables before and after HV test.
- c) HV test and measurement of leakage current after termination of cable kits (for HT cables).
- d) Checking of earth continuity for armour.
- e) Check for mechanical protection of cables.
- f) Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
- g) Check earthing of cable structures.
- h) Check safe head room in gallery area
- i) Check clearance from ventilation duct and light fittings for cable structures.
- j) Check proper fixing of cable structures.
- k) Check for proper drainage and removal of water (if any).

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall

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obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) [General arrangement drawing Cable Tray]
- b) [Cable Tray Accessories like Tee, Cross, Bends, Coupler, Reducer etc]
- c) [Cable Tray support materials]
- d) [Technical Data sheets for cable carrier system].

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		[By bidder]
2.	Size of Tray	mm	[600/450/300/150]
3.	Material		Galvanised Steel
4.	Application		[As per project requirement]
5.	Type of Tray		[Ladder/Prerforated]
6.	Thickness of Tray	mm	2mm
7.	Thickness of Galvanization		[100 microns]
8.	Tray Cover Size	mm	[As per project requirement]
9.	Cable Tray Accessories		[By bidder]

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SL NO.	DESCRIPTION	UNIT	DATA
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	a) [100] b) [50x 50 x 6]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E11

**TECHNICAL SPECIFICATION FOR EARTHING AND
LIGHTNING SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E11

1.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Earthing and Lightning Protection System complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanizing of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:9537	Conduits for electrical installation.
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
CEA	CEA Regulations and standard technical specification for main plant package.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Earthing system design shall consist of earth grids and electrodes buried in soil in the whole plant area, embedded in concrete inside all the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.
- b) The main objectives of earthing system is to:
 1. Provide safety to personnel from contact of dangerous potential caused by ground fault.
 2. Ensure sufficient grounding current for effective relaying.
 3. Stabilize circuit potential with respect to ground.
- c) The earthing conductor shall be designed for fault current of [50 kA] for duration of 1 second.
- d) It is the responsibility of the Bidder to undertake the soil resistivity measurements at site and select suitable size of conductor based on the soil resistivity.
- e) Ground conductor shall be of galvanized steel for above ground and mild steel for embedded and below ground earthing.
- f) Main earth grid conductor shall be mild steel (MS) of [40] mm dia.
- g) Suitable corrosion allowance shall be considered over ground conductor size depends upon soil resistivity.
- h) The main purposes of lightning protection system are to :
 1. Provide protection to structures from lightning strokes.
 2. Provide a low resistance-conducting path to lightning discharge.
 3. Lightning protection shall be provided as per IS: 2309 for Boiler area and other tall structures within the battery limit.

1.4 Specific requirements

1.4.1 Scope of Work

The scope of work shall include Design, Preparation of Earthing and Lightning Layout, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the safety earthing and Lightning Protection system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

- a) TG Area:
 - i) TG Platforms.

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- ii) TG area Grade Levels Maintenance area.
- iii) All equipments, structures etc of TG package.
- iv) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- b) Boiler Area:
 - i) Boiler Platforms
 - ii) Boiler Grade Levels covering coal mill and Maintenance area.
 - iii) ESP Platforms
 - iv) ESP/FOPH switchgear room.
 - v) FOPH area.
 - vi) All equipments, structures etc of Boiler package.
 - vii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- c) Balance of plant Area:
 - i) Earthing and lightning protection system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- e) AHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard, Transformer yard and BTG area are provided with earth mat of [40] mm dia MS Rod conductor buried below 600mm from ground level. Areas like AHP, CHP, Boiler and TG, and all other

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BOP area below grounding system are covered in this eBOP package and above ground earthing for AHP, CHP, Boiler, TG and Mechanical BOP are covered in respective package itself. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system for above ground are covered in respective packages and below ground is covered in this eBOP package in same way as earthing system.

1.4.2 Earthing system

- a) Earthing system shall be designed in accordance with IS 3043 and Indian Electricity Rules and Acts.
- b) Fault current for the earthing system shall be designed for [50] KA for duration of 1 sec.
- c) All electrical equipment, non-current carrying metal parts, structures, building steel, lightning protection system, transformer neutrals shall be connected to station ground grid.
- d) Treated earth pits including riser shall be provided for transformer neutral earthing.
- e) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- f) Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.
- g) All off site area of AHP , CHP etc shall be provide with peripheral earthing with at least two connection to main station earth grid through treated earth pit.

1.4.3 Ground Grid Conductor

- a) Ground grid conductor of mild steel rod shall be used.
- b) *[The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.12 mm (on diameter of conductor) per year over the design life of 40 years.]*
- c) However bidder shall consider as per CBIP norms “ Manual on Earth mat design” the corrosion allowance as below:
 - For soil resistivity greater than 100 ohm-meter: No allowance.

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- For soil resistivity greater than 25- 100 ohm-meter: 15% allowance.
- For soil resistivity less than 25 ohm-meter: 30% allowance.

1.4.4 Underground Grid

- The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80.
- [The ground grid conductors shall be buried in earth at a depth of 600 mm]. The length of ground conductors below earth shall be sufficient to ensure a ground resistance less than one (1) ohm.
- The ground grid conductor shall be so laid as to provide short and direct connection to building steel and major electrical equipment.
- Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.
- All ground grid conductor connections shall be welded type.
- Ground grid shall be interconnected with the ground grid of neighboring areas at least at two (2) points for further reducing the ground grid resistance.
- Suitable pigtails shall be provided and shown in the [layout drawing] for connection with ground grid of neighboring areas.
- A minimum earth coverage of [300] mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.
- In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.
- Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.
- Grounding conductor around the building shall be buried in earth at a minimum distance of [1200] mm from the outer boundary of the building.
- The Bidder shall carryout the grounding of all electrical equipments and connection to main earth grid.

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1.4.5 Ground Electrode

Ground electrodes shall be [40] mm dia. and [3] metre long M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductors. All connections to the conductors shall be done by arc welding process.

1.4.6 Above Ground Connections

- Galvanized steel flats shall be used for all connections above earth.
- Inside building, ground conductors shall be run for each floor supported on building steel and/or cable trays. These ground conductors in turn shall be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.
- Two separate and distinct ground connections shall be provided for each electrical equipment in compliance with I.E. Rules.
- All steel columns and structures shall be connected to the earth mat through earth leads.

All connections above ground shall be welded type except connection to equipment/structures which shall be bolted type.

1.4.7 Risers

Risers are required for connecting the equipment and structures with the ground mat. Risers are to be provided from underground mat to above ground levels where the ends shall be left free for connecting to the equipment. Each riser shall be 1 No. [40] mm dia. M.S. rod and shall project above grade level/concrete floor level by minimum 300 mm. They are to be clamped or supported along the outer edge of the concrete foundation. Connection to the ground mat shall be done by arc welding.

1.4.8 Equipment Ground Lead

- Equipment ground connections shall be sized to carry the ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.
- The minimum ground conductor sizes for various equipment and structures are given in below.

Table 2.0

DESCRIPTION	SIZE	MATERIAL
a) Main Grounding Grid Conductor	[40] mm dia Rod	Mild Steel
b) Riser/Pigtail From Grounding Grid/Mat	[40] 40 mm dia Rod	- Do -

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DESCRIPTION	SIZE	MATERIAL
c) Electrode	[40] mm dia, [3000] mm long Rod	- Do -
d) Conductor used for connection of various equipment/structures as listed below		
HV motors, Earthing ring, Earthing lead to earth pits etc.	[50 x 10] mm	Galvanised steel
Structures, Control Panels, Cable Trays etc.	[50 x 10] mm Flat	- Do -
415V Power Control Centres, Motor Control Centres, Distribution Boards etc.	[50 x 10] mm Flat	- Do -
Local Panels, Lighting Panels	[25 x 6] mm Flat	- Do -
Motors :		
Above 90 kW	[50 x 10] mm Flat	Galvanised steel
Above 30 kW Upto 90 kW	[25 x 6] mm Flat	- Do -
Above 5 kW Upto 30 kW	[25 x 3] mm Flat	- Do -
Upto 5 kW	[8] SWG	- Do -
Miscellaneous Items, viz. Push Button Station, Junction Boxes etc	[8] SWG	- Do -

{The Above size of Earth flat is indicative only. Bidder shall refer Volume II Section I for size of earth flat used for existing plant or as per design.}

1.4.9

Jointing and Connection

- All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.
- The bending of the large diameter ground conductor where necessary shall be done by gas heating.
- The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- The connections between the riser/pigtail and earthing conductors

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(galvanized steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.
- g) Equipment/structures ground connections shall be coated with weather resistant paints/cold galvanizing paints after proper checking / testing.
- h) Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

1.4.10 Earthing system installation

- a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
- b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750 mm.
- c) The earthing conductor crossing the road / track shall be laid in hume pipe or laid at a greater depth to avoid damage.
- d) When earth conductor passes through floors, walls, etc suitable pipe sleeves shall be provided and the same shall be sealed after installation.
- e) The connection between earthing pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
- f) Metallic conduits and pipes shall not be used as earth continuity conductor.
- g) Street lighting poles, flood light poles & towers, their junction boxes shall be connected to the earthing conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.
- h) The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.
- i) Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten [10] metres. Fence gate shall be separately grounded with flexible connection to permit movement.

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- j) [50 x 10] mm galvanized steel flats(minimum size) shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing. These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground. Earthing conductors can be embedded in concrete floor of the building wherever necessary without having direct contact with the reinforcement rods. At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- k) All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.
- l) Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.
- m) Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.
- n) A continuous [50 x 10] mm (minimum size) G.S. flat earthing conductor shall run along the cable trays and supporting structure of all cable routes. This earthing conductor shall be attached to each section of cable tray/trays through [50 x 10] mm G.S. flats. The earthing conductor shall be securely connected to the earth mat at both ends.
- o) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
- p) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.
- q) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- r) The cable sheaths, screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.
- s) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- t) Main plant earth grid and switchyard earth grid shall be interconnected each other by minimum two numbers of leads.

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1.4.11 Lightning Protection System Design

- a) Lightning protection design and installation work shall be provided on the basis of IS 2309 Code of Practice.
- b) Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down conductors and pipe electrodes.
- c) The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than value specified in IS shall be provided with lightning protection. However, Boiler areas, station building, switchyard building shall be provided with lightning protection irrespective of the arrived risk index.
- d) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.
- e) Down conductors shall run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.
- f) A Lightning electrode shall be provided at the connection point of the down conductor with the station ground.
- g) Galvanized steel rods and flats shall be generally used for air termination and connections. All connections shall be welded type.

1.4.12 Air Terminations

- a) The vertical air terminal rods shall be installed at the roof of Turbo generator building, Boiler and chimney etc to protect these objects from lightning strokes.
- b) The projected length of the Air termination rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.
- c) The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building, the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.
- d) All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size [50 x 6] mm galvanized steel flats.
- e) For chimney air termination, rods interconnected by circumferential conductors will be provided at the apex of flue and also upon outer shell of the chimney. The air termination system will be formed by lead coated copper conductors to prevent melting and corrosion of conductors due to flue gas.
- f) For cooling towers, air termination system will comprise of horizontal

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circumferential conductors at the top

1.4.13 Down Conductors

- a) Galvanized steel down conductors of suitable size [25 x 6] shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.
- b) Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.
- c) The connection between each down conductor and rod electrode (by means of 40 mm mild steel rod riser) shall be made by others. However Bringing down comer with test link at a level of 1500mm approximately from above ground level shall be boiler contractor scope of work.
- d) The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleared on outside of the building wall and column/structure at about 750 mm intervals unless stated otherwise in the drawing.
- e) At all supports for down conductor along the column/wall of the buildings etc. the portion embedded inside the building concrete should not touch the reinforcement bars.
- f) All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.
- g) The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

1.4.14 Switchyard Lightning protection

- a) For switchyard lightning protection shall be provided by lightning masts and/or shield wires.
- b) In case of lightning protection by shield wire, the shield wires provided shall be of GS wire strung across the pinnacles of the gantry tower structures. The size of shield wire shall be based on the lightning impulse current expected and the time duration for which it is likely to flow. Allowance shall be given in the final size to account for corrosion of the shield wire during service at rate of [0.03] mm per annum. However, minimum size of the shield wire shall not be less than [70]sq.mm. The zone of coverage for the shield wire shall be considered as 60 deg between the two shield wires and 45 deg for end shield wires. The down conductors from shield wires shall be run along the towers and

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connected to rod/pipe electrodes.

- c) In case of lightning protection by lightning protection masts, the down conductors from the masts/peaks/shield wires shall be run along the tower and connected to the test links mounted on the towers at 1500m from the ground level. Conductors from the test links shall be connected to the rod/pipe electrodes which in turn are connected to the main earth grid in the switchyard. Calculations for sizing and determining topography and number of lightning masts shall be furnished for approval.

1.4.15 Electrodes (for Lightning Protection)

The electrodes shall be [40 mm] diameter [3000 mm] long mild steel rod. These shall be driven into the ground.

All the electrodes shall be interconnected by means of one (1) [40 mm] dia mild steel rod which shall be laid under ground at a minimum depth of [600 mm] below finished grade level unless stated otherwise. This ground mats/electrode in turn shall be connected to main grounding grid.

1.4.16 Riser (for Lightning Protection)

All risers connected to grounding mat shall be [40 mm] mild steel rods and shall be projected 300 mm above grade level unless stated otherwise.

1.4.17 Jointing & Connection

- a) All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.
- b) The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- c) The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.
- d) All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.
- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- g) The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- h) The steel to copper connection shall be brazed type.

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- i) The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.
- j) The sizes and materials of earthing conductors to be used in lightning protection system are listed below :
- k) Note: The above sizes are indicative only. Actual size shall be as per Bidder design or as per existing plant details as provided in Section I in case of replacement work as called for.

Table 3.0

DESCRIPTION	SIZE	MATERIAL
a) Vertical Air Termination	[20] mm dia Rod	Galvanised steel
b) Horizontal Conductor	[50 x 6] mm flat [25 x 6] mm Flat	-----do-----
c) Down Conductors	[25 x 6] mm Flat	-----do-----
d) Ground electrode / riser	[40] mm dia Rod	Mild Steel
e) Interconnection with earth mat	[40] mm dia Rod	Mild Steel

1.5

Tests

1) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the

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Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

The following test shall be conducted:

- a) Measurement of earth resistance for each electrode.
- b) Measurement of total earth resistance.
- c) Measurement of earth loop resistance for E/F path of biggest LV drive.
- d) Check tightness of all earth connections
- e) Check earthing of all metallic equipments, cable trays, bus bar supporting structures, building column (if steel all elect equipments, pipe lines etc. as per the drawing / specification)

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[Earthing Material like conductor , flat , welding description etc]*
- b) *[Air termination rod and its accessories etc]*
- c) *[Technical Data sheets for Earthing and Lightning system].*

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1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E12

TECHNICAL SPECIFICATION FOR 6.6kV SWITCHGEAR

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E12

1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of 6.6 Switchgear, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 226	Structural steel (standard quality)
IS : 375	Switchgear bus bars, main connections and auxiliary wiring, marking and arrangement
IS : 722	AC electricity meters
IS : 728	Galvanized steel structures
IS : 2099	Specification for bushings for alternating voltages above 1 000 volts
IS : 2147	Degree of protection
IS : 2516	Alternating current circuit breakers
IS : 2544	Specification for porcelain post insulators for systems with nominab l voltages greater than 1 000 volts
IS : 2705	Current transformer specification
IS : 3043	Code of practice for earthing
IS : 3156	voltage transformers specification
IS : 3231	specification for electrical relays for power system protection
IS : 3427	A.C. metal enclosed switchgear and control gear for rated voltages above 1 kV and upto to and including 52 kV.
IS : 4710	Switches and switch isolators above 1000 V but not exceeding 11000 v.
IS : 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
IS : 6875	Control switches push buttons

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Codes	Name of Standard
IS : 8084	Specification for interconnecting bus-bars for ac voltage above 1 kV up to and including 36 kV
IS : 8686	Specification for static protective relays
IS : 9046	Specification for ac contactors for voltages above 1000 v up to and including 11 000 v
IS : 9224	Low voltage fuses
IS : 9385	HV fuses
IS : 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
IS : 9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 v
IS : 10601	Dimensions of terminals of high voltage switchgear and control gear
IS : 11353	Guide for uniform system of marking and identification of Conductors and apparatus terminals.
IS : 13118	Specification for high voltage ac circuit breakers
IEC 6044-1	Current transformer
IEC 6044-2	Voltage transformer
IEC 6056	High voltage alternating current circuit breakers
IEC-60099-1	Non-linear resistor type gapped arrestor for AC systems
IEC-60099-4	Metal oxide surge arrestor without gap for AC system
IEC 60129	A.C disconnectors and earthing switches
IEC 60255	Electrical Relays
IEC-60298	High voltage metal enclosed switchgear and control gear.
IEC 60529	Degrees of protection provided by enclosures
IEC-62271-100	High voltage alternating current circuit breakers.
CEA	CEA regulations
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All 6.6kV Switchgear shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- b. All 6.6kV Switchgear shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-)5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC System	:	(+)10% to (-)15%

- c. All motors rated above 160kW shall be feed from 6.6kV switchgear.
- d. Motor rated [160-600kW] shall be provided with [vacuum contactor/vacuum circuit breaker] and motor rated above [600kW] shall be provided shall be provided with vacuum circuit breakers.
- e. 6.6kV switchgear shall be Indoor, metal clad, floor mounted, Single front and fully draw out type. Design and construction shall be such as to allow extension at either end. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels
- f. All 6.6 kV Circuit breaker shall be draw out type & should have Service, Test and Disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- g. Local/remote selection shall be provided for all incoming/Outgoing Circuit Breaker modules. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local (Switchgear).
- h. Two out of three Incomer logic for 6.6kV Switchgear shall be provided. For Unit and station board one Incomer shall be there from Unit Transformer and Station Transformer respectively. Tie feeder shall be provided between Unit and station switchgear such that in case of loss of supplies to unit switchgear from UAT, the same shall be restored from respective station switchgear. In order to achieve the same, fast bus transfer shall be provided at Unit switchgear.
- i. All motors shall be provided with Emergency Stop Push buttons.
- j. Control and Indication voltage level shall be 220V DC.

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- k. Maximum system fault level at 6.6kV bus including initial motor contribution shall be 40kA for 1 sec.
- l. 6.6kV System shall be earthed through resistance to limit fault current to 300A.
- m. Surge arrestor shall be provided for each motor feeder/Transformer feeder.
- n. The switchgear will be located in a clean but hot humid and tropical atmosphere.
- o. Duty involves direct-on-line starting of large induction motors with motor starting current varying 6 times the full load current. For BFP starting current varying 4.5 times of full load current.
- p. For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and this specification.
- q. The switchgear and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current without any damage or deterioration of material.
- r. All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 6.6 kV switchgear shall have following minimum features.

- a. 6.6 kV switchgear shall be of indoor, metal clad, single front, single tier, floor mounted, horizontal drawout type with vacuum circuit breaker and free standing type. The Panels shall be suitable for cable entry at bottom and bus duct connection at top.
- b. Between 6.6kV Switchgear Incomer and transformer, segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with bus duct manufacturer in this regards is covered in this specification.
- c. All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d. Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and Covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels.

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- e. Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f. The switchgear enclosure shall confirm to the degree of Protection of the [IP4X] for indoor installation. However degree of protection of LV chamber shall be [IP-52]. No louvers/Opening shall be provided on the top of panel. All the other louvers if provided shall have very fine brash or GI mesh screen.
- g. Paint shade for complete panels shall be [RAL 5012] for extreme end covers for all board.
- h. The working zone shall be restricted to [750mm to 1800mm] from floor level. Total height of the switchgear panels shall not exceed [2600 mm].
- i. Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc.
- j. A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgear having more than one bus section.
- k. Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.
- l. Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module at any one cubicle. Further distribution to all verticals shall be in the scope of bidder.
- m. Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- n. Supplier shall provide total 10% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- o. Switchgear shall have provision to receive 415V, 3ph, 4wire supply. Single phase 240V balanced supply shall be derived from 415V, 3ph, 4 wire supply. Each cubicle shall be provided with thermostat controlled space heaters suitable for operation from 240 V \pm 10%, single phase, 50 Hz, + 3% - 5% supply and 5A, 240V AC, 3 pin plug socket and cubicle lamp. The space heaters shall be located at the bottom of the switchboards. Cubicle heater, plug/socket/lamp circuits shall have individual switch fuse units. Motors shall

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be provided with anti- condensation heaters at 240V.Necessary provision for supply of motor space heating shall be considered in the switchgear.

- p. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.
- q. Controls and interlocks as required for the safe switching, operation and maintenance of the switchgear shall be provided. Mechanical interlocks shall be provided in addition to electrical wherever possible.
- r. It should be possible to carryout maintenance on a feeder with adjacent feeders alive.
- s. The Fast Bus Transfer (FBT) panel shall be totally enclosed, floor mounted panel conforming to degree of protection IP-42. The minimum thickness of cold rolled sheet steel used shall be 2.0 mm. The ABT panel shall consist of a lineup of control boards, with cable entry provisions from bottom of panel. The height of FBT panel inclusive of mounting channel, anti-vibration pads etc. shall be restricted to [2400 mm].
- t. The switchgear shall be [natural cooled].
- u. The circuit breakers, contactors, bus VTs shall be mounted on withdrawable truck which shall roll out horizontally from service position to isolated position.

1.4.2

Bus and Bus Taps

- a. The main buses and connections shall be of high conductivity [aluminum / aluminum alloy].Control and auxiliary buses shall be of electrolytic copper/copper wires.
- b. Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- c. Bus insulator shall be flame-retardant, non-hygroscopic, track resistant type with high creepage surface. This shall be of non-carbonizing material such as epoxy bonded fiberglass. Bus bars shall be color coded for easy identification.
- d. The bus bar supports shall be able to withstand stresses due to maximum short circuit and also take care of any thermal expansion.
- e. Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f. The continuous rating of the main bus bars shall be same as that of the incomer circuit breaker and shall carry this continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].

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- g. The busbar chamber shall be provided with inter panel barrier with epoxy cast seal off bushings through which the buses will pass through so as to prevent fire from one panel to another.

1.4.3

Circuit Breaker

- a. The circuit breaker shall be of vacuum type.
- b. The circuit breakers shall be fully draw-out type, having service, test and disconnected positions with positive indicators for service & test positions.
- c. The breakers shall have motor operated spring charged mechanism. It shall be possible to charge the springs manually, if, required. Breakers shall be trip free and shall have an anti-pumping device. The operating duty cycle shall be 0 -3 min.-CO-3 min.-CO.
- d. For motor, spring charging shall take place automatically after each breaker closing operation. One 'open-close-open' operation of the circuit breaker shall be possible after failure of power supply to the motor.
- e. Automatic safety shutters shall be provided to ensure the inaccessibility of live parts after the breaker is drawn out. There shall be distinct overall door for the breaker compartment and shall be lockable.
- f. Truck shall have distinct service, Test and Isolated positions. It shall be possible to close the breaker compartment door in isolated position also. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions.
- g. Outgoing breakers shall be suitable for switching transformers and motors at any load. Motor feeders shall be suitable for frequent direct on-line starting of motor.
- h. Mechanical safety interlocks shall be provided to prevent
 - i. The circuit breaker from being racked in or out of the service position when the breaker is closed.
 - ii. Racking in the circuit breaker unless the control plug is fully engaged
- i. Breakers shall be adequately de-rated to account for design ambient temperature and temperature inside the cubicle.
- j. Equipment and component rating and quantities shall be suitably selected according to the requirements with adequate margin.
- k. Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage

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1.4.4 Contactor

High voltage contactor shall be of AC-3 utilization category and shall be of vacuum type. Fuse and contactor shall be mounted on withdrawable truck. The contactor shall be latched type and shall be complete with mechanical trip indicator, anti pumping relay, surge suppresser, single phasing preventor etc.

1.4.5 Bus Transfer scheme:

The 6.6kV Unit Switchgear shall be connected to their respective unit auxiliary transformer through bus duct. These buses of unit switchgear shall also be connected to 6.6kV buses of station switchgear through tie feeders and breakers located at the unit and station end. Automatic Fast bus transfer scheme shall be provided between 6.6kV unit and station switchgear such that in case of loss of supplies to unit switchgear from UT, the same shall be restored from respective station switchgear. The automatic bus transfer system shall consist of fast, slow etc. transfer in Auto/ Manual mode.

In addition to above, each switchgear shall be provided with the following provisions-

- Dead bus closing
- Manual live change over (Momentary paralleling)
- Automatic slow bus transfer.

1.4.6 Current Transformers

- a. Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made. They shall have sufficient thermal and mechanical capacity to withstand the maximum momentary current rating of the breakers.
- b. CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c. CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d. All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e. CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.
- f. Accuracy class of CT shall be 5P20 for protection, PX for differential protection and 0.5 for metering.

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1.4.7 Voltage Transformer

- a. Voltage transformers (VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b. VTs shall be of the single-phase type. VTs shall be protected on their primary side by fuse and by MCB (with auxiliary contacts) on the secondary sides.
- c. VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d. It shall be possible to replace VTs without having to de-energise the main busbars.
- e. VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Transducer

For Incoming and outgoing feeders remote metering transducer shall be provided. The output shall be 4-20 mA DC which shall correspond to the normal range. All the transducer shall be dual output type.

1.4.9 Secondary wiring

- a. The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c. Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d. Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with *[stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring (applicable for internal panel wiring).]*
- e. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.10 Terminal blocks

- a. Terminal blocks shall be of 1100 V grade, stud type with marking strips. Terminals for CT secondary leads shall have provision for easy shorting, earthing and shall be suitable for connecting 2 cables of 2.5 mm² copper.
- b. Sufficient terminals shall be provided on each terminal block to ensure that

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not more than two outgoing wires are connected per terminal. All spare contacts of auxiliary relays, timers etc. shall be wired up to the terminals. [20%] spare terminals shall be provided on each terminal block.

- c. Terminal blocks shall be located to allow easy access. Wiring shall be grouped such that the individual wires of a cable can be connected to consecutive terminals.

1.4.11 Ground bus

- a. A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b. Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c. C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.12 Control & Indication

- a. The circuit breaker shall be wired up for local & remote operation. Each breaker shall be equipped with following:
- b. Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In Local position, the breaker shall be operated from switchgear only in test position.
- c. Each cubicle shall be provided with Auto/ Manual Switch. Trip selection switch and Trip-Neutral- Close (TNC) switch.
- d. Circuit breaker shall be indicated electrically. The following indication color shall be used.
Breaker closed – Red
Breaker opened – Green
Spring Charged – White
Breaker Auto trip – Amber
- e. However any other indication shall be provided as per owner's requirements.
- f. Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.

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- g. Breakers shall be controlled locally and/or remotely as per plant operational requirement. Necessary Interposing relays & feedback signal shall be provided based on the DCS IO list.
- h. Breaker control supply shall be of 220 V DC. Breaker spring charging motor shall be suitable for 220 V DC.

1.4.13 Cable termination

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection.

1.4.14 Bus duct connection

Bus duct connection shall be generally from top of the switchgear.

All connection bus work shall have the same continuous rating as associated switchgear bus and shall be fully braced for the short circuit current mentioned in specification.

All provision such as matching flange and other accessories shall be furnished for connection to bus duct.

1.4.15 Painting

All sheet steel surfaces shall be chemically cleaned, degreased and pickled in acid to produce a smooth, clean surface free of scale, grease and rust. After cleaning, the surface shall be given a phosphate coating followed by a coat of high quality primer and baking in the oven.

The paint shade shall be subject to owner's approval. Sufficient quantity of touch up paint shall be furnished for application at site.

1.4.16 Relays, Protection & Metering

- a. The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/ diagnostic facilities shall be provided.
- b. All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner. All numerical relays shall be compatible with IEC 61850.
- c. All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.
- d. All AC operated relays shall be suitable for operation at 50 Hz. AC voltage

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operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

- e. Energy meters shall be provided for incomer of 6.6kV Switchgear and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than [0.2S]. The accuracy class of CT and VT for energy metering shall have accuracy class of [0.5]
 - f. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
 - g. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
 - h. The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
 - i. All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
 - j. Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
 - k. D.C supply shall be supervised by DC supervision relays.
 - l. Trip circuit shall be supervised by Trip circuit supervision.
 - m. Tripping shall be done through high speed lock out relays.
 - n. All meters/ instrument shall be flush mounted on front panel, at least 96 mm² size with 90 degree linear scales and accuracy class of [2.0.]
 - o. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
 - p. For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
 - q. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- r. Metering and protection shall be as per below table

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	Protections	Metering
a)	Incomers, Tie Feeders and all Outgoing Feeders except Motor and Transformer Feeders	
	<ul style="list-style-type: none"> • IDMT Over current relay (51) • Instantaneous O/C relay(50) • Inverse time over current relay residually connected for Earth Fault detection (51N). • Inverse time over current relay (51NS) connected to transformer neutral for stand-by earth fault. (Applicable for 6.6 kV Unit and Station Incomer only) 	<ul style="list-style-type: none"> • Current in all the three phases (Metering at Switchgear end) • Voltage of all three phases • (Metering at Switchgear end) • kWh meter • (Metering at Switchgear end) • kVARH meter • (Metering at Switchgear end) • Current in all the three phases • (Remote metering through dual output type transducers) • Voltage in all the three phases • (Remote metering through dual output type transducers) • Watt transducer • (Remote metering through dual output type transducers) • VAR transducer • (Remote metering through dual output type transducers)
b)	Bus Couplers	
	Protections	Metering
	<ul style="list-style-type: none"> • IDMT Over current relay (51) • IDMT Earth fault relay (51N) 	Current on all the 3 phases
c)	[Motor Feeders]	
	Protections	Metering
	<ul style="list-style-type: none"> • Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload with unbalance current features etc. • Differential Motor Protection for Motor rating above & equal to 	<ul style="list-style-type: none"> • Current on all the 3 phases from Local & Remote. • KW meter shall be provided.

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	<p>2000kW.</p> <ul style="list-style-type: none"> Winding and Bearing temperature protection by means of RTDs connecting the same to DCS. The motor protection relay shall check the actual no. of repeated starts and compare the same with the manufacturer's permitted number of starts and prevent further starting attempts once the same is exceeded. Under voltage relay. CBCT for sensitive Earth fault (if required) 	
d)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection (Fuse failure protection No Voltage protection)	Voltage on all the 3 phases from Local & Remote.
e)	Transformer Feeder (6.6/ 0.433kV)	
	Protections	Metering
	<ul style="list-style-type: none"> IDMT Over current relay (51) Instantaneous O/C relay (50) Residual Earth fault protection (51N) CBCT for sensitive Earth fault (if required) Transformer Mechanical Protection (Buchholz protection for oil type transformer/WTI high alarm and trip/ OTI high alarm & trip (for oil type) Stand By Earth fault protection (51N) Connected to transformer Neutral 	Current on all the 3 phases from Local & Remote.

1.5 Tests

I. Type Test:

For each type & rating of 6.6kV Switchgear, the Bidder shall submit the reports

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of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening for Owner's approval. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II. Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative. However the following minimum routine tests shall be conduct.

- Power-frequency voltage tests on the main circuit
- Dielectric tests on auxiliary and control circuits
- Measurement of the resistance of the main circuit
- Partial discharge measurement
- Mechanical operation tests
- Heat Run test
- Pressure tests of gas-filled compartments
- Tests of auxiliary electrical, pneumatic and hydraulic devices
- Verification of correct wiring

III. Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV. Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

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1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below.

- a. [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening]
- b. Bill of Materials.
- c. Technical Data sheet and Catalogue.
- d. Foundation drawing details with bottom view of switchgear.
- e. Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f. Control Schematics & Wiring diagram.
- g. Inspection and Test Plan (ITP).
- h. Suggestive list of protective relays.
- i. Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

6.6kV Switchgear shall comply with the particulars indicated in the following tables.

Table 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		[By Bidder]
1.2	Place & Country of manufacture		[By Bidder]
1.3	Specifications and Standards		As per Table 1.0
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		6.6 kV/7.2 kV, 3 Phase, 3 wire, 50 Hz.
2.2	System neutral earthing		Non Effectively earthed (Fault current Limited to 300A by neutral grounding resistor)
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz

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S. No.	DESCRIPTION	UNIT	DATA
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		20kV 60kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		Continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	40 kA for 1 Sec
b	Dynamic Rating	kA (peak)	100 kA
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		[Cu/Al]
2.14	Fully draw out (FD)/ Fixed (F)		FD / Single front
2.15	Entry –Top (T)/Bottom (B)		Top for bus duct, bottom for cables.
2.16	Degree of protection		[IP4X] and for LV chamber shall be [IP-52].
2.17	Color finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	[Aluminum]
2.19	Minimum clearances in air of live	mm	As per standard

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S. No.	DESCRIPTION	UNIT	DATA
	parts		
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		6.6kV,50hz,3 phase,3 pole
3.3	Rated operating duty		O-3min-CO- 3min -CO
3.4	Circuit breakers type		VCB
3.5	Short circuit withstand current for 1 sec. Duration	kA	40
3.6	Rated making current	kAp	100
3.7	Rated current at site reference ambient temp	A	[By bidder]
3.8	Type of operating mechanism		Spring charged motor and manual
3.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
3.10	Control voltage		
	Spring charging motor	V AC/DC	[220V DC]
3.11	Closing Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.12	Opening Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.13	Operating time		
	Opening time	ms	< 65
	Breaking time	ms	< 15
	Total tripping time	ms	< 80 (total break time)
	Total Closing time	ms	< 80 ms

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S. No.	DESCRIPTION	UNIT	DATA
3.14	Number of breaks per pole		One
4.0	Contactor		
	Voltage class	kV	7.2
	Short time Rating		[By bidder]
	Duty		AC3
5.0	Fuse		
	Voltage class	kV	6.6
	Rupturing capacity	kAp	100
6.0	Current Transformer		
a	Make		[By bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]
e	Basic Insulation level	kV	7.2/20/60
6.1	CT for differential protection		
	Class		PS class
	Secondary resistance at 75 ° C		[By bidder]
	Knee Point Voltage		[As per purchaser requirement]
	Excitation Current		< 30mA
6.2	CT for Metering		
	Class		[0.5]
	Secondary resistance at 75 ° C		[By Bidder]
6.3	CT for Protection		
	Class		[5P20]
7.0	Voltage Transformer		
a	Make		[By Bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]

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S. No.	DESCRIPTION	UNIT	DATA
e	Voltage ration		[By Bidder]
8.0	Meters		
a	Make		[By Bidder]
b	Type		[By Bidder]
8.1	Voltmeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
8.2	Ammeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
9.0	Indicating lamps		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Voltage	V	As specified in the specification.
d	Wattage of lamp	W	[By Bidder]
10.0	Push buttons		
a	Make		
b	Type		As specified in the specification.
c	Contact rating	A	[By Bidder]
11.0	Space heater		
a	Make		
b	Type		As specified in the specification.
c	Rated voltage	V	As specified in the specification.

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S. No.	DESCRIPTION	UNIT	DATA
d	Power rating	W	[By Bidder]
12.0	Wiring and terminal blocks		
a	Voltage grade		1.1 kV
b	Insulation		[By Bidder]
c	Minimum size of conductor for:		
	• Power wiring	Sq.mm	2.5 for CT & PT for internal panel wiring only and 4 for external wiring
	• Control wiring	Sq.mm	1.5 (for internal panel wiring only)
f	Type of terminal blocks:		
g	I) For Withdraw able Type		Sliding type
h	II) For Fixed Type		Stud & nut type
i	Minimum current rating of terminal blocks	A	10
13.0	ABT Panel		
a	Make		
b	Type		[By bidder]
c	Panel thickness	mm	2
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		Catalogue shall be furnished by the bidder.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E13

**TECHNICAL SPECIFICATION FOR VARIABLE FREQUENCY
DRIVES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E13

1.0 VARIABLE FREQUENCY DRIVE

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Variable Frequency Drives complete with all accessories for efficient and trouble-free operation of of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS-3700	:	Essential ratings and characteristic of semi-conductor devices
IS-3715	:	Letter symbols for semi-conducting devices
IS-4411	:	Code of designation of semi-conducting devices
IS-5001	:	Guide for preparation of drawings for semi-conductor devices
IS-5469	:	Code of practice for the use of semi-conductor junction devices
IS-5621	:	Hollow Insulators for use in electrical equipment
IS-6209	:	Methods for partial discharge measurement.
IS-6297	:	Transformers and indicators for electronic equipment
IS-8789	:	Performance parameters for motors
IS-12729	:	Switchgear and control gear for voltages exceeding

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		1000V- General requirements
IS-13408	:	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IEC 146	:	Semi Conductor converters
IEC 168	:	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V
IEC 270	:	Partial discharge measurement
IEC 297	:	Dimension of panels and racks
IEC 326	:	General requirements and measuring methods for printed wiring boards
IEC 352	:	Solder less wrapped connection
IEC-61800-3,4&5	:	EMC requirements and specific test methods
IEC-60664-1	:	Insulation coordination for equipment within low-voltage systems
IEC/EN-60204-1	:	Safety of machinery-electrical equipment of machines
IEC/EN-60529	:	Degrees of Protection Provided by Enclosures (IP Code)
IEC/EN-61000-3-12	:	Electromagnetic compatibility
IEEE 444	:	Protection standards for converters
IEEE 519	:	Harmonic control & reactive compensation of static power converters

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DIN 41488	:	Electrical engineering dimensions
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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) All VFDs shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The VFDs shall be suitable for operation in a highly polluted environment.
- b) All VFDs shall be suited for uninterrupted operation under the following variations in bus voltage and frequency:
 - i. Voltage Variation : +/-10%
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency
- c) The VFD shall be of modern design for similar applications in power plants. The system shall be commutated inverter type with minimum [six] pulse design, [IGBT based] and PWM controlled or better control system.
- d) VFD shall consist of Input section (rectifier and filter), control section and output section (PWM module, base drive circuits).
- e) VFD shall include an input filter for limitation of the harmonic current. General requirements of VFD shall conform to IEC 61800-2 and IEEE-519.
- f) VFD shall follow EMC directives as specified in IEC-61000.
- g) VFD model shall be suitably selected based on actual cable length from VFD to motor terminals. Shielded cables suitable for VFD applications shall be provided by the bidder.
- h) For [12 pulse] VFD, required 3 winding transformer and necessary cabling shall be provided by the bidder.
- i) Bidder shall provide inverter duty motor to withstand voltage stresses produced by PWM action

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1.3.1 Performance requirements:

- a) The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise.
- b) The system shall be suitable for the load characteristics and the operational duty of the driven equipment.
- c) The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment:
 - i. Variable torque changing as a function of speed i.e. speed squared.
 - ii. Constant torque over a specific speed range.
 - iii. Constant power over a specific speed range where the torque decreases when speed increases.
- d) The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The system shall be designed for linear continuous speed control from [10% to 100%] of driven equipment's rated speed and shall be of a modern proven design.
- e) The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800-4 and it shall be considered in the design of the motor.
- f) Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 115% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than one minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- g) During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit up to 60 seconds.
- h) The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- i) The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95 % of the minimum operational speed for more than 10 seconds.
- j) Maximum noise level of motor shall be measured as per relevant IS standard.

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- k) Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and troubleshooting/ maintenance.
- l) Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

The drive system shall ensure following:

- i. VFD induced torque pulsation are limited to maximum 1% (even at low speed) so there is minimal stress to the equipment
- ii. Motor is protected from dv/dt stresses.
- iii. No appreciable increase in motor audible noise.

1.3.2 Control requirement:

- a) The VFD and motor characteristics shall be suitable for load specific torque-speed characteristics.
- b) Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.
- c) The system shall also be equipped with a facility which shall restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart the converter shall be capable of synchronizing on to a rotating motor and develop full acceleration torque within 10 seconds.
- d) The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.
- e) The drive motor shall be speed controlled corresponding to 4-20 mA reference input signal unless otherwise specified upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed at the last speed reference available prior to the loss of signal.
- f) It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/manual selection shall be from VFD panel unless otherwise specified.
 - i. With the selector switch in "manual" mode, the operator shall be able to set the speed through keypad, mounted on front of the drive panel or from speed increase/decrease push buttons from the field. Motor operated potentiometer shall be provided as a speed set point device.
 - ii. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's DCS (Process Control) system. Necessary equipment required for interfacing with DCS shall also be provided in the drive panel.

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- g) The required provision for the interface with remote I/O *(as per requirement)* shall be through hardwired connection (with potential free contacts and transducers)
- h) Drive system shall have provision for interface with upper level automation such as electrical control system.
- i) The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.
- j) Bypass Feature
 - i. Bypass breaker / contactor-HRC fuse complete with protection, annunciation and metering shall be provided.
 - ii. All Variable frequency drives (VFD) having bypass feature shall have motor protection relay along with necessary control and metering etc. Switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended by opening its isolation devices.
 - iii. Safety interlock between inverter and bypass breaker/contactors shall be provided such that closing of healthy device is inhibited in case of external fault.

1.4 Specific Requirements

1.4.1 Constructional Requirements

- a) Panel Construction
 - i. The panel shall include suitable semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors (if required), filters (if required), control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of integrated standards.
 - ii. Upstream breaker include suitable semi conducting power devices (Diodes / IGBT) modules will be provided on the front door.
 - iii. Safety Interlock shall be provided so that power cabinet cannot be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.
 - iv. The drive shall be suitably housed in sheet steel panels fabricated with 2 mm thick cold rolled sheet steel. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. The maximum and minimum operating height shall be 1800 mm and 400 mm respectively.

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- v. Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600 mm clear from bottom of the cable gland plate.
- vi. Bus bars shall be of electrolytic copper, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.
- vii. All the switches component and accessories which are essential for normal and emergency operation shall be mounted on the door and shall be operable externally. Digital meters shall be preferred. Analogue instruments, where provided, shall be switchboard type, back connected, 72x72mm. Scale shall have red mark indicating maximum permissible operating rating.
- viii. All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- ix. All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with PVC insulated, fire retardant, copper conductor wire. 1.5 mm² size wire shall be used for control circuits, 2.5 sq.mm for CT/PT circuits and 0.75 mm² for electronic circuits. The control fuse rating is 10 Amps or less and 2.5mm² size for control fuse rating above 16A for electrical circuits and 0.7 mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered. Minimum 20% spare terminals shall be provided.
- x. All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipment and power electronic equipments shall be used.
- xi. All low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.
- xii. DC link capacitor and pre charging and discharging circuit shall be preferably mounted in the rear of the panel. Suitable removable type hooks shall be provided for lifting the panel.
- xiii. Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- xiv. All equipment shall be complete with double compression glands, lugs etc.

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b) Cooling

- i. The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Bidder shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N + 1) shall be provided.
- ii. Necessary starters shall be provided within the VFD panels for the ventilation fans, any other auxiliary motor etc.
- iii. The system provided shall be interfaced with drive starting and shut down such that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., shall be incorporated in the overall sequence logic.
- iv. MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easily accessible location.

1.4.2 Motor

The motor shall be designed, constructed and tested in accordance with the Specification for high Voltage Induction / Synchronous Motor, in addition to the following requirements:

- a) The motor shall be suitable for VFD control.
- b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- c) The motor shall be designed to operate continuously at any speed in the operating range for the driven equipment (ie; ID fan / Coal feeder).
- d) The permitted voltage variation shall take into account the voltage drop across the AC drive and all other system components upstream the motor.
- e) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications.
- f) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- g) The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4.

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- h) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

1.4.3 Static Power Converter

- a) The static power converter shall consist of a line side converter for operation as a rectifier and a load side power converter for operation as a fully controller inverter. Power converter shall be fast switching, most efficient and low loss type.
- b) The converter shall be co-ordinated with the transformers. The converter shall be able to withstand a three phase short circuit current until interrupted by normal breaker operation.
- c) Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- d) All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- e) The current rating of the converters semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range. If the parallel connection of semi conductor is applied, the above current rating shall not be less than 140% of the above values.
- f) All power diodes shall be of silicon type with minimum V_{BO} rating at 2.5 times the rated operating voltage.
- g) The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise nor reducing its service factor due to harmonic currents generated by the inverter operation.
- h) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions / tools.
- i) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

1.4.4 Converter Transformer

- a) The converter transformer, if provided, shall be copper wound dry type. Insulation class of dry type transformer shall be H with temperature rise of body limited to 75°C. Dry type transformer shall preferably be mounted inside the drive system panel. The impedances of converter input transformers with more than one secondary winding for minimum 18 pulse systems shall be selected to ensure equal load / current sharing

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between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

- b) The transformation ratio, impedances, taps and secondary voltage shall be chosen by the drive vendor to optimize system performance.

1.4.5 DC link reactor

- a) Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- b) Unless otherwise specified, the reactor shall be dry type, air cored, air-cooled or fan cooled type located within the panel.
- c) Reactor shall be suitable for withstanding earth fault continuously and for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.
- d) Noise level shall not exceed value specified in NEMA TR-1

1.4.6 Output filter

- a) VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance free and self-healing type.
- b) The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

1.4.7 Protection, Control, Metering, Indication and Annunciation

- a) The Bidder shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

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- b) Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.
- c) Protective Relays:
For details on protective relays used, refer to Technical Specifications on MV Switchgear
- d) Operator Control Panel
- i. Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to start/Stop, Local/Remote, auto/manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
 - ii. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
 - iii. Operator console shall have facility /port to connect external hardware such as Lap-Top etc. Console shall have facility for upload and download of all parameter settings from one drive to another identical drive for start up and operation.
 - iv. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing up stream breaker after all required process parameters are achieved.

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- v. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.
 - vi. Suitable interface with DCS to be provided for control and status signals of VFD.
- e) Local Motor Control Station
- i. The local motor control station shall be installed near the motor. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
 - ii. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current.
 - iii. Requirement of controls and indications required in the Local Control Station shall be as specified in the data sheet.
- f) Protective Features:
- The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:
- i. Incoming line surge protection
 - ii. Under / Over voltage protection
 - iii. Phase loss, phase reversal protection.
 - iv. Programmable Over current protection and under load protection.
 - v. Motor differential protection for motor rated above 1000 kW
 - vi. Inverter Fault.
 - vii. Over frequency operation.
 - viii. Ventilation loss,
 - ix. Over temperature of equipment.
 - x. Over speed of motor.

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- xi. Specific motor protection, including motor winding, bearing temperatures, over-current, overload, negative phase sequence, locked rotor and earth fault protections etc.
- xii. System Earth fault protection.
- xiii. Excitation system protection for synchronous motor
- xiv. Over and under frequency, rotor earth fault, field failure protection for synchronous motor
- xv. Additional protection for drive system

g) Control features

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

- i. Start/Stop
- ii. Speed control (Raise/lower)
- iii. Forward/Reverse(if Specified)
- iv. Auto/Manual /test mode
- v. Local/remote
- vi. Emergency stop
- vii. Start/stop for by pass starter (where specified)
- viii. Trip-Remote Breaker
- ix. Excitation control system for synchronous motors
- x. Sequential switching of filters

h) Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- i. Input AC Current
- ii. Input AC voltage
- iii. Input AC frequency
- iv. Output voltage
- v. Output current VFD / Bypass
- vi. Output frequency
- vii. Motor thermal state

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- viii. Drive thermal state
- ix. Motor speed
- x. Motor energy meter
- xi. DC Link voltage
- xii. Hour Run
- xiii. Voltage and current meter for excitation system for synchronous motor.
- xiv. KVAR, power factor meter for synchronous motors
- xv. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

i) Indications

Bidder shall provide indications as required for normal operation and for easy maintenance, which shall not be limited to the following indications both at local and at plant DCS.

- i. Motor running
- ii. Motor stopped
- iii. VFD System Fault
- iv. System ready to start
- v. AC mains ON
- vi. Motor over speed
- vii. Rectifier output 'ON'
- viii. Motor zero speed
- ix. Remote breaker trip
- x. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e., door mounted keypad or through hardwired indicating lamps/LEDS.

Potential free contacts of items i- iv shall be wired separately for remote indications in DCS.

j) Audio-visual annunciations

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- i. The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter, output transformer etc.
- ii. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.
- iii. Audio-visual window annunciations shall be provided on the front of the panel All annunciations as required for normal and satisfactorily operation of the drive system shall be included as per Bidder standards. These annunciations can be part of operator console panel or separately mounted type.
- iv. Bidder shall include audio-visual alarm as required for normal operation and maintenance of the system but not be limited to the following,
 - Rectifier fuse failure
 - Main AC failure
 - Inverter fuse failure
 - Inverter overload
 - Inverter high temperature
 - Cooling system failure
 - Motor failed to start
 - Transformer failure
 - Excitation system failure for synchronous motor
 - Battery monitoring healthiness
 - Communication and measurement system un healthy
 - Motor temperature high
 - Harmonic filters monitoring
- i. Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminals of DCS I/O panels for remote alarm and monitoring.

k) Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available for a period of minimum 4 days (96 hours) after a shut down even though no supply

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would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

1.4.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle lamps (CFL) etc. shall operate on 240 volts single phase AC.

All control circuit shall operate at voltage of 110V AC or 220V DC.

Bidder shall include supply of all control transformers, protective devices, required accessories etc. and any other control supply voltage as required for the system.

1.4.9 Maintenance features

The controller design shall incorporate the following maintenance features:

- a) Modular construction
- b) All components shall be easily accessible.
- c) Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

1.4.10 Painting

- a) All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.
- b) After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be as per manufacturer's standard, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

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- c) All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

Final paint shade shall be light gray and dove gray 631 and 632 as per IS-5 for indoor and outdoor equipment respectively unless otherwise specified

1.5 Tests

The Routine and Type Tests to be performed on the drive system in the presence of the purchaser of consultant shall be as follows:

1.5.1 Type Tests

For each rating and type of VFD, the Bidder shall submit for Owner's approval, the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

All type tests shall be conducted as per relevant standards and test certificates of similar panels conducted within last 5 years shall be furnished.

1.5.2 Routine tests

- a) Visual Inspection
- b) It involves checking of the various equipments/components fault diagnostic unit, Wiring, Terminals, earthing ratings etc.in line with the approved drawings and visual inspection shall not be limited to the following:
- c) Insulation Test
- d) Light Load and Functional Test
- e) Load characteristics test
- f) Load duty test
- g) Checking of Auxiliary Devices
- h) Checking the properties of the control equipment

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- i) Checking the Protective Devices
- j) Checking of control and functional requirements
- k) High voltage test
- l) Leakage and pressure test for cooling water system where provided
- m) Shaft current/bearing insulation
- n) Automatic restart/re-acceleration

Additional tests on switchgears and dry type transformers shall be carried out based on the requirement defined in the technical specification.

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data and Manuals

The engineering services scope and the documentation to be issued with the bid are described hereafter. The list shows the minimum requirements for the documentation, so that any additional documentation considered as necessary will be added to this.

- a) Engineering, manufacturing, delivering and test schedule
- b) Sub-Supplier lists.
- c) General arrangement drawings(plan, elevation, section view) with dimensions
- d) Foundation drawing including loading data.

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- e) Technical Data sheets.
- f) Electrical and control wiring diagram.
- g) Terminal arrangement drawing, interconnection wiring diagram.
- h) Cross sectional drawing.
- i) Inspection and test plan.
- j) Manufacturing Quality Plan.

1.7 Ratings and requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table 2.0

Sl. No	Technical Parameters		
		6.6 kV	415 V
1	Manufacturer Name	[By Bidder]	[By Bidder]
2	Model No.	[By Bidder]	[By Bidder]
3	Application		
4	Quantity		
5	Enclosure Protection Rating	IP-31	IP-31
6	Output Current Rating at ambient temperature	[as per requirement]	[as per requirement]
7	% derating considered for specific ambient	As per IEC	As per IEC
8	Rated Voltage (volts) Input	6.6 kV AC ± 10%, 3-phase	415 V ± 10%, 3-phase

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Sl. No	Technical Parameters		
		6.6 kV	415 V
9	Output Frequency Range (Hz)	[By Bidder]	[By Bidder]
10	Number of Phases and Frequency (Hz)	3 Phase, 50 Hz (+ 3% to -5%)	3 Phase, 50 Hz (+ 3% to -5%)
11	Rectifier type & Design	[6/12/18 Pulse Diode Bridge]	[6/12/18 Pulse Diode Bridge]
12	Inverter type & Design	[as per requirement]	[as per requirement]
13	Min/Recommended / Max switching frequencies (kHz)	[as per requirement]	[as per requirement]
14	Filters	[as per requirement]	[as per requirement]
	Line Side	[as per requirement]	[as per requirement]
	Load Side	[as per requirement]	[as per requirement]
15	Output Modulation Method	PWM	PWM
16	Speed Accuracy (+/ - %)	[as per requirement]	[as per requirement]
17	Response time (speed)	< 5ms with nominal Torque	< 5ms with nominal Torque
18	Response time (Torque)	[By Bidder]	[By Bidder]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
19	Type of cooling	[Natural/forced/water] cooled	[Natural/forced/water] cooled
20	Whether VFD is suitable for outdoor installation	No	No
21	Drive Control Capabilities		
	Start/Stop Push button	ON/Speed Increase/Speed decrease From DCS	ON/Speed Increase/Speed decrease From DCS
	Modbus control	Yes	Yes
22	Load parameters at rated voltage & frequency		
	Output Frequency (Hz)	[0 to ± 120Hz]	[0 to ± 120Hz]
	Full Load current (Amp)	[By Bidder]	[By Bidder]
	VFD Heat dissipation (w)	[By Bidder]	[By Bidder]
23	VFD Efficiency		
	At Full rated Torque	[Approx 98% (Only drive)]	[Approx 98% (Only drive)]
	At 75% of full load torque	[By Bidder]	[By Bidder]
	At 50% of full load torque	[By Bidder]	[By Bidder]
24	Drive Power factor range		
	At rated speed, Torque	[≥ 0.98 (Fundamental)]	[≥ 0.98 (Fundamental)]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
25	DC Voltage	[1.35 times of supply voltage]	[1.35 times of supply voltage]
26	Fundamental power factor	≥ 0.98(At nominal Load)	≥ 0.98(At nominal Load)
27	Switching Frequency	[By Bidder]	[By Bidder]
	Drive Dimensions	[By Bidder]	[By Bidder]
	Length	[By Bidder]	[By Bidder]
	Height	[By Bidder]	[By Bidder]
	Depth	[By Bidder]	[By Bidder]
	Weight	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E14

**TECHNICAL SPECIFICATION FOR 6.6kV SEGREGATED
PHASE BUS DUCT**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E14**1.0 6.6kV SEGREGATED PHASE BUS DUCT****1.1 General**

This specification is intended to cover the *[design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of [6.6]kV Segregated Phase Bus duct, complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code	Name of Standard
IS 8084	Interconnecting Bus bar for AC Voltage above 1kV up to and Including 36kV
IEEE C37.23	IEEE Standard for Metal-Enclosed Bus.
ANSI/IEEE C37.20	Switchgear assemblies including metal enclosed bus
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear
IEC 60947	Low Voltage Switchgear and Control gear
IEC 60439	Low-voltage switchgear and control gear assemblies.
BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) The segregated phase bus duct will serve as interconnection between the 6.6kV Indoor Switchgear and outdoor Unit/Station transformer LV terminals and also as inter-connection between Unit and Station switchgears.
- b) Busduct shall be phase segregated and shall be installed indoor/Outdoor in a hot, humid and tropical atmosphere.
- c) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- d) The portion of bus duct at the transformer/switchgear end will be subject to vibration normally prevalent for this type of installation in a power generating station. Suitable means shall be provided to isolate the transformer/switchgear vibration from rest of the bus structure / bus duct.
- e) For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be as specified in Clause 1.7 Rating and requirements.
- f) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the required short-circuit currents.
- g) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- h) The bus ducts shall be self cooled and shall not be equipped with blower or any other type of forced ventilation.
- i) The equipment rating shall be based on an ambient temperature. Same phase disposition shall be maintained throughout the run of the bus duct. Phase crossover units, if required, shall also be provided inside the Busduct itself.
- j) Bus ducts shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current.
- k) Any phase cross over if required, same shall be covered in the busduct itself.

1.4 Specific Requirements

1.4.1 General

- a) 6.6kV SPBD is provided for connection between low voltage side of Unit Auxiliary Transformer/ Station Transformer to respective 6.6kV Unit and Station Switchgear along with necessary bends, flexible at both transformer & switchgear ends, flanges, phase crossover chambers (if

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required), support structures & accessories including terminations at the equipment ends.

- b) The SPBD shall be metal enclosed, phase segregated type and natural air-cooled. The cooling medium inside the duct shall be air.
- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) The continuous current rating and momentary peak withstand current rating of the Busduct between transformers & their associated switchgear shall be same as that of the associated switchgear and as indicated in the specification.
- e) All supporting steel structures shall be hot dip galvanized.
- f) The bus ducts shall be provided with space heaters to control moisture. Slicagel breather, if required shall be provided.
- g) Wall frame assembly and seal off bushing shall be provided whenever busduct passing through the wall.

1.4.2

Bus Conductor:

- a) The material of the conductor shall be of high conductivity aluminium alloy. The grade of aluminium alloy shall be indicated by the bidder in his Bid.
- b) The temperature rise of conductor shall be as per IS:8084. Also the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.
- c) The bus conductor shall be given a coat of matt black paint to facilitate heat dissipation. However, the sizing of the bus conductor shall consider the conductor as bare and shall be designed to carry the normal rated current without exceeding temperature rise as specified in IS: 8084.
- d) The bus conductor shall be designed for bolted connections throughout the run. Flexible connection shall also be provided at all equipment terminations.
- e) All contact surfaces shall be silver plated to ensure an efficient and trouble-free connection. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- f) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.

1.4.3

Enclosures

- a) The enclosure shall be made of aluminium alloy. The grade of aluminium alloy shall be grade [63401] as per IS-5082. Thickness of the enclosure shall be minimum 3mm.

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- b) The entire bus duct shall be designed for indoor/outdoor installation with a dust and vermin-proof construction. The degree of protection shall be IP-55 confirming to water tightness and air leakage test. Outdoor portion of bus duct shall be provided with rain hood or suitably sloped enclosure to prevent accumulation of water.
- c) The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- d) The enclosure shall be rectangular in size and shall be of phase segregated type. Phase barriers shall be provided in the bus ducts for phase segregation. Minimum thickness shall be 2 mm. In case of segregated phase bus duct, the phase segregation shall be of aluminum alloy or non-hygroscopic insulating material like fibre glass.
- e) Circumferential neoprene rubber gaskets shall be provided for dust tight joints with adjacent enclosure section.
- f) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion / contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.
- g) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, switch gear terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets.
- h) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between indoor and outdoor portions of the bus duct. In case, the bus duct penetrates the firewall, the wall frame assembly and the seal shall be designed for the same fire rating as the firewall.
- i) Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct.
- j) Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- k) Space Heaters shall be provided in the bus duct.
- l) Shipping length of the busduct shall be not more than three (3) meters in length.

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1.4.4 Disconnect Link

- a) Removable bolted disconnected link shall be provided in the bus for the purpose of isolation.
- b) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- c) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- d) A minimum clearance of 300 mm. (12") shall be provided between the disconnected bus sections with the link removed.

1.4.5 Insulators

- a) Within the bus duct the bus shall be mounted and supported on insulators. The insulators shall be mounted on resilient pads provided in the bus enclosure. The insulators shall be either porcelain or resin cast.
- b) Bus support insulators shall be interchangeable, high creep, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.
- c) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- d) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator.
- e) All bolts, nuts and lock washers used in the bus assembly shall be high tensile steel, plated for corrosion resistance. Spring washers or equivalent means shall be used for ensuring good contact pressure under all operating conditions. All bolts shall be tightened using properly calibrated torque spanner by applying the recommended torque.
- f) Space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus duct.

1.4.6 Wall Frame Assembly

Wherever the bus duct passes through the plant building wall, from indoors to outdoors, a wall frame assembly with seal-off bushings shall be provided to prevent any leakage of rain water, infiltration of dust and air temperature variations from indoors to outdoors. The wall frame shall be fabricated out of aluminium angles and sheet and shall be suitable for grouting in the wall. It shall be provided with flanges on both sides to receive the bus duct flanges. A suitable size breather shall be provided for the two sections of the busduct separated by the wall frame assembly.

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1.4.7 Seal-off Bushings

The bus duct shall be equipped wherever necessary with seal-off bushings to prevent interchange of air at different temperatures. The seal-off bushings shall be flanged type.

The insulator for wall frame assembly and seal-off bushings shall be of porcelain. Also the bushings shall be designed for thermal expansion/contraction due to temperature differential for outdoor/indoor use.

1.4.8 Bellows

Joints consisting of metallic expansion bellows shall be provided on the bus enclosure at following points:

- (a) At terminations of transformers
- (b) At terminations of switchgear cubicles
- (c) In the run of the bus duct in case of long lengths as required by design.

1.4.9 Inspection Covers

Provision shall be made for periodic inspection of insulators by means of inspection covers. The inspection covers shall be provided at the bottom with quick-acting stainless steel clamps and shall have gaskets. There shall be no joints or fixing bolts on the top surface through which water could seep through.

1.4.10 Connections & Terminations

- a) All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the switchgear, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the switchgear and auxiliary transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.
- e) If the material of bus conductor and that of the equipment terminal connectors are different then suitable bimetallic connectors shall be furnished.

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1.4.11 Grounding

- a) A separately run [50X10] mm G.S. flat suitably clamped along the enclosure shall be used as the ground bus. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.
- b) Ground pad shall be bolted type to accommodate galvanized steel flats of suitable size complete with suitable tapped holes, bolts and washers.
- c) The earthing termination shall be identified by measures of the sign marked in legible and indelible manner on or adjacent to the terminals.

1.4.12 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) Indoor portion of the bus duct may be supported from the floor or ceiling beams. Outdoor portion of the bus duct shall be supported from ground below on suitable foundation in the ground. The foundations and structures in outdoor area shall clear the transformers, transformer foundations, cable trenches.
- c) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- d) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- e) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.
- f) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.
- g) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

1.4.13 Wiring

All wiring for space heaters shall be done with insulated stranded copper conductor of not less than 2.5 mm² cross-section. Each wire shall be identified at both ends with wire designation as per contractor's wiring diagram and shall be brought out to a terminal box outside the bus duct.

Terminal blocks shall be box-clamp type minimum 10 sq.mm with marking strips.

At least 20% spare terminals shall be furnished in the terminal block.

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1.4.14 Name Plate

Suitable name plate shall be furnished with each piece of equipment.

Materials for name plate shall be plastic / lamicaid, 3 mm thick, using white letters on black background.

1.4.15 Space Heater

- a) Thermostatically controlled Space heaters shall be provided in the bus ducts, wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation. At least one number space heater with thermostat shall be provided at each transformer and switchgear end.
- b) The space heaters and thermostats shall be wired up to terminals in suitably located terminal boxes to be provided by the contractor. The space heater wiring inside the busduct enclosure shall be done with high temp. resistant cables as the ambient temperature existing inside the busduct enclosure may vary.
- c) The minimum conductor size of space heater wiring shall be 2.5 sq.mm. A separate ON/OFF switch shall be provided for controlling the space heaters of each busduct in the marshalling box located at convenient height. One number single phase 240V power supply at the marshalling box for complete run of every busduct shall be provided. All cabling between space heaters/thermostats and marshalling box in the run of busduct shall be supplied and erected by the contractor. Cable entry points to the busduct shall be sealed properly by providing suitable glands.

1.4.16 Painting and Finish

- a) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint
- b) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- c) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- d) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].

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- e) The interior surface finish shall be as per manufacturer's standard.
- f) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- g) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.
- h) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- i) The paint shade shall be subject to owner's approval.

1.5

Tests

I) Type Test

For each type & rating of 6.6kV segregated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test

1.6

Drawings, Data and Manuals

Drawings, data & manuals for the 6.6kV segregated phase bud duct shall be submitted as indicated below:

- a) [Dimensional GA drawing
- b) Data sheets
- c) Typical calculation for arriving at the size of conductor and the insulator spacing.
- d) Type test report (short circuit, temperature rise test) for similar bus duct

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manufactured by the proposed manufacturer.

e) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

1.7

Ratings and Requirements

Major technical parameters of 6.6kV segregated Bus Duct are listed below..

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.0	General			
1.1	System nominal voltage	kV	6.6	
1.2	System maximum voltage	kV	7.2	
1.3	Number of phases		3	
1.4	Rated Frequency	Hz	50	
1.5	Neutral Grounding		Medium resistance grounded for earth fault current limited to [300 A for 10 secs.]	
1.6	Insulation level			
a	1 min power frequency withstand voltage	kV	20	
b	Impulse withstand voltage	kVp	60	
1.7	Short Circuit Level			
a	Symmetrical short circuit capacity	kA	40kA	
b	Dynamic capacity	kAp	100	
1.8	Space heating voltage	V	240V \pm 10%, 1ph, 50 Hz, 2 wire.	
1.9	Reference standard		IS 8084/ IEEE C37.23	
2.0	Busduct			
2.1	Make			
2.2	Type of bus duct		Segregated phase bus duct	

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2.3	Service		Indoor/Outdoor	
2.4	Type of cooling		Natural air cooled	
2.5	Nominal service voltage/rated frequency		6.6kV, 50Hz	
2.6	Busduct length		a) Between UTs and 6.6kV Unit Switchgear, b) STs and 6.6kV Station switchgear c) Tie between Unit and Station switchgear.	
2.7	Rated voltage class		7.2kV	
2.8	Continuous current rating of bus duct under site conditions between			
	a) UT and associated 6.6kV unit switchgear	Amps	[As per Project specific]	
	b) ST and associated 6.6kV station switchgear	Amps	[As per Project specific]	
	c) Tie between Station and Unit switchgear	Amps	[As per Project specific]	
2.9	Basic impulse withstand level (1.2 x 50 micro sec wave)	kVp	60	
2.10	One minute power frequency dry withstand voltage	kV	20	
2.11	Short time current for one second /Dynamic withstand current	KA /KAp	40/100	

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2.12	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
2.13	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
2.14	Maximum temperature rise of conductor over 50° C ambient when carrying short circuit current for 1 sec	°C	200	
3.0	Bus conductor			
3.1	Bus conductor Material		Aluminium alloy Grade [63401WP] as per IS-5082	
3.2	Bus conductor size for			
	a) Between UT and 6.6kV Unit Switchgear	mmx mm	[By Bidder]	
	b) Between ST and 6.6 kV Station switchgear	mmx mm	[By Bidder]	
3.3	Bus conductor shape		[By Bidder]	
3.4	Busbar Section		[By Bidder]	
4.0	Bus enclosure			
4.1	Bus Enclosure Material		Aluminium alloy Grade [63401WP] as per IS-5082	
4.2	Shape of Enclosure		Rectangular	
4.3	Cross section of enclosure	mmx mm	[By Bidder] { It shall be provided for each rating of busduct}	
4.4	Phase barriers			

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a	Material of Phase Barriers		[Al.alloy]	
b	Phase Clearance (Minimum) Phase to Phase Phase to Earth	mm mm	[120]mm [120]mm	
5.0	Parameters of busduct			
5.1	Resistance/meter/Phase at 20°C of conductor for		[By Bidder] { It shall be provided for each rating of busduct}	
5.2	Inductive reactance/meter/phase at 20°C for		[By Bidder] { It shall be provided for each rating of busduct}	
5.3	Capacitive reactance/metre/phase at 20°C		[By Bidder] { It shall be provided for each rating of busduct}	
5.4	Heat loss in the bus duct at full rated current		[By Bidder] { It shall be provided for each rating of busduct}	
5.5	Weight of 3-phase duct	kg	[By Bidder]	
5.6	Standard section length	m	[By Bidder]	
5.7	Minimum required clearances from the periphery of the bus duct			
	i) To structural steel work	mm	[By Bidder]	

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	parallel to the duct			
	ii) To structural steel work perpendicular to the duct	mm	[By Bidder]	
5.8	Type of Joints between Adjacent Sections of Bus Conductor Welded/Bolted		[By Bidder]	
9.0	Insulators and seal off bushings			
9.1	Make		[By Bidder]	
9.2	Rated Voltage	kV	7.2	
9.3	One minute Power Frequency Withstand Voltage	kVr ms	20	
9.4	Impulse Withstand Voltage (1.2 x 50 micro-second Wave)	kVp	60	
9.5	Minimum Creepage Distance	mm/ kV	25	
9.6	Insulators			
	a) Material of Insulators		[By Bidder]	
	b) Cantilever strength		[By Bidder]	
	c) Weight of insulator	kg	[By Bidder]	
	d) No of supports and insulator span		[By Bidder]	
10.0	Seal-off bushings			

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a	Current rating of Seal of Bushings	Amps	[By Bidder]	
b	Material of Seal Off Bushings		[By Bidder]	
c	Type		[By Bidder]	
d	Mechanical Strength		[By Bidder]	
e	e) Weight of each bushing	kg	[By Bidder]	
11	Earthing Material		GS	
12	Finish of Bus Enclosure		[RAL5012]	
13	Rain hood required Yes/No		Yes, for outdoor portion	
14	Degree of protection for enclosure		IP 55	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-II, PART-C
DETAILED TECHNICAL SPECIFICATION- I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No.[.] of [Name of the Power Plant]	[Logo of Utility]
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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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1. Technical Schedules-Mechanical
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1 GENERAL

This specification is intended to provide the technical guidelines for the fully coordinated Control & Instrumentation (C & I) system for the Renovation & Modernisation of Steam Turbine, Generator, Station C&I and its Auxiliaries of Thermal Power Plant of Unit No. [..] of [Name of the Power Plant] at [District], [State]. The renovated Turbo Generator shall be capable of producing the output of [210/215/220/250] MW. DCS & other common system/items procured under SG package shall be deleted from TG package.

The Control and Instrumentation system of a plant shall be designed to ensure safe, efficient and reliable operation of the plant under all regimes of operation namely start up, shutdown, normal operation, part load operation and under emergency conditions resulting in cost effective power generation with optimum fuel consumption and reduced steam requirement.

The technical specification shall serve as the guide specification for the proprietary controls of Steam Turbine Generator Integral controls (like Turbo supervisory Instruments, Turbine Run-up System (ATRS), Turbine Protection System, Electro Hydraulic Governing System (EHG) etc.) Station C&I and STG Auxiliaries, equipment packages, as also various stand alone system controls included as part of sub-packages, as in case of plant auxiliaries.

It is to be noted that where equipment or system for the Steam Turbine Generator system and its auxiliaries are described, it shall be understood that the quantities described are per unit basis, i.e., identical sets to be furnished for each of the units (If plant have multiple units). Where equipment or systems for common facilities are described, it shall be understood that the quantities described are the total quantities required.

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2**SYSTEM DESCRIPTION**

The plant C&I system is envisaged to be configured by interfacing main plant control system namely Plant DCS interfaced with other different plant control systems namely, TG Integral control system and other utility and auxiliary plant control systems (both unit specific and plant common systems) and provided with different special plant monitoring and analysis systems to provide supervisory and reporting facilities to plant personnel and management.

The plant C&I system is envisaged to permit centralized operation and monitoring of the power plant from the central control room (CCR). The system shall consist of a functionally distributed microprocessor based system (DCS) with facility for VDU (Video Display Unit) / Keyboard & Large Video Screen based operation, control and monitoring.

The control requirements of the main power plant comprising TG with associated auxiliaries (except for TG Integral control systems) to be implemented in microprocessor based Distributed Control.

TG Integral control system shall include TG Governing Control, Turbine protection system and Turbo Supervisory Instrumentation shall be an independent microprocessor based control system. Turbine Protection system shall be a fail-safe type system.

TG Integral Control System (For TG Governing Control & Turbine Protection) shall be interfaced with plant DCS through redundant bi-directional OPC link with Ethernet based TCP-I/P protocol. However for time critical signals hardwired interfacing is envisaged.

Following PLC based systems shall be interfaced with plant DCS through redundant unidirectional OPC link with Ethernet based TCP-I/P protocol.

- Plant Common Hydrogen plant (if applicable)
- Unit Specific Online tube cleaning system

CCR operation / monitoring of equipment/systems under TG Integral control systems shall be through plant DCS system OS /LCD.

Turbo Supervisory System shall be interfaced with respective unit plant DCS.

A common time synchronization system is envisaged for time synchronizing of all programmable control systems like TG Integral control system, SG Integral control system plant DCS, PLC control systems etc. for the whole station.

Operation and Monitoring of Plant Electrical 11 kV, 6.6 kV and Downstream System shall be performed through Plant DCS. Additionally, DCS shall have a redundant Software link with Substation Automation System (SAS) for monitoring of 400 KV & 220 KV switchyard systems. Switch yard system equipments shall be primarily operated from CCR (Operator stations shall be

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provided in CCR by extending the SAS bus) and control/monitored from SAS in Switchyard. For SOE inputs hardwired signals shall be connected to Plant DCS.

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3 DESIGN PHILOSOPHY

This section covers the design philosophy which shall be used for all control & instrumentation system for steam turbine generator & its auxiliaries.

1. Pressure indicators shall be used wherever indicating type Pressure transmitters are not envisaged. The applications include:
 - a) Suction and discharge lines of pumps, including header section, if two or more pumps are employed for the same service.
 - b) All input and output lines of process equipments.
 - c) Inlets and outlets of heat exchangers (both the fluid media).
2. Pressure Switches shall be avoided as far as possible and in place, smart pressure transmitters with soft limit value monitoring in Plant DCS shall be used. The applications shall include the following:
 - a) On all process lines / Equipments where parameter abnormality / status including pre trips alarms to be communicated to the operator in control room.
 - b) For all permissive and protection conditions governed by safety operation of the equipments. e.g. pressure adequate, pressure very high / very low conditions.
 - c) For all interlock conditions, governing starting of standby equipment or subsequent equipments for safety operation of the system.
 - d) Inlet and outlet of filters / strainers.
3. Differential Pressure Switches (indicating type) shall be used across filters/strainers for remote monitoring.
4. Smart Pressure Transmitter shall be used for all control applications and as demand by the process. Pressure stubs with isolating valves shall be used.
5. Differential Pressure Transmitter shall be used for all the requirements of differential pressure, flow, level measurement. Pressure stubs with isolating valves shall be used.
6. Temperature indicators (Thermometers) shall be used for following applications:
 - a) On all process lines where local indication is warranted by the system either for monitoring or testing.
 - b) On the inlet/outlet of equipments such as Heat Exchangers & Coolers for both the fluid media.
 - c) Differential temperature indicator shall be used across BFP suction and discharge service.

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7. Temperature Elements: Thermocouples / RTDs shall be used for casing metal temperature monitoring and bearing temperature monitoring of HT drives/motors.
 - a) The elements shall be duplex type with integral thermowell (except for metal thermocouples). K Type Thermocouples shall be used for all temperature measurements wherever possible. Both the elements of duplex temperature sensors shall be brought to junction boxes.
 - b) Compensating cable shall be used with all thermocouples for terminating to the control system eg. Plant DCS.
 - c) Six nos. (2 nos. per phase) Resistance temperature detectors (RTD's) shall be used for all HT motors, for winding temperature monitoring. Each element shall be 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Plant DCS system.
 - d) 1 no. duplex PRT-100 type RTD shall be used for each bearing of HT equipment and its driving equipment (motor).
 - e) All RTDs shall be PRT-100 type with each element being 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Plant DCS system.
 - f) For process temperature up to 200 degree C, RTD shall be used. Beyond 200 *C temperature thermocouple to be used.
 - g) Temperature measurement shall have upscale / down scale protection features not to cause major process upset in case of sensor failure.
8. Level gauges shall be used on all tanks and the maximum length of one gauge glass shall not exceed 1 meter. The gauge glasses shall be stacked to cover the complete height of the tanks including over flow level. There shall be an overlap of minimum 100mm, when more than one level gauge is required.
9. Level switches: The instrument shall be used for the following applications:
 - a) On all equipments (storage vessel) where parameter abnormality/status has to be communicated to the operator in the control room.
 - b) All permissive, interlock and protection conditions governed by the safe operation of the equipment.
 - c) Conductivity type level switches shall be used for all heaters and drain pots.
10. Level Transmitters Stubs with impulse pipes, root valves for mounting Level transmitters shall be used on process equipments where continuous remote monitoring and/or control of level is envisaged. Wherever necessary standpipes or float chambers and also makeup line shall be used for filling up the constant level vessel.

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- a) The instrument shall be displacement type for all low pressure and vacuum applications involving two phase media viz: condenser, hotwell and LP heaters level measurements. Optionally, guided wave radar type shall be used.
 - b) The instrument shall be differential pressure type or torque tube type for other applications.
11. Flow Glasses shall be used at the outlet of the pipe lines and shall be employed under the following conditions:
- a) Coolers
 - b) The instrument shall be rotary type with glass mounted for indication
 - c) Up to 6 inch on-line flow glasses shall be supplied and above 6 inch bypass type flow glasses shall be used. Sight flow and variable flow indicators shall be used for low pressure and low temperature applications.
12. Microprocessor based speed switches shall be used for zero speed detection, chain cut detection, locked rotor protection etc. Microprocessor based reverse rotation switch shall be used for pump protections such as BFP, CEP etc.
13. Pneumatically Operated Control Valves shall be used for all control application. If the process demands any other control, then control valves shall be used for those applications also. Where a single control valve cannot meet the turn down ratio as dictated by the process, control valves with split range application shall be used.
- a) All bypass valves of control valves shall be motor operated valves suitable for inching operation provided with position transmitters.
 - b) All integrated bypass valves shall be motor operated. Electro-pneumatic positioners shall be used for all pneumatic control valves.
 - c) Pressure test points & drains shall be used across each control valve
14. The pneumatically operated control valves shall be used with Smart Positioners, diagnostics and HART compatibility. Control Valve diagnostics shall be transmitted through this HART Protocol to Plant DCS.
15. Solenoid Valves shall be used for all pneumatic control valves hooked up with process interlock requirements and where direct tripping is involved. All solenoid valves shall be uniformly rated for 24V DC or 220V DC. The number of ways for solenoid valve shall be used as indicated below :
- a) On line two (2) way solenoid valves shall be used, where process line of less than 2 inch with low pressure & temperature application is involved.

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- b) Three (3) way solenoid valves shall be used commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder. E.g.: Pneumatic operated spray water block valve.
 - c) Four (4) way solenoid valves shall be used for operating double acting cylinders (If applicable). E.g.: Pneumatically operated on-off type dampers.
 - d) Dual coil, latch, unlatch type Solenoid valves shall be supplied for equipment trips/critical applications.
16. Position Transmitters shall be used for all motorized inching valves. Position transmitters shall be 24 V DC, 2 wire, non-contact type.
17. Electro-Pneumatic positioners shall be used for all pneumatically operated control valves, power cylinders etc., for converting controller output of 4-20 mA to appropriate pneumatic signal
18. Air Filter Regulators along with gauges shall be used in each of the:
- a) Air supply line to valve positioners /power cylinders
 - b) Air supply line to pneumatic interlocked block valves
19. Interposing relay (To be mounted in Control room cabinet) for interface to the following:
- a) Solenoid valve (if output module cannot directly drive SOV) - Relays with contact rating of minimum 2 Amps.
 - b) DC Starter ((if output module cannot directly drive) - Relays with contact rating of minimum 0.2 Amps.
 - c) Hardwired signal exchange – as required.
20. For all HT rotating equipment bearings provision for mounting vibration probes shall be used.
21. Junction Boxes/Field termination cabinet: All JBs /FTCs shall be SS. Junction Boxes shall be used for:
- a) Termination of all sensors located equipment wise.
 - b) Termination of Duplex Thermocouples / RTDS
 - c) Termination of limit switch, torque switch, position transmitter and control demand, independently for each valve.
 - d) Area wise or Elevation wise bunching of cables.
22. Instrumentation & control cables and Prefabricated Cables with Anti-Rodent treatment shall be used to:

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- a) Connect field instruments to field junction boxes/Local Panels. For switches, both the SPDT contacts of switches shall be wired up to the J.B.
 - b) Connect limit switches, torque switches and position transmitters to their respective field junction boxes.
 - c) Compensating cable shall be supplied for connection between the element and the respective junction boxes / system cabinets as per guidelines.
 - d) Prefabricated cable for connecting between system cabinets, marshalling cabinet to system cabinet, system cabinet to Relay Rack, system cabinets to engineering work stations etc.
 - e) Entire I&C cable within the battery limits.
23. All field instruments including electronics located outside control room areas shall be tropicalized and shall be designed to work in site specific atmosphere/climatic conditions and enclosed in dust tight, waterproof and weatherproof enclosures. In general, transmitters and switches installed at outdoor location shall be mounted in closed type transmitter enclosure. For other areas (indoor), open type racks may be used for installation of transmitters and process switches.
24. All alarm shall be displayed in the Plant DCS HMI/LCD. However where local panels are used for local operation/monitoring, PLC/ DCS driven alarm annunciation system with LED type lamps for local panel shall be used.
25. Pressure, temperature and flow test points shall be used in line with latest performance test code requirements.
- In general, pressure and temperature test points shall be used for the following services:
- a) At the discharge of all pumps and fans
 - b) At the inlet and outlet of the heat exchangers for the fluid media involved
 - c) Adequate number at the Combustor at different zones
 - d) At the inlet and outlet of each control valve
26. The ranges of the instruments shall be selected based on the following philosophy:
- a) For pressure and draft measurements, the maximum operating pressure shall be within 70 to 80% of the maximum scale range.
 - b) For temperature measurement, the maximum operating temperature shall be within 80 to 90% of the maximum scale range.

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- c) For pressure switches and temperature switches, the set points shall fall within 40% to 70% of the scale range selected.
 - d) For level measurement, the maximum of the range shall cover the overflow point or six inches from the top of the vessel and the minimum of the range shall be six inches above the bottom of the vessel. Also, the gauge glasses shall be stacked with overlap to cover permissive, alarm and trip levels.
 - e) For flow measurement, the maximum range shall be fixed at about 10 to 15% above the maximum operating flow
 - f) For electro-chemical measurements (conductivity, pH, dissolved O₂, Silica etc.), the maximum range shall be around 10 to 15% higher than the recommended alarm settings.
- 27.Spring-loaded/ Cage clamp type terminals shall be used for termination of instrumentation cables at field JBs, FTCs and local panels.
- 28.Signal Exchange Between different systems and Plant DCS System shall be as follows:
- a) All the signals required for interlock / alarm / SER purpose (to be implemented in the Plant DCS) shall be hardwired.
 - b) All binary outputs provided to local panels/sensors for connection from Plant DCS shall be potential free contacts with a rating of 0.2 amps at 220 V DC or 2 amps at 24 V DC or 5 amps at 240 V AC. All check backs to Plant DCS shall only be potential free contacts.
 - c) All analog outputs provided to local panels/sensors for connection from Plant DCS shall be isolated 4-20 mA DC.
 - d) Command outputs from Plant DCS to motorized valve actuator shall be logic level signal (24 V DC) and necessary interposing relays suitable to accept 24 V DC logic level command signal shall be used in MCC module for MOV actuator.
 - e) Push buttons station/panel for safe emergency shutdown of the plant shall be provided.
- 29.Flow elements for measurements of steam or water flow shall be used along with 3 (three) tapping's for measurement & Control and one tapping for test purpose.
- 30.All indication lamps shall be LED type.
- 31.All interposing relays shall be Plug in type with screw type base & LED for status indication. Relay modules/boards etc. are not acceptable.
- 32.All Limit Switch shall be Non-Contact type. If there is constraints because of process conditions/space, mechanical lever actuated Limit switch may be used.

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4 DESIGN CRITERIA

This section covers the general design criteria to be adopted in designing the Control & Instrumentation system for the TG Package.

4.1 General Requirements

Ambient Conditions

Instruments, devices and equipment for location in outdoor / indoor / air-conditioned areas shall be designed to suit the environmental conditions indicated below and shall be suitable for continuous operation in the operating environment of a coal fired Power plant and also during periods of air conditioning failure without any loss of function, or departure from the specification requirements covered under this specification.

Table 4.1
Protection Class Requirement

Ambient Temperature (outside temperature)	Pressure	Relative Humidity	Atmosphere	Required Protection class of panels /cabinets /desks
Outdoor Location				
55 oC max	Atmosphere	100%Max	Air (dirty)	IP 65
4 oC min	Atmosphere	5 % Min	Air (dirty)	IP 65
Indoor Location				
55 °C max	Atmosphere	95 % Max	Air	IP 54
4 °C min.	Atmosphere	5 % Min	Air	IP 54
Air-conditioned Area				
24 +/- 2 °C normal	Atmosphere	95 % Max	Air	IP 44
50 °C Max.	Atmosphere	5 % Min	Air	IP 44
a) For Ventilated enclosures, protection class shall be IP 42. b) For hazardous areas the protection class shall be in accordance with the requirements of the relevant NEC code for the location. c) For PCs, OWS, EWS, Servers, Printers and other peripherals, maximum temperature limit shall be 35 °C, For LCD the same shall be 25 °C & for UPS the same shall be 40 °C.				

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4.2 Codes & Standards

All equipment, system and service covered under this specification shall comply with the requirements of the latest statutes regulations and safety codes as applicable in the locality where the equipment/systems shall be installed.

The equipment, systems and services furnished as per this specification shall conform to the latest edition of codes and standards mentioned in this section. However in the event of any conflict between the requirements of two standards or between the requirements of any standard and this specification, the more stringent requirements shall apply unless confirmed otherwise by the owner/owner's engineer in writing. The decision of the owner shall be final & binding in all such cases.

All equipments supplied under this specification shall be given tropical treatment for the climatic conditions prevailing at site as described under project data. Tropical protection shall conform to IS-3202 (Climate proofing of electrical equipments) or any other applicable international standard for protection of Electrical power equipments against climatic conditions.

Reference Codes and Standards

The design, manufacture, inspection, testing, site calibration and installation of all equipment and systems covered under this specification shall conform to the latest editions of codes and standards mentioned below and all other applicable ANSI, ASME, IEEE, NEC, NEMA, ISA, DIN, VDE and Indian Standards and their equivalents.

Temperature Measurement

- Instrument and apparatus for temperature measurement ASME PTC 19.3
- Temperature measurement - Thermocouples ANSI-MC 96.1
- Temperature measurement by electrical resistance thermometers – IS: 2806.
- Thermometer-element-platinum resistance-IS-2848 / DIN 43760/ IEC 751

Pressure Measurement

- Instrument and apparatus for pressure measurement - ASME PTC 19.2
- Bourdon tube pressure and vacuum gauges - IS 3624

Flow Measurement

- Instrument and apparatus for Flow measurement – ASME PTC 19.5 Interim supplement, Part-II
- Measurements of Fluid flow in closed conduit – BS 1042 / ISO 5167.

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Electronic measuring Instruments & Control hardware

- Automatic null balancing electrical measuring instruments - ANSI C 39.4
- Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5.
- Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1.
- Dynamic response testing of process control instrumentation - ANSI MC 4.1 : ISA-S26.
- Surge withstand capability (SWC) tests - ANSI C 37.90a IEEE Std. 472. IEC - 254.1.
- Printed circuit boards - IPC TM-650, IEC 326 C
- General requirements and tests for printed wiring boards - IS 7405 (Part-I)
- Edge socket connectors - IEC 130-11.
- Requirements and methods of testing of wire wrap terminations DIN 41611 Part-2.
- Dimensions of attachment plugs & receptacles ANSI C73.
- Direct acting Electrical Indicating Instruments: IS-1248.

Electronic Cards, Subassemblies & Components

- a) Unpackaged
 - Vibration IEC 68.2.26
 - Shock IEC 68.2.27
 - Drop & Topple IEC 68.2.31
- b) Packaged
 - Vibration, Drop & Static Compression – NSTA
- c) Electromagnetic Compatibility
 - Electrical Fast Transient – IEC 801.4
 - Surge Withstand – IEC 255.4
 - Radiated Electromagnetic Field – IEC 801.3
 - Electrostatic Discharge – IEC 801.2
 - Electromagnetic Emissions – VDE 0871, Class B

Instrument Switches and Contacts

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- Contact rating - AC services NEMA ICS Part-2 125, A600
- Contact rating - DC services NEMA ICS Part-2-125, N600.

Enclosures

- Types of enclosures - NEMA Std. ICS-6-110.15 through 110.22 (Type 4 to 13).
- Racks, panels, and associated equipment - EIA: RS-310-B (ANSI C83.9)
- Protection Class for Enclosure, Cabinets, Control Panels and Desks - IS-13947 & IEC 529.

Apparatus, enclosures and installation practices in hazardous areas

- Classification of hazardous area - NFPA Art. 500, Vol.70.
- Electrical Instruments in hazardous dust locations - ISA-RP 12.11
- Intrinsically safe apparatus - NFPA Art.493 Vol.4
- Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Art. 496.

Sampling System

- Stainless steel material of tubing and valves for sampling system - ASTM A269-82 Gr. TP316.
- Submerged helical coil heat exchangers for sample coolers ASTM D 11-92.
- Water and Steam in power cycle - ASME PTC 19.11.
- Standard methods of sampling system - ASTM D 1066-69.
- The system shall be based on established Standard & Codes of Practice, such as GDCD 234 / 164 / 163, CEGB, UK.
- Sample Cooler shall be IBR approved.

Annunciator

- Specifications and guides for the use of general purpose annunciator - ISA RP 19.1.
- Surge withstand capability tests - ANSI C.37.90a and IEEE std. 472

Interlocks, Protections

- Relays and relay system associated with electric power apparatus - IEEE std.3.13.

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- Surges withstand capability tests - ANSI C.37.90a and IEEE Std. 472.
- General requirements & tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I).
- Boiler safety interlocks - NFPA Section 85B, 85D, 85E, 85F, 85G.

Control Valves

- Flow Equation for Sizing Control Valves – ISA S39.2
- Control Valve Seat Leakage – ANSI / FCI 70.2
- Face to face Dimensions of Control Valves – ANSI B16.10, ISA – S75.03 & ISA – S75.16
- Steel Pipe, Flanges & Flanged Fittings – ANSI B16.34
- Control Valve Capacity Test Procedure – ISA – S75.02
- Industrial Process Control Valves - IEC 534

Process Connection and Piping

- Codes for pressure piping power piping ANSI B31.1
- Seamless carbon steel pipe ASTM A-106.
- Forged and Rolled Alloy steel pipe flanges, forged fittings, valves and parts - ASTM A-182.
- Material for socket welded fittings - ASTM A-105.
- Seamless Ferritic alloy steel pipe - ASTM A-335.
- Pipe fittings of wrought carbon steel and alloy steel - ASTM A-234.
- Composition bronze or metal castings - ASTM B-62.
- Seamless copper tube, bright annealed ASTM B-168.
- Seamless copper tube - ASTM B-75.
- Dimensions of fittings - ANSI B-16.11
- Valves flanged and butt welding ends - ANSI B16.34.
- Nomenclature for Instrument tube fittings ISA-RP-42.1.

Instrument Tubing

- Seamless carbon steel pipe - ASTM - A106.
- Material for socket welds fittings - ASTM - A105.
- Dimensions of fittings - ANSI B16.11

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- Code for pressure piping, welding, hydrostatic testing - ANSI B31.1.
- Nomenclature for Instrument Tube Fittings – ISA RP 42.1
- Seamless Stainless Steel Tubes ASTM A 312 TP 304

Cables

- Thermocouple extension wires/cables - ANSI C 96.1.
- Colour coding of single or multi-pair cables - ICEA S-61- 402. (Third edition) NEMA WCS.
- Guide for design and installation of cable systems in power generating stations (insulation, jacket materials) - IEEE Std. 422.
- Requirements of vertical tray flame test - IEEE 383.
- Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B-33 - 81.
- Oxygen index and temperature index test - ASTM D-2863.
- Smoke generation test - ASTM D-2843 and ASTM E-662.
- Acid gas generation test - IEC-754-1.
- Swedish chimney test - SEN - 4241475 (F3)
- Instrumentation cables and internal wiring IS-1554 (Part-I) and IS: 5831.
- Mono-mode Fibre – ITU-T G.652 for Optical Fibre Cable
- IEEE 1138 / IEC 1089 / EIA-455 B for Optical Fibre Cable

Cable Trays, Conduits

- Guide for the design and installation of cable systems in power generating station (cable trays, support systems, conduits) - IEEE Std. 422, NFPA-70.
- Guide for the design and installation of cable systems in power generating station (Cable trays, support systems, conduits) Test Standards, NEMA VE-1.
- Galvanizing of Carbon steel cable trays - ASTM A-386-78.

4.3 Power Supply

1. Electric:

- 230 volts AC, 50 hertz, single-phase for low torque drives with guaranteed satisfactory operation when equipment is continuously energized at any voltage from 216VAC to 264VAC.
- 24V DC for PLC & DCS.
- 24 VDC, 110VAC or 230 VAC for Field Instruments.

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2. Pneumatic:

Clean, dry, and oil free instrument air at 4.2 to 8.6 bars gauge. All necessary pressure reducing controls, where required, shall be furnished by the equipment supplier as specified at some other place under air compressors section.

4.4 Standard Ranges of Analog Signals

The ranges of analog signals shall normally be as follows:

1. Electric -- 4 to 20 mA DC.
2. Pneumatic -- 0.2 to 1.0 kg/cm².

The use of any signal range other than the above shall not be acceptable.

4.5 Contact Ratings

The ratings of all instrument contacts used for alarms and interlocks shall be as follows:

Table 4.2
Contact Ratings

Voltage Rating (volts)	Continuous Rating	Switching Rating (break)
a) 240 AC	480 volt-amperes	1200 volt-amperes
b) 220 DC	60 watts	200 watts
c) 24 DC	12 watts	25 watts

The ratings of all microprocessor-based controller or programmable controller output contacts shall be as required by the controlled devices. Where necessary for higher current ratings or isolation, interposing relays shall be used.

4.6 Reliability and Availability

1. Each component and system shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
2. Detailed reliability calculations shall be used for each system/ equipment (with the help of a schematic of various sub-system connected in series or in parallel as the case may be and MTBF & MTTR values for the various equipments). Availability calculation shall be as per IEEE Standard-P1046 or equivalent.
3. When more than one device uses the same measurement or control signal, the transmitter and other components/ module shall be fully equipped to provide all signal requirements. The system shall be arranged so that the failure of any monitoring device or control components or spurious intermediate grounding in the

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signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.

4. To ensure availability, adequate redundancy in system design shall be used at hardware, software and sensor level to satisfy the availability criteria. For the protection system, independent sensing device shall be used to ensure adequate safety of plant equipment.

4.7 Standardization & Uniformity of Hardware

To ensure smooth and optimal maintenance, easy interchange ability efficient spare parts management of various C&I instruments, ensure that all instruments/devices (Processor modules, input/output modules, power supply modules etc.) are of the same family of hardware. For example, all 4-20 mA electronic transducers, control hardware, control valves, actuators instruments/ local devices etc. being furnished shall be boiler manufacturer specific. Take special care towards selection of SG Integral Control system.

4.8 Redundancy

1. Reliability of the Control System shall be established by judicious incorporation of redundancy. In general all critical parts shall have hot standby feature to render the system immune to any single failure.
2. Measurement system (MS), Closed Loop Control System (CLCS) and Open Loop Control System (OLCS) shall all be configured with redundancy at processor modules, communication modules, data bus and power supply modules.
3. Both CLCS & OLCS shall be configured with I/O channels redundancy for each sensor/signals. Where redundant sensors are provided redundant I/O channels shall be used for each sensors/signals.
4. Two out of three measurements philosophy shall be adopted for the control of all closed and critical open loop variables for reliability of operation. The control system shall select the median value for the normal control purpose.

4.9 Operability & Maintainability

1. The design of the control systems and related equipments shall adhere to the principle of 'Fail Safe' operation wherever safety of personnel / plant equipment is involved. 'Fail Safe' operation signifies that the loss of signal or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips are avoided / minimized.
2. The types of failure which shall be taken into account for ensuring operability of the plant shall include but not be limited to:
 - a) Failure of sensor or transmitter,
 - b) Failure of main and/or redundant controller/other modules,
 - c) Loss of motive power to final control element,
 - d) Loss of control power.

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- e) Loss of instrument air
- 3. The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:
 - a) Standardization of parts.
 - b) Grouping of functions.
 - c) Interchangeability.
 - d) Malfunction identification facility/self surveillance facility.
 - e) Easy modular replacement.
 - f) Fool proof design providing proper identification and other features to preclude improper mounting and installation.
 - g) Appropriate derating of electronic components and parts.

4.10 Metering Bases of Units

The following system of units shall be followed throughout the specification unless otherwise mentioned.

Table 4.3
Metering Bases of Units

S.No	Parameter	Unit
1	Pressure	Kg/sq. cm
2	Differential pressure	mm of H ₂ O column or Kg/sq. cm
3	Draught	mm of H ₂ O column
4	Vacuum	mm of Hg
5	Temperature	Degree Celsius
6	Flow (Steam / Feedwater)	Tonnes / hr or Kg/hr
7	Flow (Air / Gas)	Tonnes / hr or N. Cu. M /hr
8	Flow (Oil)	Tonnes / hr or Kg/hr
9	Density	gm / c.cm
10	Level	mm or M
11	Conductivity	Micro-mho/cm

4.11 Grounding System

All panels, desks, cabinets shall be used with a continuous bare copper ground bus. The ground bus shall be bolted to the panel structure on bottom on both sides. The bolts shall face inside of panels.

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The system ground shall be isolated from the panel ground with suitable isolators. All internal component grounds or common shall be connected to the system ground, which shall be fabricated of copper flat (size 25 mm x 6 mm min, length as applicable).

Shield on instrumentation cables shall be grounded on panel side. When shielding termination is required in cabinets furnished under this specification, suitable terminals shall be furnished on copper flat forming system ground. System and shield ground shall be connected to earthing strip at 0.0 meter level using suitable size of cable.

4.12

Flow Element Selection

Table 4.4
Flow Element Selection

S. No	Type of Flow meter	Fluid medium	Process Parameter	Pipe sizes suitable for FE	Application	Type of connection
1	Orifice Plate	Water (DM Water)	As per process requirement	For all sizes Except very large diameter pipe	DM Water Flow To CST	Flange
2	Orifice Plate	Steam	For any condition	< 3"	Soot blowing steam flow	BW
3	Flow nozzle(AISI Type31 6L)	Water	As per process requirement	For all pipe sizes except very large diameter Pipe	(i) FW Flow to boiler drum (ii) SH/RH Spray water flow	BW
4	Flow nozzle(AISI Type31 6L)	Steam	As per process requirement		AUX. Steam flow	BW
6	Any Other Services required	Subject to approval.				

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4.13 Drive Control Philosophy

The Drive control & measurement philosophy for the project is detailed in this section.

1. Bi-directional drives (inching or open/close)

- (a) All bi-directional drives shall be operable from Remote i.e. from CCR.
- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Open/Close commands, generated in control system shall be issued to MCC module through interposing relays located in respective MCC module in the MCC room. Latching of commands shall be used in control system logic which shall be reset by Limit/Torque switch feedback. The Limit/Torque switch feedback from drive shall be directly wired to Control System.
- (d) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
- (e) Following signal exchange shall be envisaged between Drive & Control system:
 - Open Limit Switch (Both NO & NC contacts)
 - Close Limit Switch (Both NO & NC contacts)
 - Open Torque Actuation
 - Close Torque Actuation
 - Position feedback (4-20 mA, two wire electronic type) for inching drive
- (f) Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in/near MCC room):
 - Switchgear available
 - Switchgear disturbance
 - Open Command
 - Close Command

2. Unidirectional LT drives

- (a) Unidirectional LT drives shall be operable only from Remote i.e. from CCR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays located in respective MCC modules.

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- (d) Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
 - (e) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
 - (f) Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives greater than 90 KW. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules.
 - (g) Following signal exchange shall be envisaged between MCC & Control system(Remote I/O cabinet of control system located in MCC room):
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Start Command
 - Stop Command
 - (h) All Numerical relays/Intelligent controllers for LT drives shall be interfaced to Control System through IEC 61850 protocol.
3. Solenoid Operated drives
- (a) Solenoid operated drives shall be operable only from Remote i.e. from CCR.
 - (b) Remote manual operation of all drives shall be carried out from OWS.
 - (c) Remote Open/Close commands shall be generated in Control system & shall be issued to the Solenoid through interposing relays, located in Relay Panel.
 - (d) Necessary process interlocks shall be realized in Control system.
 - (e) Following signal exchange shall be envisaged between solenoid drive & Control system:
 - Open Limit Position
 - Close Limit Position
 - Open Command
 - Close Command

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4.14 HT drives

1. HT drives shall be operable only from Remote i.e. from CCR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
2. Remote manual operation of all drives shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays located in respective MCC modules.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
5. Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
6. Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules
7. Following signal exchange shall be envisaged between MCC & Control system(Remote I/O cabinet of control system located in MCC room):
 - a) Switchgear available
 - b) Switchgear disturbance
 - c) Master Trip relay Operated
 - d) On Feedback
 - e) Off Feedback
 - f) Trip Feedback
 - g) Emergency stop feedback
 - h) Start Command
 - i) Stop Command
 - j) Current Feedback
8. All Numerical relays/Intelligent Controllers for HT drives shall be interfaced to Control System through IEC 61850 protocol.

4.15 Variable Frequency Drives (VFD)

1. VFD shall be operable from Remote i.e. from CCR & from VFD Local Display unit. In addition, Local pushbutton shall be used only for emergency stopping of drive.
2. Remote manual operation of VFD shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to VFD Panel through interposing relays located in VFD Panel.

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4. Emergency stop of the drive shall be envisaged from the local pushbutton provided in the field. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to VFD panel.
5. Necessary Electrical protections shall be realized at VFD module whereas process interlocks & protections shall be realized in Control system.
6. Following signal exchange shall be envisaged between VFD & Control system:
 - a) Switchgear available
 - b) Switchgear disturbance
 - c) On Feedback
 - d) Off Feedback
 - e) Trip Feedback
 - f) Emergency stop feedback
 - g) Start Command
 - h) Stop Command
 - i) Current Feedback
 - j) Speed feedback
 - k) Speed Setpoint
7. The VFD shall also be interfaced with control system via Modbus soft link.

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5 TG INTEGRAL CONTROL SYSTEM

The microprocessor based Control System shall be provided for the safe and efficient operation of Steam Turbine Generator Protection in all regimes of operation. The control, monitoring, interlock and protection schemes consists of Steam Turbine Generator including Turbine Protection System, Turbine Electro-hydraulic Governing System with Free Governor operation in the interconnected grid (FGMO & RGM0), Turbine Stress Control System, Automatic turbine Testing, Automatic Turbine Run-Up System etc.

For all the CLCS for TG and auxiliaries like Heaters Level Control, Condenser hotwell Level Control, Deaerator Level, Pressure & Temperature Control, etc. & OLCS like BFP, CEP, etc. Interfacing strategy between TG control system & Plant DCS is required for controlling the final output generation of unit as per standard design practice.

5.1 Control System Requirements

1. The TG Integral control system shall consists of the following System controls:
 - a) Turbine Protection system
 - b) Turbine Electro-Hydraulic Governing System
 - c) Turbine Automatic Run-Up System
 - d) Turbine Automatic Testing System
 - e) Turbine Stress Control System
 - f) Turbine Supervisory Instrumentation
2. The Control System shall function reliably under the environmental conditions as specified in Design Criteria/Philosophy. It shall be immune from the interference resulting from disturbance in power supply feeders, signal lines, inputs, outputs, etc. as experienced in a Power station.
3. The Control System shall have on-line simulation and testing facility. Further, it shall be possible to on-line configure and tune controllers through engineering workstation.
4. The system shall have the flexibility to easily reconfigure any controller at any time without requiring additional hardware or system wiring changes and without disabling other devices from their normal operation mode. Modifications shall not require switching off power to any part of the system.
5. Power supply to individual functional group shall be from redundant 24 V DC feeders with diode auctioneering and further sub-distribution.
6. Independent and dedicated controllers (main and its 100% hot standby) shall be provided for each of the System except for TG protection system where triple redundant controllers are to be used. All the 100% hot / redundant backup

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controllers shall be identical in hardware and software implementation to their corresponding main controllers and shall be able to perform all its tasks. The backup controller shall track its corresponding main controller. There shall be an automatic and bumpless switchover from the main controller to its corresponding backup controller in case of main controller failure and vice versa without resulting in any change in control status. In case of switchover from main controller to the 100% hot backup controller, the back-up controller shall work as the main controller. Facility shall also be provided for manual switchover from main to 100% hot back-up controller and vice versa from the Engineer's Work Station.

7. The control system hardware design shall be such that it is able to withstand power line disturbances.
8. The loop / logic reaction time shall be suitable to match actual process requirements, subject to minimum requirement wherever specified.

5.1.1 Turbine Protection system (TPS)

1. Fully proven microprocessor based system, based on hardware and software specifically designed for Turbine protection application meeting the Provenness criteria and Triple Modular Redundancy shall be provided to achieve the turbine protection action.
2. The system design shall be such that safety function of the total system must not be jeopardized on occurrence of fault. Any single fault in primary sensor, input/ output modules, controller modules etc. shall in no way jeopardize the safety of the turbine. All modules to be used in this system shall be of failsafe design.
3. The Turbine Protection System shall also be implemented in 2 out of 3 voting logic. Three independent trip channels each having its own and dedicated processing modules, controllers, Input/output modules etc. shall be provided to achieve 2 out of 3 voting logic. The outputs of the three channels shall be used to implement 2 out of 3 voting logic in two relay units, the output of which shall be fed to the two turbine trip relays.
4. The independent channels or any of the triple redundant sensors is faulty, the same shall be alarmed and the balance two channels/sensors shall operate in one out of two mode.
5. All the input signals (trip signals etc. from the field devices) shall be fed in parallel to all the three redundant channels of protection system as mentioned above via signal conditioning cards designed for such application. Further, the computation of field input voting logics i.e. 2 out of 3 etc. shall also be performed in the controllers of all the three channels of protection system which shall then perform the computation of 2 out of 3 voting logic independently. Additional signal for each trip input shall be made available to 1ms resolution

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SOE System at the input level itself, without any processing, so as to enable analysis in SOE list, the exact cause of trip.

6. All the required primary sensors etc. required for protection system shall be provided as per standard and proven practices of manufacturer. All trip signal inputs required for the safety of the turbine shall be based on 2 out of 3 logics.
7. The system shall include turbine lock-out relays, redundant turbine trip solenoids and necessary hardware required for testing.
8. The tripping devices shall be designed to operate on DC supply. The trip coils shall be monitored continuously for healthiness and failure shall be alarmed.

5.1.2 Turbine Electro-Hydraulic Governing System

Following two alternatives for the Turbine Governing System shall be acceptable and shall be proven as per standard practices.

Alternative - I

In this alternative, the turbine generator unit shall be equipped with electro-hydraulic governing system backed-up by mechanical hydraulic control system. The system shall be designed such that the governing of the steam turbine shall be automatically and safely transferred to mechanical hydraulic control system during operation, in the event of a fault developing in electro-hydraulic control system.

Alternative - II

In this alternative, the EHG system shall be provided with 100% hot redundancy i.e. the system shall consist of two independent channels right from sensors, transmitters, other field mounted devices, input modules, controller modules, output devices etc. of the Electro hydraulic converter. Further, each of these channels shall be fed from independent power supplies.

Both the above mentioned alternatives shall meet the following functional requirements.

1. All transducers shall be electronic type. The acquisitioned signals shall be processed electronically and processed signal shall be given to Electro-Hydraulic Converter, which converts the electronic signal to hydraulic Signal. Hydraulic signal before application to Control Valve Servomotors shall be suitably amplified.
2. The controls covered in this system shall basically consist of speed controller, load controller, valve-lift controller, inlet steam pressure controller and output frequency droop characteristic controller. The speed controller shall ensure controlled acceleration of the turbine generator and shall prevent over-speed without tripping of the unit under any operating condition or in the event of full load throw-off.

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3. The speed controller shall limit the over-speed of the turbine on loss of full load to a value less than 8% of rated speed. The governing system shall be equipped with speed/load changer to control the speed or power output of the steam turbine within the limits. The speed/load changer provided shall be capable of adjusting the speed of the turbo set to any value in the range of 94% to 106% of rated speed for manual/auto synchronization of the generator with the bus. It shall be capable of varying the load on the machine from no load to full load.
4. For remote control, suitable motor drive shall be provided. Indication of the speed/load changer position shall be provided on the OWS and console panel insert.
5. The turbine governing control system shall be equipped with the logics and signals for starting the steam turbine from turning gear speed to rated speed, accelerating safely at the preselected rates, selectable from OWS in conjunction with Turbine Stress Control System. The control system shall provide the loading and unloading of steam turbine after synchronization in conjunction with TSCS and coordinated master control implemented in plant DCS. Loading/ unloading rate shall be selected from OWS. It shall be facilitated with on-load testing of all steam admission valves individually and sequentially on a periodic basis.
6. The speed governing system shall be capable of controlling with stability the speed of the turbine at all power outputs between zero and specified maximum power output, when the unit is operating isolated or in parallel with other units.
7. The governing system in association with the over speed protection devices shall limit the speed of the unit to a value less than the trip setting in case of a full load trip out.
8. The steady state speed regulation shall be within the range of not less than 3.5% and not more than 5% when the speed changer specified herein is set to give rated speed with rated power output and shall be capable of adjustment between 2.5% and 7%, inclusive, at this setting, in steps not exceeding 0.5%. The dead band at rated speed and at any power output within the rated power output shall not exceed 0.06% of rated speed.
9. The steam turbine shall be equipped with independent safety devices in the form of duplicate emergency over speed governor(s). These shall be mounted on the steam turbine shaft and shall be arranged to actuate a tripping device at a predetermined speed which shall rapidly close the emergency stop, & control valves and reheat stop & control valves and also by Plant DCS the non return valves in the extraction lines for speeds of about 110 % of the rated speed.
10. System shall be capable of being reset by operator when the speed is reduced to approximately normal thus permitting the machine to be synchronized with other units. The emergency over speed governor shall be provided with mean for testing its operation when the machine is on load without exceeding rated speed

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of the unit. A duplicate governing system shall be provided so that the emergency valve remains active during the test. In addition to the above, as a third safety element to protect the turbo generator in the event of failure of over speed limiter or turbine stop valve close, a trip shall be provided in the form of trip signal generated from the speed measuring element of the governing system to close the motorized boiler stop valves

11. Free Governor Operation in the interconnected grid (FGMO & RGMO).

5.1.3 Automatic Turbine Run-Up System (ATRS)

ATRS shall run the turbine automatically from zero speed to synchronizing speed and then load the machine up to block loading and continuously check the operation up to 100% MCR without impairing the life of the turbine.

The automatic run up system shall be designed to provide the following functions:

1. Automatic start up / shut down sequence
2. Stress / temperature margin controlled acceleration as per the pre selected mode i.e. slow, normal and fast.
3. Stress / temperature margin controlled loading / unloading
4. Automatic synchronization and loading up to 100% MCR.
5. Unloading and shut down of the machine.

The functional group turbine shall include sequence control, interlock and protection of all valves, drives, equipment / devices related to turbine drains, gland steam supply, turbine run up / shut down, auto synchronizer etc. Similarly, functional group lube oil supply shall include all the above-mentioned functional features for all equipment / auxiliaries related to lube oil system and turning gear.

5.1.4 Automatic On-Line Turbine Testing System (ATT)

The ATT system shall be provided for on load testing of turbine protective equipment automatically in a sequential manner without disturbing normal operation and keeping all protective functions operative during the test. The ATT facility shall include but not be limited to the following.

1. Opening and closing of Emergency stop and control valves reheat stop and interceptor valve.
2. Over speed trips.
3. Low vacuum trip.
4. Thrust bearing trip.
5. Electrical remote trip.

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ATT mentioned with item 2, 3, 4 & 5 above shall be possible to be carried out on 100% load.

5.1.5 Turbine Stress Control System (TSCS)

A proven Turbine Stress Control System shall be provided which shall work in conjunction with turbine governing system and ATRS and achieve the following functional requirements.

1. Continuous on-line monitoring of thermal stress levels in all critical parts of the turbine such as main stop valves, control valves, HP casing, HP shaft and IP shaft etc.
2. Continuous on line computation of stress margins available for the above-mentioned critical components of the turbine during various regimes of operation i.e. run-up, synchronization, loading, load maneuvering, normal operation, run backs, unloading, shutdown etc.
3. Computation of the limits of speed and load changes allowable at any particular instant before synchronization and after synchronization respectively. The system shall be designed to inhibit further operation like speed/steam temperature raising or lowering wherever upper and lower temperature margins are not available (during periods prior to synchronization) and load/steam temperature raising or lowering whenever upper/lower load/temperature margins are not available (after synchronization) within allowable limits.
4. Carry out a fatigue analysis for all affected components of the turbine and also to compute the percentage service life consumption of the turbine.
5. Display the stress margins etc. on a separate dedicated color VDU/Printer as well as on OWS for operator guidance and storage of necessary data such as percentage service life consumption etc.
6. Store long term data & carry out Residual Life Analysis.

The system shall be complete including measuring transducers for generator load and wall temperature, measured value processing modules, microprocessor based controllers for stress calculations and turbine life calculations etc., dedicated color CRT monitor etc.

5.1.6 Turbine Supervisory Instrumentation System (TSI)

1. Vital parameters of the steam turbine shall be continuously supervised and monitored in order to provide information related to the operational conditions of the turbine during various stages of the operation like start-up, loading, load changes and shutdown.
2. The measurement system shall include all necessary adapters / mounting pads, sensors mounted on the turbine, sensor housings, flexible leads for connection to junction boxes, circuitries for processing the sensor signal along with power supply monitoring, signal level monitor, test circuits, trip relays etc. to generate information about the following parameters, as minimum

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- a) Absolute as well as relative shaft vibration measurement, of each bearing in both X & Y direction (both for Turbine & Generator bearing)
 - b) Differential expansion of rotor & cylinder for HPT, IPT & LPT.
 - c) Overall expansion of HPT & IPT.
 - d) Absolute bearing vibration measurement of each bearing in both X &
 - e) Y directions (both for Turbine & Generator bearings)Stator winding
 - f) Vibration measurement in radial & tangential directions.
 - g) Axial shift of the rotor (3 Sensors)
 - h) Turbine speed (3 Sensors)
 - i) Emergency stop and control valve position
 - j) Main Steam and hot reheat steam inlet temperature and pressure
 - k) Turbine bearing and casing metal temperature
 - l) In case of vibration, shaft mounted reference detectors and required supervisory instrument circuitry shall also be provided.
 - m) Any other measurement recommended by the Turbine manufacturer or required for the safe & reliable operation.
3. For all vibration measurements indicated above viz. bearing vibration and shaft vibrations, computer based system shall be provided to achieve the following functions:
 - a) Online spectrum / harmonic analysis.
 - b) Identification of the exact nature of failure resulting in increase in bearing vibration and direct message on the TFT indicating the exact nature of fault e.g. mal-alignment, shaft crack, bearing looseness etc. through use of intelligent software packages.
 - c) Storage and comparative analysis of vibrations.
 - d) Generation / Analysis of Bode Plot / Orbit Plot and time waveform / Nyquist plot etc.
 4. All the vibration parameters as well as turbine supervisory parameters shall also be fed to the Plant DCS through hardwiring as well as soft link so that all these parameters are suitably displayed on the OWS/LCD. All required I/O cards and software interface modules shall be provided for this purpose.
 5. Test calibration jigs for site calibration of all sensors of TSI System shall be provided. Telephone jacks shall be incorporated in all the cubicles for communication during site calibration etc.
 6. The system shall be adequate for providing necessary information for balancing various sections of the TG, shall be from the latest proven range of reputed manufacturer with proven experience in similar application, shall have suitable

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interface with Plant DCS for integrated data archiving and display. Brief specifications are as follows:

a) Bearing Vibrations

- The seismic type pickup shall be mounted on the bearing pedestal.
- The measurement of shaft vibration shall be carried out in a contact less manner according to the eddy current method.
- The measurement system shall be designed to operate satisfactorily over the frequency range and shall measure the amplitude of displacement. Failure of sensor and field cables shall be annunciated.

b) Absolute Shaft Vibrations

Measurement of absolute shaft vibration shall be done by the measuring the relative shaft vibration with respect to the bearing pedestal and by adding the bearing vibration to it.

c) Axial Shaft Position of the Rotor

- The measurement shall continuously monitor the position of the shaft in the thrust bearing and on wear of the bearing, as axial shift beyond permissible limits would lead to mechanical interference and surface rubbing.
- The measuring principle shall be carried out in a contact less manner based on eddy current principle.

d) Relative Expansion

Relative expansion of HP, IP and LP turbines shall be monitored by contact less measurement for relative displacement between casings and rotors of the turbine due to their different thermal inertia particularly during start up and in case of major load changes.

e) Absolute Expansion

- This measurement shall be carried out at the front pedestal as well as at the middle-bearing pedestal.
- The displacement sensor shall be mounted on the foundation and connected to the casing.

f) Valve Position

The measurement shall be carried out for both the HP and IP control valves and stop valves with the help of (non-contact) displacement sensors.

5.1.7 Steam Turbine Water Induction Prevention (TWIP) Logic

The turbine water induction prevention logic detects the presence of potential water admission sources, disposes of accumulated water, and isolates the

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turbine from the water source as required. The turbine water induction prevention logic shall be designed in accordance with ASME Standard TDP-1.

The TWIP logic so developed shall:

1. Prevent water accumulations by inhibiting the use of attemperation sprays at low loads.
2. Prevent the carry-over of water from sources such as the boiler and Deaerator.
3. Dispose accumulation of water in low point drains by forcing drain valves open during low load operations and prior to turbine startup.
4. Isolate heaters on High level resulting water ingress inclusion of gland seal condenser.

The TWIP logic shall be implemented in the Turbine Protection system. The logic shall be implemented in three trains, with each train receiving process status information through separate input cards. In addition, process status information shall be transmitted to the Plant DCS via the data highway. The Turbine Protection System outputs which act to trip the steam turbine via its proprietary control system shall also be from separate cards and shall be configured in a 2-out-of-2 de-energize to trip scheme.

5.1.8 HP/LP Bypass System

5.1.8.1 HP Bypass Control System

HPBypass System shall consist of integral type pressure reducing and de-superheating stations (PRDS) along with integral type de-super heater, the integral type de-super heater getting spray water from Boiler Feed Pump discharge.

The system shall consist of steam pressure control loop & steam temperature control loop. HP Bypass system shall be implemented through a set of redundant controller modules, I/O modules, primary sensors etc. & suitably interface with other SG C&I controls like BMS.

Pressure and temperature measurements for control of HPBP system shall be in 2/3 voting circuit.

Spray Control valves for HP Bypass system shall be pneumatically operated.

The system shall have control provision from CCR and shall have necessary control oil unit, pressure gauges, temperature elements and transmitters.

5.1.8.2 LP Bypass Control System

LP Bypass System shall consist of integral type pressure reducing and de-superheating stations (PRDS) along with de-super heater, de-super heater getting spray water from Condensate Extraction Pump discharge.

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The LP Bypass control system shall consists of steam pressure control loop and steam temperature control loop. LP Bypass system shall be implemented through a set of redundant controller modules, I/O modules, primary sensors etc. & suitably interface with other SG C&I controls like BMS.. Further condenser exhaust hood spray valve shall be interlocked to open whenever LP Bypass comes into operation.

Pressure and temperature measurements for control of LPBP and Auxiliary steam system shall be in 2/3 voting circuit.

Spray Control valves for LP Bypass system shall be pneumatically operated.

The system shall have control provision from CCR and shall have necessary control oil unit, pressure gauges, temperature elements and transmitters.

5.2 General Requirements of Generator Auxiliaries

5.2.1 Generator Auxiliary Control

Generator auxiliary control shall be done from the TG control system & operation shall be from Operator's Console assigned for TG in CCR. The console shall be utilized to perform operation of complete system including excitation, automatic synchronization, generator circuit breaker operation, seal oil system, Hydrogen cooling system including hydrogen drier, Generator cooling system, load control etc. with required indication & metering of active power, reactive power, power factor, energy meter & annunciation. Complete field instruments comprising of transmitters, switches, local gauges, analyzers, local panels, duplex temperature sensors etc. shall be provided for complete system.

In general three sensors shall be provided for protection.

5.2.2 Generator Gas System

1. Generator Gas System should have:

Control cubicle / panel for gas system to house all the instruments and control valve required to fill and empty the generator casing and to monitor the normal operation of the gas system. A suitable regulator shall be provided within the cubicle to maintain the casing gas pressure at the required value and to take care of any leakage with hydrogen gas from the gas cylinders connected to manifold. The cubicle shall also include a three range explosion proof gas analyzers, indicators for indicating gas temperature, H₂ and CO₂ manifold pressure, moisture content meter, casing gas pressure and the differential pressure across the generator fans. Signals shall also be provided to Plant DCS operator console for remote monitoring.

a) Moisture in Hydrogen measurement shall be of sampling type. A sample handing system provided with flow and pressure control device, flow

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chamber and drain valve for oil draining in presence of oil shall be provided. Use of direct insertion type probe shall be avoided.

- b) The system shall include adequate number of pressure, temperature and differential pressure switches, liquid leakage detectors etc. for various alarms and interlocks.
 - c) Explosion proof gas pressure transmitters for H₂ pressure in the casing and manifold for remote indication.
 - d) All instruments, controls etc. to be supplied with H₂ system shall be of explosion proof design.
2. In addition to the above following instrumentation shall also be considered:
- a) Pressure indicator for the pressure of hydrogen in the hydrogen manifold.
 - b) Pressure indicator / local gauge for gas pressure inside the generator.
 - c) Gas purity indicator
 - d) Temperature indicator for hot and cold hydrogen inside casing
 - e) Dew point indicator for casing hydrogen across drier inlet and outlet lines
3. Following alarms & annunciation shall be provided in Plant DCS operator consoles:
- a) Hydrogen pressure in generator casing Low/High.
 - b) Hydrogen pressure in hydrogen cylinders-Low
 - c) Pressure of cooling water hydrogen coolers Low/High
 - d) Purity of hydrogen in generator casing-Low
 - e) Liquid level in the generator casing – High
 - f) Temperature of cold/hot gas in the generator - High.
 - g) Dew point level, in hydrogen gas across the drier inlet and outlet lines– High.
 - h) Hydrogen leakage into cooling water

5.2.3 Generator Seal Oil System

1. Generator Seal Oil System should have:
- a) Dial type mercury in steel thermometers for measuring the temperature of cooling water, seal oil.
 - b) Twin resistance temperature detectors for measuring and recording the temperature of seal oil.
 - c) Pressure gauges at the outlet of each pump, Cooling water pressure at inlet to oil coolers, hydrogen side and air side seal oil pressure at inlet to seals.
 - d) Differential pressure indicators and differential pressure switches across the strainers to check their performance and for annunciation of choking. Flow

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indicators to measure seal airflow through seals and cooling water flow through oil coolers.

- e) Adequate number of pressure, temperature and differential pressure, and level switches and transmitters shall be provided for alarms interlocks and monitoring of parameters at Plant DCS.
 - f) Adequate number of sensors / transmitters shall be provided for unit interlock and protection requirement.
 - g) Adequate number of liquid detectors at the bottom of the generator tank to detect any liquid leakage into the seal oil. The detector shall have potential free contact rated for 0.5 amps at 220 V DC for alarm purpose at high liquid level.
 - h) A water detector with sight glass and drain valves shall be mounted adjacent to the gas manifolds at the end of a pipe connected to the bottom of the generator casing.
 - i) Oil level indicator shall be provided in the different tanks for visual checking of oil level and level switches shall be provided for tank level low, high alarm.
 - j) A local H₂ and seal oil signaling panel with necessary indicators, controls switches and status indication lamps, together with necessary annunciators system shall be furnished. The panel shall be cubical type and shall be provided with suitably rated indirect strip heaters. The instruments mounted on the front of the panel shall include H₂ pressure indicators for gas pressure in the manifold, casing hydrogen purity indicator, indicator for gas temperature leaving the generator gas coolers, seal oil pressure indicator, hydrogen seal oil differential pressure indicator, etc.
 - k) 4-20 mA DC signal for remote indication shall be provided for hydrogen and seal oil differential pressure, hydrogen pressure and hydrogen purity.
 - l) All the local annunciators shall be repeated in the Plant DCS operator consoles in CCR.
 - m) Facility for starting & stopping of drives and monitoring of status at plant DCS.
2. In addition to the above following instruments shall be included in the system:
- a) Pump discharge pressure transmitters.
 - b) Indicators for seal oil pressure at the seal (for both hydrogen and air side stream)
 - c) Indicators for seal oil-hydrogen differential pressure
 - d) Indicators for temp. of seal oil at the seals
 - e) Indicators for thrust oil pressure.
 - f) Temperature elements for measurement of Differential temperature of oil & water across seal oil cooler.

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g) Level transmitters at Seal oil storage tanks and seal oil tank etc

3. Following alarms & annunciation shall be used in Plant DCS operator consoles:

- a) Pressure of seal oil-Low
- b) Pressure of thrust oil-Low
- c) Oil level in hydraulic seal-High
- d) Oil level in hydraulic seal-Low
- e) Automatic switching on of AC standby oil pump
- f) Automatic switching on of DC emergency oil pump.
- g) Differential pressure between oil and hydrogen-High.
- h) Differential pressure between oil and hydrogen-Low
- i) Seal oil temperature -high

5.2.4 Generator Hydrogen Cooling System

The system has adequate nos. of pressure, temperature and differential pressure switches, liquid leakage detector etc. for a various alarms and interlocks. All signals shall be interfaced with Plant DCS for remote monitoring. All instruments, controls etc. for H₂ system shall be of explosion-proof design.

In addition to the above recommended instruments following instruments shall also be considered for remote monitoring:

1. Pressure transmitters on DM water line at I/L & O/L of H₂ and Exciter cooler.
2. Temperature measurements on DM water line at I/L & O/L of H₂ and Exciter cooler.

5.2.5 Generator Stator Water Cooling System

1. Generator Stator Water Cooling System shall have:

- a) A local stator water cooling system, Signaling panel with necessary indicators, controls switches and status indication lamps, together with necessary annunciations system. The panel shall be cubical type and have suitably rated indirect strip heaters. The instruments mounted on the front of the panel shall include:
 - Indicator for primary water flow in the stator winding
 - Indicators for primary water conductivity at the inlet of winding and after the demineraliser.
 - Indicator for stator winding differential pressure
 - Indicators for primary water temp. at the inlet and outlet of stator winding
 - Indicator for primary water pressure at the inlet of stator winding
- b) All the local annunciations shall be repeated in the Plant DCS operator consoles in CCR.

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- c) Adequate number of conductivity meters in the main water circuit and after the demineraliser. Also pH meter shall be provided to monitor the pH of the cooling water.
 - d) Set of flow switches (at least two nos.) to monitor low distillate condition and flow transmitters/meters for primary water to stator winding and main bushing, make up water etc.
 - e) Sets of pressure gauges at the inlet and outlet of stator water filters, differential pressure switches for the filters, differential pressure gauge across stator winding and pressure transmitters as required.
 - f) Set of resistance temperature detectors, local indicators for primary water before and after the generator winding, bushing and cooler. Vapour filled temperature detectors shall also be provided to give signals for high temperatures.
 - g) Set of dial type thermometers for cooling water at the inlet and outlet of the cooler.
 - h) Water level gauge, transmitters, level switches for high and low level alarms and other accessories for primary water tank.
2. Following alarms & annunciation shall be provided in Plant DCS operator consoles:
- a) Water level in the primary water tank- low/high
 - b) Temp. of primary cooling water at the outlet of stator winding – high
 - c) Temp. of primary cooling water at the inlet of stator winding – high
 - d) Flow of primary cooling water to the stator winding – Low/very low
 - e) Conductivity of primary cooling water at the winding inlet – high
 - f) Conductivity of primary cooling water at the winding outlet-high
 - g) Pressure of primary cooling at the inlet of winding – Low
 - h) Differential pressure across the primary water strainer – high
 - i) Stator water cooling pumps tripped
 - j) Differential pressure across stator winding - high.
 - k) Leakage of hydrogen into primary water
 - l) Primary stator bar water temperature – high

5.2.6 Generator Excitation & Voltage Regulating System

1. The Generator excitation & Voltage Regulating system shall be provided with necessary interface equipment for interfacing through suitable protocol with TG integral control system (Turbine Automatic Run up system and Electro-Hydraulic Governing System).

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2. Necessary hardwiring shall be done for signal exchange with TG Integral control system and also with Plant DCS for SOE & alarm logging annunciation etc.
3. Facility shall be provided for operation from Plant DCS OWS/LCD.
4. Facility shall also be provided in Plant DCS OWS/LCD to view Generator capability curve at various operating regions showing actual operating point & MW/MVAR of the generator corresponding to actual situation

5.2.7 Generator Protection & Synchronizing System

1. The Generator Protection & Synchronizing system shall be provided with necessary interface equipment for interfacing through suitable protocol with TG integral control system
2. Necessary hardwiring shall be done for signal exchange with TG Integral control system and also with Plant DCS for SOE & alarm logging annunciation etc.
3. Facility shall also be provided for operation from Plant DCS OWS/LCD.
4. The Status of following shall be provided at Plant DCS OWS/LCD.
 - a) All generator Protection Protective relays
 - b) All alarms from Protection & synchronizing panel.

5.3 Boiler Feed Pumps

Boiler feed pumps shall include:

1. Pneumatic actuators for hydraulic coupling system with all mounting accessories. Standard 4-20 mA DC Signal for I-to-P converter and position transmitter signal interface.
2. Pump and motor bearing vibrations, axial play, speed both at local and remote and key phasor for complete machine monitoring & protection. The system shall be a part of the Vibration Monitoring System with required signal exchange with Plant DCS. Pump and motor bearings temperatures shall also be used for monitoring, interlocks and protective functions.
3. All pressure and temperature stubs, thermo-wells, root valves, impulse lines, gauges, manometers, thermometers, analyzers, sample retrieval system and other instruments for performance guarantee test measurements. Stubs and take-off points for performance guarantee test measurement shall be separate and shall not be shared with online measuring instruments.
4. Pressure and temperature gauges and switches for lube oil, working oil, cooling water, heat exchangers and other important systems and auxiliaries related to basic system performance and safety and for the purpose of monitoring critical parameters.

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5. All level switches, gauge glasses, flow switches, pressure & flow transmitters, RTDs, Thermocouples for complete system with all accessories, for equipment performance and safety.
6. Local gauges board for individual BFP; housing following local gauges & instruments:
 - a) Oil supply pressure and drain oil temperature gauges of each bearing.
 - b) Differential pressure across feed water suction strainers, Discharge pressure of Main and Booster pump, Suction Pressure of the Booster pump, Balance leak-off pressure.
 - c) Lube oil and cooling water temperature at inlet and outlet of coolers.
 - d) Inlet and outlet temperature of seal water and its cooling water.
 - e) Suction and discharge temperature of Feed Water pump.
 - f) Pressure switches for main and booster pump suction and discharge, balance leak-off, lube oil-permissive & trip, Auxiliary Oil Pump cut-in and cut-out etc.
7. Local start-stop facility for feed pump, auxiliary oil pumps, open & close operation facility of cooling water discharge valves, feed water discharge valve, re-circulation valve.
8. Duplex RTDs / Thermocouples for Motor winding and bearing temperature, Thrust bearing of Main and Booster pumps. Journal bearing of Main and Booster pumps, Suction and discharge of Main and Booster Pumps and differential temperature, Bearing drain oil temperature, Bearing temperature of driven and non-driven end of pumps & motors, Seal water outlet temperature at driven and non-driven end.
9. In addition following instruments shall be provided for remote monitoring of parameters at Plant DCS.
 - a) Pump re-circulation flow and Balance leak off pressure & flow.
 - b) Lube oil tank level.
 - c) Lube oil temperature and pressure at strainer outlet.
 - d) DP across lube oil and working oil strainer and feed pump suction strainer.
 - e) Differential temperature across pump suction and discharge.
 - f) Seal water inlet and outlet pressure.
 - g) Cooling water pressure at inlet and outlet of lube oil cooler, working oil cooler and motor amateur cooler.
 - h) Cooling water and lube oil flow at outlet of lube oil cooler.
 - i) All bearing oil pressure and temperature.
 - j) Lube oil temperature at inlet and outlet of Lube oil cooler.

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- k) Open and close indication of all manual isolating valves related to feed water, seal water, DM cooling water.
 - l) Cooling water flow at outlet of motor armature cooler.
 - m) Lube oil temperature at inlet and outlet of working oil cooler etc.
10. Flow elements and transmitters for lube oil, cooling water, working oil or any other auxiliary system as required. Turbine type flow meter may also be used for cooling water and Coriolis type flow meter for oil flow measurement. Flow nozzle for feed water flow measurement may be envisaged.
 11. Feed pump re-circulation valves of suitable size and capacity and having proven background for BFP re-circulation flow service for similar operating condition with pneumatic (0.2-1kg/cm² full stroke) actuators.
 12. Signal cables exposed to high temperature area shall be Teflon coated.
 13. All primary sensors shall be terminated to one master junction box for each pump in accessible vibration free location and all associated cables, conduits, fixtures and raceways from the sensors to the master junction box shall be provided. Termination box for sensors on bearing pedestals is not acceptable.
 14. All stubs for pressure and temperature measurement, root valves, protruding well beyond thermal insulation, level chamber isolating valves, expanders / reducers for impulse pipe connection, take-off nipple pieces up to accessible terminal points, stand pipes, drain and vent valves for level chambers, connecting pipes between the main vessel and level chambers and stand pipes, sampling take off points with isolating valves, matching flanges for instruments with blank flanges, float chambers with isolating, drain & vent valves for level switches, matching flanges for flange-ended control valves, strainers essential for in-line instruments, all trays and raceways for instrument cabling work and all other interfaces for instrumentation. Necessary supports with access shall also be provided.

5.4 Condenser & Air Extraction System

Following instruments shall be provided as a minimum (level instruments shall be mounted on stand pipes with isolation & drain/vent Valves for isolation of instruments):

1. Direct level Gauge for Hotwell level indication.
2. Level transmitters for Hotwell level measurement and control in 2-out- of-3 mode.
3. Direct reading manometer type instrument for local indication of condenser vacuum.

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4. Level transmitters at Hotwell for alarm and safety interlock. 2-out- of-3 logic shall be implemented for safety interlock. Safety interlock shall be configured in separate electronic units.
5. Pressure transmitters for remote indication / recording of condenser pressure in Plant DCS.
6. Conductivity measurement in both sides of the Hotwell. Necessary tapping for insertion type Conductivity probes shall include analyzer probe.
7. Temperature gauge and temperature element for monitoring condensate temperature on CEP suction.
8. CEP minimum Re-circulation control valve.
9. CEP discharge flow and pressure transmitters shall be provided with 1 –out-of-2 voting philosophy.
10. Direct level gauge, level switch, pressure and temperature gauge for gland steam condenser.
11. Measurement of CEP motor winding and bearing temperature at Plant DCS. Necessary duplex RTDs / Thermocouples shall be provided.
12. Flow integrator for measurement of make-up water consumption at DCS.
13. Start, Stop and Status monitoring of pumps at Plant DCS.
14. Start permissive and Trip logic shall be configured in Plant DCS. Critical parameters for trip interlocks shall be configured in 2 out of 3 voting philosophy.
15. Remote & Local monitoring of DP across suction strainer shall be provided.
16. Open and Close indication of suction valves at Plant DCS.
17. Flow transmitters at ejector for monitoring of ejected air flow at Plant DCS.
18. Ejector steam pressure control.
19. Condensate Extraction pumps to HP valve sealing water pressure and
20. Open and Close position indication of respective valves for monitoring at Plant DCS.
21. Open and Close position indication of condensate I/L and O/L bypass valves of gland steam cooler and ejectors for monitoring at Plant DCS.

5.5 Feed Water & Deaerator System

Following instruments shall be provided:

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1. Field instruments viz. pressure gauge, temperature gauge, direct gauge glass, level switches for process and safety interlocks and alarms shall be provided on Deaerator.
2. Temperature gauge and duplex type temperature elements shall be provided at the inlet and outlet of all heaters for both coolant and cooling medium.
3. Pressure transmitters, level transmitters and temperature elements shall be provided for remote monitoring and control of Deaerator parameters in Plant DCS.
4. On LP and HP heaters, level transmitters shall be provided for process alarms and safety interlocks. 2 out of 3 logic shall be implemented for safety interlocks. Each switch used for safety interlock shall be configured in separate electronic unit.
5. Level gauge shall be provided on feed water heaters and Deaerator.
6. Level transmitters shall be provided for remote monitoring and control parameters related to heaters viz. normal and emergency level control.
7. All level transmitters on Deaerator shall be implemented on 2 out of 3 logic for safety interlocks.
8. Open and Close position indication of all manual isolating and vent valves related to Deaerator for monitoring at Plant DCS.
9. Shell temperature measurements for HP and LP heaters.

5.6 Other TG Auxiliary Systems

1. Complete and independent PLC based Control and Instrumentation system with all accessories & associated equipments and cables shall be used for the safe, efficient and reliable operation of the following plant auxiliary systems.
 - a) Condenser Online Tube cleaning system
2. All instruments and control equipments like primary and secondary instruments etc. shall meet the requirements specified in sub-section on Measuring Instruments. In addition, all electrical instrument devices like switches/transmitters/ controllers/ analyzers/ solenoid valves which are located in the field/hazardous locations shall be provided with explosion proof enclosure suitable for hazardous areas described in National Electric Code (USA), Article 500, Class-I, Division-I. All field wiring should be through conduits. All fittings, cable glands etc. shall be strictly as per NEC recommendation article, 500 to 503.
3. ON/OFF control, indication, annunciation of incomers and bus-coupler are also to be performed from respective control system for each of the above system as applicable.

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4. The control system shall be able to operate in non-air conditioned area.

5.6.1 On-line Condenser Tube Cleaning System (OLCTCS)

PLC based system is envisaged for OLCTCS. The PLC & Complete instrumentation system required for this shall be designed for safe & trouble free operation. The PLC shall be linked to plant DCS via soft link for monitoring of the operation of OLCTCS.

Operation of the condenser on-line tube cleaning system & debris filter with necessary audio visual alarm/indications shall be implemented in PLC based Local Control Panel. The system shall be controlled either in manual or Auto mode. Provision for manual override of any automatic operation shall be made available in control panel. Potential free contacts shall be provided for interfacing with MCC & other systems.

1. Start-up of the cleaning system after manually feeding the requisite number of balls into the collector. The above operation shall be achieved by setting the control switch in Auto mode & pressing the System 'ON' Pushbutton. Other steps shall follow sequentially viz. tilting of the screens in the strainers to ball circulating position, starting the recirculation pumps, turning the ball catching Flap in the collector to ball circulation position, etc. In case of manual, all steps shall be achieved manually by pressing the respective pushbuttons.
2. Automatic shutdown of cleaning system either automatically or as required by operator by pressing the stop pushbutton from the local control panel. Under Auto mode, pushing the 'OFF' pushbutton shall initiate the above operation through steps like turning the ball catching flap in the collector to ball catching position, stopping the recirculation pump after a set period.
3. Monitoring of strainer section screen fouling by differential pressure measuring systems.
4. Following indicators minimum shall be provided on Local Control Panel:
 - a) Tube cleaning system 'ON' & 'OFF' status
 - b) Recirculation pump 'ON' & 'OFF' status
 - c) Screen in operation
 - d) DP high & normal status
 - e) MOV open & close status
 - f) Various equipments failure indications
5. Following Alarms minimum shall be provided on Local Control Panel:
 - a) Recirculation Pump Tripped
 - b) DP high/ very high

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c) MOV fail to Open or Close

d) Screen actuator failure

5.6.2 Analog Controls/Close Loop Control System (CLCS) Functions

1. The CLCS shall continuously act on valves or other mechanical modulating devices such as hydraulic coupling etc., which alter the plant operation conditions. The system shall be designed to give stable control action in steady state condition and for load changes in step / ramp over the load range of 60% to 100% MCR with variation or parameters within permissible limits.
2. The controller capability shall, as a minimum, include (i) P, PI, PD and PID control functions and their variations (ii) cascade control (iii) feed forward control (iv) state-variable based predictive control (v) on-off control, (vi) ratio and bias control, (vii) logical operation etc. The loop reaction time (from change of output of the sensor of the transmitter/temperature element to the corresponding control command output) shall be within 250ms. However, for faster loops such as feed water flow control loop the same shall be based on actual process requirement.
3. The loop response time, for conventional I/Os, is the cumulative response time inclusive of input scan time, Controller Execution time and output card throughput time (in other words loop response is the time taken by the system to read a change in field signal at the input card terminal, process the controller task associated with the input and to make the required change in the control output at the output terminal of the output card)
4. The control system shall be bumpless transferred to manual on the conditions such as Control power supply failure, failure of redundant controllers, field input signal not available, analog input exceeding preset value, etc as minimum conditions.
5. Any switch over from auto to manual, manual to auto and switchover from TFT operation to auto manual station operation and vice versa shall be bumpless and without resulting in any change in the plant regulations and the same shall be reported to the operator.
6. Buffered analog output (positioning signal) of 4-20mA DC shall be used from CLCS to the respective E/P converters. For electrical actuators, pulse type output (bound less control) shall be preferred. CLCS shall also provide all the necessary outputs for indicators & recorders with output loop resistance of 500 ohms for each channel of the output module.
7. The system being supplied shall be such that when permissible limits are exceeded, an automatic switchover from an operation governed by maximum efficiency, to an operation governed by safety and availability is affected.

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8. For safety reasons, switchover logics associated with the modulating control loops shall be performed within the closed loop control equipment.
9. Time supervision facility shall be used to monitor the final control element.
10. It shall be possible to block the controller output on a pre-programmed basis.
11. All controllers shall be freely configurable with respect to requisite control algorithms.
12. Whenever, alternate measurement is available for a control input the alternate measurement value shall be automatically substituted in the control loop in case of loss of control input. All necessary software for switching and reconfiguration shall be used. In addition, such substitution shall be balance less and bumpless and shall be reported to the operator.

5.6.3 Binary Controls/Open Loop Control System (OLCS) Functions

1. The OLCS shall include sequence control, interlock & protection for various plant auxiliaries/valves / drives etc. The sequence control shall provide safe and automatic start up and shut down of plant and of plant items associated with a plant group. The interlock and protection system shall ensure safe operation of plant/plant items at all times and shall automatically shut down plant/plants items when unsafe conditions arise.
2. The OLCS shall be arranged in the hierarchical control structure consisting of unit level, group level, subgroup level and drive level (as applicable).
3. It shall be possible to perform automatic unit start up and shutdown by issuing minimum number of command from OWS / LCD. Thus, the unit level shall control all the Control System Blocks and issue appropriate start up and shutdown commands to various blocks of Control System.
4. The group level shall control a set of functional sub-groups of drives. Appropriate start-up and shut down commands shall be issued to the sub-group control and various check-backs shall be received from sub-groups of drives. Each sub-group shall execute the sequential start-up and shut down programs of a set of inter-related drives along with system interlocks and protections related to individual drive falling under that sub-group. The drive level shall accept commands from the sub-groups, push buttons (wherever provided) etc., and transmit them to the respective drive, after taking into account various interlocks and protections and the safety of that particular drive. For HT drive, first-up logic shall be incorporated to indicate the cause of protection / trip.
5. Sequence Control
 - a) A sequence shall be used to move a set of groups and sub-groups from an initial steady state (for instance 'OFF') to a final steady state (for instance

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'ON'). The sequence initiating command for the unit and group level shall be issued from OWS/LCD.

- b) A sequence shall be made of steps. The steps shall be executed in predetermined order according to logic criteria and monitoring time consisting of the interlock & protection requirements and check back of previous step which shall act as pre-conditions before the sequence control can execute the command for that step.
- c) Each step shall have a "waiting time" implying that the subsequent step would not be executed unless the specified time elapses. A monitoring time shall also be defined as the maximum time required in executing the commands of any step and the time required for appearance of check back signals. In case, this is not completed within the specified time, a message shall be displayed and programme shall not proceed further.
- d) Manual intervention shall be possible at any stage of operation and the sequence control shall be able to continue at the correct point in the programme on return to automatic control. Protection commands shall have priority over manual commands, and manual commands shall prevail over auto commands.
- e) Open or close priority shall be selectable for each drive.
- f) The sequence start up mode shall be of the following types:

- **Automatic Mode**

In this mode of operation, the sequence shall progress without involving any action from the operator. The sequence start / stop command shall be issued from the OWS / LCD.

- **Semi-Automatic Mode**

In this mode of operation, once the sequence is initialized, the step progressing shall be displayed on the OWS / LCD. But the step execution command shall be prevented and shall be sent by the operator via the keyboards. It shall be possible to bypass and / or simulate one or more criteria to enable the program to proceed. This facility shall allow the program to be executed even if some criteria are not fulfilled because of defective switching devices, etc., while the plant condition is satisfactory. All the criteria bypassed shall be logged and displayed. It shall be possible to put the system on the Auto-mode after operating it on semi-automatic mode for some steps or vice-versa, without disturbance to the sequence operation.

- **Operator Guide Mode / Test Mode**

It shall be possible to use the sequential control in operator guide mode / test mode i.e. the complete system runs and receives input from the plant and the

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individual push button stations (where provided) / keyboards but its command output is blocked. The whole programme, in this case shall run in manual mode. This mode shall allow the operator to practice manual operation using step and criteria indications. The actual protection should remain valid during this mode of operation also.

6. The sequence shall be started by putting the sequence on 'auto' and on receipt of 'start' command from the OWS / LCD or from a higher-level group / protection action as defined. The sequence shall then progress as per the defined logics. It should be possible to select alternative operation in the same sequence depending on certain process / equipment condition. Some step can be automatically bypassed also based on certain process / equipment condition. When the expected results of the sequence are reached the sequence is considered as "END". If during sequence initialization or sequence progressing or during normal running of the drive, a shutdown criterion is present, the sequence shall be stopped and the shut down sequence initiated.
7. For the drives, the command shall be used through O/P module to MCC / SWGR / Actuator as applicable and input (status, SWGR and process) shall be acquired through input modules. The drive logic shall be implemented in the redundant controller. The status for the HT drives and some other important drives shall also be wired in parallel to redundant input modules so that on failure of the single input modules, the information regarding the status of the affected drive remains available in OLCS.
8. The output modules shall have the feature that ensures that in case of failure, all the outputs are driven to zero. The 24V DC command outputs to drives for ON / OPEN, OFF / CLOSE shall be separate and independent and the inverted outputs shall not be employed. For inching type of drives, position transmitter shall be used.
9. The termination for ON / OPEN, OFF / CLOSE command for the drive actuator shall be performed. These commands to the drives under OLCS shall be given through interposing relays in MCC/ SWGR. However ON/OPEN feedback, OFF/CLOSE feedback, Switch gear disturbance feed back as a minimum shall be monitored in OLCS.
10. The drive function i.e. basic interlocks and protection logic of the drive shall be implemented in redundant controllers. The drive function shall ensure that protection signals for the safety of the drive shall be effective under all conditions and under all modes of operation. The different commands shall be performed according to the priority of protection 'OFF', protection 'ON', manual and automatic. The standard functions like running time monitoring, status signaling, alarm / drive annunciation, etc. shall be performed in drive function. The drive function shall prevent hunting of the actuator in the presence of both

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open and close commands for actuators of the valves and dampers. The drive function shall be implemented in dedicated standard software functional block

5.7 General TG Control System Requirements

The requirements for Control System for TG integral control are indicated on functional basis in this section. It is not the intent or purpose of this specification to specify all individual system components.

The control and automation system and the field instruments and actuators as well as its support systems, power supplies and data networks shall be immune to the electromagnetic interference and shall conform to the internationally accepted standards.

5.7.1 System Configuration

The TG integral control system shall basically consist of:

1. Distributed Processing units (Controllers) for TG Protection, EHGS ATRS, ATT, TSCS.
2. I/O modules
3. Data communication system
4. System Programming & Documentation facility (Engineering Work Station)
5. Interfacing with plant DCS
6. Integrated Annunciation functions

5.7.2 System Expandability

Modular System design shall be adopted for TG control system in order to facilitate easy system expansion. The capability and facility for expansion through the addition of controller modules, I/O cards etc shall be provided. The system shall have the capability to add any new control loops, groups / subgroups in control system, while the existing system is fully operational. The future expansion shall be expandable to allow at least 50% only by addition of extra modules without removing or modifying any existing hardware.

5.7.3 Online Maintenance

It shall be possible to remove / replace modules online (like I/O module, interface modules etc.) from its slot for maintenance purpose without switching off power supply to the corresponding rack. System design shall ensure that while doing so, undefined signaling and releases do not occur and controller operation is not affected in any way (including any control loop trip to manual, etc) except that information related to remove module is not available to controller. Further, it

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shall also be possible to remove / replace any of the redundant controller modules without switching off the power to the corresponding rack and this shall not result in system disturbance or loss of any controller function for the other controller. The on-line removal / insertion of controller, I/O modules etc. shall in no way jeopardize safety of plant and personnel.

5.7.4 Fault Diagnostic

The control system shall include on-line self-surveillance, monitoring and diagnostic facility so that a failure / malfunction can be diagnosed automatically down to the level of individual channels of modules giving the details of the fault on the Engineers Work Station (EWS) monitor and printers. The faults to be reported shall also include faults in main and standby power supplies, sensor fault, Controller fault, any channel fault in 2V3 channels, failure of links to other systems. These faults shall be identified by local indication on the faulty channel / module and on respective rack / cubicle. The diagnostic system shall ensure that the faults are detected before any significant change in any controller output has taken place.

5.7.5 Fault Tolerance & Controllability

1. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is jeopardized. Control System shall be designed to prevent abnormal swings due to loss of control system power supply, failure of any control system component, open circuits, instrument air supply failure etc. On any of these failures the control system output shall either remain in last position before failure or shall come to fully open / close or on / off state as required for the safety of plant / personnel / equipment. System shall be designed such that there shall be no upset when Power is restored.
2. No single failure either of equipment or power source shall be capable of rendering any part / system / sub-system of control system inoperative to any degree or loss of generation.
3. No single failure, whatsoever in any part of Control system result in loss of communication.
4. The controlled variable response rate and controllability shall be limited by the characteristics of main equipment, which is being controlled, and control system shall not impose any limitations in the response rate or controllability. Controlled process variables shall return to normal values in a stable manner and without control loop interactions or cycling of generation when generation matches with load demand.

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5.7.6 Signal Exchange

1. All the signal exchange between various functional groups of each control group shall be implemented through redundant main system bus and local system bus within a subsystem as per standard practice. It shall be ensured that any single failure in electronics involved for such communication e.g. communication controllers, bus interface modules, physical communication media, etc. does not result in loss of such signal exchange and there is no deterioration in specified system response and system parametric requirements. In case a controller utilizes some inputs generated / processed by any other controllers / functional group and the requirement of controller response time as specified is not met due to inadequate communication rate / procedure, then it shall provide hardwired signal exchange for such inputs.
2. However critical signal exchanges are found required shall be hardwired. Control and Protection signal exchange between control system of TG and Plant DCS shall be hardwired only. Protection signals shall necessarily be hardwired even for exchange between the same sub-systems.

5.7.7 Redundancy

The Following shall be completely redundant:

- All the parallel & serial communication buses
 - All the communication devices
 - All the Process controllers
 - Servers (if Server based system)
 - All the Power Packs
 - Critical drives related I/O Modules.
1. The redundant communication buses between the process stations and the operator supervision stations shall follow different paths. The redundant processor shall be connected to the same I/O's of the processor that it is associated to and shall be able to carry out all the operations assigned to this processor. In the case of a processor failure, the redundant processor shall become operative within the cycle time, without causing any loss of data or the interruption of the process control. The switch between the processor being utilized and the reserve processor shall be bump less and shall be within 20 ms which shall not cause any interruptions or stopping of the station functions. Furthermore, this switch must also be signalled by a high priority alarm.
 2. The operator station shall be able to guarantee, from any work station. The operator station electronic units shall be in dual configuration and independently connected to the system buses. In case of an operator stations failure, the station shall remain operative without the operator having to carry out any type of action. Each operator electronic unit and each process station shall be

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powered by redundant power packs those are able to power the entire load. In case of a failure, the switch between the power packs shall not cause stops or interruption in the carrying out of the station functions. The switch between the power packs shall be signalled by a high priority alarm.

3. In order to establish a high degree of system availability, the various control systems which comprise the overall unit control system shall be configured such that no single component failure can cause a failure or mal-operation of critical automatic or manual control functions. The failure of a redundant component shall be alarmed to the operator to allow on-line removal/replacement or at the first shutdown opportunity. The system's redundancy schemes shall be designed such that the transfer from any critical element to its redundant backup shall occur without upset to normal process control or to system displays, data collection, or other normal DCS functions within 50 m sec.
4. The signal distribution from sensors which are shared due to process restrictions between control loops, logics, monitoring purposes shall be as follows:-
 - a) In the case of multiple inputs to a card, input cards used shall be restricted to a maximum of 16 inputs per card for analog input and 32 for digital inputs.
 - b) In case there is either process redundancy (Left, Right) or transmitter or switches redundancy, the inputs shall be routed through independent input cards.
 - c) No two control loops/interlock loop shall share the inputs (either binary or analog) wide input cards if process signals are independently available.
 - d) Protective inputs for two drives shall not be allotted to the same input card.
 - e) Output cards shall be independent for each control loop.
 - f) For outputs to HT and LT motors, the following shall be adopted :
 - g) Each HT motor and unidirectional drives shall have dedicated output cards. No other drive shall be combined with HT motor drive output card. However indication outputs can be driven from this output card for the concerned logic loop.
 - h) Not more than two bidirectional drives shall share one output card.
 - i) For unidirectional drives, not more than one drive shall be allotted to one output card.
 - j) For signal distribution or fan-out, suitable electronic cards (opto couplers) shall be used.
 - k) The processors shall contain the logic required to group individual process and system alarms into common groups as well as the annunciation sequence logic.
5. Redundant components and equipment within given systems shall be distributed among processors and I/O cards to the extent practical.

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6. Critical inputs shall be supplied with redundant sensors/transmitters with each input connected to different input cards. Where redundant inputs exist, the DCS shall be configured to automatically reject erroneous data. Where required, one-of-two, two-of-two, two-of-three, or median select schemes shall be utilized to ensure the integrity of critical inputs.
7. The use of redundant outputs driving the same final element or equipment shall generally be avoided in favour of failsafe design and redundancy of the plant equipment.
8. The operator stations shall be identical in capability and independently linked to the system. Although these stations shall be normally dedicated to a specific function, any station can replace the function of any other station at any time.
9. All power source and power conditioning equipment in the system shall be redundant.

5.7.8 System Spare Capacity

Philosophy shall be followed for the spare capacity of the TG and Auxiliaries Control system (refer Subsequent section 6.2.7).

1. Following philosophy shall be followed for the spare capacity of the TG and Auxiliaries Control system:
 - a) Twenty (20) percent spare channels in each of the functional groups for each type of input/output modules fully wired up to marshalling / field termination cabinet TBs.
 - b) Ten percent (10%) installed spare I/O modules which may be capable of hot swapping.
 - c) Wired-in "usable" space for 20% modules in each of the system cabinets for mounting electronic modules shall be provided for future use. Empty slots between individual modules / group or group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice, shall not be considered as wired-in 'usable' space for I/O modules. Field Terminal assemblies, PCB / Connectors, corresponding to the I/O modules shall be provided for above mentioned 20% blank space, distributed proportionally to main population.
 - d) Each controller shall have 40% spare functional capacity to implement additional function blocks, over and above implemented logic / loops. Further, each controller shall have spare capacity to handle minimum 40% additional inputs / outputs of each type, over and above implemented capacity. Under worst loading condition, Controller should not be loaded beyond 60%. Each of the corresponding communication controllers shall also have same spare capacity as that of controller.
 - e) The data communication system (including main system Bus and other bus system) shall have the capacity to handle the additions mentioned above.

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- f) Each Communication Network Switch shall have 20% spare ports.
 - g) Twenty (20) percent spare relays of each type and rating mounted and wired in relay cabinets. All contacts of relays shall be terminated in terminal blocks of relay cabinets. In each of the relay cabinets 20% spare terminal blocks shall be provided so that additional relays can be mounted and wired.
 - h) For power distribution board 20% spare feeder fully wired ready for use with MCBs fuses, TBs etc. Other hardware such as signal distribution isolation, trip amplifiers etc. shall be provided with 20% spares wired ready for use.
2. Sufficient and additional software capacity shall be available in the system to take care of spares requirement as specified above to meet all functional requirements. The calculation for processor power and memory for all nodes should be furnished. Also, the dynamic processor load for all nodes either in terms of idling time or percentage load shall be available in VDU.
 3. The spare capacity as specified above shall be uniformly distributed throughout all functional groups. The system design shall ensure that above mentioned additions shall not require any additional controller / processor / peripheral drivers / cabinets in the system delivered at site. Further, these additions shall not deteriorate the system parametric requirement like response time / duty cycle etc. from those stipulated under this specification and shall meet other redundancy / functional requirement.

5.7.9 System Programming & Documentation facility

1. Programming facility (Engineering Workstation) shall be provided for Control system and system documentation.
2. The programming tools shall have in-built safety features that shall protect the system against inadvertent and unauthorized use of these tools. Necessary hard key locks and software locks, etc. shall be used for this. During on line programming, external plant / equipment should not be affected.
3. The system shall also have facility to permit the programmer to add text information at the beginning and end of each program, wherein programmer shall list out his name, time, date of change which has been made, name of the person who has authorized the change, etc.
4. Any modification done in Control System shall be suitably logged so that it can be traced to the user log-in ID and time of change
5. Structuring / configuring and tuning facilities shall be provided for structuring / modification, storing / loading, testing, tuning, monitoring, etc. of all the microprocessor based controllers of the control system. The configuration and tuning unit shall be hooked up with the system bus. In case different hardware is employed for different parts of control systems and it is not possible to provide structuring/ configuration and tuning of these from the same station.

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6. It shall be possible to configure the system with ease without any special knowledge of programming or high level languages. Control strategy shall be implemented using familiar and conventional automation function blocks (software implemented). Whenever any change in configuration is done, it shall be recorded and modified configurations shall be available for printing and documentation and shall be stored in non-volatile memory. The entire system configuration, tuning / fixed parameters shall be documented and printed in form of function diagrams and lists respectively.
7. On-line tuning of the control loops shall be possible without causing any disturbance in the execution of the control loops. Provision to store and retrieve on immediate and long term basis the system configuration, data base etc. on some device such as DVD shall be included. Facility shall be used to reload / down-load the system or controller module from the already stored data, on-line.

Table 5.1
Specifications for Engineering Work Station

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 series or better
2	Configuration	Tower
3	Internal Clock	3.2 GHz
4	Architecture	64 Bit
5	Video Card	PCI
6	System Memory	4 GB or better
7	Hard Drive	1 TB
8	Cache	2 MB
9	CD Drive	52X DVD R/RW
10	Audio Controller	16 bit
11	Operating System	WIN NT or higher
12	Graphic Accelerator	8 MB (minimum)
13	Monitor	

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S.No.	Features	Minimum Requirements
a	Type	TFT Color Monitor
b	Screen Diagonal	21"
c	Display	XGA or better
d	Resolution	1280 X 1024 32 bit color support
e	Degree of Protection	IP-30
f	Power supply	230 V, 50 Hz
g	Ambient Temperature	0-50 *C
h	Humidity	95% non condensable

5.7.10 Data Communication System

1. The Data Communication System shall include a redundant System Bus for major subsystems with hot back-up. The data highway shall be high speed digital links of speed preferable 10/100 M baud. Bus protocols at control levels shall conform to OPC compliant ISO-7 layer protocol in master less, token ring or token bus (as per IEEE 802) or any standard proven and acceptable protocol in deterministic mode. Extensive error checking (CRC-16/12) or error correcting codes shall be used in these levels to improve the reliability of communication.
2. Redundant communication controllers shall be used to handle the communication between each functional group of controllers of Control System and the System Bus. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station / module connected to the system bus shall not result in loss of any communication function to and from any other station / module.

5.7.11 Sequence of Event Recording System

1. The DCS system shall perform the SOE functions like stamping of SOE inputs / points with 1 ms resolution. The SOE function shall be built-in function of DCS.
2. SOE shall be capable of accepting minimum 512 inputs per unit including 10% spare channels (included in total 512 inputs).

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3. The system shall monitor SOE inputs with a resolution of one millisecond at all times for all inputs including spare inputs. That is, all SOE points entering status change shall be reported and time tagged within 1 (one) millisecond of their occurrence. Input card shall be equipped with digital filters with filter delay shall be such that it should meet SOE time resolution of 1 msec (identical for all points) to eliminate contact bounce such that field contact which is changing state must remain in the new state for stipulated time to be reported as one event. The start of data collection for SOE report shall be reported to OWS within 1 sec of SOE data collection initiation.
4. SOE shall be envisaged as an integral part of DCS with 1 millisecond time resolution. The SOE data base shall be an integral part of the DCS database and same shall be made available at all the OWS / EWS resident on the network. Operator can access the SOE on activation of SOE alarm page. All SOE inputs shall have real time "time-stamping" following any tripping of major equipment, or sub-system or the plant as a whole.
5. The SOE system of Plant DCS shall collect process and report SOE inputs of TG control system for a consolidated master SOE system. Necessary communication with required hardware & software at TG control system end and engineering co-ordination with Plant DCS supplier shall be done for successful implementation of a consolidated master SOE system. Consolidated master SOE system shall be used by the Plant DCS supplier.
6. The system shall have provision of rejection of chattering inputs.
7. The system shall have the facility for adding a field adjustable software delay on as per point basis.
8. The system shall also include provision for historical storage and retrieval of SOE reports for 3 months period.
9. The SOE report collection shall begin on occurrence of change of status of any SOE point and shall be printed after an operator selectable time interval of 1 to 3 min. or 100 status changes have taken place after the first event. Adequate numbers of buffers shall be provided to prevent loss of data before transferring to HSR.
10. SOE reports shall include a list of major equipment trip in chronological order and include the points that initiated SOE collection. The inputs for SOE shall include
 - a) Hardwired inputs in input cards and
 - b) Calculated points / generated points of Control System.
11. All the operator initiated actions such as trip inactivation (bypass) & trip activation (inline) shall form input to SER.
12. All the SOE inputs shall also be available for interlock / protection functions.

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13.SOE of other systems (SG/TG integral control systems) shall also be integrated in this system. The SOE system shall collect process & report SOE inputs of SG & TG control system for a consolidated master SOE system. Necessary communication with required hardware & software and necessary engineering co-ordination with SG & TG Supplier shall be done for successful implementation of a consolidated master SOE list.

14.SOE time stamping shall occur at I/O level.

15.Self Diagnostic Features like scanner test (a periodic test for communication between several levels), functional test by simulating abnormal Conditions shall be provided.

16.One (1) no dedicated SOE viewing station with SOE Log printer shall be provided.

5.7.12 Historical Storage & Retrieval System

The HSRS of Plant DCS will collect store and process system data from TG control system for a consolidated master HSRS system. Necessary communication with required hardware & software at TG control system end and engineering co-ordination with Plant DCS supplier shall be done for successful implementation of a consolidated master HSRS system.

5.7.13 Master & Slave Clock System

A Global Positioning Satellite (GPS) based Master Clock System will be provided by the Plant DCS supplier. Necessary signal output for time synchronization from Master Clock System will be made available to the TG control system to have common time reference.

5.7.14 Power Supply & Grounding

1. Redundant UPS power feeder for all 230VAC equipments and/or redundant feeders for 24 V DC are required for TG control system requirements.
2. Make suitable arrangements with redundant distribution boards for each system with proper auto change over scheme to change the load from one feeder to other, in case of one feeder failure.
3. All panels, desks, cabinets shall be used with a continuous bare copper ground bus. The ground bus shall be bolted/ welded to the panel structure and shall efficiently ground the entire structure. All individual cabinet grounds shall be connected to separate earthing riser to be provided for C&I system signal grounding. The grounding requirements of various parts of the C&I system shall be properly co-ordinated with design of plant earthing system.

5.7.15 System Cabinets/Panels

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1. All Control system modules, power supply components, other control devices which are required for completeness of the system shall be housed in cabinets. All equipment and dedicated cabinets required for termination, marshalling and proper interface within system and also with other systems shall also be provided.
2. The cabinet mounted equipments shall be fully assembled, installed in mounting racks, wired and fully tested as per specification requirements and approved drawings in the manufacturing works of a qualified manufacturer prior to shipment to the project site. It shall be ensure that the cabinets are complete and ready for installation before dispatch from manufacturing works. The installation work at project site for these cabinets should only involve connections through multi pair cables from marshalling cabinets (wherever provided) to system cabinets and inter-cabinet.
3. The Control system cabinets shall be grouped into physically separate cabinets as follows:
 - a) Control System Cabinets
 - b) Marshalling Cabinets
 - c) Relay Cabinets

However, in case the system design requires the termination cabinet independent from system cabinet, the marshalling cabinets can be combined with the termination cabinet. In case, the termination arrangement is part of the system cabinet, independent marshalling cabinets shall be provided.
4. A special note shall be indicated that in case termination of field cables directly to control system cabinet is not acceptable.
5. The Control system cabinets shall house all types of modules / hardware to achieve all functions of Control System including signal conditioning modules, controller modules, I/O modules, communication controller modules and all other requisite hardware for a complete system.

5.7.16 System Software Requirement

1. The system shall be provided with all licensed software packages with media required by the system for meeting the intent, functional / parametric requirements and performance requirements of the specification.
2. The system shall utilize a readily upgradeable, public domain software platform proven for real-time operation environment at the control and monitoring level overlaid with a relational database program. The desirable features are indicated below:
 - a) The software system shall be fully modular.
 - b) The software shall meet the following general requirements:

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- Simple, easy-to-learn editing language for editing and on-line operation.
 - Wide range of standard and non-standard peripheral support capability by modular controllers / supervisors.
 - Effective task scheduling and support of multiple priority structure including event based interrupt etc.
 - Effective debugging.
 - Provision for on-line editing and program development without interrupting on-line functions.
 - Self-diagnostic routines.
 - Efficient memory management and effective utilization of system time.
 - Quick start-up and loading.
 - Support of multiprogramming and multi-user operation.
3. Industry standard operating system like UNIX/WINDOWS NT etc. to ensure openness and connectivity with other system in industry standard protocols (TCP / IP etc.) shall be provided. The system shall have user oriented programming language & graphic user interface.
 4. All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics / debug software, peripheral drivers software shall be provided. Latest versions of standard PC-based software for database handling, word-processing, spread sheet, Anti-virus etc. and latest WINDOWS based packages etc. and any other standard language offered shall be furnished as a minimum. Systems having program development environments like EWS, Station LAN Server shall have high level programming support like Microsoft Visual Studio, Oracle, RDBMS etc.
 5. The programming language shall support Relational Data Base Management in a global and truly distributed Client-Server environment and shall have the following minimum features:
 - a) Modern high-level block structures type
 - b) Powerful, compact syntax
 - c) Logical organization that facilitates documentation, modification and maintenance of programs
 - d) Early detection of errors at compiles and run time
 - e) Fast debugging
 - f) Improved program reliability
 - g) Clearly defined data structure complemented by flexible user-declared data types
 - h) Fast execution.

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6. All application software for control system functioning like input scanning, acquisition, conditioning, processing & control along with communication among various Control System functional blocks shall be provided.
7. The system shall be provided with software locks and passwords to engineers at site for all operating & application software in order to prevent unauthorized access and only authorized engineers are able to do modifications at site.
8. Two sets of all final / latest software on non-rewritable/non-editable media shall be provided as back-up.
9. **Software License**
 - a) The system shall be provided with software license for all software being used in the DCS system. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware / machine-specific. That is, if any hardware / machine is upgraded or changed, the same license shall hold good / renew license due to up-gradation / change of hardware / machine in control system at site. All licenses shall be valid for the continuous service life of the plant.
 - b) In case the s/w license is dependent on no. of points, then quantity to be considered is 30% above the finally implemented points.

10. Software Upgrades

The system software's installed in the plant DCS shall be periodically upgraded with the new releases, that would be taking place after the system is commissioned.

5.7.17 Measurement Functions Of Control System

All the signals coming into / going out of the Control System shall be routed through marshalling cabinets. The input / output modules employed in the Controls System shall be separated from controller hardware.

5.7.17.1 Analog Signal Conditioning & Processing

1. The conditioning and processing functions to be performed as a minimum for the analog input coming for control and information purpose are:
 - a) Galvanic isolation of input signals for which power supply source is other than the measurement system of the control system.
 - b) Transmitter power supply with per point fuse protection or current limiting and power supply monitoring.
 - c) Transducer / transmitter signal output limit check
 - d) Implementation of multiple measurement schemes
 - e) Square root extraction
 - f) Pressure and temperature compensation.

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- g) On-line ADC gain and drift monitoring and correction at periodic intervals.
 - h) Linearization of temperature signals (from thermocouples and RTD through temperature transmitters).
 - i) Reasonability checks for all analog inputs.
 - j) Monitor sensor wire break / open circuit / short circuit and take suitable actions in logic / loop. (This shall include blocking of trip signals in case of RTD failure).
 - k) Rate of rise / fall calculation
 - l) LVM generation.
2. All analog signals for control purpose shall be acquired, validated, processed and their respective Controller data base updated at a maximum interval of 250 ms except for some fast-acting control loops for which the above referred time shall be as per process requirement. The validated analog inputs shall be converted into engineering units on per point basis. Analog input processing (scanning to alarm checking) shall be performed once every scan cycle.
 3. The analog 4-20 mA input cards shall have input loop resistance ≥ 250 ohm for interfacing transmitters / analyzers giving 4-20 mA DC signals along with superimposed HART interface signals. 4-20 mA DC signal shall only be used for control purpose and superimposed HART signal shall be used for configuration, maintenance, diagnostic and record keeping facility for electronic transmitters and Analysers etc.
 4. Triple measurement scheme for analog inputs employing three independent transmitters connected to separate tapping points shall be employed for the most critical measurements. The three signals shall be auctioneered to determine the median / average value, which shall be used for control purpose. In case one transmitter fails or shows excessive deviation with respect to others, it shall be removed from computation of median / average value and the average of the other two transmitter outputs shall be used for controls. The control loop shall trip to manual when any two of the three transmitter signals fail. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.
 5. Dual measurement scheme for analog inputs employing two independent transmitters connected to separate tapping points / temperature element shall be employed for the remaining measurements used for analog control functions. The output of the redundant transmitters shall be continuously monitored for excessive deviation. In case the deviation is within limits, the mean value shall be used for the control loop. If the deviation becomes high (with both transmitters remaining healthy), the loop shall be automatically transferred to manual. However, if one transmitter fails and other transmitter remain healthy, then the output of the healthy transmitter shall be used for control. If the other transmitter also fails, loop shall trip to manual. The outputs of the transmitters

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shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.

6. Individual transmitter signal, their value and selected value for control/measurement shall be available in OWS.

5.7.17.2 Binary Signal Conditioning & Processing

1. The changeover type contacts (i.e. 'NC' + 'NO' together) shall be wired to the controller system for all the binary inputs required for control purposes, except for inputs from MCC / SWGR. The binary inputs required for information purposes only shall be wired to control system in the form of non-changeover type contacts.
2. The conditioning and processing functions to be performed as a minimum for the binary inputs coming for control and information purposes are:
 - a) 24 VDC power supply for contact interrogation for all potential free contacts with per point fuse protection or suitable current limit feature / isolation through optocoupler.
 - b) Contact bounce filtering delay time of 15ms. However for SOE inputs, it shall be 4ms.
 - c) Facility for automatic pegging of the binary signal to logic one / zero or last correct value in case of failure of binary input module.
 - d) Binary signal distribution to different user shall be in such a way so as to ensures that a short / ground fault on one user is not reflected to the other user.
 - e) Implementation of multiple measurement schemes for signals for control purpose.
 - f) All binary signals shall be acquired, validated, processed, alarm checked and their data base updated within one second. In addition to this requirement, binary signals required for SOE shall have resolution of 1 millisecond.
 - g) Checking for excessive number of status changes for all binary / contact inputs and making it off-scan, if the total no. of changes exceeds a limit within pre-defined time.
 - h) The non-coincidence monitoring shall be used for binary inputs for all changeover signals.

5.7.18 Wiring Scheme for Inputs to Control System

1. Each of the triple redundant binary and analog inputs shall be wired to three separate input modules. In addition, for functions employing 2V3 controllers (e.g. BMS protection), each of the redundant binary and analog signals shall be wired to separate input modules associated with each controller. Similarly each of the dual redundant binary and analog inputs shall be wired to two separate input modules. These redundant modules shall be placed in different racks, which shall

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have separately fused power supply distribution. Implementation of multiple measurement schemes of these inputs shall be performed in the redundant hardware. Loss of one input module shall not affect the signal to other modules. Other channels of these modules can be used by other inputs of the same functional group.

2. No single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant input signals to control system. Similarly, no single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant output signal from the control system.
3. The single (i.e. non-redundant) binary and analog signal required for control purpose shall be wired as follows:
 - a) The on-off status of HT drives and Breakers with synchronization provision shall be wired to two input modules in parallel.
 - b) All analog and binary inputs including the limit switches of valves / dampers / MCC / SWGR, check-backs of all drives, SOE and information related signals should be wired to single input modules.
4. It is envisaged to use remote I/O modules in plant areas where it is required from location point of view. The remote I/O signals shall be connected to the respective functional groups through redundant extended I/O bus. The hardware independence of functional groups shall be applicable for remote I/O as well. The remote input / output modules shall be located in cubicles in respective areas. Remote input / output modules shall be designed in such a way to work continuously under the harsh environment expected to be encountered in these areas (high temp, dust level, humidity etc.). It shall be ensured that extending of I/O bus of functional group in field does not result in false signalling / noise pickups. Further, it shall in no way deteriorate the performance of that functional group and Control System.
5. Power supply arrangement for these cubicles shall be similar to DCS System cabinets
6. The measurement system of control system should be capable of acquiring data from various equipment and system in digital form through serial port, field bus/ Profibus, Ethernet connection using industry standard protocols. The control system shall include requisite modules for accepting such signals.
7. The maximum number of inputs/outputs to be connected to each type of modules shall be as follows:

a) Analog input module	16
b) Analog output module	08
c) Binary input module	32
d) Binary output module	32

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8. The following requirements shall be met for analog/binary input / output modules as applicable:
 - a) Input filters to attenuate noise shall be used
 - b) All analog / binary inputs and outputs shall be capable of withstanding 500V DC common mode and 500V AC peak to peak between analog and digital parts. All analog outputs shall be short circuit proof.
9. Any single sensor / transducer / transmitter failure alarm shall be used on Engineer's Station monitors for all sensors / transducers / transmitters. Similarly sensor break alarm for thermocouples etc. shall also be logged and displayed.

5.7.19 Redundancy in Measurement

Minimum redundancy requirement (1 out of 2 or 2 out of 3) of measurements and controls including are given below. For critical Closed Loop controls 2 out of 3 sensors / transmitters shall be provided including 2 out of 3 signals for compensation signals.

Table 5.2
Redundancy Requirements

Parameter	Input Redundancy
Steam Pressure at Turbine Inlet	2 out of 3
HP & LP Heaters Level	2 out of 3
BFP Discharge header Pressure	1 out of 2
Hot well level control	2 out of 3
Deaerator level control	2 out of 3
Gland seal steam pressure control	1 out of 2
Deaerator pressure control	2 out of 3
CEP discharge flow	1 out of 2
CEP discharge pressure	1 out of 2
BFP Suction temperature	2 out of 3
BFP discharge temperature	2 out of 3
BFP recirculation flow	1 out of 2
Turbine lube oil pressure	2 out of 3
Turbine control oil pressure	2 out of 3
Feedwater Flow	2 out of 3

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6 DISTRIBUTED CONTROL SYSTEM (DCS)*{TO BE DELETED, IF ALREADY PROCURED UNDER SG PACKAGE.}***6.1 General Requirements**

1. The requirements for Distributed Control System are indicated on functional basis in this specification. The System shall be state of the art microprocessor based & of proven design, the performance & high availability having adequately demonstrated over a substantial period of successful operation.
2. The system shall have distributed intelligence architecture and shall comprise independent multifunction processors for execution of open loop and closed loop control and data acquisition functions.
3. If DCS & other common system/items (CMMS, STMS, Station LAN, SWAS, Master Clock System etc.) have been procured under SG package, then chapter-6 for DCS, and other common system/items shall be deleted from TG package.
4. The microprocessor based Distributed Control System shall have following capabilities:
 - a) Scan, acquire, validate, time-tag, process, store, update, archive, retrieve and display all analog and digital data and parameter.
 - b) Monitor real and calculated variables for multi-level alarm conditions.
 - c) Accept and execute operator's commands and pre-programmed routines and run-times.
 - d) Perform all open and closed loop control functions.
 - e) Display plant mimics, bar-graphs, control templates, point description, trend graphs (real time & history) in interactive mode with the operator.
 - f) Prepare and print logs and reports.
 - g) Perform performance calculation based on real-time and manually entered data.
 - h) Dynamically reconfigure itself on command from engineering station.
 - i) Run its own diagnostics, watch dogs, system checks and consequent fallback routines.
 - j) All system information and diagnostic alarm like failure of I/O channel, I/O card, Multifunction controller, communication modules, node failure, CPU loading, Network loading, workstation diagnostic etc. shall be annunciated and displayed at any workstation.
 - k) Dynamic data exchange (DDE) for communication with other computers
5. When more than one device utilizes the same signal for measurement and control, signal splitting shall be performed in such a way that disconnecting, shorting or failure of one receiver device shall not cause any upset at any other consumer point or cause any change in transmitter calibration.
6. Comprehensive self-diagnostic features shall be provided to facilities easy fault location and detection of failure without individually checking each module. On-

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line testing facility of control system while the unit is in operation shall be provided with suitable indication for easy identification of faulty module.

7. DCS offered shall have 'open' system architecture with open connectivity for viewing at remote locations without virus infection to control network and employing non-proprietary hardware/software. Latest hardware models & software versions shall be offered.
8. DCS shall be of distributed architecture type with VDU based operation. The entire system shall be bus organized and the plant operator shall run the plant through console consisting of LCD screens, Mouse and Keyboards. All the screens and key boards for ease of operation shall be of same design and shall enable the operator to view process data, control outputs, shut down status and to change all parameters necessary to control the plant.
9. The system software shall be governed by the operating system running in a real time mode. It shall meet all functional requirements specified in this specification as a minimum. The latest version of software at the time of SAT shall be supplied even if it is introduced after Contract finalisation.
10. All the inputs shall be galvanically isolated, provided with suitable noise filter and routed through individual fuse. Isolation shall also be provided between operator console and related sub-systems connected to it. The digital outputs shall be routed through interposing relays. Each output shall be short circuit proof and protected by fuse.
11. The system shall be capable to detect open, short and earth fault conditions. The open sensor reading shall be either upscale or downscale and it shall depend on field requirement and shall be programmable from engineering station.

6.2 Design Requirements

6.2.1 System Expandability

Modular System design shall be adopted to facilitate easy system expansion. The system shall have the capability and facility for expansion through the addition of controller modules, I/O cards etc. The system shall have the capability to add any new control loops, groups / subgroups in control system, while the existing system is fully operational. The system shall be expandable to allow at least 50% future expansion only by addition of extra modules without removing or modifying any existing hardware.

6.2.2 Online Maintenance

It shall be possible to remove / replace modules online (like I/O module, interface modules etc.) from its slot for maintenance purpose without switching off power supply to the corresponding rack. System design shall ensure that while doing so, undefined signalling and releases do not occur and controller operation is not affected in any way (including any control loop trip to manual, etc) except that information related to remove module is not available to controller. Further, it

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shall also be possible to remove / replace any of the redundant controller modules without switching off the power to the corresponding rack and this shall not result in system disturbance or loss of any controller function for the other controller. The on-line removal / insertion of controller, I/O modules etc. shall in no way jeopardize safety of plant and personnel.

6.2.3 Fault Diagnostic

The control system shall include on-line self-surveillance, monitoring and diagnostic facility so that a failure / malfunction can be diagnosed automatically down to the level of individual channels of modules giving the details of the fault on the Engineers Work Station (EWS) monitor and printers. The faults to be reported shall also include faults in main and standby power supplies, sensor fault, Controller fault, any channel fault in 2V3 channels, failure of links to other systems. These faults shall be identified by local indication on the faulty channel / module and on respective rack / cubicle. The diagnostic system shall ensure that the faults are detected before any significant change in any controller output has taken place.

6.2.4 Fault Tolerance & Controllability

1. The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is jeopardized. Control System shall be designed to prevent abnormal swings due to loss of control system power supply, failure of any control system component, open circuits, instrument air supply failure etc. On any of these failures the control system output shall either remain in last position before failure or shall come to fully open / close or on / off state as required for the safety of plant / personnel / equipment. System shall be designed such that there shall be no upset when Power is restored.
2. No single failure either of equipment or power source shall be capable of rendering any part / system / sub-system of control system inoperative to any degree or loss of generation.
3. The system design shall ensure that no single failure, whatsoever in any part of Control system result in loss of communication.
4. The controlled variable response rate and controllability shall be limited by the characteristics of main equipment, which is being controlled, and control system shall not impose any limitations in the response rate or controllability. Controlled process variables shall return to normal values in a stable manner and without control loop interactions or cycling of generation when generation matches with load demand.

6.2.5 Signal Exchange

1. All the signal exchange between various functional groups of each control group

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shall be implemented through redundant main system bus and local system bus within a subsystem as per standard practice. It shall be ensured that any single failure in electronics involved for such communication e.g. communication controllers, bus interface modules, physical communication media, etc. does not result in loss of such signal exchange and there is no deterioration in specified system response and system parametric requirements. In case a controller utilizes some inputs generated / processed by any other controllers / functional group and the requirement of controller response time as specified is not met due to inadequate communication rate / procedure, then the it shall provide hardwired signal exchange for such inputs.

2. However critical signal exchanges are found required shall be hardwired. Control and Protection signal exchange between control system of SG/TG and Plant DCS shall be hardwired only. Protection signals shall necessarily be hardwired even for exchange between the same sub-systems.

6.2.6 Redundancy

The Following shall be completely redundant:

- All the parallel & serial communication buses
 - All the communication devices
 - All the Process controllers
 - Servers (if Server based system)
 - All the Power Packs
 - Critical drives related I/O Modules.
1. The redundant communication buses between the process stations and the operator supervision stations shall follow different paths. The redundant processor shall be connected to the same I/O's of the processor that it is associated to and shall be able to carry out all the operations assigned to this processor. In the case of a processor failure, the redundant processor shall become operative within the cycle time, without causing any loss of data or the interruption of the process control. The switch between the processor being utilized and the reserve processor shall be bump less and shall be within 20 ms which shall not cause any interruptions or stopping of the station functions. Furthermore, this switch must also be signalled by a high priority alarm.
 2. The operator station shall be able to guarantee, from any work station, the complete control of the plant. The operator station electronic units shall be in dual configuration and independently connected to the system buses. In case of an operator stations failure, the station shall remain operative without the operator having to carry out any type of action. Each operator electronic unit and each process station shall be powered by redundant power packs those are able to power the entire load. In case of a failure, the switch between the power packs shall not cause stops or interruption in the carrying out of the station

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functions. The switch between the power packs shall be signalled by a high priority alarm.

3. In order to establish a high degree of system availability, the various control systems which comprise the overall unit control system shall be configured such that no single component failure can cause a failure or mal-operation of critical automatic or manual control functions. The failure of a redundant component shall be alarmed to the operator to allow on-line removal/replacement or at the first shutdown opportunity. The system's redundancy schemes shall be designed such that the transfer from any critical element to its redundant backup shall occur without upset to normal process control or to system displays, data collection, or other normal DCS functions within 50 m sec.
4. The signal distribution from sensors which are shared due to process restrictions between control loops, logics, monitoring purposes shall be as follows:-
 - a) In the case of multiple inputs to a card, input cards used shall be restricted to a maximum of 16 inputs per card for analog input and 32 for digital inputs.
 - b) In case there is either process redundancy (Left, Right) or transmitter or switches redundancy, the inputs shall be routed through independent input cards.
 - c) No two control loops/interlock loop shall share the inputs (either binary or analog) wide input cards if process signals are independently available.
 - d) Protective inputs for two drives shall not be allotted to the same input card.
 - e) Output cards shall be independent for each control loop.
 - f) For outputs to HT and LT motors, the following shall be adopted :
 - g) Each HT motor and unidirectional drives shall have dedicated output cards. No other drive shall be combined with HT motor drive output card. However indication outputs can be driven from this output card for the concerned logic loop.
 - h) Not more than two bidirectional drives shall share one output card.
 - i) For unidirectional drives, not more than one drive shall be allotted to one output card.
 - j) For signal distribution or fan-out, suitable electronic cards (opto couplers) shall be used.
 - k) The processors shall contain the logic required to group individual process and system alarms into common groups as well as the annunciation sequence logic.
5. Redundant components and equipment within given systems shall be distributed among processors and I/O cards to the extent practical.
6. Critical inputs shall be supplied with redundant sensors/transmitters with each input connected to different input cards. Where redundant inputs exist, the DCS shall be configured to automatically reject erroneous data. Where required, one-of-two, two-of-two, two-of-three, or median select schemes shall be utilized to ensure the integrity of critical inputs.

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7. The use of redundant outputs driving the same final element or equipment shall generally be avoided in favour of failsafe design and redundancy of the plant equipment.
8. The operator stations shall be identical in capability and independently linked to the system. Although these stations shall be normally dedicated to a specific function, any station can replace the function of any other station at any time.
9. All power source and power conditioning equipment in the system shall be redundant

6.2.7 System Spare Capacity

1. Following philosophy shall be followed for the spare capacity of the Distributed Control system:
 - a) Twenty (20) percent spare channels in each of the functional groups for each type of input/output modules fully wired up to marshalling / field termination cabinet TBs.
 - b) Ten percent (10%) installed spare I/O modules which may be capable of hot swapping.
 - c) Wired-in "usable" space for 20% modules in each of the system cabinets for mounting electronic modules shall be provided for future use. Empty slots between individual modules / group or group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice, shall not be considered as wired-in 'usable' space for I/O modules. Field Terminal assemblies, PCB / Connectors, corresponding to the I/O modules shall be provided for above mentioned 20% blank space, distributed proportionally to main population.
 - d) Each controller shall have 40% spare functional capacity to implement additional function blocks, over and above implemented logic / loops. Further, each controller shall have spare capacity to handle minimum 40% additional inputs / outputs of each type, over and above implemented capacity. Under worst loading condition, Controller should not be loaded beyond 60%. Each of the corresponding communication controllers shall also have same spare capacity as that of controller.
 - e) The data communication system (including main system Bus and other bus system) shall have the capacity to handle the additions mentioned above.
 - f) Each Communication Network Switch shall have 20% spare ports.
 - g) Twenty (20) percent spare relays of each type and rating mounted and wired in relay cabinets. All contacts of relays shall be terminated in terminal blocks of relay cabinets. In each of the relay cabinets 20% spare terminal blocks shall be provided so that additional relays can be mounted and wired.
 - h) For power distribution board 20% spare feeder fully wired ready for use with MCBs fuses, TBs etc. Other hardware such as signal distribution isolation, trip amplifiers etc. shall be provided with 20% spares wired ready for use.

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2. Sufficient and additional software capacity shall be available in the system to take care of spares requirement as specified above to meet all functional requirements. The calculation for processor power and memory for all nodes should be furnished. Also, the dynamic processor load for all nodes either in terms of idling time or percentage load shall be available in VDU.
3. The spare capacity as specified above shall be uniformly distributed throughout all functional groups. The system design shall ensure that above mentioned additions shall not require any additional controller / processor / peripheral drivers / cabinets in the system delivered at site. Further, these additions shall not deteriorate the system parametric requirement like response time / duty cycle etc. from those stipulated under this specification and shall meet other redundancy / functional requirement.

6.3 System Configuration

The Distributed Control System shall basically consist of the following:

- Control system including Auto Controls & Interlocks, Protection & Sequential control system.
- Measurement system
- Data Communication Bus system for control & communication with Process
- Man-Machine Interfacing System
- Maintenance Engineers System (Engineering Station)
- Software

The basic configuration of Distributed Control System shall be as indicated in the Drawings.

DCS system shall be independent yet connected at network level so that, even when system for any unit is not in service (in case of long term shutdown of a unit) or non- functional, the functioning of other unit or plant common systems shall not be disturbed.

6.3.1 Control System Requirements

The control system shall be broadly divided into SG - C&I, TG - C&I and BOP - C&I.

1. The SG- C&I part of DCS system shall perform the following function as minimum but not limited to:
 - a) Burner management system (BMS) including control & protection of coal mills, fuel oil system etc.
 - b) Analog control functions pertaining to secondary air damper control etc.
 - c) Soot blower control.
2. The TG- C&I part of DCS system shall perform the following functions:

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- a) Turbine protection system function (TPS)
 - b) Turbine governing system for main turbine
 - c) Turbine stress control system (TSCS)
 - d) Automatic turbine testing (ATT)
 - e) Automatic turbine run up system. (ATRS)
 - f) HP&LP bypass control system
 - g) Turbine generator control system
 - h) EHG, interlock & protection for turbine driven BFP
3. The BOP- C&I system shall perform the following functions:
- a) Analog control functions, other than those covered in SG-C&I and TG-C&I, like co-ordinated master control, furnace draft control, SH/RH steam temperature control, FW flow control, heaters/deaerator/condenser level control, Auxiliary PRDS pressure & temperature control etc.
 - b) Binary control functions pertaining to main plant auxiliaries like FD/ID/PA fans, APH, BFP etc., Generator auxiliary systems and electrical breakers etc.
4. **Close Loop Control System (CLCS):** Modulating control functions for SG/TG/BOP system includes the CLCS SADC Control, Air/Fuel oil flow control Drum Level Control, FW Flow Control, SH/RH Temperature Control, Furnace pressure, wind box air damper, Auxiliary PRDS Coordinated Master Control, De-aerator Pressure & Level Control, HP/LP Bypass control, Hotwell Level Control, HP/LP heaters Level Control, BFP Scoop control, BFP & CEP minimum Recirculation Control & individual control and operation of modulating drives.
5. **Open Loop Control System (OLCS):** Binary control functions pertaining to SG control system such as Sequence/ Interlock/ Protection of SG Auxiliaries includes the OLCS for FD Fan, ID Fan, APH, Soot Blowers etc. This includes controls of all HT drives, LT drives, motor operated valve, solenoid valves, Soot blower protection & auto-standby of HT & LT drives.
- However the binary control functions pertaining to TG & BOP control system such as Sequence/ Interlock/ Protection of TG Auxiliaries includes the OLCS for the BFP, CEP, CW, ACW, ECW Drain & Vent Valves etc. and individual control & protection of Binary drives. This includes controls of all HT drives, LT drives, motor operated valve, solenoid valves, Electrical breaker, auto-standby of HT & LT drives.
6. Time stamping of SOE inputs/points, Integration of BOP PLC's etc.
7. Other Miscellaneous controls, signal processing etc.
8. For each of the Functional Groups (FG), separate sets of controllers, I/O modules, communication controllers, power packs / modules, etc. shall be provided. Mixing of hardware of two or more FG's shall not be acceptable. However, splitting of any functional group in more than one FG's due to any

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limitation in system (e.g. limitation in handling number of inputs /outputs including spare capacity, limitation in implementation of number of functional blocks including, spare blocks etc.) shall be acceptable, subject to Consultant's approval. It may be noted that after splitting of the functional groups, each FG must have its own set of controllers, I/O modules, communication controllers, power packs / modules etc. It shall be ensured that failure of any set(s) of hardware of any FG does not affect other FG(s) and data communication between other FG(s) and MMI.

9. The minimum functions to be realized in the Control System shall be as per requirements specified under subsequent clause of this specification. The system shall provided with all hardware /software, whether or not specifically indicated in this specification to fully meet operational / maintenance / safety requirement as well as statutory /international standards and proven practices.
10. The Control System shall function reliably under the environmental conditions as specified in design philosophy & in design criteria of this specification. It shall be immune from the interference resulting from disturbance in power supply feeders, signal lines, inputs, outputs, etc. as experienced in a power station.
11. The Control System shall have on-line simulation and testing facility. Further, it shall be possible to on-line configure and tune controllers through Engineering Station.
12. The system shall have the flexibility to easily reconfigure any controller at any time without requiring additional hardware or system wiring changes and without disabling other devices from their normal operation mode. Modifications shall not require switching off power to any part of the system.
13. Power supply to individual functional group shall be from redundant 24 V feeders with diode auctioneering and further sub-distribution.
14. The assignment of I/O channels for inputs / outputs, arrangement of modules within cabinet etc shall be identical for both units except those inputs / outputs which are common for both units. Further uniformity should be maintained for redundant stream of process equipment within a unit.
15. The application programs for the functional controllers shall be software based which shall be maintained even during power supply failure. The application program shall be alterable through the configuration and tuning station for all configuration and strategy changes, etc. and through the operator's console for set points / bias changes, device selection, etc. Parts replacement or parts removal shall not be required in order to accomplish changes in application programs including system tuning.
16. Independent and dedicated controllers (main and its 100% standby) shall be provided for each of the functional group (FG) of Control System. All the 100% hot / redundant backup controllers shall be identical in hardware and software implementation to their corresponding main controllers and shall be able to

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perform all its tasks. The backup controller shall track its corresponding main controller. There shall be an automatic and bumpless switchover from the main controller to its corresponding backup controller in case of main controller failure and vice versa without resulting in any change in control status. In case of switchover from main controller to the 100% hot backup controller, the back-up controller shall work as the main controller. Facility shall also be provided for manual switchover from main to 100% hot back-up controller and vice versa from the Engineering Work Station.

17. The loop / logic reaction time shall be suitable to match actual process requirements, subject to minimum requirement wherever specified.

6.3.1.1 Binary Controls/ Open Loop Control System (OLCS) Functions

- These clauses are applicable for all the Binary controls of Systems for the systems of SG & TG which are to be implemented in Plant.
- The OLCS shall include sequence control, interlock & protection for various plant auxiliaries/valves /dampers/drives etc. The sequence control shall provide safe and automatic start up and shut down of plant and of plant items associated with a plant group. The interlock and protection system shall ensure safe operation of plant/plant items at all times and shall automatically shut down plant/plant items when unsafe conditions arise.
- The OLCS shall be arranged in the hierarchical control structure consisting of unit level, group level, subgroup level and drive level (as applicable).
- It shall be possible to perform automatic unit start up and shutdown by issuing minimum number of command from OWS / LCD. Thus, the unit level shall control all the Control System Blocks and issue appropriate start up and shutdown commands to various blocks of Control System.
- The group level shall control a set of functional sub-groups of drives. Appropriate start-up and shut down commands shall be issued to the sub-group control and various check-backs shall be received from sub-groups of drives. Each sub-group shall execute the sequential start-up and shut down programs of a set of inter-related drives along with system interlocks and protections related to individual drive falling under that sub-group. The drive level shall accept commands from the sub-groups, push buttons (wherever provided) etc., and transmit them to the respective drive, after taking into account various interlocks and protections and the safety of that particular drive. For HT drive, first-up logic shall be incorporated to indicate the cause of protection / trip.
- A sequence shall be used to move a set of groups and sub-groups from an initial steady state (for instance 'OFF') to a final steady state (for instance 'ON'). The sequence initiating command for the unit and group level shall be issued from OWS/LCD.
- A sequence shall be made of steps. The steps shall be executed in predetermined order according to logic criteria and monitoring time consisting of

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the interlock & protection requirements and check back of previous step which shall act as pre-conditions before the sequence control can execute the command for that step.

8. Each step shall have a "waiting time" implying that the subsequent step would not be executed unless the specified time elapses. A monitoring time shall also be defined as the maximum time required in executing the commands of any step and the time required for appearance of check back signals. In case, this is not completed within the specified time, a message shall be displayed and programme shall not proceed further.
9. Manual intervention shall be possible at any stage of operation and the sequence control shall be able to continue at the correct point in the programme on return to automatic control. Protection commands shall have priority over manual commands, and manual commands shall prevail over auto commands.
10. Open or close priority shall be selectable for each drive.
11. The sequence start up mode shall be of the following types:

a) Automatic Mode

In this mode of operation, the sequence shall progress without involving any action from the operator. The sequence start / stop command shall be issued from the OWS / LCD.

b) Semi-Automatic Mode

In this mode of operation, once the sequence is initialized, the step progressing shall be displayed on the OWS / LCD. But the step execution command shall be prevented and shall be sent by the operator via the keyboards. It shall be possible to bypass and / or simulate one or more criteria to enable the program to proceed. This facility shall allow the program to be executed even if some criteria are not fulfilled because of defective switching devices, etc., while the plant condition is satisfactory. All the criteria bypassed shall be logged and displayed. It shall be possible to put the system on the Auto-mode after operating it on semi-automatic mode for some steps or vice-versa, without disturbance to the sequence operation.

c) Operator Guide Mode / Test Mode

It shall be possible to use the sequential control in operator guide mode / test mode i.e. the complete system runs and receives input from the plant and the individual push button stations (where provided) / keyboards but its command output is blocked. The whole programme, in this case shall run in manual mode. This mode shall allow the operator to practice manual operation using step and criteria indications. The actual protection should remain valid during this mode of operation also.

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12. The sequence shall be started by putting the sequence on 'auto' and on receipt of 'start' command from the OWS / LCD or from a higher-level group / protection action as defined. The sequence shall then progress as per the defined logics. It should be possible to select alternative operation in the same sequence depending on certain process / equipment condition. Some step can be automatically bypassed also based on certain process / equipment condition. When the expected results of the sequence are reached the sequence is considered as "END". If during sequence initialization or sequence progressing or during normal running of the drive, a shutdown criterion is present, the sequence shall be stopped and the shut down sequence initiated.
13. For the drives, the command shall be provided through O/P module to MCC / SWGR / Actuator as applicable and input (status, SWGR and process) shall be acquired through input modules. The drive logic shall be implemented in the redundant controller. The status for the 11 KV, 3.3 KV drives and some other important drives shall also be wired in parallel to redundant input modules so that on failure of the single input modules, the information regarding the status of the affected drive remains available in OLCS.
14. The output modules shall have the feature that ensures that in case of failure, all the outputs are driven to zero. The 24V DC command outputs to drives for ON / OPEN, OFF / CLOSE shall be separate and independent and the inverted outputs shall not be employed. For inching type of drives, position transmitter shall be provided.
15. The termination for ON / OPEN, OFF / CLOSE command for the drive actuator shall be performed as specified in Chapter-4 Clause-4.13. However ON/OPEN feedback, OFF/CLOSE feedback, Switch gear disturbance feed back as a minimum shall be monitored in OLCS.
16. The drive function i.e. basic interlocks and protection logic of the drive shall be implemented in redundant controllers. The drive function shall ensure that protection signals for the safety of the drive shall be effective under all conditions and under all modes of operation. The different commands shall be performed according to the priority of protection 'OFF', protection 'ON', manual and automatic. The standard functions like running time monitoring, status signaling, alarm / drive annunciation, etc. shall be performed in drive function. The drive function shall prevent hunting of the actuator in the presence of both open and close commands for actuators of the valves and dampers. The drive function shall be implemented in dedicated standard software functional block.

6.3.1.2 Analog Controls/ Close Loop Control System (CLCS) Functions

1. These clauses are applicable for all the Analog controls of Systems included in for the systems of SG & TG which are to be implemented in Plant.
2. The CLCS shall continuously act on valves, dampers or other mechanical modulating devices such as hydraulic coupling etc., which alter the plant

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operation conditions. The system shall be designed to give stable control action in steady state condition and for load changes in step / ramp over the load range of 60% to 100% MCR with variation or parameters within permissible limits.

3. The controller capability shall, as a minimum, include (i) P, PI, PD and PID control functions and their variations (ii) cascade control (iii) feed forward control (iv) state-variable based predictive control for SH/RH temperature control (v) on-off control, (vi) ratio and bias control, (vii) logical operation etc. The loop reaction time (from change of output of the sensor of the transmitter/temperature element to the corresponding control command output) shall be within 250 ms. However, for faster loops such as feed water, furnace draft, PA header pressure control loop etc. the same shall be based on actual process requirement.
4. The loop response time, for conventional I/Os, is the cumulative response time inclusive of input scan time, Controller Execution time and output card throughput time (in other words loop response is the time taken by the system to read a change in field signal at the input card terminal, process the controller task associated with the input and to make the required change in the control output at the output terminal of the output card)
5. The control system shall be bumpless transferred to manual. Control power supply failure, failure of redundant controllers, field input signal not available, analog input exceeding preset value, etc.
6. Any switch over from auto to manual, manual to auto and vice versa shall be bumpless and without resulting in any change in the plant regulations and the same shall be reported to the operator and recorded automatically.
7. Buffered analog output (positioning signal) of 4-20mA DC shall be provided from CLCS to the respective E/P converters. For electrical actuators, pulse type output (bound less control) shall be preferred. CLCS shall also provide all the necessary outputs for indicators & recorders with output loop resistance of 500 ohms for each channel of the output module.
8. The system being supplied shall be such that when permissible limits are exceeded, an automatic switchover from an operation governed by maximum efficiency, to an operation governed by safety and availability is affected.
9. For safety reasons, switchover logics associated with the modulating control loops shall be performed within the closed loop control equipment.
10. Time supervision facility shall be provided to monitor the final control element.
11. It shall be possible to block the controller output on a pre-programmed basis.
12. All controllers shall be freely configurable with respect to requisite control algorithms.
13. Whenever, alternate measurement is available for a control input the alternate measurement value shall be automatically substituted in the control loop in case of loss of control input. All necessary software for switching and reconfiguration

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shall be provided. In addition, such substitution shall be balance less and bumpless and shall be reported to the operator.

Table 6.1A
Specifications for Controller

S.No.	Features	Minimum Requirements
1	Type	Microprocessor based, multi loop, multi function, dual redundant configuration.
2	No. of Loops	40 (maximum/per controller)
3	Word Length	32 bits
4	Register add cycle time	1 microsecond (typical)
5	Instruction Cycle time	75 microseconds (maximum)
6	I/O address capability	256 points (minimum)
7	Memory	RAM 12 MB (minimum) with battery backup
8	Redundancy Supported	Yes
9	Fall back transparent	Yes
10	Power Supply	24V, 5V DC
11	Mounting	Sub-rack
12	Indication	Processor status & fault display
13	Diagnostic	Invalid command checking, Automatic periodic illegal address detection, routine check and memory parity check, watch dog report to engineering terminal, time - out checking,

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6.3.1.3 Guidelines for Functional Grouping of Plant DCS Controllers

The guidelines for functional grouping of controllers in Plant DCS shall be as described in this clause.

1. Stream wise process redundancy is to be maintained in Plant DCS. That is, if there is more than one main equipment in a process block, these are to be allocated in different functional groups. For example, ID fan – A & B shall be allocated to two different functional groups, BFP- A, B & C shall be allocated to three different functional groups, etc. In the functional groups thus obtained, main equipment of similar stream shall be allocated. For example, if one functional group caters to Stream-A main equipments, all main equipments of Stream – A of the same block should be put together e.g. FD fan-A, ID fan-A should be put together. Further the auxiliaries of main equipment shall be allocated in the same functional group where corresponding main equipment is allocated e.g. Lube oil pump-A & Lube oil pump- B of FD fan –A should be allocated with FD fan-A.
2. For different streams of process blocks defined below, separate sets of functional groups shall be provided. Where different streams of process blocks are not defined, separate sets functional groups shall be provided for the process blocks. The functions of two streams/process blocks should not be mixed in any case.
3. The information signals of respective process areas shall be kept along with the main equipment.
4. Electrical system of unit shall be a separate process block.
5. The Plant DCS shall be divided into following major sub-systems:
 - a) BOP – SG
 - b) BOP – TG
 - c) Common System
 - d) Electrical system

For each of the above major sub-systems, the process blocks, along with major equipments/control loops in each block shall be as follows:

A. BOP - SG

- **Air Block:** ID Fans- A & B, FD Fans-A & B, SA Fans– A & B, Primary APH –A & B along with flue gas temperature control/fire detection, stack path, Furnace draft control, Secondary SCAPH – A & B, Air Flow Control etc.
- **Steam & Water Block:** SG vents & drains, Main Steam/RH/SH valves along with temperature control, ECW Pumps- A & B along with DP control, Chemical Dosing, Feed water valves, SG misc. Drives, Coordinated Master Control, Feed Water Control, Group Control, RH Protection, SWAS, BCWP - A, B & C, etc.

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- **Mills & feeder Block:** Mills/feeder – A, B, C, D, E, F, G & H controls for outlet temperature, Primary APH – A & B along with fire detection & temperature control, Primary SCAPH – A & B, etc.

B. BOP - TG

The BOP- TG shall include the following major equipments/controls:

- BFP – A, B & C
- CEP – A, B & C along with recirculation controls
- ACWP – A, B & C
- HP Heaters valves & Level control (all HP heaters should be kept in same Functional group)
- LP Heaters valves & Level control (all LP heaters should be kept in same Functional group)
- Hotwell level control
- ECW Pumps- A & B along with DP control
- TG misc. Valves/drives controls etc.

C. Common system

The Common systems shall include the following major equipments/controls:

- Compressed Air System block
- CW pumps – A, B & C (CW pumps shall be allocated to three different functional groups)
- LDO/HFO handling system block.

D. Electrical system

All Electrical breakers, bus couplers etc. shall be covered in this sub-system.

6. The major aspects to be considered shall be as follows:

- a) Hardware capacity, including spare capacity.
- b) Software capacity, including spare capacity.
- c) Response time/signal acquisition time requirement of Plant DCS.
- d) Parametric Requirement of Plant DCS.
- e) Tentative Functional grouping as described in Table 6.1A.

7. The equipments, logics, controls indicated in the functional grouping are tentative & shall be dependent on the design, recommended logics & controls of the SG & TG Vendors.

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Table 6.1B
Functional Grouping of Controllers

S.No.	Functional Group	Functions
1	FG-01	FD Fan – A, ID Fan –A, SA Fan –A, Stack Path A & B, etc
2	FG-02	Furnace Draft Control, RAPH-A, RAPH – A Temperature Control, SCAPH –A, RAPH –A fire detection, etc.
3	FG-03	FD Fan – B, ID Fan –B, SA Fan –B, Stack Path C & D, etc.
4	FG-04	Air flow control, Fuel Flow Control, Coal Feeder Speed Control, HFO/LDO control, RAPH-B, RAPH- B Temperature Control, SCAPH –B, RAPH –B fire detection, etc.
5	FG-05	SG misc. drives, SG Drains & Vents, SG DMCWP –A, BSCP-A, Soot Blower Control, SADC, etc.
6	FG-06	Coordinated Master Control, Group Control, RH protection, Misc. Boiler Controls, etc.
7	FG-07	RH temp. Control, SH temp. control, RH/SH spray drains & vents, Eco. I/L valves, BSCP-B, Boiler Fill Pump-A, Aux. PRDS Control, etc.
8	FG-08	FW valves, SG DMCWP-B, SG misc. drives, BSCP-C, Boiler Fill Pump-B, Dosing system drives, etc.
9	FG-09	CEP-A, CEP-A recirculation system, etc.
10	FG-10	Hotwell level control, CEP – B, CEP – B recirculation control, GSC Minimum flow, etc.
11	FG-11	ACW –A, TG ECW –A, TG ECW CLCS, LP heaters CLCS, LP Heaters Drives (valves), etc.
12	FG-12	CEP-B, CEP-B recirculation system, HP bypass system,

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S.No.	Functional Group	Functions
		etc.
13	FG-13	ACW –B, TG ECW –B, HP heaters CLCS, HP Heaters Drives (valves), LP Bypass system, etc.
14	FG-14	MDBFP, Deaerator Level control, Deaerator Pressure Control, Deaerator Overflow Control, Deaerator Drives, CEP-C, CEP-C recirculation system, etc.
15	FG-15	ACW –C, TG Misc. Drives, etc.
16	FG-16	IA Compressor –A , CWP- A, HFO Transfer pump –A, LDO Transfer pump –A, Service Air Compressor –A, LDO System Misc. drives, etc.
17	FG-17	HFO Transfer pump -B Handling system, CWP – B, IA Compressor –B, LDO Transfer pump –B, Service Air Compressor – C, HFO Misc. drives, etc.
18	FG-18	CWP- C, HFO Transfer pump –C, IA Compressor –C, LDO Transfer pump –C, etc.
19	FG-19	Electrical systems, UPS, etc.
20	FG-20	Electrical Systems, 24 V DC system, etc.

6.3.2 Measurement System Requirements

All the signals coming into / going out of the Control System shall be routed through marshalling cabinets. The input / output modules employed in the Control System shall be separated from controller hardware.

6.3.2.1 Analog Signal Conditioning & Processing

1. The conditioning and processing functions to be performed as a minimum for the analog input coming for control and information purpose are:
 - a) Galvanic isolation of input signals for which power supply source is other than the measurement system of the control system.
 - b) Transmitter power supply with per point fuse protection or current limiting and power supply monitoring.
 - c) Transducer / transmitter signal output limit check

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- d) Implementation of multiple measurement schemes
 - e) Square root extraction
 - f) Pressure and temperature compensation.
 - g) On-line ADC gain and drift monitoring and correction at periodic intervals.
 - h) Linearization of temperature signals (from thermocouples and RTD through temperature transmitters).
 - i) Reasonability checks for all analog inputs.
 - j) Monitor sensor wire break / open circuit / short circuit and take suitable actions in logic / loop. (This shall include blocking of trip signals in case of RTD failure).
 - k) Rate of rise / fall calculation
 - l) LVM generation.
2. All analog signals for control purpose shall be acquired, validated, processed and their respective Controller data base updated at a maximum interval of 250 ms except for some fast-acting control loops for which the above referred time shall be as per process requirement. The validated analog inputs shall be converted into engineering units on per point basis. Analog input processing (scanning to alarm checking) shall be performed once every scan cycle.
 3. The analog 4-20 mA input cards shall have input loop resistance ≥ 250 ohm for interfacing transmitters / analyzers giving 4-20 mA DC signals along with superimposed HART interface signals. 4-20 mA DC signal shall only be used for control purpose and superimposed HART signal shall be used for configuration, maintenance, diagnostic and record keeping facility for electronic transmitters and Analysers etc.
 4. Triple measurement scheme for analog inputs employing three independent transmitters connected to separate tapping points shall be employed for the most critical measurements. The three signals shall be auctioneered to determine the median / average value, which shall be used for control purpose. In case one transmitter fails or shows excessive deviation with respect to others, it shall be removed from computation of median / average value and the average of the other two transmitter outputs shall be used for controls. The control loop shall trip to manual when any two of the three transmitter signals fail. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.
 5. Dual measurement scheme for analog inputs employing two independent transmitters connected to separate tapping points / temperature element shall be employed for the remaining measurements used for analog control functions. The output of the redundant transmitters shall be continuously monitored for excessive deviation. In case the deviation is within limits, the mean value shall be used for the control loop. If the deviation becomes high (with both

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transmitters remaining healthy), the loop shall be automatically transferred to manual. However, if one transmitter fails and other transmitter remain healthy, then the output of the healthy transmitter shall be used for control. If the other transmitter also fails, loop shall trip to manual. The outputs of the transmitters shall be continuously monitored for excessive deviation which shall be displayed, logged and alarmed.

6. Individual transmitter signal, their value and selected value for control/measurement shall be available in OWS.

6.3.2.2 Binary Signal Conditioning & Processing

1. The changeover type contacts (i.e. 'NC' + 'NO' together) shall be wired to the controller system for all the binary inputs required for control purposes. The binary inputs required for information purposes only shall be wired to control system in the form of non-changeover type contacts.
2. The conditioning and processing functions to be performed as a minimum for the binary inputs coming for control and information purposes are:
 - a) 24 V DC power supply for contact interrogation for all potential free contacts with per point fuse protection or suitable current limit feature / isolation through opto-coupler.
 - b) Contact bounce filtering delay time of 15 ms. However for SOE inputs, it shall be such that it should meet SOE time resolution of 1 ms.
 - c) Facility for automatic pegging of the binary signal to logic one / zero or last correct value in case of failure of binary input module.
 - d) Binary signal distribution to different user shall be in such a way so as to ensures that a short / ground fault on one user is not reflected to the other user.
 - e) Implementation of multiple measurement schemes for signals for control purpose.
 - f) All binary signals shall be acquired, validated, processed, alarm checked and their data base updated within one second. In addition to this requirement, binary signals required for SOE shall have resolution of 1 millisecond.
 - g) Checking for excessive number of status changes for all binary / contact inputs and making it off-scan, if the total no. of changes exceeds a limit within pre-defined time.
 - h) The non-coincidence monitoring shall be provided for binary inputs for all changeover signals.

6.3.2.3 Wiring Scheme for Inputs to Control System

1. Each of the triple redundant binary and analog inputs shall be wired to three separate input modules. In addition, for functions employing 2V3 controllers, each of the redundant binary and analog signals shall be wired to separate input

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modules associated with each controller. Similarly each of the dual redundant binary and analog inputs shall be wired to two separate input modules. These redundant modules shall be placed in different racks, which shall have separately fused power supply distribution. Implementation of multiple measurement schemes of these inputs shall be performed in the redundant hardware. Loss of one input module shall not affect the signal to other modules. Other channels of these modules can be used by other inputs of the same functional group.

2. No single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant input signals to control system. Similarly, no single failure in any component of the control system shall lead to unavailability of more than one of dual / triple redundant output signal from the control system.
3. The single (i.e. non-redundant) binary and analog signal required for control purpose shall be wired as follows:
 - a) The on-off status of HT drives and Breakers with synchronization provision shall be wired to two input modules in parallel.
 - b) All analog and binary inputs including the limit switches of valves / dampers / MCC / SWGR, check-backs of all drives, SOE and information related signals should be wired to single input modules.
4. It is envisaged to use remote I/O modules in plant areas where it is required from location point of view. The remote I/O signals shall be connected to the respective functional groups through redundant extended I/O bus. The hardware independence of functional groups shall be applicable for remote I/O as well. The remote input / output modules shall be located in cubicles in respective areas. Remote input / output modules shall be designed in such a way to work continuously under the harsh environment expected to be encountered in these areas (high temp, dust level, humidity etc.). It shall be ensured that extending of I/O bus of functional group in field does not result in false signalling / noise pickups. Further, it shall in no way deteriorate the performance of that functional group and Control System.
5. Power supply arrangement for these cubicles shall be similar to DCS System cabinets
6. The measurement system of control system should be capable of acquiring data from various equipment and system in digital form through serial port, Field bus/ Profibus, Ethernet connection using industry standard protocols. The control system shall include requisite modules for accepting such signals.
7. The maximum number of inputs/outputs to be connected to each type of modules shall be as follows:

a) Analog input module	16
b) Analog output module	08

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- c) Binary input module 32
- d) Binary output module 32
8. The following requirements shall be met for analog/binary input / output modules as applicable:
- a) Input filters to attenuate noise shall be provided
- b) All analog / binary inputs and outputs shall be capable of withstanding 500V DC common mode and 500V AC peak to peak between analog and digital parts. All analog outputs shall be short circuit proof.
9. Any single sensor / transducer / transmitter failure alarm shall be provided on Engineer's Station monitors for all sensors / transducers / transmitters. Similarly sensor break alarm for thermocouples etc. shall also be logged and displayed.

Table 6.2
Specifications for High Level Analog Input Modules

S.No.	Features	Minimum Requirements
1	No. of Inputs/module	16
2	Type of Input(Linear)	4-20 mA & 1-5 V
3	Accuracy	0.1% or better
4	A/D Converter	Integrating, 15 bit + Sign or better
5	Temperature Effect	0.01%/Deg. C or better
6	CMRR	60 dB (at 50 Hz) or better
7	NMRR	20 dB (at 50 Hz) or better
8	Stability	0.03%/year or better
9	Diagnostic	<ul style="list-style-type: none"> • Limit check • A/D converter fault • Channel fault • Wire break • Short Circuit • Auto Gain Correction

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Table 6.3
Specifications for Low Level Analog Input Modules

S.No.	Features	Minimum Requirements
1	No. of Inputs/module	16
2	Type of Input (Grounded & Un-grounded)	Thermocouple (J,K,R,S,T) RTD (Pt-100) {Two wire & three wire}
3	Cold Junction Compensation	On module/Local RTD
4	Accuracy	0.1% or better (Linearized)
5	A/D Converter	Integrating, 15 bit + Sign or better
6	Temperature Effect	0.01%/Deg. C or better
7	CMRR	60 dB (at 50 Hz) or better
8	NMRR	20 dB (at 50 Hz) or better
9	Stability	0.03%/year or better
10	Diagnostic	<ul style="list-style-type: none"> • A/D converter fault • Channel fault • Wire break • Short Circuit • Auto Gain Correction

Table 6.4
Specifications for Binary Input Modules (Slow Scan)

S.No.	Features	Minimum Requirements
1	No. of Inputs/module	32
2		24 / 48 V DC

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S.No.	Features	Minimum Requirements
	Type of Input	NO/NC/Change Over Contacts
3	Input Current	5-10 mA
4	Diagnostic	<ul style="list-style-type: none"> Input Simulation Wire Break detection Short Circuit

Table 6.5
Specifications for Binary Input Modules (Fast Scan SOE)

S.No.	Features	Minimum Requirements
Same as Table 6.4 above but resolution 1 milli Second		

Table 6.6
Specifications for Pulse Input Modules

S.No.	Features	Minimum Requirements
Same as Table 6.4 above but, with 16 channels/module (maximum) and Leading/Trailing edge detection. Minimum Pulse width 1 milli Second.		

Table 6.7
Specifications for Analog Output Modules

S.No.	Features	Minimum Requirements
1	No. of Points/module	08
2	Type of Output(Linear)	4-20 mA
3	Accuracy	0.4% or better
4	Load	600 Ohms (current) 1000 Ohms (Voltage)
5	Diagnostic	<ul style="list-style-type: none"> Channel fault

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Table 6.8
Specifications for Binary Output Modules

S.No.	Features	Minimum Requirements
1	No. of Points/module	32
2	Type of Output	Relay with one changeover contact
3	Contact Rating	60VA
4	Contact Voltage Rating	60 Volts
5	Switching Frequency	2 Hz
6	Contact Life	1 million operations

6.3.3 Data Communication Bus System Requirements

The System offered shall be an open system and shall conform to Open Industry Standard (IEEE). A redundant 10 / 100 MBPS Ethernet based high speed switched fault tolerant Data Communication System shall be deployed that provides for multiple simultaneous bi-directional communications. Communication shall be full duplex and with TCP-IP protocol. All interfaces links of controllers, gateways, MMI stations, switches and all other communication devices on the network shall be dual so that a single point failure shall not lead to system shutdown. Network shall be capable of handshaking with any third party system following standard protocol. The primary objective shall be centralized monitoring, presentation & report of data for information and analysis of entire plant. All the functional groups shall be connected to a common high-speed data network for global distribution and peer-to-peer data communication. Any data shall be available at any point on the network as and when required. The control system shall be modular, expandable and flexible so the expansion of the system is possible by adding extra stations on the data communication bus. Comprehensive self-diagnostic features have been envisaged to facilitate easy fault location and detection of hardware and software while the unit is in operation. It shall be able to direct intelligent routing of messages without the drawbacks of traffic jamming etc.

The Data Communication System shall include a Redundant System Bus for major subsystems with hot back-up. The data highway shall be high speed digital links of speed preferable 10/100 MBPS. Bus protocols at control levels shall conform to OPC compliant ISO-7 layer protocol in master less, token ring or token bus (as per IEEE 802) or any standard proven and acceptable protocol in deterministic mode. Extensive error checking (CRC-16/12) or error correcting codes shall be used in these levels to improve the reliability of communication.

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The Data Communication System shall have following minimum features:

1. Redundant communication controllers shall be provided to handle the communication between each functional group of controllers of Control System and the System Bus. The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station / module connected to the system bus shall not result in loss of any communication function to and from any other station / module.
2. If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.
3. Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bumpless and the same shall be suitably alarmed / logged. The above changeover shall not result in any data loss.
4. The design and installation of the system bus shall take care of the environmental conditions and hazardous area classification as applicable to similar services.
5. Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 50% spare capacity shall be available for future expansion.
6. Passive coaxial cables or fibre optic cables shall be employed for System Bus. It may proposed with other type of cables as per their standard also which shall be subject to Consultant's approval. However the following buses shall be fibre-optic only.
 - a) System bus connections between Control Room & Control Equipment Room.
 - b) System bus from locally mounted control system cabinets / OWS to central location.
 - c) I/O Bus from remote I/Os to centrally located system cabinets. The redundant buses shall be physically separate and shall be routed separately.
7. If UTP / STP cables are used, then it shall routed with flexible conduit.
8. In case of any distance or other limitation in the Data Communication System, then it shall be provide with special type of cables like optical fibres with repeaters as required to make the system fully operational.
9. Serial device interface module shall be capable of providing communication interface with serial devices. The Modbus interface shall support MODBUS RTU protocol and use EIA-422/485 multi loop configuration by establishing direct digital communication. The nominal capacity of a link shall not be less than 5000 digital and 200 analog inputs. The acquired & transmitted data shall integrate

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seamlessly with DCS database. The physical medium of communication can be twisted wire, coaxial or fibre optic cable, depending on transmission distance and surrounding electrical interference.

10. In redundant network, the communication cables of each network shall be uniquely colour coded.

6.3.3.1 DCS System Interfacing Requirements

Following Interfacing facility shall be provided for DCS System.

1. One (1) no. independent Redundant Bi-directional OPC/ Soft Link, for monitoring, operation & effective control of the system (without time delay), with Ethernet based TCP-IP protocol for SG integral Control System.
2. One (1) no. independent Redundant Bi-directional OPC/Soft Link, for monitoring, operation & effective control of the system (without time delay), with Ethernet based TCP-IP protocol for TG integral Control System.
3. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Coal Handling Plant Control System.
4. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Ash Handling Plant Control System.
5. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Water Treatment & Effluent Treatment Plant Control System.
6. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Raw Water Intake Pump house Control System.
7. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Hydrogen Generation Plant Control System.
8. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the Substation Automation System.
9. One (1) no. Independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for the ESP Control System.
10. One (1) no. Independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for Water Lance System.
11. One (1) no. independent Redundant Bi-directional OPC/Soft Link with Ethernet based TCP-IP protocol for the Emergency DG Control System.
12. One (1) no. Independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for Turbine Supervisory Instrumentation (TSI) System.
13. One (1) no. Independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for Online Tube Cleaning System.
14. One (1) no. Independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for Turbine Lube Oil Purification System.

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15. One (1) no. independent Redundant Uni-directional OPC/Soft Link with Ethernet based TCP-IP protocol for AC & Ventilation Control System.
16. One (1) no. independent Redundant Uni-directional OPC/Soft Link with Ethernet based TCP-IP protocol for Fire Detection & Protection System.
17. One (1) no. independent Redundant Uni-directional OPC Link with Ethernet based TCP-IP protocol for MIS system.
18. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for Computerized Maintenance Management System (CMMS).
19. One (1) no. independent Redundant Bi-directional OPC Link with Ethernet based TCP-IP protocol for PADO system.
20. One (1) no. independent Redundant Bi-directional Communication Link with Ethernet based TCP-IP protocol for Vibration Monitoring & Analysis System.
21. One (1) no. independent Redundant Uni-directional Communication Link with RS-485 Modbus Protocol for interfacing with SWAS.
22. One (1) no. independent Redundant Uni-directional Communication Link with RS-485 Modbus Protocol for interfacing with CEMS.
23. One (1) no. independent Redundant Uni-directional Communication Link with RS-485 Modbus Protocol for interfacing with Instrument & Service Air Compressors (NTA-1 Package).
24. Uni-directional Communication Link with IEC 61850 Protocol for interfacing with Numerical Protection relays.
25. Redundant Bi-Directional Communication Link with RS-485 Modbus Protocol for interfacing with Variable Frequency Drives.
26. Any other Communication Link as required for proper functioning of Complete System.
27. Two (2) nos. Redundant Bi-directional communication OPC Link with Ethernet based TCP-IP protocol as spare provision.
28. Two (2) nos. Redundant Uni-directional communication OPC Link with Ethernet based TCP-IP protocol as spare provision.
29. Two (2) nos. Uni-directional Communication Link with RS-485 Modbus Protocol as Spare Provision.
30. Four (4) nos. Uni-directional Communication Link with IEC 61850 Protocol as Spare Provision.

6.3.4 Man-Machine Interfacing System

1. Man-Machine interface system shall be designed and engineered for safe, efficient, reliable and convenient operation. MMI shall employ high performance, non-priority open system architecture to ensure fast access and response time and compatibility with other system and portability of third party software. MMI System shall be used primarily for the following functions:

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- a) As operator interface for control operation for the plant for accepting data from and issuing commands to control system etc.
- b) To perform plant supervisory, monitoring and information functions.
- 2. No single failure in MMI System shall lead to non-availability of more than one OWS or one LCD or one printer. In such an event i.e. single failure leading to non-availability of any OWS / LCD, it shall be possible to operate the entire plant in all regimes of operation including emergency conditions from each of the other available OWS / LCD.
- 3. The Plant data pertaining to one unit shall be available in the MMI of the respective unit. Data from common system shall be available in the MMI of both units. Further, suitable displays with selection facility shall be provided for common system drives so that all common system drives can be controlled from any of the unit.

6.3.4.1 Operator Interface Requirements

- 1. The Operator interface of the MMI system shall consist of TFT Monitor, Mouse, Keyboards of OWS, LCD, Printers, etc. as follows:
 - a) Six (6) Nos. OWS with 21" TFT Monitors, Optical Mouse, Keyboard etc. for Unit Operation.
 - b) Two (2) Nos. OWS with 21" TFT Monitors, Optical Mouse, Keyboard etc. for Common system Operation
 - c) Two (2) Nos. OWS with 21" TFT Monitors, Optical Mouse, Keyboard etc. for Shift In Charge Engineer.
 - d) Two (2) Nos. 65" LCD with work station for display control and all other accessories, for Operation & Monitoring.
 - e) One (1) No. 65" LCD with work station for display control and all other accessories, for Operation & Monitoring of Plant Common System.
 - f) One (1) No. 65" LCD with work station for display control and all other accessories, for Operation & Monitoring of Plant Electrical System.
 - g) Two (2) Nos. Dot Matrix Printer (A3 size) for Alarm Printing.
 - h) Two (2) Nos. Dot Matrix Printer (A3 size) for Log Printing.
 - i) Two (2) Nos. Color Laser Jet Printer (A3 size) for Hard Copy Printing.
 - j) One (1) No. Color Laser Jet Printer (A4 size) for Shift In charge Station.
- 2. All OWS / LCD of the MMI System shall be fully interchangeable i.e. all operator functions including control, monitoring and operation of any plant area shall be possible from any of the OWS / LCD at any point of time without the necessity of any action like downloading of additional files. Each OWS / LCD shall be able to access all control information related data under all operating conditions including a single processor / computer failure in the MMI System. Further, simultaneous operation of at least two drives of control system shall be possible

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from a single display without calling additional display for multiple drive operation.

3. The operator functions for each OWS / LCD shall as a minimum include control system operation (A/M selection, raise / lower, set point / bias change, on / off, open / close operation, mode / device selection, bypassing criteria, sequence auto, start / stop selection, drive auto selection, local-remote / other multi-position selection etc.), alarm acknowledge, call all kind of displays, logs, summaries, calculation results etc., printing of logs and reports, retrieval of historical data and any other functions required for smooth operation, control and management of information.
4. All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays and other operator functions.
5. The display selection process shall be optimized so that the desired display can be selected with the minimum number of operations. Navigation from one display to any other should be possible efficiently through paging soft keys as well as through targets defined on the displays. There should be no limitation on number of such targets.
6. The system shall have built-in safety features that shall allow certain functions and entry fields with a function to be under password control to protect against inadvertent and unauthorised use of these functions. Assignment of allowable functions and entry field shall be on the basis of user profile. The system security shall contain various user levels with specific rights, which shall be changeable by the programmer.
7. Set points and other entries made shall be automatically checked for validity of range.
8. In addition to the OWS & LCD, minimum amount of conventional instrumentation (i.e. Push button Stations etc.) shall be provided as per standard practice for safe shut-down of the unit.

6.3.4.2 MMI System Functional Requirement

The MMI System shall be designed as an on-line system which shall process, display and store Information to provide the operator, either automatically or on demand. The Following functions shall be performed by MMI system as a minimum:

1. Plant Control Displays

Various displays on the OWS / LCD shall as a minimum include P&ID displays or mimic, bar chart displays, X-Y and X-T plot (trend) displays, operator guidance message displays, group displays, plant start-up / shut-down message displays, system status displays etc. Number of displays and the exact functionality shall be on as required basis.

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Minimum contents and functionality of various types of displays shall be as under:-

a) Mimic Display

These displays shall depict the process in graphical form and shall cover all the drives operable from DCS and all process areas being monitored therein. There shall be two types of mimic display, broadly, i.e. Overview displays and sub-area / individual displays. Operation of sequences and drives shall generally be carried out through the sub-area / individual displays.

Facility of adding a user specific symbol to the standard library shall be possible. It shall be possible to go to a predefined trend display on selecting a field on any analog point on the displays.

b) Control Tile Display

In this display the drives of a loop shall be displayed with related parameters such as process value, set point, deviation for the loop along with facility for any selections (like A/M selection, valve selector etc.) and the command output, disturbance status and the position feedback signals, for each drive. It shall be possible to call this display as a Pop-up window from the controlled drives in main mimics.

c) Trend Display (X-T Plots)

These displays shall show the trend of analog points with respect to time. These displays shall be continuous curve plot and not point plots. Time spans of displays shall have operator selectable intervals of 5, 10, 15, 30, 60 minutes, 8, 24 and 72 hours. In addition, zoom in / out, stretching facilities etc. shall be provided. Sufficient buffer space shall be provided to store data for minimum 500 points at MMI system scan rate for 72 hours.

d) X-Y Plot Display

There shall be fifteen number of such X-Y plot displays each of one page, pre-programmed in the system. At any instant of time, this page shall include up to 3 independent X-Y point Plots (values of X and Y variables) of up to three equipment typically in the form of a cross 'X'. Operating curves shall be superimposed over the X-Y plot. Alphanumeric information shall be overlaid to indicate X and Y scales, point identification, current operation point value with engineering units, etc. Two or three pairs of X and Y variables having common operating curves shall be displayed on one display page only. In such cases distinct symbols shall be used to show operating point for each. The balance shall be programmable at site.

e) X-Y Plot Display using stored data

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This type of display shall show the analog trend of X-axis variable with Y-axis variable with facility to select time period. Ten numbers of such displays, each of one page shall be pre-programmed in the system.

f) Sequence Display

Sequence chain displays for each group and sub-group shall be used to trace the sequence of a control chain as well as to facilitate the operator interventions and enable mode changes / auto selection. Sequence chain display shall present complete sequence chain, in functional blocks, steps being carried out, criteria, running time, monitoring time, waiting time, operating mode, various parameters with associated engineering units for each step and criteria. It shall be possible to display a list of missing criteria for each sequence chain on Operator's demand. The sequence chain display shall automatically move forward when the auto sequence is in operation.

g) Drive Level Display

For each drive (both binary & modulating) a drive level display shall be provided which shall indicate the value / status of drive related inputs / outputs, permissive and protection conditions, the drive level logic and other drive related information including individual drive faults and disturbance criteria. It should be possible to call these displays as pop-up displays.

h) CLCS Display

The loop schematic for each loop shall be available in a display form which shall show the individual analog and binary values (input / output and intermediate) and the loop tuning parameters also.

i) Group Display

The group display shall present point information including point ID, description, current value, range, function group, quality tag and engineering unit of a group of points. (Number of points in a page shall be minimum 20).

j) Bar Graph Display

Horizontal and vertical bar charts shall be provided for the display of related points. Number of bars in a display shall be limited only due to visibility and resolution and no restriction shall be there in the numbers otherwise.

k) Alarm/Fault Analysis Display

In order to guide the operator in case of a process fault / alarm, a fault analysis display shall be provided so that the cause of the alarm, is presented to the operator. For each alarm, various reasons for the cause of the alarm shall be displayed.

l) Alarm Querying facility

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On each display, one icon shall be provided. Clicking this icon shall lead to a display indicating all the lamp boxes and list of alarms in each box along with its status. Clicking on the alarm text of a lamp box shall give detailed list along with status of the individual alarm if it is a group alarm.

m) Point Detail Display

From any display, i.e. mimic alarm or any other group display, facility shall be provided to select any point for point detail display. This display shall include all the database attributes of the point. For field I/Os, the termination and interconnection details up to field sensors shall additionally be available. In the point detail display of calculated point, by simple clicking of point or through soft key it shall be possible to display the calculation used and to get further details of any other calculated points used in the calculation.

n) LCD Display

In addition, top area of the LCD (around 300mm), shall be reserved for display of soft replica of Conventional annunciation fascia (for permanent viewing i.e., not operator changeable). LCD based overview display shall be provided, which shall be overlaid across all LCD for viewing as video wall.

2. Log/ Summaries/ Reports

The system shall generate three basic types of reports / logs i.e., Event activated, Time activated and Operator demand log and summaries. The system shall have the facility for viewing of the logs / summaries on the OWS / LCD as well as for their copying in formats compatible to be used with MS-Office or similar tools.

The system shall be designed for automatic printing of all the reports / logs with a provision of inhibition of the print function for each log separately, with selectable duration and selectable page / group of each log. Manual printing of time-actuated log shall also be possible.

Automatic switching of any log function from a pre-selected primary printer to a pre-selected secondary printer (defined on a per log basis) shall be possible. However, change in the assignment of the printers shall be possible through OWS/EWS.

a) Event Activated Logs

Event activated logs shall as a minimum include alarm log, trip analysis log, start-up log, control related logs and operator action log. All operator actions, modification in database etc. shall be logged (with historical storage) along with the username responsible for that action.

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The trip analysis log shall record 30-100 pre-trip and 30-100 post-trip readings, operator selectable at site for the pre-defined parameters (not less than 250 points), sub-divided in to 25 groups. The data collection rate shall be of scan rate 2 minutes (operator selectable at site).

The system shall be capable of generating and printing TG start-up logs, the functionality of which shall be similar to the trip analysis log.

b) Time Activated Logs

Time activated logs shall include shift log and daily log as a minimum. Each of these shall provide hourly record of a minimum 250 points sub divided into 25 groups

c) Operator Demand Logs

Operator demand logs shall include, as a minimum, digital trend log, maintenance data log. Summary log, performance logs and some special logs.

The system shall be capable of generating and printing trend log for a minimum of 80 groups of 15 points each.

Maintenance Data Log (MDL) shall provide schedule of preventive maintenance and routine equipment inspection for 100 numbers of equipment per unit and for auxiliary plant. The data in MDL shall include current status, total running time, running time since last maintenance, running time in current financial year, loss due to downtime etc.

Performance log shall provide results of performance calculations.

d) Various Summaries

Various summaries shall include off scan summary, constants summary, point quality summary, substituted values summary, peripheral status summary, alarm annunciation group summary, etc. These summaries shall also be available process area or sub-area wise, as well as based on any other data base criterion like functional group number, cabinet number, type of signal etc.

e) Generated Reports

It shall be possible to generate certain reports in some of the PC's on the station LAN, which shall constitute partly off-line data entered there-in and on-line information collected from the system. There shall be provision of generation of minimum ten (10) such reports per PC on the LAN.

f) Log Generation Utility

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The system shall have a log generation utility to generate a log / report having following facilities as a minimum:

- Define format of the log like header information, time, date etc.
- Selection of any point (scanned and calculated) from the data base and assign it to a log group.
- Selection of log data collection process initiating event, collection intervals (1, 2, 3, 5, 10, 30 & 60 minutes) for each point of a particular log group. Facility shall also be provided for selection of 100 points at a collection interval of 1, 2, 3, 5, 10 and 30 seconds.
- Assignment of log printout initiation on event or time including selection of the printing interval for particular log group and time of printing. (For time initiated logs).
- Assignment of number of samples to be collected for each point.
- Select points for which minimum, maximum accumulation over a selected period, average, etc., values can be printed. Also facility shall be provided to tag the time at which the parameter passed through maximum / minimum.

It shall be possible to define 100 log groups of 15 points each. Any log group can have any point from the database. One log shall include at the maximum 10 such groups.

3. Alarm Monitoring & Reporting

- a) The system shall display history of alarms in chronological order on any of the OWS. The MMI system shall have the capability to store a minimum of 1000 alarms each with paging features allowing the operator to view any page. The system shall have all alarm functions and related function keys like alarm acknowledge, reset, paging, summaries etc. Other design features like set point / dead band adjustments, provision of alarm priority, manual inhibition and automatic inhibition based on predefined logic etc., shall be provided. The alarm display / report format shall be subject to approval.
- b) Facility of audio annunciation including voice audio shall be provided in OWS upon the occurrence of alarms irrespective of whether alarms are displayed or not. Facility to disable the audio annunciation per OWS shall be provided under the security level of Maintenance or Administrator.
- c) At least four levels of alarm priority shall be available which shall be displayed in different colour. It shall be possible to display and print alarms of any of the four levels only on a per OWS basis.
- d) Alarm boxes shall be provided in each display to alert the operator about an alarm when he is viewing some other picture. Number of alarm boxes shall be for each process area and with priority therein.
- e) Features viz. root cause analysis, alarm filtering, alarm cut out and display of alarms on LCD shall be provided.

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4. Calculations

- a) All the algebraic / logical calculations related to analog points e.g. sum / difference / average / maximum / minimum / integration, selection of one analog point out of two based on status of digital point, duration for which an analog point is above / below a threshold, digital point (e.g. AND / OR / COMPARE etc.), transformations , like running average, periodic average, weighted average, hourly / daily maximum / minimum (or for a specified duration) and time of maximum / minimum, flow calculations, time projection or rate of change calculations, duration in alarm (or duration in a band), number of transgression of a point in a band etc. shall be provided. All the calculated values of the plant shall be available in the database and can be assigned to all functions just like any scanned point. It should be possible to add new algorithm for basic calculations to the standard library.
- b) Using one hour average data of process parameters, the system shall have the capability to calculate present value, expected value and deviations for parameters like plant heat rate (net and gross), boiler efficiency, major drives efficiency calculation, auxiliary power consumption. The performance calculation package shall be based on latest codes & standards as applicable like ASME, BS & HEI.
- c) Provision shall be made, including all required custom programmed software, for performing the calculations described in this clause. All calculations shall use a high level language. Calculations shall be made using floating point arithmetic. These equations shall be changeable on line at the job site.
- d) An extensive set of steam property subroutines based on the latest ASME steam tables shall be included. The calculation results shall automatically be quality coded according to the worst quality of any of the inputs to each calculation. The results of these calculations shall be available through the data base, for appropriate logs and operator displays.
- e) Calculation for monitoring the performance of the unit shall be performed. These calculations are categorized into two classes.
 - I. Class I calculations include those calculations that are made every scan cycle, generally for the purpose of detecting and alarming unit malfunctions. The following class I calculations shall be included:
 - Cold reheat steam approach to saturation temperature
 - Drum Water Saturation Temperature rate of change
 - First stage superheat outlet temperature approach to saturation temperature
 - Turbine steam metal temperature differences
 - Turbine metal temperature rates of change
 - Feed water individual heater terminal temperature difference.

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- Excess air deviation from standard.
 - Feed water leaving each heater temperatures deviation from standard
 - Metal Temperature differences for SH'Y' , RH 'Y' region and any specific location.
 - Turbine steam supply accounting.
- II. Class II calculations include those calculations that are made to determine the performance of individual items of equipment and the overall unit. Class II calculations shall be performed on-line using averaged data which is accumulated over a period of time. This time period shall be selectively adjustable from 10 to 30 minutes. The system shall also collect this averaged data. The operator shall be able to input coal analysis data into the computer for the class II calculations.

Class II turbine performance calculations shall comply with the recommendations of ASME Performance Test Code Report PTC 6S latest as applicable, simplified procedure for Routine Performance Test of Steam Turbines. The vendor shall be responsible for altering his standard performance programme to comply with this specification and to conform to the cycle of these units.

Boiler efficiency shall be computed by the heat loss method and the input-output method. Percentage deviation between the two methods shall be calculated as recommended in the ASME Test Code PTC 4.1-latest, Steam Generating Units. If the test codes require measured data that is not actually available in the process, manually substituted values shall be used.

The following Class II calculations shall be performed.

- Unit heat rate
- Boiler Efficiency
- Operating Hours
- Air Heater Performance
- Economizer Performance
- Deaerator Performance
- HP & LP turbine enthalpy drop efficiency
- LP turbine enthalpy drop efficiency (using dry exhaust)
- Turbine heat rate
- Feed water heater performance
- Condenser performance
- Plant Load/Availability Factors
- Unit Availability Calculations

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- Deviations from Expected Values for Each Calculations

5. Quality Tags

- The system shall identify and tag the quality of all data (scanned and calculated points) in a way that makes all users (control, calculations, logs, display, etc.) aware of its quality. Quality of data other than 'good' shall be clearly identified in all printouts and displays by appending quality character to the value / status of point. The quality tagging shall include good, bad, substitute, doubtful, missing, etc.
- Typically 'Good' shall designate variable that satisfies all tests for quality, 'Substitute' designating a value that has been manually substituted, 'missing' and 'bad' designating an open circuit, transducer limit violation on both upper & lower side, etc. for analog inputs & open fuses, excessive number of chattering etc for digital inputs

6. Database

- The database shall be organized in such a way that searching / querying & sorting of any field shall be possible. There shall be minimum 10 process areas and each database point shall have various attributes.
- Based on these attributes & its combinations, the sorting / searching of the data shall be done.
- The attributes shall include as a minimum single point ID, additional tag number, description, current value, quality tag, engineering unit (if applicable), alarm limits, dead band, alarm cut out point identifier, variable limit point identifier, conversion constants, electrical signal value & unit, alarm status, scan status, historical / long term storage frequency, plant area / sub area hardware details, reference of logic / loop diagram number & page etc.
- All the points i.e. I/O's, OLCS/CLCS, generated signals, computed signals of calculations, OPC tags, shall be identified by unique tag throughout the networked DCS system/ sub-systems including station LAN.

7. Messaging System

It shall be possible to send pre-defined messages either periodically or on occurrence of certain events in the form of:

- Operator guidance message to OWS / LCD.
- E-mail messages to various clients on the station LAN.
- Messages to pre selected Mobile numbers

Adequate safety in the system shall be built up to avoid any unauthorized access to DCS system. All necessary Hardware & Software shall be provided to achieve the same.

6.3.4.3 MMI System Hardware Requirements

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1. The MMI system shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.
2. The Workstation / Servers employed for HMIPIS implementation shall be based on industry standard hardware and software, which shall ensure easy connectivity with other systems and third party software.
3. Power Fail auto Restart facility with automatic time update shall be provided.
4. Necessary hardware and software for quick backup and restore shall be provided.
5. Minimum amount of conventional mosaic compatible hardware devices mounted on draw out portion of Control Desks.
6. All the peripherals shall conform to the following minimum requirement but the exact make & model shall be subject to approval.

A) Operator Workstation

Table 6.9
Specifications for Operator Workstations

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better /64 bit latest generation
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	1 TB
4	Monitor Support	Dual
5	CD Drive	52X Read/Write
6	Power Supply	230 V 50 HZ
7	Keyboard	ASCII
8	Pointing Device	Optical Mouse
9	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

B) Servers

Table 6.10
Specifications for Servers

S.No.	Features	Minimum Requirements
1	Processor	64 bit latest generation

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S.No.	Features	Minimum Requirements
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	3 X1 TB ultra wide SCSI/7200 RPM, Hot swappable
4	RAID	SCSI-channels, hardware RAID level 5 implemented
5	Monitor Support	Dual
6	CD Drive	52X Read/Write
7	Power Supply	Redundant Hot swappable, 230 V 50Hz 1-phase
8	Removable Bulk storage Drive	1 TB minimum
9	No. of Removable bulk storage media for above	10 nos.
10	Keyboard	ASCII
11	Pointing Device	Optical Mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

C) LCD Screen

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LCD display complete with control units & associated accessories shall be supplied as per the following specifications.

Table 6.11
Specifications for LCD

S.No.	Features	Minimum Requirements
1	Viewable Picture Area	65 inch measured diagonally
2	Resolution	1920 X 1080
3	Aspect Ratio	16:9
4	Display Colors	16.9 million colors
5	LCD Panel	Active matrix TFT LCD
6	Contrast Ratio	800:1
7	Brightness	500 cd/m2, Anti-glare
8	Viewing Angle	178° Horizontal & Vertical both
9	Computer Interface	VGA, DVI-D, HDMI,
10	Cabinet Material	ABS
11	Finish	Black
12	Mounting	Fixed Wall Mounting
13	Power supply	230 V, 50 Hz, 1-phase
14	Accessories	Universal Tilt wall mount stand, IR Remote, Power cord

Other Features of LCD

1. LCD shall be designed for continuous viewing (24 hours in a day) under normal room ambient lighting without any need to darken the room. Suitable darkening of the projection screen for light absorption shall be provided for this purpose.
2. The screen should be flicker free and there shall not be any screen burn-in due to display of same information for a long time.

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3. Auto brightness adjustment between each screen shall be provided.
4. The control unit shall interface with the unit LAN. The control units shall have dual Ethernet connection with the respective Unit LANs and shall be located in the LCD panel.
5. Suitable facility shall be provided to the Operator for transferring the screens, without any need of changing of hardware / wiring or software.
6. Master control unit shall be capable of projecting MMI displays over a part of screen to multiple screens. Any communication of windows shall be possible. Facility for overlays shall be provided.
7. The LCD Screens shall have additional features to work in association with multiple numbers of plant cameras also to be supplied under this package.

D) Printers

Table 6.12
Specifications for Dot Matrix Printer

S.No.	Features	Minimum Requirements
1	Type	Heavy duty (at least 50000 pages/month)
2	No. of Needles	24 pin
3	Printing Speed	300 characters per second/ 1000 Lines per minute
4	Character dimension	9 x 8
5	Buffer	80 KB (minimum)
6	Local Memory	RAM with battery backup
7	Communication Port	Ethernet/RS-232/parallel
8	Power supply	230 V, 50 Hz, 1-phase
9	Paper size	132 column continuous fan fold type/A4/A3
10	Paper input capacity	continuous
11	Character sets	ASCII, IBM, Italics,
12	Transfer distance	200 mtrs. Minimum
13	Print features	Graphic print, Emphasized, double width, underlined, subscript, superscript, double

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S.No.	Features	Minimum Requirements
		strike, backspace, margin etc.
14	Reliability	MTBF > 8000 hrs.
15	Noise Level	Less than 60 dBA
16	Ribbon Life	2 million characters
17	Diagnostics	Self diagnostic, LED error code display, Audio alarm – paper exhausted
18	No. of Copies	Minimum Original + 3
19	Accessories	Printer stand Table top receiving station Interface cable Paper tear box Ribbon

Table 6.13
Specifications for Laser jet Printer

S.N	Features	Minimum Requirements
1	Type	Electro-Laser photographic, Table top type
2	Printing speed	Monochrome : 24 ppm – A4 Color : 6 ppm – A4
3	Printer Memory	256 MB (minimum)
4	Resolution	1200 X 1200 DPI in color
5	No. of Color (Basic)	4 nos.
6	Duty cycle	Monochrome 75000 pages/month
7	Power supply	230 V, 50Hz, 1-phase
8	Paper size	A3/A4

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S.N	Features	Minimum Requirements
9	Print media	Plain paper, Transparency, Thick stock, Glossy stock, Envelopes
10	Communication Port	Ethernet port/ Parallel port
11	Paper input capacity	500 pages
12	Others	Auto duplex function

6.3.5 Maintenance Engineer Station (Engineering Work Station)

- The system shall be provided with programming facility (Engineering Workstation) for Control system and system documentation. Three (3) Nos. of EWS shall be provided on per unit basis placed in Engineering Room. The system shall be complete with monitor, keyboard & Optical mouse.
- The system shall be also provide minimum Two (2) Nos. of Laptop computers with latest hardware configuration and loaded with suitable operating & application program as a backup portable programming and configuration station.
- Each station shall be equipped with DVD writer for archiving of the configuration.
- EWS shall have all the features of OWS and in addition shall have the following capabilities as a minimum:
 - To generate control software through logic diagrams without any programming knowledge
 - To generate graphic display and control displays, facility to change/enter all the attributes of analog and digital I/O points, calculated and Boolean variables and constants like scan rate, process range
 - To test, configure/reconfigure process interface modules/cards
 - CLCS tuning
 - To accumulate I&C faults to analyse downtimes and time to repair
 - To run offline system diagnostic programmes
 - On- line fault detection through diagnostics
 - Other maintenance Engineer's functions.
- Online modification/addition of loops without hampering of smooth operation of plant. In case of errors in programming at engineering station, same shall be notified along with suggested corrections by the system itself, before loading.
- The programming tools shall have in-built safety features that shall protect the system against inadvertent and unauthorized use of these tools. Necessary hard key locks and software locks, etc. shall be provided for this. During on line programming, external plant / equipment should not be affected.

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7. The system shall also have facility to permit the programmer to add text information at the beginning and end of each program, wherein programmer shall list out his name, time, date of change which has been made, name of the person who has authorized the change, etc.
8. Any modification done in Control System shall be suitably logged so that it can be traced to the user log-in ID and time of change. Facility for modifications shall be user friendly
9. Structuring / configuring and tuning facilities shall be provided for structuring / modification, storing / loading, testing, tuning, monitoring, etc. of all the microprocessor based controllers of the control system. The configuration and tuning unit shall be hooked up with the system bus. In case different hardware is employed for different parts of control systems and it is not possible to provide structuring/ configuration and tuning of these from the same station, then the system shall be provided with necessary number of stations for the purpose.
10. It shall be possible to configure the system with ease without any special knowledge of programming or high level languages. Control strategy shall be implemented using familiar and conventional automation function blocks (software implemented). Whenever any change in configuration is done, it shall be recorded and modified configurations shall be available for printing and documentation and shall be stored in non-volatile memory. The entire system configuration, tuning / fixed parameters shall be documented and printed in form of function diagrams and lists respectively.
11. On-line tuning of the control loops shall be possible without causing any disturbance in the execution of the control loops. Provision to store and retrieve on immediate and long term basis the system configuration, data base etc. on some device such as DVD shall be included. Facility shall be provided to reload / down-load the system or controller module from the already stored data, on-line.
12. The Engineering station shall be equipped with system/software to calculate the tuning constants i.e. P, I & D values of control loops automatically. Facility shall be provided to conduct open loop tests (i.e. controller in manual mode) and close loop tests (i.e. controller in auto mode) on control loops through GUI based user interface. It shall be possible for the user to adjust the step size of disturbance, sample time and duration of test. Facility shall be provided to choose the type of process to be tuned i.e. PI, PID etc., controller type i.e. regulating or tracking and the type of process being controlled i.e. Integrating, non-integrating etc. Further it shall also be possible to calculate the tuning constants by capturing the process changes during normal process disturbance (without conducting any test). The calculation of tuning constants shall follow internationally accepted tuning procedures.
13. Online system shall be provided for programmed development / modification to achieve various functions including development, modification and testing of software of MMI, generation and modification of graphics, logs, and HSRS

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functions in an interactive manner, MMI Database modification / creations, down loading the software with associated data base from the console and other features necessary for system maintenance. Also facility shall be provided to print system fault as detected by the online self-diagnostic routine.

14. The system shall have the facility to generate the associated documentation for both the Control System & MMI. The document, to be generated by the system shall include P&ID drawings, control loop drawings, sequence drawings, signal distribution list / drawings, system interconnection drawings, cabinets general arrangement drawings, measurement list, drive schedule, alarm schedule, system hardware and functional configuration drawings for displays, logs, trends, graphics etc. The system shall also include all required software and hardware tools for creating, modifying and printing CAD drawings to achieve paperless documentation for DCS.

Table 6.14
Specifications for Engineering Workstations

S.No.	Features	Minimum Requirements
1	Processor	64 bit latest generation
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	1 TB
4	CD Drive	52X DVD Read/Write
5	Power Supply	230 V 50 HZ 1-phase
6	Keyboard	ASCII
7	Pointing Device	Optical Mouse
8	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

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Table 6.15
Specifications for Engineering Laptop

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better latest generation
2	Memory	4 GB DDR3 SDRAM expandable to 6 GB
3	Hard Disk	SATA2/ 1 TB/7200 RPM
4	CD Drive	52X combo CD/DVD Read/Write
5	Power Supply	230 V, 50 HZ, 1-Phase
6	Communication Ports	2 Nos. USB 1 No. Ethernet 2 Nos. Serial Port 1 Nos. Parallel port
7	Screen	15.4" TFT LCD screen
8	Battery	6-cell, LI-Ion Battery

6.3.6 Software Requirements

1. The system shall be provided with all licensed software packages with media required by the system for meeting the intent, functional / parametric requirements and performance requirements of the specification.
2. The system shall utilize a readily upgradeable, public domain software platform proven for real-time operation environment at the control and monitoring level overlaid with a relational database program. The desirable features are indicated below:
 - a) The software system shall be fully modular.
 - b) The software shall meet the following general requirements:
 - Simple, easy-to-learn editing language for editing and on-line operation.
 - Wide range of standard and non-standard peripheral support capability by modular controllers / supervisors.
 - Effective task scheduling and support of multiple priority structure including event based interrupt etc.
 - Effective debugging.

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- Provision for on-line editing and program development without interrupting on-line functions.
 - Self-diagnostic routines.
 - Efficient memory management and effective utilization of system time.
 - Quick start-up and loading.
 - Support of multiprogramming and multi-user operation.
3. Industry standard operating system like UNIX/WINDOWS NT etc. to ensure openness and connectivity with other system in industry standard protocols (TCP / IP etc.) shall be provided. The system shall have user oriented programming language & graphic user interface.
 4. All system related software including Real Time Operating System, File management software, screen editor, database management software, On line diagnostics / debug software, peripheral drivers software shall be provided. Latest versions of standard PC-based software for database handling, word-processing, spread sheet, Anti-virus etc. and latest WINDOWS based packages etc. and any other standard language offered shall be furnished as a minimum. Systems having program development environments like EWS, Station LAN Server shall have high level programming support like Microsoft Visual Studio, Oracle, RDBMS etc.
 5. The programming language shall support Relational Data Base Management in a global and truly distributed Client-Server environment and shall have the following minimum features:
 - a) Modern high-level block structures type
 - b) Powerful, compact syntax
 - c) Logical organization that facilitates documentation, modification and maintenance of programs
 - d) Early detection of errors at compiles and run time
 - e) Fast debugging
 - f) Improved program reliability
 - g) Clearly defined data structure complemented by flexible user-declared data types
 - h) Fast execution.
 6. All application software for control system functioning like input scanning, acquisition, conditioning, processing & control along with communication among various Control System functional blocks shall be provided.

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7. The system shall be provided with software locks and passwords to engineers at site for all operating & application software in order to prevent unauthorized access and only authorized engineers are able to do modifications at site.
8. Two sets of all final / latest software on non-rewritable/non-editable media shall be provided as back-up.

9. Software License

- a) The system shall be provided with software license for all software being used in the DCS system. The software licenses shall be provided for the project (e.g. organization or site license) and shall not be hardware / machine-specific. That is, if any hardware / machine is upgraded or changed, the same license shall hold good / renew license due to up-gradation / change of hardware / machine in control system at site. All licenses shall be valid for the continuous service life of the plant.
- b) In case the s/w license is dependent on no. of points, then quantity to be considered is 30% above the finally implemented points.

10. Software Upgrades

The system software's installed in the plant DCS, shall be periodically upgrades with the new releases, that would be taking place after the system is commissioned.

6.4 DCS Sub-Systems

The DCS shall consist of the following broad sub-systems, functionally independent of each other except for mutual signal exchange.

- Sequence of Event Recording System (SOE)
- Integrated Annunciation system
- Historical storage & Retrieval system (HSRS)
- Plant Performance Analysis, Diagnostic & Optimization system (PADO)
- Management Information System (MIS)

6.4.1 Sequence Of Event Recording System

1. The DCS system shall also perform the SOE functions like stamping of SOE inputs / points with 1 ms resolution. The SOE function shall be built-in function of DCS.
2. SOE shall be capable of accepting minimum 512 inputs per unit including 10% spare channels (included in total 512 inputs).
3. The system shall monitor SOE inputs with a resolution of one millisecond at all times for all inputs including spare inputs. That is, all SOE points entering status change shall be reported and time tagged within 1 (one) millisecond of their occurrence. Input card shall be equipped with digital filters with filter delay such

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that it should meet SOE time resolution of 1msec (identical for all points) to eliminate contact bounce such that field contact which is changing state must remain in the new state for stipulated time to be reported as one event. The start of data collection for SOE report shall be reported to OWS within 1 sec of SOE data collection initiation.

4. SER is envisaged as an integral part of DCS with 1 millisecond time resolution. The SER data base shall be an integral part of the DCS database and same shall be made available at all the OWS / EWS resident on the network. Operator can access the SER on activation of SER alarm page. All SER inputs shall have real time "time-stamping" following any tripping of major equipment, or sub-system or the plant as a whole.
5. The system shall also have provision of rejection of chattering inputs.
6. In addition to above, facility for adding a field adjustable software delay on a per point basis shall be provided.
7. The system shall also include provision for historical storage and retrieval of SOE reports for 3 months period.
8. The SOE report collection shall begin on occurrence of change of status of any SOE point and shall be printed after an operator selectable time interval of 1 to 3 min. or 100 status changes have taken place after the first event. Adequate numbers of buffers shall be provided to prevent loss of data before transferring to HSR.
9. The SOE reports shall also include a list of major equipment trip in chronological order and include the points that initiated SOE collection. The inputs for SOE shall include
 - a) Hardwired inputs in input cards and
 - b) Calculated points / generated points of Control System.
10. Further, all the operator initiated actions such as trip inactivation (bypass) & trip activation (inline) shall form input to SER.
11. All the SOE inputs shall also be available for interlock / protection functions.
12. SOE of other systems (SG/TG integral control systems) shall also be integrated in this system. The SOE system shall collect process & report SOE inputs of SG & TG control system for a consolidated master SOE system. Necessary communication with required hardware & software and necessary engineering co-ordination with SG & TG Supplier shall be done for successful implementation of a consolidated master SOE list.
13. SOE time stamping shall occur at I/O level.
14. Self Diagnostic Features like scanner test (a periodic test for communication between several levels), functional test by simulating abnormal Conditions shall be provided.

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15.One (1) no dedicated SOE viewing station with SOE Log printer shall be provided

Table 6.16
Specifications for SOE Station

S.No.	Features	Minimum Requirements
1	Processor	64 bit latest generation
2	Configuration	Tower
3	Internal Clock	3.2 GHz or better
4	Memory	4 GB RAM expandable to 6 GB
5	Hard disk	2 TB/7200 RPM
6	CD Drive	52X Combo CD/DVD read/write
7	Graphic Accelerator	16 MB
8	Communication Port	2 serial port, 1 parallel port, 4 USB port, dual 100 MBPS Ethernet port
9	Monitor support	dual
10	Keyboard	QWERTY 101 keys Keyboard
11	Pointing Device	Optical mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz.

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Table 6.17
Specifications for SOE Log Printer

S.No.	Features	Minimum Requirements
1	Type	Heavy duty Dot Matrix Printer
2	No. of Needles	24 pin
3	Printing Speed	300 characters per second/ 1000 Lines per minute
4	Character dimension	9 x 8
5	Buffer	80 KB (minimum)
6	Local Memory	RAM with battery backup
7	Communication Port	Ethernet/RS-232/parallel
8	Power supply	230 V, 50 Hz, 1-phase
9	Paper size	132 column continuous fan fold type
10	Paper input capacity	continuous
11	Character sets	ASCII, IBM, Italics,
12	Transfer distance	200 mtrs. Minimum
13	Print features	Graphic print, Emphasized, double width, underlined, subscript, superscript, double strike, backspace, margin etc.
14	Reliability	MTBF > 8000 hrs.
15	Noise Level	Less than 60 dBA
16	Ribbon Life	2 million characters
17	Diagnostics	Self diagnostic, LED error code display, Audio alarm – paper exhausted
18	No. of Copies	Minimum Original + 3
19	Accessories	Printer stand

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S.No.	Features	Minimum Requirements
		Table top receiving station Interface cable Paper tear box Ribbon

6.4.2 Annunciation System

- The LCD annunciation shall emulate salient features of conventional hardware annunciations while presenting more flexibility.
- The annunciation system shall be implemented as an in built function of DCS. The field contacts shall be acquired through DCS only. The annunciation points shall be presented on topmost area of LCD screens. The annunciation area shall be divided into multiple "alarm bands". There shall be 3 nos. of alarm bands in each LCD screens.
- The annunciation functionality shall be implemented through the LCD as described below as a minimum:
 - There shall be one alarm for each alarm window. Group alarms shall be provided only for pre-defined system/field faults. The alarm text is to be displayed only when alarm is present. A top up window shall be associated with each alarm window which shall show tag no. of alarm point when cursor is brought over the alarm window.
 - Hooters/speakers (not PC Speakers) of different frequencies shall be available for reporting new alarms & resetting of alarms etc. All flashing windows shall flash together (synchronized) in any LCD screen. Suitable means shall be provided to distinguish between new alarms & return to normal message.
 - Annunciation points shall be distributed on various LCD screens based on process area.
 - No fixed space shall be fixed for any alarm band. Once a particular alarm band is full the new alarm on this band shall be reported by shifting old alarm on left side band one by one on FIFO basis. A scroll bar shall be provided to view older alarms.
 - The hooter alarms sound shall be different for both units.
 - Facility shall be provided by which the operator can view details of the alarms, acknowledge the alarm, acknowledge the hooter etc. by clicking on the pop up window options.
- The above annunciation features shall also be replicated on all OWS.

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6.4.3 Historical Storage & Retrieval System(HSRS)

1. Historical storage and retrieval facility shall allow collect and store data and parameters including trends, alarms and events from DCS data base periodically and automatically to removable data storage devices once every 24 hour for long term storage and retrieval.
2. HSRS of other systems (TG integral control systems) shall also be integrated in this system. The HSR system shall collect, process & report HSR inputs of TG control system for a Consolidated master HSR system. Necessary communication with required hardware & software and necessary engineering co-ordination with TG Supplier shall be done for successful implementation of a consolidated master HSRS.
3. Provision shall be made to notify the operator when the disk is certain percentage full.
4. The data to be stored in the system shall include alarm & event list, periodic plant data, selected logs/trends/reports etc.
5. Historical storage should permit trending of all analog inputs with time scale selectable as 1 sec., 10 sec., 30 sec., 1 min., 5 min., 30 min., 1 hour, 8 hours & 24 hours. Vertical Range (parameter range) shall be freely programmable. It shall be possible to map real time & history trend on the same trend group display. History data shall be for minimum 30 days & after expiry shall automatically/manually transferred to the external storage device such as DVD writer or external hard disk.
6. The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on OWS / LCD or printer in form of trend / report by specifying date, time & period through point IDs / group of points. Further, suitable index files / directories shall also be provided to facilitate the same.
7. The System shall store following data as a minimum:

a) Periodic Plant Data

- 1000 analog points with 1 sec rate
- 1000 analog points with 5 sec rate
- Balance analog points with 30 sec rate
- Binary points on status change (with suitable protection against excessive status change)

b) Logs & Reports

- All hourly, shift, daily, monthly, yearly logs
- All alarm logs
- All control related logs

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- All event based logs
- Pre-Trip & Post-trip logs
- Start up logs
- SOE Reports
- Maintenance data log

Apart from this other logs comprised of computed data such as running hour logs of drives, fuel consumption log, water consumption log, Auxiliary power consumption log, metal temperature logs or calculated values like efficiency etc.

8. Dedicated Redundant workstation with dot matrix & Laser jet printer shall be provided (per unit) for historical storage & retrieval system.
9. Provision for export of data to Excel spreadsheet package shall be available.

Table 6.18
Specifications for HSRS Station

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better 64 bit latest generation
2	Configuration	Tower
3	Internal Clock	3.2 GHz or better
4	Memory	4 GB RAM expandable to 6 GB
5	Hard disk	2 TB/7200 RPM
6	CD Drive	52X DVD read/write
7	Graphic Accelerator	16 MB
8	Communication Port	2 serial port, 1 parallel port, 4 USB port, dual 100 MBPS Ethernet port
9	Monitor support	Dual
10	Keyboard	QWERTY 101 keys Keyboard
11	Pointing Device	Optical mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz.

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Table 6.19
Specifications for HSRS Log Printer

S.No.	Features	Minimum Requirements
Same as Table 6.17		

Table 6.20
Specifications for HSRS Laser Jet Printer

S.N	Features	Minimum Requirements
Same as Table 6.13		

6.4.4 Plant Performance Analysis, Diagnostic & Optimization System

6.4.4.1 General

1. PADO system shall provide critical analysis of the plant performance and guidance for optimisation on continuous on-line basis. The system shall analyse dynamically the status of the process and the equipment of the power generating units and shall automatically generate the operator guidance instructions for remedial actions for maintaining the process and the system / equipment in the plant to their optimum performance.
2. PADO shall incorporate the complete thermal design model of the plant and shall use the measured data from the plant DCS acquired through a suitable interface.
3. The system to be provided shall include all necessary hardware, software, firmware and interfaces required for implementing a fully functional PADO system. PADO shall include but not limited to the details specified in subsequent paragraphs.
4. PADO system shall be independent.

6.4.4.2 Functional Requirements

PADO system shall provide following functional requirements:

- Performance analysis and monitoring of systems and components
- System and performance diagnosis
- System and performance Optimisation
- Emission analysis and monitoring
- Boiler performance optimisation
- Boiler Stress Condition Analysis
- Regenerative cycle performance Optimisation
- Interactive water and steam chemistry management system

1. Performance Analysis & Monitoring of Systems & Components

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Performance analysis and monitoring of systems and components shall involve and facilitate the following:

- a) Computation of thermal performance status of the plant and efficiency of generation.
- b) Computation of all the key system performance indicators at system level such as heat rate, plant and equipment efficiency, generator output and controllable losses.
- c) Computation of all the key system performance indicators at major component. This shall include the following:
 - Assessment of boiler operation based on efficiency, excess air and cleanliness factors of super heater, re heater and economiser.
 - Turbine performance evaluation considering efficiency, enthalpies, steam flow and gland leakage flow estimation.
 - Air Pre-heater performance involving efficiency and pressure losses.
 - Condenser performance based on heat duty and heat transfer co-efficient and cleanliness factors.
 - Performance of re-generative heaters by computing extraction flows, drain flows, terminal temperature difference and drain cooling approach.
- d) Analyse the impact of individual component performance on overall losses or gains in total unit generation along with computation and display of cost of individual loss/gain.
- e) Performing detailed analysis of each component including computation of key performance indicators such as efficiency, heat transfer co-efficient, TTD, DCA and fouling factor.
- f) Visualisation of individual component efficiencies & performances and display of the same.
- g) Visualisation of impact of incremental change of the major process parameters including but not limited to the following on boiler efficiency, turbine heat rate and unit heat rate etc. through 'What If' query facility for operator:
 - Main Steam pressure
 - Super heater Spray flow
 - Re heater Spray flow
 - Economiser Inlet Temperature
 - Excess Air
 - Coal Analysis
 - Surface effective for super heater, re heater and economiser

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- h) Performance computations to be carried out at specified intervals based on time averaged data during steady state operating conditions.
- i) Computations to be based on process signals, equipment status, design criteria and manual input data (where ever needed). Raw measured value for process signals shall be reconciled before usage.

2. Systems & Performance Diagnosis

- a) System and performance diagnosis shall involve detection of the abnormalities and diagnosis of system and component performance degradation up to component level to pin-pointing root cause of abnormalities existing in the process and guiding the operating personnel to attend to the same.
- b) Diagnosis function involves the following:
 - Equipment health diagnosis for high/ low pressure, temperature, level & vibration etc.
 - Plant performance diagnosis for boiler, turbine, condenser, feed water and regenerative heating system
 - Identifying degradation of measuring instrument for important parameters using data validation checks.
- c) Diagnosis based on expert system in the form of "Fault Trees" / Neural and Bayesian belief networks etc. Expert systems shall draw inferences based on knowledge base, on-line measured data and computed performance indices.
- d) Diagnosis system shall be capable to provide following helps:
 - Avoiding a possible trip
 - Maintaining process parameters within safe limits thereby enhancing the life of the equipment
 - Drawing the operator's attention to the degradation of the equipment and instruments

3. Systems & Performance Optimization

System and performance optimisation involves optimisation of set points for controllable parameters by recommending to the operator the optimum set points for optimising the given process or activity at the measured operating condition using state of the art optimisation techniques.

4. Emission Analysis & Optimization

Emission analysis and monitoring functions involves the following:

- a) Monitoring, tracking and analysing plant emissions such as SO₂, NO_x, CO, CO₂ etc. in real time.

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- b) Monitor and analyse ESP & Stack conditions such as temperature, humidity, gas flow rate and opacity.
- c) Facilitate obtaining lowest emissions by recommending optimal damper position to minimise the NOX level measured at the stack while maintaining the CO value and unburnt carbon below desired permissible limits.
- d) Facilitate obtaining lowest emissions while maintaining combustion efficiency.
- e) Facilitate to set alarms to highlight conditions that violate pre-defined conditions

5. **Boiler Performance Optimization System (BPOS)**

BPOS shall enable operating personnel to improve boiler performance and optimise fuel consumption including optimised operation of Soot Blowing system. This system shall have following features:

- a) Incorporates the complete thermal design model of the boiler capable of both forward and backward computation of complete boiler thermal performance.
- b) Boiler thermal design model calibrated to made "Site- specific" based on series of field trials of thermal performance of the boiler during start up and prior to trial operation.
- c) BPOS to function continuously taking into consideration the performance of furnace, super heater, economiser, air heater and pulveriser based on the continuous on-line measurement of the including but not limited to the following parameters:
 - Flue gas temperature at ECO I/L
 - Flue gas oxygen content
 - Other fluid temperature(s) entering and exiting various heat transfer surfaces
 - Coal Characteristics
- d) BPOS shall be capable for continuous on-line calculation of the thermal performance of the boiler for the operating conditions indicating performance prediction zonal absorption, metal temperature and shall have the following features:
 - Fuel switching capability
 - "What If" query capability
 - Selective soot blowing of furnace/Super heater based on trends of zonal absorption.
- e) Expert system diagnostics for quick identification of the Root Cause of deviations from the predicted parameters.

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6. Boiler Stress Condition Analysis (BSCA)

- a) BSCA monitors the thermal stresses and assess life exhaustion in thick walled components like super heater and re heater outlet headers by estimating the expended life due to low cycle fatigue and creep.
- b) BSCA shall guide the operator during start- up and shut down regarding controlling of rate of heating or cooling of metal within specified limits and also guides the margins available for the rate of steam generation (for fuel firing) during start-up.

7. Regenerative Cycle Performance Optimization System (RCPOS)

Regenerative cycle performance optimisation system shall involve the following:

- a) Analysis of deviation of performance of the turbine cycle by examining the deviation of important parameters of the turbine cycle.
- b) Analysis of actual efficiency of individual stages of turbine.
- c) Evaluation of LPH & HPH performance by comparing current values of TTD/ DCA to the reference values.
- d) Heater level evaluation

8. Interactive Steam & Water Chemistry Management System

- a) Interactive water and steam chemistry management system shall be capable of guiding the operator for appropriate chemical dosing to maintain the chemical balance, optimal blow down and carry out further investigation as advised by the system.
- b) The system shall have following features:
 - Monitoring of various steam and water parameters at certain pre-determined points in the flow cycle and warning the operator about any distinct aberration and guiding on precautionary as well as corrective actions to be taken.
 - The system shall use "Decision Trees" and "Fault Trees" or other suitable methods for each parameter to diagnose deviations in controlled parameters in order to find the root cause and advise corrective actions.
- c) The system shall provide following benefit to the user/operator:
 - Minimisation of makeup water consumption
 - Decrease in consumption of dosing chemicals
 - Prevention of carryover of impurities into the turbine
 - Decline in degradation of turbine components
 - Lessening of boiler tube scale formation
 - Reduction in energy consumption

6.4.4.3 Design Requirements

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1. PADO system shall be based on Client- Server and expert system. The system shall operate on a commonly used hardware platform and network operating system.
2. System shall be suitable for simultaneous use by multiple users.
3. The system shall be suitable for a wide range of tagging systems and in particular KKS tagging system.
4. The system shall be password protected. It shall be possible to organise system users into groups and each group shall have a separate security profile. It shall be possible to provide additional personal security settings for individuals within a group.
5. The system shall be able to obtain requisite plant system / equipment and process data from the plant DCS. To meet the above requirement, PADO system shall be interfaced with Plant DCS through redundant bi-directional communication link.
6. The system shall have facility to store bulk data with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user friendly utilities to retrieve and analyze stored data.
7. Each PADO system shall include all hardware and software as required for proper functioning of the system including:
 - a) One (1) No. Redundant Server (with monitor, keyboard, Mouse etc.) per unit
 - b) One (1) No. User Workstation (with monitor, keyboard, mouse, Colour Printer etc.) per unit.
 - c) PADO Software with required user License's
 - d) Bulk Data Storage & Retrieval facility
 - e) Redundant OPC communication Link with all necessary hardware & software.
8. All software licenses shall be valid for entire life of the plant. It shall be possible to upgrade the installed system with latest available version of the software model without any additional hardware/software requirements during entire life of the plant.

Table 6.21
Specifications for PADO Server

S.No.	Features	Minimum Requirements
1	Processor	Intel i5 or better /64 bit latest generation
2	Memory	4 GB RAM expandable to 6 GB
3	Hard Disk	2X1TB ultra wide SCSI/7200 RPM, Hot

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S.No.	Features	Minimum Requirements
		swappable
4	RAID	SCSI-channels, hardware RAID level 5 implemented
5	Monitor Support	Dual
6	CD Drive	52X Read/Write
7	Power Supply	Redundant Hot swappable, 230 V, 50Hz, 1-Phase
8	Removable Bulk storage Drive	1 TB minimum
9	Removable bulk storage media for above	10 nos.
10	Keyboard	ASCII
11	Pointing Device	Optical Mouse
12	Monitor	Min 21" TFT Flat Monitor with resolution of 1600 x 1200 non-interlaced refresh rate min. 85 Hz

Table 6.22
Specifications for PADO Workstation

S.No.	Features	Minimum Requirements
Same as Table 6.16		

Table 6.23
Specifications for PADO Laser jet Printer

S.No.	Features	Minimum Requirements
Same as Table 6.13		

6.4.5 Management Information System

1. An integrated Management Information System (MIS) shall be provided for the plant. System shall be able to provide information related to the following aspects to management personnel:
 - a) Plant Operation Information (Dynamic Mimics)
 - b) Plant Maintenance related Information

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- c) Environmental Information
- 2. MIS shall provide following plant information:
 - a) Environmental and hazard management
 - b) Equipment maintenance history
 - c) Fault cause analysis
 - d) On job information report
 - e) Plant Operation history
 - f) Plant performance details
 - g) Any other plant operation data/ details
- 3. MIS shall be based on client server & relational data base environment. The system shall operate on commonly used hardware platform & network operating system.
- 4. System shall be suitable for simultaneously used by multiple users. It should have at least 20 user licenses.
- 5. The system shall be password protected. It shall be possible to organize system users into groups and each group shall have a separate security profile. It shall be possible to provide additional personal security settings for individuals within a group.
- 6. MIS processing shall be carried out in an independent server interfaced with plant DCS, All BOP & offsite plant PLC control systems, Plant Performance Analysis, diagnostics & optimization system (PADO), Computerized Maintenance management system (CMMS) for polling of plant operational and performance data, and maintenance details. Plant environmental data shall be obtained from DCS. The MIS system server shall be connected with station LAN and all user PCs shall be connected with the station LAN.
- 7. The system shall have facility to store bulk data with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user friendly utilities to retrieve and analyze stored data.
- 8. MIS shall include all hardware and software as required for proper functioning of the system including
 - a) One (1) No. Redundant Server (with monitor, keyboard, Mouse, colour printer etc.) per unit
 - b) Twenty (20) Nos. (to be finalized by purchaser during detail engineering) User Workstation (with monitor, keyboard, mouse, etc.)

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- c) 42" LCD Monitor for display in different areas of plant such as Conference Room, station Entrance etc. These display boards shall include the following minimum parameters along with engineering units:
- Unit MW
 - Unit frequency
 - Unit auxiliary power consumption
 - Station-Total MW (common)
 - Station-Total auxiliary power consumption (common).
- d) MIS Software with minimum 50 nos. user License's
- e) Bulk Data Storage & Retrieval facility
- f) Redundant OPC communication Link with all necessary hardware & software.
- g) Servers & user PC's operating licenses
9. All software licenses shall be valid for entire life of the plant. It shall be possible to upgrade the installed system with latest available version of the software model without any additional hardware/software requirements during entire life of the plant.

Table 6.24
Specifications for MIS Server

S.No.	Features	Minimum Requirements
Same as Table 6.21		

Table 6.25
Specifications for MIS Workstation

S.No.	Features	Minimum Requirements
Same as Table 6.16		

Table 6.26
Specifications for MIS Laser jet Printer

S.No.	Features	Minimum Requirements
Same as Table 6.13		

Table 6.27
Specifications for MIS LCD Monitor

S.No.	Features	Minimum Requirements
1	Viewable Picture Area	42 inch measured diagonally

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S.No.	Features	Minimum Requirements
2	Resolution	1920 X 1080
3	Aspect Ratio	16:9
4	Display Colors	16.9 million colors
5	LCD Panel	Active matrix TFT LCD
6	Contrast Ratio	800:1
7	Brightness	500 cd/m2, Anti-glare
8	Viewing Angle	178° Horizontal & Vertical both
9	Computer Interface	VGA, DVI-D, HDMI,
10	Cabinet Material	ABS
11	Finish	Black
12	Mounting	Fixed Wall Mounting
13	Power supply	230 V, 50 Hz, 1-phase
14	Accessories	Universal Tilt wall mount stand, IR Remote, Power cord

6.5 DCS Power Supply Requirements

1. Redundant UPS power feeder shall be provided for all 230VAC equipments and/or redundant feeders for 24 V DC for DCS requirements. The necessary cabling & termination at both ends for receiving the power supply shall be furnished as per the contact requirement.
2. The DCS shall work on 24 V DC Power supply & Computers and peripherals shall work on single phase AC supply from UPS.
3. All power supply in the System cabinets shall be redundant and shall have auto change over facility or diode auctioneering. Power supply monitoring shall be provided in the DCS.
4. The power supply shall be provided with suitable arrangements with redundant distribution boards for each system with proper auto change over scheme to change the load from one feeder to other, in case of one feeder failure.

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5. Redundant DC feeders (One each from DCDB) shall supply each of the connected loads. However, 25% spare feeders (minimum 1 no.) of each rating shall be provided in each DCDB.
6. Redundant AC UPS feeders (One each from UPS ACDB) shall supply each of the connected loads. However, 25% spare feeders (minimum 1 no.) of each rating shall be provided in each UPS ACDB.

6.6 DCS System Cabinets/Panels

1. All Control system modules, power supply components, other control devices which are required for completeness of the system shall be housed in cabinets. All equipment and dedicated cabinets required for termination, marshalling and proper interface within system and also with other systems shall also be provided.
2. The cabinet mounted equipments shall be fully assembled, installed in mounting racks, wired and fully tested as per specification requirements and approved drawings in the manufacturing works of a qualified manufacturer prior to shipment to the project site. It shall be ensure that the cabinets are complete and ready for installation before dispatch from manufacturing works. The installation work at project site for these cabinets should only involve connections through multi pair cables from marshalling cabinets (wherever provided) to system cabinets and inter-cabinet.
3. The Control system cabinets shall be grouped into physically separate cabinets as follows:
 - a) Control System Cabinets
 - b) Marshalling Cabinets
 - c) Relay Cabinets

However, in case the system design requires the termination cabinet independent from system cabinet, the marshalling cabinets can be combined with the termination cabinet. In case, the termination arrangement is part of the system cabinet, independent marshalling cabinets shall be provided.

4. A special note shall be indicated that in case termination of field cables directly to control system cabinet is not acceptable.
5. The Control system cabinets shall house all types of modules / hardware to achieve all functions of Control System including signal conditioning modules, controller modules, I/O modules, communication controller modules and all other requisite hardware for a complete system.

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6.7 DCS System Response Requirements

DCS System response requirement (Under worst loading conditions) shall be as follows:

Table 6.29
DCS System Response Requirements

S.No.	Parameter/Function	Requirement
1	Scanning rate of Analog Signals	Maximum 1 sec for measurement
2	Scanning rate of digital signals	Maximum. 100 ms
3	Scanning rate of pulse signals	Maximum 100 ms
4	Loop execution time for CLCS	Maximum 250 ms (For all Loops)
5	Loop execution time for OLCS	Maximum 100 ms (For all Loops)
6	Controller output update for CLCS	Every 250 ms (For all CLCS Loops)
7	Controller output update for OLCS	Every 100 ms (For all OLCS Loops)
8	Updating rate of Analog display	Maximum 2 seconds (for measurement)
9	Updating rate of Analog display	Maximum 1 second for OLCS/CLCS
10	Updating rate of Digital value display	Maximum 4 seconds (for measurement)
11	Updating rate of Digital value display	Maximum 1 second for OLCS/CLCS
12	Time for display in CRT screen	Maximum 1-2 seconds on demand
13	Keyboard command execution time	Maximum 1 sec
14	Controller Loading	Maximum 60 %
15	Data Bus Loading	Maximum 50 %

Table 6.30
DCS System Display Response Requirements

S.No.	Parameter/Function	Requirement
1	All control related displays	1-2 seconds
2	Point details display (single point)	1-2 seconds
3	Bar chart display (20 points, current display)	2-3 seconds
4	Plant mimic display of fair complexity with a minimum of 120 nos. of dynamic data items	2-3 seconds
5	Group review display (20 points, current values)	2-3 seconds
6	X-Y Plot display (2 X-Y Plot & single display requiring both history as well current data)	2-3 seconds

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S.No.	Parameter/Function	Requirement
7	X-T Plot display (Trend of six analog points and a single display requiring both history as well as current data)	3-4 seconds
8	Plant summary display (e.g. bad points summary, limit check removed point summary. Assume the whole database search is required & summary display contains ten points)	3-4 seconds

6.7.1

Performance Requirement for Close Loop Control System

Table 6.31
Performance Requirement for CLCS

S.No.	Load/Rate of load change (% of MCR per min.)	Maximum Deviation of Parameters from Set Point					
		Throttle pressure deviation (Kg/cm ²)	Flue gas oxygen deviation (% O ₂)	Furnace pressure deviation (mmwcl)	S.H. steam temperature deviation (Deg.C)	R.H. steam temperature deviation (Deg.C)	*Drum Level deviation (mmwcl)
A	Steady state condition						
1	90% to 100%	± 2.0	± 0.4	± 8.0	± 5.0	± 5.0	± 15.0
2	60%	± 2.0	± 0.4	± 8.0	± 5.0	± 5.0	± 15.0
B	Ramp test (change for max. duration of five minutes)						
1	± 3%	± 3.0	± 0.6/-0.4	± 12.0	± 8.0	± 8.0	± 25.0
2	± 5%	± 3.0	± 0.8/-0.4	± 12.0	± 10.0	± 10.0	± 30.0
3	± 10%	± 4.0	± 0.1/-0.5	± 15.0	± 15.0	± 15.0	± 50.0
C	Step Load changes						
1	From 100% to 80% at the rate of 10% per minute	± 5.0	± 1.5/-0.5	± 20.0	± 15.0	± 15.0	± 50.0

Notes:

1. Sufficient time shall be allowed as setting period between conducting the tests.

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2. Plant operating condition, i.e. main equipment status, availability of auxiliaries, operational and equipment constraints, which can influence the test, shall also be recorded.
3. Control system shall be running in the coordinated master control (CMC) mode i.e. boiler master, fuel flow, air flow, feed water and turbine load control shall be in automatic mode. Load set point, maximum and minimum load set point, rate of raise / lower of load shall be set through the TFT, keyboard/conventional console.
4. The the control system shall be responsive and stable and shall maintain the deviation of controlled variables from set point within the limits specified so that the equipment being controlled shall operate as specified over the range required. The controls shall operate automatically, with no assistance from the operator. The controller shall successfully demonstrate the performance of Closed Loop Control Systems before acceptance and taking over of this system.
5. Applicable for Drum type boiler.

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7. PROGRAMMABLE LOGIC CONTROL (PLC)**7.1 General Technical & Design Requirements**

Programmable Logic Controller (PLC) shall be microprocessor-based system. The PLC shall be versatile, expandable, user friendly and latest state of art technology. The system shall be envisaged for the purpose of sequential operation, protection and interlock, data acquisition system, alarm functions, closed loop control and data archiving for fully automatic operation. Logic controller shall be used with adequate and reliable protection safeguard for various equipments and to assist the operator for easy safe and efficient starting and stopping of various drives in the process. The system shall be designed by selecting high-grade components of proven quality and proper design of system electronics. The system shall be able to operate satisfactorily with reference to the specified environmental conditions as indicated in the specification.

1. The system shall be modular in construction and expandable in future by adding additional electronic modules, which shall be easily accessible for maintenance and repair. The modules shall preferably be Rack/Rail mounted. The types of modules shall be kept to minimum possible in order to have interchangeability and spares inventory.
2. The system shall have extensive self-diagnostic hardware and software features for easy and fast maintenance of the PLC. Safety barriers shall be used for intrinsically safe input / output circuits.
3. The PLC shall have very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and electromagnetic disturbances expected in a power plant.
4. The system shall be programmed as per the logic requirements required for the functioning of the systems and equipment.
5. Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.
6. On-line replacement of any module shall be possible in such a way that the removal and addition of the module shall be possible without de-energizing the system or causing any interruption in the system while replacing a faulty module except for the inputs /outputs which are being handled by that module. However, in case of triple modular redundant or dual PLC configurations, there shall not be any process upset while replacement.
7. PLC shall be used with 20% hard wired installed spare I/O Channels.
8. The system shall be capable of handling the long-term storage of data for 15 days and retrieval.
9. The system shall be used with programming and diagnostic facility. Each PLC shall be used with one no. Laptop of latest configuration with programming software & communication cable.

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7.2 PLC System Configuration

PLC shall consist of following sub systems:

7.2.1 Input/output Sub system

1. I/O subsystem shall be suitable for accepting discrete inputs, BCD inputs and analog inputs. The I/O modules shall be mounted in the I/O racks.
2. Each I/O shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 500 V DC.
3. Each module shall have LED for each digital I/O channel to indicate the status of each input / output. Redundancy in I/O level shall be maintained as per the process requirement.
4. PLC inputs shall be used with potential free dry contacts. All the inputs shall be double ended i.e., two wires per input and not common return for all inputs. The contact interrogation voltage for input contacts shall be 24V DC minimum. Each input channel shall be protected by separate fuse.
5. Output contacts from the PLC shall be potential free dry contacts. Each output shall be short-circuit proof and protected by fuse.
6. Visual indication of fuse blown must be provided for each input and output channel.
7. There shall be at least 20% spare capacity available on input & output modules, over and above the system requirement.
8. All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
9. PLC shall have the following monitoring features:
 - a) Power supply monitoring.
 - b) Contact Bounce filtering.
 - c) Optical isolation between input and output signals with the internal circuits.
 - d) In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode.
 - e) Further, keying-in of individual wire connectors shall be used to ensure that only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs.

7.2.2 Processor Sub system

1. The processor sub system shall include CPU, memory, power supply, communication interface etc.

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2. Dedicated PLC's shall be envisaged for each Auxiliary system. The processor shall have capability to implement all the control functions required. The processor shall have sufficient memory for storage of the program instructions as applicable to the logic requirements. CPU shall be of 32/64 bit or upgraded version of microprocessor.
3. Memory shall be non-volatile, preferably EEPROM type. However, in case volatile memory is provided, battery backup shall be used for a minimum of three months to keep the stored program intact. A battery drain indication shall be used at least one week before the battery gets drained. Memory shall be used with adequate capacity with 40% spare capacity under worst loading condition.
4. The healthiness of processor hardware and software shall be continuously monitored by watchdog timer.
5. PLC's shall be used as a minimum with dual redundant processor subsystem including CPU, memory and power supply. Redundancy shall be used such that, in case of failure of the main processor, the standby processor shall take over automatically and vice - versa. The changeover shall be bumpless and shall not result any process or system upset.
6. In case of failure of complete processor system i.e., both processors, outputs shall take fail safe state automatically.
7. The scan time of programmable controller shall be of the order of 100 milliseconds or better. Scan time of PLC is defined as the cycle time taken by the system to read input, process input executing logic and update control output for all the logics configured within the system. Other activities like diagnostic routines, output / dump of data to peripherals, or any other activity which consume processor time shall also be accounted while computing scan time.

7.2.3 Communication Sub system

1. The communication subsystem shall provide reliable and high speed data transfer between the processor subsystem, I/O subsystem, PLC console and other devices connected to the system.
2. Redundancy in communication subsystem shall be used, such that on the failure of the active device, communication link or bus, the redundant device communication link or bus shall take-over automatically without interrupting the system operation. The communication bus shall be of coaxial / Fiber optic type.
3. Information about the failed device shall be displayed locally as well as on the PLC console. It shall be possible to manually switch-over the communication from main bus device to redundant bus device without interrupting the PLC functions.
4. The PLC shall have provisions of communication interface facility with Plant DCS system in order to make the entire system operational from CCR. Bi-directional,

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Redundant soft links shall be used in the PLC for the connectivity with the Plant DCS.

5. Following are also included in the system:
 - a) Cables required for interfacing with DCS.
 - b) Implementation of Tags and establishing the Link.
 - c) Any other software/hardware required.

7.2.4 System Power Supply

1. For PLC system, redundant 24 V DC power supply shall be used. The required power supply cable shall be used from the UPS DCDB & ACDB for SG integral control system
2. For separately mounted I/O racks, separate power supplies shall be used. Power supply module shall be of ample capacity to supply all modules. In addition 20% spare capacity for future shall be used. All the drives shall be switched ON/OFF through 24V DC coupling relays to be provided in HT/LT SWGR panels.
3. For the Operator Stations and Engineering Station the power supply shall be from the 230 VAC UPS system.

7.2.5 PLC Console

1. PLC Console or operating panel/display panel shall be used as operator Interface station for control and monitoring of the plant. This shall be done through dynamic mimic displays and control displays.
2. PLC console shall also be used for program storage, display, fault diagnostic and alarm monitoring. It shall be possible to modify, add or delete the application program on-line without affecting the outputs. It should be possible to modify or create new displays from PLC Console.
3. Isolation shall be used between programming terminal and related subsystems, if there is any possibility of high voltage from TFT being transmitted to other subsystems.
4. The PLC system shall have provision to shift the Operator Station/ Engineering Station to the CCR in future with third party interactive communication facility.

7.2.6 Displays

The system shall be capable of reading the status of equipments, acquiring the analog signals, displaying the status in the form of mimic diagram, video trend, bar graph, periodic display, alarm display, alarm overview display, logs such as hourly/shift/daily logs, alarm logs etc.

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Displays include plant mimic diagrams, which shall include the complete auxiliary plant system indicating each major components of the system and the operating status of individual equipment and devices

7.2.7 Alarms

1. The system shall display history of alarms in chronological order of occurrence on the Operator Station TFT. At least three (3) levels of alarm priority shall be available which shall be displayed in different color. It should be possible to display and print alarms. System shall have all alarm related functional keys like acknowledge, reset etc. Other design features like set point / dead band adjustment, alarm priority, manual and automatic inhibition based on predefined logic etc. shall be used.
2. The alarm display shall be built bottom up with the most recent alarm at the top of the list. When a point returns to normal, the associated alarm line shall change color suitably and on acknowledgement, the line shall be blanked out.
3. The alarms below the blank lines shall move upward to fill the empty lines. If the capacity of the OWS display page is exceeded, alarm history shall be stored in memory to accept the over- flow. This alarm history shall be displayed upon operator demand.
4. When a point goes into an alarm state and appears on the alarm screen, the time of alarm shall flash until acknowledged by the operator. Acknowledgement by the operator shall cause the time to stop flashing. All alarm initiations and return to normal, shall be logged on a printer.

7.2.8 System Software

1. Complete licensed software for PLC based system including the communication software system shall be supplied and implemented to meet completely the specification requirements.
2. Application software shall be built based on approved logic diagram, graphics etc and shall include controls, graphics, logs, trends, history, report generation etc.
3. The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics.
4. Diagnostic software shall have the capability to provide information about the failed module / system either in the form of a system configuration display or provide information in the form of a statement.
5. The software's shall not be machine specific. All software licenses shall be valid for the continuous service life of the plant and equipment.
6. Password security shall be used in order to ensure security level to the plant operation.

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7.2.9 Peripherals

Following Peripherals shall be used for PLC:

1. VDU/ TFT shall be multi-sync, 21" color monitor with intelligent terminal and key board. TFT shall be used with graphic and mimic capabilities with minimum 64 distinct colors. The graphic resolution shall be 600x 1280 dots minimum with 0.25 mm dot pixel and refresh rate shall be 85 Hz or better
2. Suitable optical filter for minimum secondary glare shall be used.
3. One number black & white laser printer shall be used for printing A4 size paper. Printing speed shall be minimum 24 ppm. The printer shall be heavy-duty type with minimum 50,000 pages/month printing capability, 600 dpi resolution, 128 MB memory and 3000 sheet input capability.

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8. COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM (CMMS)

{TO BE DELETED, IF ALREADY PROCURED UNDER SG PACKAGE.}

8.1 General

1. A completely integrated computerised maintenance management system (CMMS) with relevant data base completely populated and system customised for power plant application shall be used. The system includes all necessary hardware, software, firmware and interfaces required for implementing a fully functional CMMS system suitable for integrated maintenance management function for a modern power generation utility.
2. CMMS system shall be common for the equipment/systems for the whole plant including all the units and the plant common systems.
3. If CMMS is procured under TG Package then it shall be deleted from SG package.

8.2 Functional Requirement

CMMS shall meet following functional requirements:

8.2.1 Asset Management & Asset Register Function

1. Asset management function shall facilitate the creation of an asset register which shall hold the comprehensive details of each asset/ equipment. It shall have following features:
 - a) Building the location details and it's hierarchy
 - b) Building the equipment, it's hierarchy and specification details including drawings.
 - c) Creating hierarchies identifying operating locations as a part of multiple systems.
 - d) Defining relationship between equipment, location and system.
 - e) Building spare parts and sub-assembly catalogues of the asset/equipment.
 - f) Tracking the equipment, movements, associated costs, histories of planned and un-planned maintenance & failures.
 - g) Facility to launch condition based preventive maintenance work orders based on preset equipment- wise upper and lower limits.
 - h) Links to inventory management and purchase functions.
2. The asset management facility shall be capable of performing the following:
 - a) Control the company's list of maintainable assets through an asset register.
 - b) Control the accounting of assets, purchase price, depreciation rates etc.

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- c) Control maintenance inventory (stores management, requisition and purchasing).

8.2.2 Inventory Management Function

Inventory management function shall have following features:

1. Specifying attributes and then ability to search by attribute for items, equipment and locations
2. Tracking of stocked and non-stocked items through multiple stores.
3. Tracking of items, costs and balances by bin, lot and storeroom.
4. Stock replenishment when inventory falls below minimum levels
5. Automatic reorder of items through “ lights out replenishment”
6. Tracking of items by last cost, average cost or user definable standard cost.
7. Usage of ABC analysis to assign inventory item prioritising.
8. Employing just in time methodologies to generate purchase orders.
9. Identifying out of stock items and making substitutions with alternate parts, vendor and location tracking capabilities.
10. View of work order reservations for inventory items
11. Linked up with asset register.

8.2.3 Work Order Function

Work order function shall have following features:

1. Viewing comprehensive and detailed planning information such as following:
 - a) Work Plans
 - b) Schedules (Target and scheduled date tracking)
 - c) Costs
 - d) Labour, materials, Skill set / crafts, Special tools requirement etc.
 - e) Equipment
 - f) Failure analysis
2. Recording of maintenance work and closure of work orders.
3. Scheduling of work orders based on real time criticality and logistics.
4. Sequencing of work orders for multiple equipment based on location and / or equipment.
5. Comparison of real time budgets or estimates with actual and historical data.
6. Tracking of equipment down time.
7. Tracking of equipment failure history with cause and remedy. Facility for generation of micro-level failure/ cause stratification diagram.

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8.2.4 Job Planning Function

Job planning function shall have following features:

1. Tracking of costs by operation or job plan
2. Linking job plans sequentially, each with it's own parts, labour and tool estimates.
3. Duplicate job plans for modification and use as templates

8.2.5 Resource Planning Function

Resource function shall allow to maintain detailed resource information to plan and analyze maintenance work related to company, service contract, tools etc.

8.2.6 Schedule Planning Function

Scheduling function shall enable to forecast future preventive maintenance dates for resource planning.

8.2.7 Preventive Maintenance Function

1. Preventive maintenance schedule shall be capable of performing the following:
 - a) Allows each asset / equipment to have a defined maintenance profile
 - b) Helps to schedule planned preventive maintenance routines
 - c) Control preventive maintenance procedures
 - d) Control the issue and documentation of planned and un-planned maintenance work.
2. Preventive maintenance function shall have following features:
 - a) Generation of preventive maintenance work-orders on demand, batched or automatically.
 - b) Generation of preventive maintenance work-orders for planned shut downs.
 - c) Sequence multiple job plans and consolidate multiple procedures on one preventive maintenance schedule.
 - d) Facilitates clustering of PM work orders for various departments / divisions to take reduced planned equipment downtime.
 - e) Capable of generating PM work orders on the basis of fixed frequency intervals or run hours.
 - f) Reservation of inventory for scheduled PM works.

8.2.8 Purchasing Function

Purchasing function shall have following features:

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1. Creation of purchase requisitions or purchase orders either from scratch or from the inventory or work order modules
2. Create RFQs for multiple vendor bids
3. Automatic release of agreement Purchase orders
4. Creation of special orders for parts not stocked in inventory.
5. Elimination of costly "Maverick Buying" by establishment of approved vendors.
6. Direct issue of purchase orders and issue parts and services directly to work orders for the expense off items.
7. Analyzing of vendor performance before ordering of parts
8. Use of invoice matching
9. Defining multiple tax rates to budget for interstate and international purchasing
10. Auto re-orders PR/PO generation for the spares, when stock falls below re-order level.
11. PR to PO consolidation to group PRs by vendor into single purchase order.
12. Line item /Purchase order status generation-Initiated (Unapproved), Approved, Partial receipt, Completion of receipt, Invoice matched, Cancelled etc.

8.2.9 Personnel Function

Personnel function shall have following features:

1. Creation of employee details including employment and personnel information tracked.
2. Assignment details like department, preferred staff and available weekly work hours tracked.
3. Craft / salary rates-employees can be expensed to work orders by an average craft rate or actual hourly rates.
4. Training / certifications of employees tracked by the system.
5. Security levels-each employee can be assigned access security levels for each of the functional areas in the system.

8.2.10 Financial Function

Financial function shall have following features:

1. Facility for supporting double entry accounting for integration with any financial system.
2. Creation of user defined financial calendars to correlate directly with accounting periods.

8.2.11 Other Functions

Other facilities required are as follows:

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1. Interface to MS project/Primavera to permit planning of work carried out in CMMS system to MS project/Primavera for scheduling. Work progress can then be tracked in CMMS and used to update the project.
2. CAD / Image viewing capability to enable users to store, mark up and view drawings, scanned images, word documents etc.
3. Account code or project budgeting to enable users to set up periodical project budgets. The system shall then be able to track actual and committed costs against budgeted costs
4. Interfacing with existing On Line Integrated Material Management System (OLIMMS)

8.2.12 Reporting Functions

Reporting facilities required are as follows:

1. Standard Reports-Generation of standard reports on work orders, safety plans, inventory values and other critical points about maintenance operations.
2. Report types- Capabilities shall include columnar reports, forms, Bar Charts, Pie Charts, Cross tabs etc.
3. Report generation- Crystal reports.
4. Data export capability via crystal reports to Text, Excel, Word documents, E-mail, HTML & ODBC etc.

8.3 Design Requirements

1. CMMS shall be based on client server & relational data base environment. The system shall operate on commonly used hardware platform & network operating system.
2. System shall be suitable for simultaneously used by multiple users. It should have at least 20 user licenses.
3. The system shall be password protected. It shall be possible to organize system users into groups and each group shall have a separate security profile. It shall be possible to provide additional personal security settings for individuals within a group.
4. CMMS processing shall be carried out in an independent server interfaced with plant DCS, All BOP & offsite plant PLC control systems. Further CMMS system shall be interfaced with MIS system server for transmission of maintenance related details for usage with MIS. To meet the above requirements CMMS system shall be interfaced with all control systems through redundant communication links. The CMMS system server shall be connected with station LAN and all user PCs shall be connected to CMMS server through station LAN.
5. The system shall have facility to store bulk data with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/back up media and provide user friendly utilities to retrieve and analyze stored data.

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6. Wherever required same user workstations shall be used for CMMS & MIS systems. Together with MIS system total 50 nos. user workstations shall be provided.
7. All software licenses shall be valid for entire life of the plant. It shall be possible to upgrade the installed system with latest available version of the software model without any additional hardware/software requirements during entire life of the plant.

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9. SMART TRANSMITTER MAINTENANCE STATION (STMS)

{TO BE DELETED, IF ALREADY PROCURED UNDER SG PACKAGE.}

9.1 General

A dedicated standalone PC based Smart Transmitter Maintenance Station (STMS) shall be provided for centralized configuration, maintenance, diagnostic and record keeping of all electronic smart transmitters, smart positioners & Analyzers. Transmitter signals shall be wired parallel to DCS and HART modules of STMS, which shall be connected to PC through suitable communication modules. Complete diagnostic, record keeping, calibration and configuration, event and log reports, historical data base records of all transmitters shall be possible from the STMS.

9.2 Design Requirements

1. The signals from each of the transmitter shall be wired in parallel to DCS and to HART interface modules. The DCS shall necessarily use 4-20 mA analog signals and superimposed digital signal shall be used in HART interface modules.
2. The multiplexed signal from HART interface modules shall be hooked up to a PC through associated communication modules, converters, etc. The communication module shall provide data on RS-485 link at a minimum speed of 19.2 K baud. If HART interface modules has integral communication module to provide RS-485 link, the same shall also be acceptable. In all HART interface modules, provision for connecting at least 30% extra transmitters over and above the engineered quantity shall be kept for future additions.
3. An RS-485 to RS-232 Converter shall be provided for interfacing HART data of transmitters to PC station. This converter shall also provide proper isolation to ensure data integrity.
4. Any failure / short / open-circuit and / or removal of any of the cards /devices / cables in this centralized configuration, maintenance, diagnostics and record keeping system, including failure / removal of HART interface modules, communication modules, converter, etc. shall, in no way, affect the 4-20mA analog signals being used in DCS. Further, the HART interface modules shall be organized in such way that separate cards are used for signals going to different DCS cabinets.
5. Suitable redundant & diode auctioneered 24V power supply packs / modules and redundant feeders shall be provided to feed all modules / devices. These power supply packs / modules shall be fed from redundant feeders of UPS system or from 24V DC power supply system.
6. All modules / cards / power supplies shall be mounted in cabinets to be located in Control Equipment Room. The PC station and printer shall be located in Engineering Room.

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9.3 Functional Requirements

The system shall have following functionalities as a minimum:

1. Constant scanning to monitor faults or changes to instrument configuration.
2. Purchaser-defined and standard calibration and configuration procedures for all transmitters.
3. Constant signal data collection facilities to maintain continuously updated records.
4. Automatic tracking of configuration changes made in the field, such as may be introduced by hand-held communicator. All configuration function associated with hand-held communicators shall be available in the system.
5. Event and log reports on screen as well as on printer.
6. Any addition / deletion of transmitter shall be reported on printer and logged in hard disk

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10. STATION WIDE LOCAL AREA NETWORK

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10.1 General

1. A plant wide Local Area Network (LAN) encompassing the different plant buildings shall be provided. The Station LAN shall interconnect the buildings together and shall facilitate the smooth transfer of Data from one building to the other.
2. A plant wide Fibre Optic high speed (100/1000 MBPS) back bone & work groups is envisaged. This network is used by different users for viewing selective plant graphics & data on real time basis, historical data & trends, MIS reports & CMMS data.
3. The MMI of unit & common system, all BOP & offsite PLC's, PADO, CMMS, MIS, CCTV etc. Shall be connected to station wide redundant Ethernet LAN. The interface with these systems shall be through OPC client-server architecture. PC stations shall also be connected to this LAN to monitor data.
4. For achieving this, the above requirement all necessary hardware & interfaces such as the Station LAN Server, LAN Switches (main & secondary) with suitable number of ports, electric / optic and optic / electric converters / trans-receivers etc., software and data communication cables shall be provided. The redundant unit LANs of the each unit shall be connected through the station LAN switch and server. It shall be ensured that failure of this network component(s) shall in no way affect individual unit operation & monitoring function in any way.
5. The Station LAN shall connect following buildings:
 - a) Station Building- Central Control Room
 - b) Service Building
 - c) Coal Handling Plant
 - d) Ash Handling Plant
 - e) ESP Control Room
 - f) CW Pump House
 - g) Water Treatment & effluent Treatment Plant
 - h) Air Compressor House
 - i) Hydrogen Generation Plant (if applicable)
 - j) Workshop
 - k) Stores

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l) Switchyard Control Building

m) Any other plant area/ building where Station LAN needs to be provided for the purpose of CMMS, MIS or for Plant security/ surveillance system.

6. The LAN network to be provided for all user points in all the rooms in the buildings.
7. The various buildings shall be interconnected through the use of minimum 4 Core single mode fibre and shall be connected to the main switch in the CCR in a STAR topology.
8. Each building shall be provided with a 12.U high wall-mountable communications cabinet complete with glass door, 6 way power distribution unit, shelves and force ventilation. All units are to be supplied with cage nuts and bolts to house LAN switches.
9. Inter building wiring shall be a minimum of Category 5E STP cable manufactured, tested and verified to ISO11801 EIA/TIA standard. Internal building wiring shall be of the structured cabling type and shall incorporate patch panels on every floor or as required.
10. A minimum of two RJ-45 ports shall be provided for each specified location. Category 5E shuttered modules shall be used in pre-assembled faceplates to save installation time. Modules shall include a slide label system.
11. If Station Wide LAN is procured under TG package, then it shall be deleted from SG package.

10.2 Design & Functional Requirements

1. The station LAN shall be achieved through the station LAN Server and High capacity Ethernet switch (station LAN switch). The Station LAN server shall have the hardware and shall maintain a combined plant database (complete database from each unit MMI updated at 1 sec.) and data from other systems through industry standard protocols and formats, on an Open standard RDBMS package like Oracle Enterprise version or equivalent, for open access to the same from any PC station in the plant running a suitable client software. This server shall function as a database server for the Plant Wide LAN.
2. The LAN shall be of the Gigabit type (1000 MBPS) and shall utilize standard IEEE 806.3 protocols such as Ethernet.
3. The Station LAN Switch shall be a layer-III switch & shall have hot pluggable redundant power supply, Gigabit back plane (switch fabric) capability, 1000 MBPS per port minimum data speed, fibre optic and UTP cable connectivity and Gigabit ports and shall support expandability / Stackability through a dedicated high speed expansion port. It shall support minimum Four numbers virtual LANs as a minimum and shall be routable, remotely manageable and configurable. The switch shall have extensive self diagnostic and logging facilities and shall use

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structured cabling facilities. The Station LAN switch shall be suitably sized to provide additional ports for connecting Servers / PC-stations etc. In future and fibre optic ports for connectivity and DCS TCP/IP ports for interconnection to standard third party sub-systems.

4. Network Monitoring & Management tool shall be provided so that loading etc. on the LAN switch can be ascertained.
5. The station wide LAN shall connected to IT LAN, through which the CMMS server data shall be made available to existing Online Integrated Maintenance Management System (OLIMMS). Also the PC stations for various plant personnel shall be connected to station LAN for monitoring data of all units as well as that of common systems & offsite systems. These Connections shall be through Firewall.
6. Redundant Hardware Firewalls in failover mode with intrusion prevention system (IPS) features shall be provided to ensure security of network & prevent unauthorised access.
7. Firewall shall have minimum three zones. One inside (DCS network), one outside (IT LAN/ OLIMMS network) & the De-militarized zone (DMZ). Station LAN Servers shall be placed in DMZ zone. Data required for intranet (plant PC Network) & for OLIMMS shall be made available to the redundant station LAN Servers.
8. Station LAN switch shall be provided with a network based intrusion detection system (IDS) of a make different from IPS provided with Firewall to achieve a multi layered defence mechanism against intrusion as well as to guard against possible misuse/attack from within LAN.

10.3 Security Features Requirements

1. Firewall

- a) Firewall appliance should facilitate multi-vendor, multi-application environment and should support third-party products on open alliance. It should support Active-Active configuration.
- b) The firewall should contain following features:
 - Stateful inspection of packets.
 - NAT functionality, including dynamic and static NAT translations
 - Latest version of SNMP
- c) The firewall must send log information to a separate log server via an encrypted connection. Firewall logging must not impact firewall performance.
- d) Remote network access to the firewall should only be possible through the administration interface.

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- e) The firewall administration station must be capable of pushing firewall security policies and configurations to individual or multiple firewalls through a secure, encrypted connection to the firewall administration interfaces.
- f) Graphical User Interface (GUI) and a Command Line Interface (CLI) for making changes to the firewall rules set should be provided. (Access to the firewalls via the GUI or the CLI must be through a secure encrypted channel).
- g) Any changes or commands issued by an authenticated user should be logged to a database configured on any of the machines in the LAN. The administration station must allow for a hierarchical architecture for rules set administration and viewing of firewall configurations Management.
- h) Firewall should also meet the following requirements.
 - The firewall must not support any unencrypted means of access to the firewall.
 - It should Monitor ALL network traffic-traffic at Firewalls (Internet and external networks) and detects known threat through deep packet inspection.
 - Detects unknown threats via anomaly scanning.
 - Detect unknown threats via behaviour pattern to protect from zero day attacks.
 - Keeps up-to-date on new threats and vulnerabilities.

2. Intrusion detection system (IDS) & Intrusion Protection System (IPS)

In order to inspect all inbound and outbound network activity and identify suspicious patterns that may indicate a network or system attack from someone attempting to break into or compromise a system on the Station LAN Network, the recommended IDS/IPS should contain the following features as a minimum:

- a) Able to analyze, detect and report on security related events.
- b) Able to inspect traffic and to drop malicious traffic based on the configuration of security policy.
- c) Able to inspect the content of network packets for unique Sequences/signatures.
- d) Able to detect and prevent known types of attacks such as worm or Trojan infections and hacks.
- e) Able to prevent denial of service (DOS) and Distributed Denial of Service attacks.

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- f) Able to prevent abnormal behaviours by monitoring and learning normal network behaviours.
- g) Keeps up-to-date on new threats and vulnerabilities.
- h) Should provide user friendly interface to queries and reports on threats and event data so that security administrators can gain a better understanding of their ability to protect their network.
- i) Should provide detailed activity logs for auditing.
- j) Able to detect known threats via deep-packet inspection.
- k) Able to detect unknown threats via anomaly scanning.
- l) Able to detect unknown threats via behaviour pattern to protect from zero day attacks.

10.4 Network Monitoring & Management Requirements

The network monitoring & management software should contain the following features as a minimum:

1. Graphical user interface (GUI) management.
2. Automated discovery and display of Ethernet topology and devices.
3. Real-Time SNMP Support
4. Monitor traffic flow through the device
5. View a device image indicating which ports are active and which modules are installed. If a particular network device is down, it should give the tools like ping/telnet options in the same screen to further diagnose the problem.
6. Real-time activity and utilization statistics and graphical trends.
7. Facility of providing pre-defined actions like e-mail, SMS etc. upon any event generated in the network.
8. Facility of viewing logical graphs of devices like routers, web servers, according to the needs.
9. The following parameters should be monitored.
 - a) Device status
 - b) Port Status
 - c) CPU utilization
 - d) Memory Utilization
 - e) All port utilization including uplink ports.

Table - 10.1

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Specifications for Station LAN Switch

S.No.	Features	Minimum Requirements
1	Type	Layer-3 Ethernet Managed type
2	Ports	24/48 RJ45 connectors for 100 Base-T/1000 Base-TX; Two (2) 10BASE-T/100BASE-TX/1000BASE-T ports; 2 mini-GBIC ports; console port; auto medium dependent interface (MDI) and MDI crossover (MDI-X); RPS port for connecting to redundant power supply unit
3	Cabling Type	Unshielded twisted pair (UTP) Category 5 or better for 10BASE-T/100BASE-TX; UTP Category 5 Ethernet or better for 1000BASE-T
4	Switching Capacity	17.6 GBPS non-blocking
5	Management interface	One 10/100/1000 Mbps RJ-45 out-of-band management port One DB9 serial console port (straight-through)
6	Management Methods	SNMP, SSH, RMON, RADIUS etc.
7	Optical Transceiver	SFP/ XFP- 1 GBPS/10 GBPS
8	Power supply	Redundant
9	Standards compliance	802.3 10 BASE-T Ethernet, 802.3u 100 BASE-TX Fast Ethernet 802.3ab 1000 BASE-T Gigabit Ethernet 802.3z Gigabit Ethernet, 802.3x flow control, 802.3ad; 802.1D Spanning Tree Protocol (STP), 802.1Q/p VLAN, 802.1w Rapid STP, 802.1s Multiple STP, 802.1x port access authentication
10	Enclosure protection class	IP 67
11	Mounting	DIN Rail or Direct panel mounting

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11. STEAM & WATER ANALYSIS SYSTEM (SWAS)

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11.1 General Requirements

1. The steam and water analysis system shall be designed to monitor the chemistry of the steam and water cycle to ensure the desired quality. The online chemical analysis for pH, Conductivity, hydrazine, sodium ion, Silica, dissolved oxygen, chloride, phosphate etc. Shall be carried out in the plant cycle at strategic points. Information from the analyser shall be used to control the high pressure and low pressure dosing system. Long term monitoring and trending of essential elements shall be carried out, to provide an indication of the general condition of the mechanical plant.
2. The sample points, their location, type of chemical analysis to be carried out for each sample, measurement ranges etc., shall be as per plant standards. The SWAS as a composite system includes sample probes, sample piping, safety valves, ball valves, relief valves, grab sample collection facility, pressure, temperature, level, flow indications, coolers, on line analysers etc. The SWAS shall include the following:
 - a) Sample conditioning panel with all accessories.
 - b) Analyzer Panel housing cells, analyzers, monitors etc.
 - c) The sample conditioning and analyser panels shall be physically separated from each other. Analyser panel shall be located in a separate air-conditioned room. Sample conditioning panel shall be walk in corridor type/open rack type. All SWAS panels shall be designed for ready access of components for easy maintenance.
 - d) PC based station for display of information & alarms to the operator, to be located in SWAS room (connected to station LAN)
3. The SWAS system should be unitised and located at the ground floor of TG building.

11.2 Design Requirements

1. Design criteria for continuous on line analytical measurements of important plant media such as water, steam shall be based on microprocessor based instruments only.
2. Separate Steam and Water Analysis System shall be furnished for continuous monitoring and control of water and steam purity in the plant cycle of Unit and at other important points as specified in this specification.
3. The sampling system shall obtain samples from steam and water system, which shall be adequately conditioned and fed to analyzers for continuous analysis and provide parallel facility for grab sampling as specified.

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4. The system shall be designed in accordance with the recommendations in ASME PTC 19.11 Part II, Water and Steam in Power Cycle, ASTM standards - 31 water and ASTM D1066-69 standard method of sampling steam.
5. The equipment shall be constructed to operate accurately and safely under the operating conditions described or implied in this specification, without undue heating, vibration, wear, corrosion or other operating troubles.
6. All parts subject to high pressure or temperature or other severe duty shall be of materials suitable for the service.
7. All piping, tubing, fittings and other wetted parts in the sampling and analyzing system shall be of SS 316 or other suitable material for the service. No plastics or rubber shall be permitted except within analyzers as furnished by the manufacturer.
8. All SWAS system components and accessories shall be from the latest proven product range of qualified manufacturers.
9. To ensure operation under adverse conditions the equipments mounted outside the Sampling and Analysis Room shall be designed for outdoor conditions.
10. Sample room located instruments and electronic hardware shall be required to operate normally in an air-conditioned area.
11. However, they shall also be able to operate indefinitely with ambient room temperature between + 5°C to + 55°C and relative humidity up to 95%, during air conditioning failure.

11.3

Sample stream Requirements

SWAS shall be provided in accordance with the following guidelines:

Table 11.1
Guideline for Analytical requirements

S.No.	Stream	Analysis
1	Make up water	<ul style="list-style-type: none"> • Specific Conductivity • Cation Conductivity
2	Hotwell	<ul style="list-style-type: none"> • Specific Conductivity (both sides) • Cation Conductivity (both sides)
3	CEP Discharge	<ul style="list-style-type: none"> • pH • Specific Conductivity • Cation Conductivity • Dissolved Oxygen • Sodium
4	Deaerator Outlet	<ul style="list-style-type: none"> • Dissolved Oxygen

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S.No.	Stream	Analysis
5	Feed water at Economizer Inlet	<ul style="list-style-type: none"> • pH • Specific Conductivity • Cation Conductivity • Silica • Hydrazine • Dissolved Oxygen
6	Main Steam	<ul style="list-style-type: none"> • pH • Specific Conductivity • Cation Conductivity • Sodium • Silica
7	Saturated Steam	<ul style="list-style-type: none"> • pH • Specific Conductivity • Cation Conductivity • Sodium
8	Reheated Steam	<ul style="list-style-type: none"> • Cation Conductivity
9	Condenser Cooling Water	<ul style="list-style-type: none"> • pH • Specific Conductivity

11.4 Sample Conditioning System

1. The sample conditioning system shall provide samples at 250C or a preset temperature required by the analyzer with in tolerance of +/- 1 0C, at a pressure of about 2 Kg/cm2 and at a flow rate as required by individual Analyzer/stream.
2. Sample conditioning system shall be designed and constructed to receive and condition all samples as required by the respective analyzers connected to the sample streams. This shall include all conditioning equipment mentioned herein and covers the following:
 - a) Primary Sample Cooling in the field
 - b) High Pressure reduction in the field
 - c) Two (2) nos. racks shall be provided per unit for mounting primary coolers & high pressure reducing elements in the field.
 - d) Sample filtering
 - e) Secondary sample cooling & temperature control
 - f) Pressure reduction & control as required

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g) Flow rate control & measurement

h) Other treatment as required by individual analyzers or mentioned herein

3. Sample line to analyzers shall incorporate an anti-siphon design to prevent possibility of running dry because of a broken or plugged sample line.

11.4.1 Primary Sample Cooling

1. Primary cooling of all samples having temperature in excess of 45 °C shall be accomplished by passing each sample through one or more individual sample coolers of shell and tube heat exchanger type.
2. The primary coolers shall use plant auxiliary cooling water.
3. The overall capacity (flow rate and heat transfer capacity) for both sides of cooler/ coolers in cascade shall be adequate to cool all samples to within ± 5 °C of the cooling water inlet temperature for the combined flows of each required analyzer sample plus a manual grab sample flow rate of 500 CC/Min.
4. Provision shall be kept for adjustment of the temperature of each sample line individually to an optimum value.
5. Sample coolers shall be of submerged helical coil type of shell and tube design with removable shell meeting the intent of ASTM D1192-64 (Equipment for Sampling Industrial Water and Steam). Sample tubing and coils in the coolers shall be continuous and shall extend through the cooling jacket. The sample tubing shall be of seamless type with no welded or other joints inside the cooling jacket. Unions shall be provided to facilitate removal of coils.
6. All sample tubing, fittings and other components wetted by the samples shall be constructed of SS 316.
7. Primary cooler/s shall be removable without disturbing the sample coil connections.
8. Primary cooler shall be protected on the cooling water side by relief valve on the water header. The cooling water header is provided with pressure gauge and isolating valves.
9. Provision shall be made for draining the heat exchanger shell. The drain line shall be valved and piped to waste drain header.

11.4.2 High Pressure Reducing Element

1. Pressure reduction of samples above 40 kg/cm² shall be accomplished by means of a "variable rod-in-tube capillary" or equivalent capable of discharging low flow at low pressure into a sample stream as per the requirements of all samples/analyzers under all operating conditions.
2. The device shall be designed for inlet pressure of 350 kg/cm² operating temperatures of 65 °C and flow rate of not less than 2000 milliliters per minute. The device shall be sized for maximum required sample flow rate under all operating conditions (i.e. from 25% of rated operating pressure onwards to accommodate starting conditions).

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11.4.3 Sample Filtering

Sample particulate removal shall be accomplished by passing samples through cartridge type filters with 316 stainless steel body or Y-Strainer. The filter elements shall be capable of retaining particulates of 40 microns and larger. The filter elements shall be installed immediately after the sample shut off valve.

11.4.4 Temperature Switch & Solenoid Valve

Thermostat and Solenoid Valves shall be provided in the sample line downstream of sample filter and upstream of the Secondary Cooler. The thermostat shall be a bimetallic sensor to operate a micro-switch when a preset temperature is reached. This shall close the Solenoid Valve through logic, when sample temperature is above preset value (60 °C).

11.4.5 Secondary Sample Cooling

1. Secondary Cooler shall be employed to cool the sample from approximately 45 OC to 25 OC +/-1 OC. The secondary coolers shall also be of submerged helical coil type of shell and tube design. The secondary cooler shall use chilled water at 20 OC. Chilled water for secondary cooler shall be provided by packaged refrigeration unit (chillers). Secondary cooler shall be protected by a relief valve on the cooling water jacket of each cooler in addition to a relief valve at the cooling water header. Provision shall be made for heat exchanger shell drain duly valved and piped to waste drain header.
2. Alternatively, secondary cooling may also be proposed with field proven isothermal bath.

11.4.6 Chilled Water System

1. Each chiller unit shall be designed with sufficient refrigeration capacity to ensure each sample stream temperature to 25 OC \pm 1 OC when all streams are simultaneously at maximum flow rate and maximum temperature. The chiller capacity shall have a provision of 25% spare capacity for future samples.
2. Suitable temperature monitoring and control systems shall be provided for maintaining the chilled water temperature at chiller outlet at 20 OC or at a designed preset value and within the desired band.
3. The compressor shall be readily accessible for service and shall include low noise hermetically sealed motors. Compressor assembly shall also include crank case heaters, suction and discharge valves, oil sight glasses, forced feed lubrication system and an integrated motor protection system along with the necessary instruments.
4. The condenser shall be water cooled, cleanable shell and tube with water regulating valve. The cooling water shall be supplied from closed cooling water system at a maximum temperature of 40°C and a maximum flow rate of 100 litres per minute.

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5. Chiller shall be of the direct expansion type with refrigerant tubes inside a shell, completely insulated and to be constructed in accordance with the ASME code for unfired pressure vessels.
6. Refrigerant circuit shall be complete with a thermostatic expansion valve, liquid line solenoid valve, sight glasses, filter-dryer, refrigerant shut-off and charging valves.
7. The chiller water pump shall be of the centrifugal type, close coupled, bronze fitted construction, complete with motor. Pump & motor shall be designed for continuous operation.
8. Vibration dampeners shall be mounted between the packaged chiller and the channel base.
9. Cooling water and chilled water piping shall be provided with block valves.
10. The chiller system shall be provided with 100% redundant chilled water pumps with suction and discharge pressure gauges and temperature gauges; Chilled water circulation pump with 100% standby facility; Storage tank automatic water make up with manual by-pass facility, temperature indicator, level gauge and drain and overflow connection, in addition to any other instruments/equipments required for smooth, convenient operation of the system.

11.4.7 Sample Pressure Conditioning

1. Pressure reduction of samples above 40 kg/cm² shall be accomplished by using high pressure reducing element.
2. All samples below 40 kg/cm² pressure shall be provided with back-pressure (upstream pressure) regulating valves (PCV).
3. Each sample line shall have Pressure Indicator and Temperature Indicator upstream of pressure reducer. The gauge shall be 100 mm dial with suitable stainless steel wetted parts. Casing shall be stainless steel construction.
4. Each sample line shall include a safety relief valve set at about 3 kg/cm²g, upstream of the rate set valve, having stainless steel wetted parts.

11.4.8 Flow Restricting Element

Flow Restricting Element located at grab sample line tapped from common samples to analyzers shall be provided for all samples, to maintain constant sample flow at a preset sample inlet pressure.

11.4.9 Other Requirement

The Steam and Water Analysis system shall be provided with the sample shut off valves, blow down valves, solenoid actuated valves, pressure reducing valves, safety relief valves, back pressure regulating valves, high pressure reducing valves etc. The requirements of the important valves are specified as under:

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1. The sample shut off valves, blow down valves and pressure reducing valves shall have stellite spindle tip and shall be suitable for an operating pressure of 400 bars and an operating temperature of 400°C.
2. The back pressure regulating valve shall be globe type and shall be suitable for a pressure range of 0 - 50 psi. The back pressure regulating valve shall consist of a range spring and a diaphragm assembly. The back pressure of the regulating valve is adjusted to the required set point by the range spring. In case of any excess pressure the diaphragm shall be lifted to release the excess pressure to maintain back pressure equal to the set value.

11.5 Sample Pumps

1. Two (2) nos. of sample pumps for each generating unit, along with necessary pipes, valves, etc. shall be provided for condenser cooling water samples. Sampling pump motor shall be adequately rated for continuous service duty and shall meet the requirement for drive motors as per international codes and standards.
2. Pump start/stop shall be done from local. All necessary accessories including power supply, wiring and grounding for control and safe operation of the pumping system. Pump shall be of make and model whose performance and reliability has been established

11.6 Sample Patch Board

1. A quick disconnect patch board area shall be furnished on the SWAS panel. The patch board shall allow sample to be routed to any analyzer through quick disconnect valve at patch board on the sample conditioning panel. The area shall consist of a patch board with bulk head tube fittings with double end shut-off and hose inserts. Body protector plugs shall be provided for each bulkhead tube fittings.
2. The plugs shall be of type 316 SS construction. Sufficient length of 6mm ID, 9.5mm OD tygon tubing shall be provided for complete spanning of the patch board area for interconnection of the bulkhead tube fittings. Each connection shall be provided with a Phenolic name plate engraved with a legend.

11.7 Grab Sample

Grab sample valves on the SWAS panel front shall be furnished to allow grab sample flow to be directed to either a drain header or through grab sample nozzles to the sample trough. Approximately 300 mm of flexible tubing shall be furnished for each sample to allow grab sample collection and prevent splashing. Valve body and trim shall be of SS-316.

11.8 Sample Sink

A continuous sink, located at the place of grab sample analysis, shall be provided. The sink shall be of 316 stainlesssteel, 14 gauge minimum. The

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sample sink shall be connected to waste drain header. Sample sink shall contain an integral stainless steel ledge to accommodate sample container. DM water connection shall be provided for cleaning of sample containers.

11.9

Analyzers

All Analyzers shall be of microprocessor-based design. The general technical specification of the analyzers is provided in this section. Each analyzer shall be indicated with the sample flow requirement and the total quantity of cooling water required for the system.

Table 11.2
Specifications for Conductivity Analyzer

S.No.	Features	Minimum Requirements
A	Sensor	
1	Type of Cell	Continuous flow through type. Removable type cells for Hotwell
2	Conductivity Range	0 - 1 $\mu\text{s}/\text{cm}$ to 0 - 10,000 $\mu\text{s}/\text{cm}$
3	Cell Constant	0.01/0.1/1.0 depending upon range
4	Temperature Compensation	Manual in steps of 0.1 $^{\circ}\text{C}$ selectable and Automatic (Integral) up to 0 - 120 $^{\circ}\text{C}$ with Pt-100 Sensor
5	Process Connection	Screwed
6	Wetted Parts	Electrodes: HASTALLOY Insulators: KYNAR and VITON
7	Pressure rating	10 Kg/cm^2
8	Accessories	Tee/Vessel (PVC or Hastalloy)
9	Cable	Up to transmitter in flexible conduit
B	Transmitter	
1	Type	Microprocessor based
2	Mounting	Flush Panel

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S.No.	Features	Minimum Requirements
3	Protection Class	As per TS requirement
4	Output	4-20 mA DC (isolated)
5	Display	<ul style="list-style-type: none"> Digital Display of process variable in Engineering Unit, Temperature, Alarm Status Red / Green LED Character Height 18 mm
6	Zero/span Adjustment	Front Panel Membrane type Keyboard
7	Temperature Compensation	Manual or Automatic- Compensation selectable through keyboard
8	Diagnostics	Self diagnostic programme for electronics, measuring electrode, open wiring etc
9	Alarm	Dual alarm set point, hysteresis and time delay adjustable on membrane keyboard.
10	Enclosure	Polypropylene
11	Cable Termination	Internal (cable entry through conduit)
12	Accuracy	± 0.25% of measured range
13	Response Time	less than 1 sec.
14	Measuring Cycle	less than 5 sec.
15	Repeatability	± 0.95% output range
16	Stability	± 0.5% of output range / month non-cumulative
17	Power Supply	230 V AC, 50 Hz, 1-phase
18	Operating Temp	0 - 60°C
19	Accessories	<ul style="list-style-type: none"> For Cation conductivity analyzer Dual Ion- Exchange column, resin, etc. (minimum 12 months requirements) Phenolic Nameplate Portable test Kit.

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S.No.	Features	Minimum Requirements
20	Standard	IS 1911 except as modified in this specification.

Table 11.3
Specifications for pH Analyzer

S.No.	Features	Minimum Requirements
A	Sensor	
1	Type of Cell	Continuous flow through type.
2	Temperature Compensation	Manual in steps of 0.1 °C selectable and Automatic (Integral) up to 0 – 120 °C with Pt-100 Sensor
3	Process Connection	Screwed
4	Pre Amplifier	Integral
5	Pressure rating	10 Kg/cm ²
6	Range	0 – 14 pH
7	Measuring	Platinum or Antimony Electrodes
8	Liquid Junction	Ceramic / Kynar or Equivalent
9	Accessories	Tee/Vessel (PVC or Hastalloy)
10	Cable	Up to transmitter in flexible conduit
11	Applicable Standard	IS: 6804 except as modified in this specification.
B	Transmitter	
1	Type	Microprocessor based
2	Mounting	Flush Panel
3	Protection class	As per TS requirement
4	Output	4-20mA DC (isolated)

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S.No.	Features	Minimum Requirements
5	Display	<ul style="list-style-type: none"> Digital Display of process variable in Engineering Unit, Temperature, Alarm Status Red / Green LED Character Height 18 mm
6	Calibration	Computer assisted 2 point calibration – within pH 0 to 14 for zero with standard buffer solutions.
7	Temp. Compensation	Manual or Automatic – selectable through keyboard
8	Diagnostic	Self diagnostic for “Calibration required”/“calibration O.K.”, electrode checking etc.
9	Alarm	Dual alarm set point, hysteresis and time delay adjustment on membrane keyboard.
10	Enclosure	Polypropylene
11	Cable Termination	Internal (cable entry through conduit)
12	Accuracy	± 0.02 pH or better
13	Repeatability	$\pm 0.1\%$ or better
14	Response Time	7 seconds for FSD or better
15	Stability	$< \pm 0.001$ pH per week
16	Power Supply	230 V AC, 50 Hz
17	Operating Temp.	0 - 60°C
18	Accessories	<ul style="list-style-type: none"> Ultrasonic Electrode Cleaner. Phenolic nameplate giving tag number, service, etc. Pre-amplifier, special cable. Ultrasonic cleaner, etc. Buffer tablets. Sample coolers, flow and pressure Regulators, standard pH solutions, SS impulse tubing & fittings, isolation and drain valves as required, electrode

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S.No.	Features	Minimum Requirements
		holders, RFI/EMI shielded, whether & corrosion proof casing, alarm settings & indications on monitor, sample rate set valves and other accessories as required

Table 11.4
Specifications for Silica Analyzer

S.No.	Features	Minimum Requirements
1	Type	"Multi Channel" Calorimetric Analyzer (With auto reagent shut-off feature in case of sample loss or power loss) built in phosphate inhibition feature and Microprocessor based.
2	Operating range	0-50/500/5000 μ g/litre (field adjustable)
3	Output	4-20 mA DC (isolated) into 600 ohm
4	Readout	Digital indicating meter for direct Readout
5	Accuracy	\pm 1% of F.S.D or better
6	Reproducibility	\pm 2% of F.S.D or better
7	Calibration	Manual and Automatic 2 point zero & slope Programmable 1 – 240 hrs
8	Response time	< 16 minutes (including sample switching)
9	Operating ambient	0-60°C temperature
10	Ambient humidity	Up to 95% relative humidity
11	Mounting	Flush panel
12	Life of light source	10,000 hours (min.)
13	Power supply	240V, 50Hz, 1 Phase
14	Alarm Facility	2 HI and 2 LO independently adjustable over span.

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S.No.	Features	Minimum Requirements
15	Alarm for	<ul style="list-style-type: none"> • Monitor mal-function • Monitor on standby • Monitor auto-zeroing • Concentration high • Loss of sample • Concentration low • Loss of reagent
16	Preferred features	<ul style="list-style-type: none"> • Hi and Lo alarm LED visible from front. • Power supply on/failure LED visible from front. • user friendly menu operated programming • Serial interface
17	Accessories	<ul style="list-style-type: none"> • Reagent cabinet • Sample strainer • Reagent Reservoir etc. • Phenolic nameplate • Reagents and consumables • Special cables up to transmitter with flexible conduit • Chilling Plant (if required) • Automatic temperature compensation between 5 to 50 Deg.C • Automatic serving provision • SS tubing and vessels • All chemical reagents for 12 months operation of analyzer • Sample rate set valves • Comprehensive diagnostic & alarm features • Others as required
18	Applicable Standard	ASME PTC 19.11 except as modified in this specification.

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Table 11.5
Specifications for Sodium Analyzer

S.No.	Features	Minimum Requirements
1	Type of cell	Continuous Flow through Sample
2	Flow Chamber	Flexi Glass Body or equivalent
3	Operating Range	0.05-1.0ppm
4	Measuring Electrode	Sodium Selective Glass Electrode
5	Output	4-20mA DC (isolated) into 600 ohms
6	Temperature	Automatic up to 60 Deg. C Compensation
7	Read Out	Digital Indicating meter
8	Accuracy	± 0.01 ppb/2.5% or better
9	Response Time	2 minutes or better
10	Operating Ambient	0-60° C
11	Ambient Humidity	Up to 95% relative humidity
12	Mounting	Flush panel
13	Calibration	Manual through Zeroing Solution
14	Power Supply	230 V, 50 Hz 1 Phase
15	Alarm Facility	2 HI and 2 LO independently adjustable over span.
16	Serial Interface	To be provided as per requirement
17	Error Reports	<ul style="list-style-type: none"> Excessive zero drift Lack of sample Slope value out of the acceptable range Temperature & flow over-range or under-range
18	Accessories	<ul style="list-style-type: none"> Phenolic tag plate etc. Sample filter. Pressure regulator & flow meter Automatic calibration kit Reagents and consumable

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S.No.	Features	Minimum Requirements
		<ul style="list-style-type: none"> Special cables up to transmitter with flexible conduit Others as required

Table 11.6
Specifications for Hydrazine Analyzer

S.No.	Features	Minimum Requirements
1	Type	Continuous Electrochemical
2	Operating Range	0-50, 0-100, 0-200 ppb
3	Output	4-20 mA DC linear and 1-5 volts
4	Readout	Digital Indicating Meter, linear read-out
5	Accuracy	+/- 4% of FSD or better
6	Reproducibility	2% of FSD or better
7	Drift	2ppm/month or better
8	Temperature Compensation	Automatic up to 120° C
9	Operating Temperature Ambient	0-60° C (maximum)
10	Response Time	2 minutes or better
11	Mounting	Flush panel
12	Pressure rating	0 - 5 Kg/Sq. cm
13	Power Supply	230 V 50 Hz, 1 Phase
14	Alarm Facility	2 HI and 2 LO, Independently adjustable over span.
15	Preferred Feature	<ul style="list-style-type: none"> HI and LO alarm LED visible from front Power supply on/failure LED visible from front All chemical reagents for 12 months operation etc. Phenolic nameplate etc. High sensitivity Self cleaning electrode

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Table 11.7
Specifications for Dissolved Oxygen Analyzer

S.No.	Features	Minimum Requirements
1	Type	Continuous Flow through Sample Electro-chemical, Microprocessor based
2	Range	0-0.1, 0-1.0, 0-10.0 ppb manually selectable range
3	Enclosure	IP-55 or better
4	Output	4-20mA DC isolated to load of 600 ohms (minimum)
5	Temperature Compensation	Automatic up to 650 C
6	Ambient Temp.	0-600 C
7	Readout	Digital indicating meter
8	Accuracy	Better than + 5% of full scale for Transmitter
9	Sensor Response Time	Automatic up to 60 OC
10	Mounting	Flush Panel
11	Readable Distance	3 meter (minimum)
12	Power Supply	230V AC, Single Phase, 50Hz
13	Sample	Flow rate approx. 500 ml/minute
14	Alarm facility	2 HI & 2 LO independently adjustable over entire span Contact rating, 5A, 230 V AC/0.5A, 220V DC
15	Preferred Feature	<ul style="list-style-type: none"> • HI and LO Alarm LEED visible from front. • Power supply on/failure LED visible from front. • In-built calibration facility
16	Accessories	<ul style="list-style-type: none"> • Phenolic nameplate giving tag no., service etc. • reagent Cabinet (if applicable) • Reagent Reservoir (if applicable) • Other as per requirement including piping etc.

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Table 11.8
Specifications for Phosphate Analyzer

S.No.	Features	Minimum Requirements
1	Type of Cell	Colorimetric / flow through
2	Flow Chamber	Plexi Glass Body or equivalent
3	Operating Range	0.1-10 / 20 / 50 Selectable manually
4	Output	4-20mA DC linear
5	Temperature Compensation	Automatic
6	Read Out	Digital Indicating meter
7	Accuracy	$\pm 1\%$ of scale range or better
8	Response Time	90% in 3 minutes or better
9	Operating Ambient Temperature	0-60° C
10	Ambient Humidity	Up to 95% relative humidity
11	Mounting	Flush Panel
12	Calibration	Manual through Zeroing solution / Automatic 2 point zero & slope programmable
13	Power Supply	230V AC, Single Phase, 50Hz
14	Alarm facility	2 HI & 2 LO independently adjustable over entire span Contact rating, 5A, 230 V AC/0.5A, 220V DC
15	Accessories	<ul style="list-style-type: none"> • Phenolic tag plate etc. • Sample filter. • Pressure regulator and flow meter • Automatic calibration kit • Reagents and consumables.

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Table 11.9
Specifications for Chloride Analyzer

S.No.	Features	Minimum Requirements
1	Type of Cell	Continuous flow through sample type
2	Flow Chamber	Flexi Glass Body or equivalent
3	Operating Range	0-10 , 0 – 100, 0 -1000 ppb, manually selectable
4	Output	4-20mA DC linear
5	Temperature Compensation	Automatic
6	Read Out	Digital Indicating meter
7	Accuracy	\pm 1% of scale range or better
8	Sensitivity	Better than 1 ppb
9	Response Time	90% in 3 minutes or better
10	Operating Ambient Temperature	0-60° C
11	Ambient Humidity	Up to 95% relative humidity
12	Mounting	Flush Panel
13	Calibration	Manual through Zeroing solution Automatic 2 point zero & slope programmable
14	Power Supply	230V AC, Single Phase, 50Hz
15	Alarm facility	2 HI & 2 LO independently adjustable over entire span Contact rating, 5A, 230 V AC/0.5A, 220V DC
16	Accessories	<ul style="list-style-type: none"> • Phenolic tag plate etc. • Sample filter. • Pressure regulator and flow meter • Automatic calibration kit • Reagents and consumables.

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11.10 SWAS Panels

1. The SWAS Panels shall have two sections namely sample conditioning section and analyzer section. The first section shall be the wet section of SWAS panels which shall be called as the "Sample Table". The second section shall be the dry section housing the analytical transmitters, signal conditioning devices and other requisite accessories.
2. All monitoring instruments and controls for sampling system shall be located on the front panel and shall be grouped accordingly to function in a logical and orderly fashion. There shall be a general progression of flow from top-to-bottom and left-to-right to minimize sample line length, purge times and material exposed to sample. Similarly, the conditioning components for each stream shall be grouped together wherever possible.
3. Indicating instruments such as pressure, temperature and flow shall be arranged in a vertical line directly above the grab sample valve. Sufficient clearance shall be maintained between instruments banks of adjacent sample points so that there is no confusion in reading these instruments.
4. Sample conditioning & analyzer panels shall be designed for ready access of components. Panel design shall ensure that:-
 - a) Parts subject to wear, corrosion or other deteriorations or requiring adjustments, inspection or repair are readily accessible and capable of convenient removal, when required.
 - b) Individual components or groups of components mounted on sub-panels can be removed for replacement or repair without the need of prior removal of components of other healthy streams.
 - c) Flow meters, pressure gauges and temperature indicators can be removed for repair or replacement from the front of the panel without disturbing any piping.
 - d) Filter elements and pressure reducing elements can be easily disassembled for periodic cleaning.
5. SWAS panels shall be designed based on human engineering considerations fully keeping in view the convenience of operation and maintenance personnel.
6. Each sample inlet shall be provided with bulkhead type tubing connection and an isolation valve or block valve suitable for sample operating conditions. A blow down connection and suitable blow down valve shall be furnished upstream of each isolating valve. Blow down valves shall be manifolded into a suitable blow down header. Strainers, filters, relief valves etc. shall be provided as specified and as required to properly protect the coolers, valves, analyzer elements etc.
7. All drains shall be piped into two separate drain headers. One header shall be called "Waste Drain Header" and shall receive all drains which contain

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substances not wanted in the plant heat cycle water. The other header shall be called "recoverable drain header" and shall receive all other drains not containing unwanted substances. All drains shall be headered as indicated above. Vendor shall pipe the waste drain header to the building drain system.

11.11 Constructional Features

1. The SWAS panel (wet panel) shall be constructed of 3 mm thick steel plates except for the extreme top of the Sample Table and Analyzer Panel (Dry Panel) which shall be of 2 mm sheet steel. The counter top, sample sink and front section above the counter top shall be 2.5 mm type 304 or 316 stainless steel.
2. The sample table shall be of free standing, open rack whereas the Dry Panel shall be of free standing, totally enclosed construction with back doors.
3. All SWAS panels shall be furnished with 100 mm base angle for bolting to 100 mm high concrete curb.
4. Following panels are to be provided:
 - a) Sample conditioning panel : 5000 (W) x 2300 (H) x 2400 (D) mm
(Wet Panel)
 - b) Analyzer Panel : 3000 (W) x 2300 (H) x 2400 (D) mm
(Dry Panel)

The dimensions given above are tentative only.

5. Panel sections shall be reinforced to ensure true surfaces and adequate support for instruments and equipment. All equipment and piping shall be firmly anchored and supported from within the respective panel section to ensure vibration free operation.
6. Doors and equipment arrangement shall be such that all items are readily accessible for maintenance and repair. Doors shall have concealed type hinges and three point type latches to assure tight closing. Doors shall have turned back edges and additional bracing where required to assure rigidity.
7. All surfaces shall be free from waves, bellies, or other imperfections. All stainless steel surfaces shall have uniform finish. All exterior steel surfaces shall be sand blasted, ground smooth, filled, primed, sanded and finished with smooth backed enamel.

11.12 Piping, Tubing & Accessories

11.12.1 Internal Piping & Tubing

1. All internal piping, tubing and system components required for making the system complete shall be shop installed and tested as per applicable codes, prior to shipment to project site.

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2. All tubing and wiring shall be located behind the face of the panel with projections allowed only for indicator faces, valve handles, manual grab sample lines etc. The physical arrangement of the tubing and wiring shall, in all cases, be so as to permit easy access for maintenance of all items of equipments.
3. All piping and tubing materials, fabrication, erection and application of piping materials shall be in accordance with the latest applicable requirements of the code for pressure piping (ANSI B 31.1,B36.19) and all other applicable regulations.
4. Unless otherwise specified, fittings used with pipe 50 mm and smaller shall be socket welding type, and fittings used with larger pipe shall be butt-welding type. All fittings shall be constructed of materials equivalent to the pipe with which they are used.
5. All piping and tubing shall be neatly installed and securely braced to ensure adequate mechanical rigidity. Routing and support of tubing shall be such that expansion and contraction of tubing or equipment mounted in the sample table do not impose any excessive stress on the tubing.
6. Special tools shall be used for all bending and forming operations. Bends in tubing shall be based on the requirement of the code for Pressure Piping (ANSI B 31.1), concerning tube thinning at the bends. Tubing shall be carefully handled to avoid flat spots, kinks and short bends. Any tubing so damaged shall not be used in this sample table.
7. All piping and tubing shall be blown with oil free compressed air after installation and before attachment to equipment at either end.
8. All piping and tubing terminal connections shall be suitably capped after completion of installation and tests to prevent entry of foreign materials during transit, storage etc.
9. All piping and tubing shall be installed so as to ensure easy accessibility for any maintenance or repair that may be required. High density tubing runs shall not interfere with accessibility to any system component and shall not impair system function.

11.12.2 Sample Piping

1. This shall include piping, fittings, valves and accessories from tapping point's up to SWAS conditioning panel located in SWAS rooms on as required basis. All sample piping shall be 3/4" NB seamless type of material ASTM A213 TP 316 H, conforming to ANSI B36.19. The schedule number shall be suitable for the particular application.
2. All fittings shall be socket welding type and of material ASTMA182 F316H conforming to ANSI B 16.11.

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3. Single and multi tubes shall run with the minimum number of changes in direction. Suitable identification tags shall be provided for easy check up and for proper connections.
4. The valves to be used in sample piping shall be of globe type, forged construction and stainless steel conforming to ASTM A182. The pressure temperature ratings shall be as per ANSI B16.34. The valve design shall be such that the seats can be reconditioned and stem and disc can be replaced without removing valve body from the line.

11.12.3 Material Specification for Piping

The material for piping to be furnished and installed for SWAS shall be as indicated below:-

Table 11.10
Specifications for Piping Material

S.No.	Piping System	Material Requirement
1	Piping from the sample inlet bulk-head fittings the shut-off valve for low pressure samples	Stainless Steel, ASTM A-213 Type 304 or 316, 16 BWG tubing
2	Piping from the sample inlet bulk-head fittings to the pressure reducing valves for high pressure samples and sample blow down piping	Stainless Steel, ASTM A-213 Type 304 or 316, 14 BWG tubing
3	Blow down header	Stainless Steel, ASTM A-312 Type 304 or 316, Sch. 160
4	Miscellaneous drains receiver header	Stainless Steel, ASTM A-312 Type 304 or 316, 16 BWG tubing
5	Piping from the shut-off valves for low pressure samples and from the pressure reducing valves for high pressure samples to the terminal points including branch piping	Stainless Steel, ASTM A-312 Type 304 or 316, 16 BWG tubing
6	Closed cooling water piping except grab sample	Carbon Steel, ASTM A-53 Gr. A, Sch. 40
7	Sample through drain piping and waste header piping	Carbon Steel, ASTM A-53 Gr. A, Sch. 40

11.13 Wiring

1. All control and instrumentation wiring used within the SWAS panel sections shall conform to NEC and NEMA standards. All measurement and control circuits shall be factory wired and tested by energizing at operating voltage.

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2. All electric connections shall be made between devices within the SWAS panel sections and shall be made to suitable terminal blocks, if devices are to be connected to equipment outside the SWAS panel.
3. All electrical connections shall enter and leave through the top or bottom of the panels.
4. High impedance circuits shall be connected using shielded or co-axial wire suitable for the service. Terminals shall be furnished for termination of shield.
5. Wiring in the sampling section shall be routed in covered metallic trays located as distant as is practicable from sampling lines and drains with due care taken to isolate electric wiring, termination etc. from liquid areas.

11.14 Power Supply & Grounding

Power supply to all instruments and control systems shall be through UPS and separately fused, it should be possible to disconnect any instrument without interrupting power supply to any other equipment/device.

11.15 Lighting & Receptacles

1. Sample table and analyzer section shall be provided with rapid start, low noise, fluorescent strip fixtures installed in a continuous row along the top of each section.
2. The panel shall have a ceiling mounted fluorescent illumination. Light switches shall be provided within the panel sections at suitable locations.
3. Three receptacles shall be provided on the front of the sample table below the work surface. These shall be equally spaced. Two more receptacles shall be provided inside the sample table and one receptacle shall be installed inside the panel.
4. Wiring for lighting and receptacles shall be run in flexible metallic conduits.

11.16 Control & Monitoring System

All alarm shall be available on the panel for the entire SWAS system, with repeat facility for each alarm in DCS in the Control Room.

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12. VIBRATION MONITORING SYSTEM**12.1 General**

1. The vibration monitoring system shall provide health of rotating machines on continuous on-line basis and shall guide the plant maintenance personnel regarding the nature of fault and the maintenance action required.
2. The system to be provided shall include all necessary hardware, software, firmware and interfaces, all special and field signal cabling required for implementing a fully functional system. System shall include but not limited to the details specified in subsequent paragraphs/Clauses.
3. Vibration monitoring system shall be independent.

12.2 Design & Functional Requirements

1. The vibration monitoring system shall provide condition monitoring the bearings of all critical machines, equipments with HT drives and their driven equipment. These shall include but not limited to the following:
 - a) Boiler Feed Pumps
 - b) Condenser Extraction Pumps
 - c) Any other device with HT motor
2. The vibration monitoring system shall be complete with vibration sensors, Key Phasor sensors, signal conditioning cards, amplifiers, special cables, vibration monitor (if required) etc. together with all necessary equipment and accessories.
3. Vibration sensors shall be provided for measurement in both X (horizontal) and Y (vertical) axis at 90° angle to each other for each bearing.
4. For bearings of high speed machines (= / >1500 rpm) accelerometer type sensor and for low speed machines (<1500 rpm) velocity type sensor shall be provided.
5. Necessary, one or two stage integrators for obtaining vibration measurement in terms of displacement shall be provided in the system.
6. Vibration monitoring system shall provide the vibration measurement in the form of 4 - 20 mA DC signal to be directly connected by hardwired cable to plant DCS for monitoring. Limit value generation (soft) for alarm and protection applications for the auxiliaries and their drive equipment shall be carried out in DCS or applicable control system (PLC).
7. Vibration monitoring system shall be an independent microprocessor based system (PC based). The system shall be interfaced with Plant DCS system through redundant communication link in addition to hardwired signal exchange. The system shall interface with plant DCS for any process signals which may be required to perform condition monitoring functions through soft link.
8. The Vibration Monitoring system shall have Following minimum features:
 - a) Bar graph and point display indicating the set points.

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- b) Graphical plant and machine area representation with location of sensors and the current value.
 - c) Diagnostic of the system and sensors. Alarm to be retransmitted to DCS.
 - d) Current and history trend with resolution of 10 msec.
 - e) Spectral band and waveform plotting
 - f) Multiple trends display including process value for data correlation.
 - g) Orbit and time base plotting.
 - h) Shaft centreline plot indicating position of a machine rotor.
 - i) Bode and polar plot.
 - j) Date and Time stamped alarm list.
 - k) Log and Report generation.
 - l) Provision for beeping icon in case of appearance of alarm.
 - m) Export and import of DCS data. Both way redundant communication links with the DCS shall be provided.
 - n) Electronic documentation.
9. The system shall have facility to store bulk data for 5 years duration with facility for retrieval of the same. The system shall have facility to share all the data in the hard disk/ back up media and provide user friendly utilities to retrieve and analyze stored data.
10. Data collected in the system shall also be accessed by CMMS resident on the Station LAN for condition based maintenance.
11. The system shall be time synchronised with GPS based master clock.
12. The vibration transducers shall be installed in accordance with API-670 requirements.
13. Two nos. vibration monitoring cum programming stations shall be provided in Central Control Room.

12.3 Technical Requirements

12.3.1 Vibration Sensors

1. Inductance/ piezoelectric type transducers shall be used. The sensors shall be either velocity or accelerometer type. However, the sensor type shall be selected taking into consideration equipment manufacturer's recommendation. Vibration sensors as recommended by main equipment manufacturers shall be installed both in horizontal (X) and vertical (Y) directions at each bearing housing of pump and motor. One number key-phaser (proximity type) shall also be provided for each equipment i.e. Pump/ Fan.
2. The vibration sensors shall have wide frequency response to monitor the harmonics and be housed in stainless steel enclosure conforming to protection degree of IP-67. Sensor shall be provided with all accessories like mounting pad/

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cube, Low noise cables & conduits, Extension cables, Junction boxes, Prefab connectors etc.

- Vibration transducers shall be complete with all required pre-amplifier / driver/charge amplifier as necessary for proper operation of the entire vibration monitoring system.

Table 12.1
Specifications for Vibration Sensor

S.N	Features	Minimum Requirements
1	Sensitivity	4 mv/mm/sec
2	Measurement range	0 to 25.4 mm/s pk
3	Frequency Range (+/- 10%)	3 – 1000 Hz
4	Resolution	0.1 mm/s pk
5	Linearity	+/- 1%
6	Temperature Range	0 – 60 °C
7	Sensing Element	Ceramic
8	Sensing Geometry	shear
9	Housing material	SS 316
10	Sealing	Welded hermetic
11	Electrical connection type/ position	Molded Integral cable / Top
12	Excitation Voltage	12 – 30 V DC
13	Cable type/length	Polyurethane/ 10 ft.

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Table 12.2
Specifications for Key Phasor Sensor

S.N	Features	Minimum Requirements
1	Type	Proximity non-contact type
2	Sensitivity	200 mv/mil
3	Measurement range	0 to 20 mil
4	Frequency Range	0 – 10 KHz
6	Linearity	+/- 1%
7	Temperature Range	0 – 60 °C
8	Probe tip material	Polyphenylene sulfide
9	Probe body material	SS 316
10	Electrical connection type/ position	Molded Integral cable 1 metre length with connector for extension / Top
11	Excitation Voltage	24 V DC from monitoring unit
12	Cable type	Polyurethane

12.3.2 Vibration Monitors/ Signal Conditioning Modules

1. The vibration monitors/ modules shall be micro-processor based with extensive self diagnostic facility. Monitoring module shall be fully software configurable.
2. One buffered 4-20 mA signal for connection to Plant DCS, and one buffered raw signal for use in vibration monitoring system shall be made available from each measuring point channel of monitor/ module. The signal shall be suitable for use as an input to DCS for analog monitoring, linear in proportion to vibration velocity as well as displacement. Monitor shall provide vibration indication calibrated in velocity units along with provisions of changing to displacement unit (field-programmable) for each measurement point in both horizontal & vertical planes.
3. Monitoring modules shall allow “hot” insertion or removal.
4. The maximum no. of channels per monitor/ module shall be four. The allocation of channels shall be such that loss of one monitor shall not affect more than one side of the bearing of one machine.
5. Sensor fault, monitor fault, power supply fault monitoring shall be provided. On sensor fault / wire break in the sensor circuit, the system shall have the feature of

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identifying the same through suitable means like the output being forced to a value less than 4 mA, to enable 'bad' signal detection. In case, such a feature is not available, then suitable contact shall be provided from the monitor for sensor fault/ wire break in sensor circuit.

6. Programmable high pass and low pass filtering facility shall be available to improve the frequency response.
7. All the calibration of the monitors/ modules and transducers shall be possible from the front panel.
8. All incoming and outgoing signals shall be connected through a terminal block or connection mounted at the back of the monitor.
9. In addition to the above, the monitor/ module shall contain all other required signal conditioning devices and accessories required for proper functioning.
10. Sensitivity of vibration monitoring module shall be 100 mV/mil or better
11. The Vibration monitoring system shall have an accuracy of +/- 1 % of Full Scale.
12. Input frequency shall be user programmable.

12.3.3 Power Supplies

1. System shall have provision to receive two numbers 230 V, 50 Hz feeders from purchaser UPS, further conversion and distribution shall be in done as per scope. If required, redundant external Power supply shall be provided to ensure that failure of one power supply shall not affect any monitoring function in the system. Also any power supply failure/ earth fault in any of the monitors shall be isolated without affecting other monitors/ common power supply. However, if any power supply modules internal to the monitors are envisaged, the failure of one such module should not affect more than one monitor.
2. Power supply monitoring feature with suitable indication and external alarms shall be provided.

12.3.4 Cables, Conduits & Junction box

1. Each transducer shall be furnished with low noise cable in flexible conduit, as indicated earlier, in actual length as required. Conduit fittings shall be furnished or connection to vibration transducer. The other end of the flexible conduit shall be connected to a suitable junction box. The flexible conduit shall not be directly terminated to the vibration transducer to avoid any damages due to vibration. Pre-wired plug-in- type connector shall be provided for connection of the low noise cable to the vibration transducer. Terminals shall be provided for terminating the low noise cable to the junction box.
2. Provision of suitable canopy on the JB and panels installed in open area shall be provided.

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Table 12.3
Specifications for Flexible Conduits

S.N	Features	Minimum Requirements
1	Type	Stainless steel flexible conduit
2	Material	AISI 304
3	Formation	Single overlapped/Square Locked
4	Minimum Bending Diameter	75 mm
5	Flexibility	Should not be permanently distorted when bent in complete turn round on a cylinder of 75 mm diameter.
6	Tensile strength	400 N or better
7	Diameter & length	As per requirement

12.3.5 Programming Functions

Suitable means shall be provided for programming the components of the system. This shall include range change, set point change, sensor fault detection/ monitoring related functions etc.

12.3.6 System Cabinet/ Monitor Racks

- The system mounting rack shall preferably be 19" EIA rack mount for monitor based systems. The system mounting rack shall house monitor modules, indicating units, power supplies. Rack shall be fully factory wired up to rear terminal block. The Internal arrangement shall take into consideration aspects of access/ ease of maintenance etc.
- Panel shall be provided with necessary Isolation transformers, MCBs, switch etc. Power and signal cable shall be routed in separate raceways.
- All necessary accessory items and electrical materials shall be installed in the monitoring panels as required for completeness of the panels. These shall include but not be limited to the following:
 - Terminal blocks with identification tags.
 - Terminal lugs and wire markers at both ends of all wires.
 - Panel hardware including vibration isolating devices
 - Grounding bus
- Incoming cables from the field shall be terminated in suitable terminal blocks in logical sequence.

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5. Each vibration monitor and mounting rack shall have nameplate engraved to indicate the main equipment to which the module is catering and the bearing details.
6. In case of monitor based system, the front door shall be of glass, for the portion where the monitors are mounted to enable viewing of the same.

12.3.7 Wiring

1. All instrument wiring used within the panels shall conform to NEC and NEMA standards and shall be factory installed and tested at the works.
2. Signal circuit shields shall be grounded at the system cabinet end only or as recommended by manufacturer.
3. All internal wiring (except low level instrument wiring) shall be National Electric Code Type SIS, Polymeric / Elastomeric insulated, copper stranded conductor & switchboard wire.
4. Panel wiring shall have a flame resistant insulation with adequately sized copper conductor based on current carrying capacities as set forth by the National Electric Code.

12.3.8 Terminal Blocks

1. For all inputs to the system emanating from the field or “others” systems, the system shall be furnished with screw less cage clamp type terminals suitable for core size of 0.5/1.5 square mm. stranded conductor.
2. At least 20 per cent spare unused terminals shall be provided, for circuit modifications and for termination of all conductors in a multi conductor control cable

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13. FIELD INSTRUMENTS & FINAL CONTROL ELEMENTS

13.1 General Requirements

1. All instruments shall be of proven reliability, accuracy, repeatability requiring a minimum of maintenance. They shall comply with the acceptable international standards.
2. Every panel mounted instrument requiring power supply shall be used with a pair of easily replaceable glass cartridge fuses of suitable rating. Every instrument shall be used with a grounding terminal and shall be suitably connected to the panel grounding bus.
3. All local gauges as well as transmitters, sensors, and switches for parameters like pressure, temperature, level, flow etc. as required for the safe and efficient operation and maintenance as well as for operator and management information (including all computation) of equipment shall be used.
4. The necessary root valves, impulse piping, drain cocks, gauge-zeroing cocks, valve manifolds and all the other accessories required for mounting/erection of these local instruments shall be furnished, even if not specifically asked for, on as required basis. The contacts of equipment mounted instruments, sensors, switches etc. for external connection including spare contacts shall be wired out in flexible/rigid conduits, independently to suitably located common junction boxes. The proposal shall include the necessary cables, flexible conduits, junction boxes and accessories for the above purpose. Double root valves shall be used for all pressure tapings where the pressure exceeds 40 kg/sq cm.
5. For protection purposes, transmitters can be considered in place of switches.

13.2 Pressure / Differential Pressure / Flow / Level Transmitter

Table 13.1

Specifications for Pressure / Differential Pressure / Flow / Level Transmitter

S.N	Features	Minimum Requirements
1	Type	Microprocessor based 2 wire type, HART protocol compatible
2	Sensor Type	Capacitive/ Piezo-electric
3	Output Signal	4-20 mA signals superimposed with HART signal.
4	Signal Processing Unit	Microprocessor based
5	Overpressure	150% of max. operating pressure. For vacuum service, the element shall have

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S.N	Features	Minimum Requirements
		under – range protection to full vacuum
6	Turn-down Ratio	10:1 for vacuum / very low pressure applications. 100:1 for other applications.
7	Stability	± 0.1% of calibrated span for six months up to 70 Kg/cm ² and ± 0.25% for range more than 70 Kg/cm ² (g).
8	Span and Zero drift	± 0.015% per deg. C at max span & 0.11% per deg. C at min. span.
9	Enclosure Class	Weather proof as per IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500
10	Zero & span adjustability	Continuous, tamper proof, remote as well as manual from instrument with zero suppression and elevation facility.
11	Local Indicator	To be provided
12	Display	Digital LCD Integral Display (minimum 5 digit) Engineering Unit
13	Process connection	½ " NPT (F)
14	Electrical Connection	½ " NPT
15	MOC of Electrical Housing	Aluminum Alloy or better
16	Ambient Temperature	65 Deg. C
17	Operating Voltage	16 – 48 Volts DC
18	Load	600 Ohms (minimum) at 24 Volts DC
19	Accuracy	± 0.075% of span or better
20	Response Time	100 millisecond or better

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S.N	Features	Minimum Requirements
21	Adjustment/ calibration/ maintenance	Port/provision for Centralised PC based system maintenance.
22	Diagnostic	Self Indicating feature
23	Accessories	Diaphragm seal, pulsation damper, siphon, 3-valve or 5valve manifolds.

1. All transmitters shall be equipped with all necessary accessories like valve manifolds, mounting bracket etc. Pulsation dampeners shall be used where the process media is unstable for measurement such as at the discharge of a pump. For absolute pressure transmitter, 2 valve manifold; for gauge / vacuum pressure transmitter, 3 valve manifolds and for DP / level / flow transmitter, 5-valve manifold shall be provided. In case if it becomes necessary to use a DP transmitter for pressure measurement then a 3 valve manifold shall be used in place of 2 valve manifold.
2. Pressure transmitter shall have easily accessible span, zero and time constant adjustments. A range suppression / elevation device shall be used wherever required.
3. For pressure / differential pressure transmitter, proof pressure shall be 200% of maximum static process pressure.
4. All transmitter cases shall be dust – tight and rugged. Weather – proof and explosion – proof cases shall be used in outdoor and hazardous areas respectively. Protection clause shall be of IP 67 or better.
5. Transmitters for pressure / DP measurements of liquid and steam shall always be installed below the sampling point, preferably with the connection at the top.
6. Transmitters for pressure / DP measurements for gases and air shall always be installed above the sampling point, preferably with the connection at the bottom.
7. Transmitters with diaphragm seal system shall be considered when
 - a) The process temperature is outside of the normal operating ranges of the transmitter and cannot be brought into those limits with impulse piping.
 - b) The process is corrosive and would require frequent transmitter replacement or unusual materials of construction or
 - c) The process contains suspended solids or is viscous and may plug the impulse piping or
 - d) There is a need to make density or interface measurements or
 - e) The process medium may freeze or solidify in transmitter or impulse piping.

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8. Diaphragm seal shall be either capillary type or direct mounted type depending upon the application. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.
9. Differential pressure type level transmitters shall be used for range above 1219 mm, for services requiring purge or where liquid might boil in external portions.
10. Differential pressure type level transmitters for use on corrosive service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type DP transmitter shall be considered for special application. Diaphragm material shall normally be stainless steel or any other special alloy.
11. Differential pressure type flow transmitters shall have in-built square-root extractors.

13.3 Temperature Transmitter

Table 13.2

Specifications for Temperature Transmitter

S.N	Features	Minimum Requirements
1	Type	2-Wire, Smart (HART)
2	Output Signal	4-20 mA signals superimposed with HART signal.
3	Signal Processing Unit	Microprocessor based
4	Accuracy	± 0.075 % of span or better
5	Local Indicator	To be provided
6	Display	Digital LCD Integral Display (minimum 5 digit) Engineering Unit
7	Input	Ohm input from Pt-100 RTD/ mV signal from thermocouples
8	Stability	± 0.1 % of reading or 0.1° C, whichever is greater, for 24 months for RTDs. ± 0.1 % of reading or 0.1 °C, whichever is greater, for 12 months for thermocouples
9	Output	4-20 mA DC, linear

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S.N	Features	Minimum Requirements
10	Load	600 Ohms (minimum) at 24 Volts DC
11	Power Supply	24 VDC, 2- Wire Loop Power
12	MOC of Electrical Housing	Aluminum Alloy or better
13	Enclosure Class	IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500

- The temperature transmitter of following types (2-wire Loop Powered temperature transmitter) compatible with thermocouples and RTDs shall be used. Cold junction temperature compensation of the thermocouples shall be performed in the temperature transmitter itself.

Single Input DIN-rail mounted Temperature Transmitter

These shall be suitable for mounting on DIN-rails in Panels/JBs in air conditioned room. This temperature transmitter shall be the ones which are especially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category.

Dual-input Temperature Transmitter with Indicator

These shall be suitable for mounting on pipes/ supports. Indicator shall be used with these transmitters. These transmitters shall have bump-less change over facility to second sensor in case first sensor fails .This changeover is to be alarmed. Protection class shall be IP67 minimum.

- Transmitters shall be used with following features:
 - Sensor drifts alarm for sensor failure prediction
 - Differential & average temperature measurement if required.
 - Automatic switch-over to back-up sensor on primary sensor failure.
 - Accepts any combination of two sensor types (RTDs, T/Cs, mV or ohms)
 - Ambient temperature compensation
 - Fault detection for electronics & sensors with fail-safe alarming.
 - Provision of built-in CJC
- Transmitters to be used for RTD sensors shall be used with RTD EMF correction features so that it shall detect and eliminate EMF errors which are the result of small voltage produced by RTD sensing elements.
- The product and make shall be selected so that with one make of transmitter all applications with respect to measuring range, temperature sensor (resistance

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thermometer / thermocouple) and connection type (2/3/4) wire connection of resistance thermometers) shall be covered.

5. Transmitters shall be capable of communication with HART (Highway Addressable Remote Transducer) communicator. HART communicator shall be used with transmitters for tuning / configuring / diagnosing / maintenance of the transmitters. It shall meet the intrinsic safety requirement if required depending upon the application.
6. All transmitters' cases shall be dust-tight and rugged. Weather-proof and explosion-proof cases shall be used in outer and hazardous areas respectively.

13.4

Thermocouple

Table 13.3
Specifications for Thermocouple

S.N	Features		Minimum Requirements
1	Wire Gauge		16 AWG (for K type) 24 AWG (for R type)
2	Protective tube		O.D. 8 mm Material SS 316 seamless Filling – Compacted Magnesium Oxide (Purity above 99.4)
3	Loading		Shall be spring loaded to ensure positive contact with the well. Prevention of rotation of the insert with respect to head and resultant twisting of leads shall be ensured.
4	Accuracy		As per ANSI MC 96.1 / IEC 751 / IS-2054 / 2055.
5	Characteristic		Linear with respect to temperature within +/- ½ per cent of top range value.
6	Reference		For temperature vs. mV characteristics, following IS shall be applicable : Type K IS – 2054 Type R IS - 2055
7	Head	Type	IP-65 universal screwed type (Explosion proof for NEC class-1, division-1 area)

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S.N	Features		Minimum Requirements
		Material	Die-cast aluminium or better material painted with black enamel paint.
		Terminal Block	Brass screw type / silver plated on ceramic head.
		Cable Connection	½ " NPT gland & grommet
		Cover	Screwed cover with suitable gasket & SS Chain
8	Instrument connection to Well		½ " NPT
9	Accessories	a)	Adjustable nipple-union-nipple {1/2" Sch. 80 X1/2" NPT (M)} with thermowell connection
		b)	Compression fittings/union
		c)	Flanges etc. (For flanged connection only)
		d)	SS 316 forged/barstock thermowell as per ASME PTC code. Process connection M33X2 (M) in general or 1 ½ " Flanged for Flue gas/ Furnace air etc. application

- The following types of sensors shall be used for the different temperature ranges:
 - For measurement of temperatures of up to max. 1100 °C, rapid-responded sheathed thermocouples with insulated tip, 16 AWG wire, as Chromel-Alumel (NiCr-NiAl, ISA type K) measuring element, with admissible deviation of thermo voltage of half the values stated in IS-2054 or DIN 43710.
 - For measurement of temperature between 1100°C and 1300°C, 24 AWG, Platinum Rhodium (13%) – Platinum (ISA type R) measuring elements, with admissible deviation of thermo voltage of half the values stated in IS-2055 or DIN-43710.
- All thermocouples shall be duplex type with tip grounded. Thermoelectric properties and accuracy shall be as per ANSI MC 96.1 / IS-2054 / 2055.

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3. The design of thermocouple assemblies shall be such that replacement on line is possible.
4. Gas-tight ceramic sheaths partially reinforced with stainless steel sheath shall be used as protective tube for Pt Rh – Pt thermocouples. For other type of thermocouple stainless steel tubes shall be used as protective sheaths. For measuring temperature of high pressure process fluid, tapered protection sheath made from solid bar stock shall be used.
5. The time-constant of thermocouples shall suit the process requirement.
6. The thermocouples shall be supplied with factory tested and calibrated assemblies. The assemblies shall be complete with thermo well, sensing element, connection lead, duplex terminal block, extension nipple, compression fittings / unions /flanges etc. to meet all functional requirements. The thermocouples equipped with thermo well shall be spring loaded for positive contact with the well.
7. The duplex terminal block shall be constructed with high temperature ceramic base with brass screw type terminals.
8. Thermocouple shall be suitable for steam, water or any other liquid application. For air & flue gas service, suitable protection tubes shall be used for the thermocouples.
9. All thermocouples shall be terminated to the nearest junction boxes. The cold junction compensation shall be implemented within the measuring module level, no local/ field cold junction compensation box is allowed.

13.5 Resistance Temperature Detector (RTD)

Table 13.4

Specifications for RTD

S.No.	Features	Minimum Requirements
1	Type	3 / 4 wire , Pt-100 (100 ohm at 0 deg C) (as per DIN 43760)
2	No. of Element	Duplex
3	Housing/Head	IP-65/Diecast Aluminium. Plug in connectors are to be provided for external signal cable connection
4	Sheathing of RTD	Metal sheathed , mineral insulated, ceramic packed
5	Calibration and accuracy	As per DIN-43670 Class-A for RTD

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S.No.	Features	Minimum Requirements
6	Stability	Zero & span drift within 0.1% of span for a 6 month period.
7	Characteristic	Linear with respect to temp, within $\pm 1/2$ percent of top range value
8	Standard	As per DIN-43670 for RTD & ASME PTC-19.3 for Thermowell
9	Accessories	a) Adjustable Nipple-Union-Nipple with thermo well connection / plug in connectors
		b) Compression fittings / unions
		c) Flanges etc.
		d) Thermowell as per requirement

1. RTDs shall be of duplex, platinum three / four wire type with a nominal resistance of 100 ohms at 0°C and conform to DIN 43760 / BS 1904.
2. Stability of RTD over full range shall be better than 0.05 ohms and the repeatability figure shall be better than 0.02 ohms. Accuracy shall be of the order of 0.15% or better and response time shall be less than 20 seconds with thermo well.
3. The protective-sheath material shall be SS 316, seamless tubes using compacted magnesium oxide packing for insulation. The insulation resistance at 540°C shall not be less than 5 mega-ohms.

13.6

Metal Temperature Thermocouple

Table 13.5

Specifications for Metal Temperature Thermocouple

S.No.	Features	Minimum Requirements
1	Measuring medium	Metal Temperature
2	Type	K-Type
3	Wire Gauge	16 AWG
4	No. of Element	Duplex with separate hot junctions, ungrounded type
5	Sheathing/Insulation/Dia.	Metal sheathed (SS 321) , mineral insulated (Magnesium oxide), ceramic packed, 8 mm

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S.No.	Features	Minimum Requirements
		Dia.
6	Bending Radius	30 mm (minimum)
7	Cold End Sealing	SS pot seal with color coded PTFE headed sleeve insulated flexible tails. Sealing compound – Epoxy Resin
8	Standard	ANSI MC 96.01
9	Thermocouple Length	30 Mtrs. (minimum)
10	Accessories	1/2" BSP SS sliding end connector, weld pad, weld on clamps of heat resistant steel SS310.

1. For metal temperature measurement, care shall be taken for proper contact with metal surface. The thermocouples sheath for metal temperature measurement shall have to be thermally insulated to avoid radiation / conduction / convection loss. Thermocouple assembly for metal temperature measurement shall suit the functional requirement.
2. The thermocouple shall be attached to the heater tube surface by being furnished with stainless steel welding pads or by the use of thermocouple attachment blocks. The multiple holes in these blocks shall allow for spare thermocouple element for quick replacement.
3. The differential temperature “inside / centre” of the wall shall be measured by means of sheathed thermocouples NiCr-Ni, dia 3.2 mm. For this special protective sleeve shall be used. Particular emphasis shall be put on compliance with the stipulated depth of the bores in the tube wall material.
4. For detection of leakage of various drain valves, drain pipe metal temperature thermocouples and for SH, RH metal temperature thermocouples shall be used.

13.7 Cold junction Compensation (CJC) Boxes

Table 13.6A

Cold Junction Compensation (CJC) Boxes

S.No.	Medium	MOC
1	Reference Temp	60°C (+/- 1.3°C) for type K thermocouple 60°C (+/- 2°C) for type R thermocouple
2	Effect of ambient temp. variation	+/- 0.1% per 10°C

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S.No.	Medium	MOC
3	Material	4 mm thick fiberglass reinforced polyester with polyetherene paint and glazed finish
4	Protection class	IP 55
5	Cable entry	Bottom with gland plate suitable for cable used along with blanking facility.
6	Temp. Control	Automatic with remote temp. monitoring
7	Power supply	24VDC

13.8 Thermowell for Temperature Elements

1. The design of the thermo well shall take into consideration the temperature, pressure, medium and fluid velocity specified in the process in accordance with ASME Standard PTC 19.3.
2. Thermo wells shall, in general, be of SS 316 and shall be drilled from bar stock except for air and flue gas services. However, selection of thermo well material shall be as per following guideline.

Table 13.6B
Thermowell MOC Selection

S.No.	Medium	MOC
1	Steam lines	SS 316 and pipe material compatible for high temperature steam
2	Water lines	Low carbon steel/ SS316

3. Welded type thermo wells with 38 mm O.D. for welding & ½" NPT internal threads shall be used for pressure above 100 kg / sq cm or temperature above 400 deg C. Socket weld type thermo well with 34 mm O.D. for welding & ½" NPT internal thread, shall be used for pressure between 40-100 kg/cm2 and temperature up to 400°C. Screwed type thermo wells with ½" NPT internal threads & M33X2 (M) outer threads shall be used for pressure below 40 kg/cm2 and temperature below 400°C. For pipes having probability of prolonged vibration, seal welding may be done all around after tightening the thermo well within the base.
4. Thermo well manufacturing drawing covering material specification, dimensional details, details of special treatment, finish etc. as well as test procedure. Material certificate shall have to be furnished for each thermo well.
5. Wherever any approval is necessary from any recognized body / authority during manufacturing of high pressure wells.

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6. The thermo well immersion depth (U) shall be sufficient to eliminate conduction error. A general rule which may be followed is to use an immersion length equaling a minimum of 10 times the diameter of the protective tube or well. In general, immersion length of thermo wells for different line sizes shall be as follows:

Table 13.6C
Thermowell Immersion Length

S.No.	Line Size	Immersion Length
1	From 4" to 6"	65 mm
2	From 8" & onwards	140 mm
3	Vessels	400 mm

13.9

Pressure Gauge/ Differential Pressure Gauge/Draft Gauge

Table 13.7
Specification for Pressure Gauge/ DP Gauge/ Draft Gauge

S.No.	Feature	Minimum Requirement
1	Type	Bourdon / Bellows / Diaphragm
2	Sensing Element Material	AISI 316 SS
3	Movement Material	AISI 304 SS
4	Case Material / Protection Class	SS / IP 65
5	Dial Size	150 mm For Special application like drum pressure, Main Steam pressure etc. 250 mm shall be used
6	Scale	Black lettering on white background in 270 °C arc
7	Range Selection	Normally operate at 75% of its maximum pressure range. Instruments measuring varying pressures shall operate in a band of 60% of its maximum pressure range.
8	Over range Protection	150% of maximum range by internal stop. External stop below zero.
9	Adjustment	External Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
10	Stop at Max. Reading	Shall be used
11	Element Connection	Argon welding
12	Process Connection	½" NPT(M) bottom connection for local mounting, back connection for panel mounting
13	Accuracy	+/- 1.0 % of full scale or better

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S.No.	Feature	Minimum Requirement
14	Operating Ambient Temperature	50 °C (Max. continuous)
15	Safety Feature	Neoprene Safety Diaphragm (Blowout disc) at the back
16	Window	Shatter-proof glass
17	Chemical Seal Unit	SS 316 Flange and Diaphragm, PTFE coated / block, Silicon Oil filling fluid
18	Accessories	Snubber for pulsating fluid applications / 3-way gauge cock / 2-valve manifold / Pigtail / Siphon for steam service / Gauge Saver, if maximum or Design Pressure is very high than the Operating Pressure / Counter Flanges / Bolts, Nuts, Gaskets / SS Tag Plate

1. Directly connected pressure measuring instruments shall be diaphragm, bourdon or bellow type elements depending upon the services conditions. In general, diaphragm elements shall be used in the range of 0 to 1000 mm water column pressure, bellow type element for ranges of 0 to 1 Kg/cm² and bourdon type element for ranges greater than 1 Kg/cm².
2. Primary element material shall be corrosion resistant to process fluid or diaphragm seals shall be used for protection.
3. For draft measurement Teflon coated beryllium copper diaphragm shall be used.
4. Snubber shall be floating pin type, externally mounted and externally adjustable. It shall be used for all pulsating services.
5. Diaphragm seals, filled type or mechanical type shall be furnished where plugging of the element may occur or where suitable material is not available in highly corrosive services. When chemical seals are required, they shall be the clean out type with flushing connection.
6. Over-range protection shall be used to at least 150 % of range. For vacuum service, the element shall have under-range protection to full vacuum
7. Ranges of the gauges shall be so selected that the gauge normally operates in the middle third of the scale and conform to IS 3624 standard dials, wherever necessary.
8. The sensing elements for all gauges shall be properly aged and factory tested to remove all residual stresses and shall be SS 316 with forged socket and tip of the same material. Elements above 70 Kg/sq. cm range shall be bored instead of drawn.

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13.10 Temperature Gauge

Table 13.8
Specification for Temperature Gauge

S.No.	Feature	Minimum Requirement
1	Type	Mercury filled
2	Sensing Element material	Bourdon AISI 316 SS
3	Movement Materials	AISI 304 SS
4	Case Material/Protection class	SS / IP65
5	Capillary Armouring	SS Flexible
6	Capillary	SS 316 (5 mtr. Length for Local & 15 metre for panel Mounting)
7	Bulb/Stem Diameter	12 mm
8	Dial Size	150 mm
9	Window	Shatterproof glass
10	Scale	Black lettering on white background in 270 °C arc
11	Adjustment	Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
12	Pointer	Externally Adjustable
13	Range Selection	Normal Process Temperature – approximately two third of Temperature range.
14	Stop at Max. Reading	Shall be used
15	Over range Protection	150% of FSD
16	Instrument Connection	Bottom connection for local mounting, back connection for panel mounting.
17	Process Connection	½" NPT with Thermowell
18	Performance :-	
a	Accuracy	+/-1.0% of full scale or better
b	Repeatability	Less than 0.5% of full range
c	Response Time	30 seconds (max.) with Thermowell and 15 seconds Bare.
19	Operating Ambient Temperature	50 °C (Max. continuous)
20	Accessories	Mounting brackets, Bolts, Nuts, Gaskets / SS Tag plate, SS Thermowell etc.

1. Temperature gauges shall be dial thermometers (liquid spring / steam pressure spring / metal expansion thermometer), either rigid stem or capillary tube depending upon application; if this is not possible for design reasons, industry type liquid – in – glass thermometers shall be used.

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2. Case shall have back or bottom connection with adjustable gland to permit adjustment of thermometer into the thermo well.
3. Thermometer stem adjustable gland with union connection and bushing shall be suitable for ½ inch NPT connection.
4. Bi-metallic type dial thermometer, if used, shall be hermetically sealed, back or bottom connection type, with 150 mm dial.
5. The gauges shall be used with automatic ambient temperature compensation.
6. Scale ranges shall be selected so that normal process temperature in middle two – third of full scale range.

13.11 Level Gauge

Table 13.9
Specification for Level Gauge

S.No.	Feature	Minimum Requirement
1	Sensing Element & material	Tempered toughened Borosilicate gauge glass steel Armored reflex or transparent type
2	Body Material	Forged carbon steel / 304 SS
3	End Connection	Process connection as per ASME PTC and drain / vent 15 NB
4	Accuracy	+ 2 %
5	Scale	Linear vertical
6	Range Selection	Cover 125 % of max. of scale
7	Over Range Test	Test pressure for the assembly shall be 1.5 to the Maximum design pressure at 38 degree C
8	Housing	CS / 304 SS leak - proof
9	Identification	Engraved with service legend or or laminated phenolic Name plate
10	Packing	PTFE Teflon

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S.No.	Feature	Minimum Requirement
11	Illumination	220 V, 50 Hz, 25 / 40 Watts either with deflector or diffuser (for transparent type level gauge) / 220V , 50 Hz, 25 /40 Watts with red and green filter for bicolor gauge
12	Accessories	Gasket for all KEL – F shield for transparent type vent and drain valves of CS / SS as per requirement
13	Others	Anti – Frost extension for low temperature service. Heating / cooling arrangement

- Level gauges shall be steel armoured reflex or transparent or bi –colour type, top and bottom connection as per pressure vessel standard of ASME PTC code and 15 mm NB (1/2 inch NPT) Drain and Vent connection.
- Body material and cover material shall normally be forged carbon steel, 304 stainlesssteel or other superior material.
- Reflex type gauges shall be used for clean and colorless liquids and transparent type for other liquids.
- The gauge glass must have a rating equal to or more than the vessel design pressure and temperature.
- The maximum length of a single gauge glass shall not exceed 1400 mm. Where large range is required, multiple gauges of preferably equal lengths shall be used with 50 mm over – lapping in visibility.
- The visibility shall cover the operating level range and the maximum and minimum ranges expected considering start – up conditions as well as alarm and shut down points. Internal heating shall be used for viscous liquids. Integral illuminators shall be used for transparent gauges, if necessary.
- Stand – pipes shall be used for multi – gauge glass and level controller installation and on horizontal drum or exchanger with top and bottom connections to have visibility of the complete span. The stand pipe shall not be used with block valves.
- Primary isolation valves shall be used In addition to the gauge glass valves unless otherwise specified. When the process fluid may create lugging or leakage problem, gauge valves may be omitted. For low temperature liquid having high

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vapor pressure at ambient temperature, isolation and gauge valves shall not be permissible. Safety valve shall be used at the vent connection of the gauge glass where isolation is required.

9. For high pressure service such as HP/LP Heaters etc., the gauge glass shall be multi – port illuminated type (Bi – colour type). Indication of water space shall be ‘green’ and indication of steam space shall be ‘red’.

10. Bi – colour level gauges shall have following features:

- Temperature equalizing column expansion bend and chain patterned hand – wheel
- Certification by Inspectorate of Boiler

13.12 Pressure/ Differential Pressure Switch

Table 13.10
Specification for Pressure/DP Switch

S.No.	Feature	Minimum Requirement
1	Type	Piston for high pressure application Bellow/Diaphragm for low pressure application
2	Sensing Element material	AISI 316 SS
3	Wetted Parts material	AISI 316 SS
4	Case Material	Epoxy coated Die Cast Aluminium
5	Setter Scale	Black graduation on white linear scale. Graduation 0 – 100% with red pointer for set points.
6	Over range for Pressure / Vacuum Switch	150% of maximum pressure
7	Set Point	Adjustable throughout switch operating range.
8	Static Pressure for Differential Pressure Switch	Maximum Line Pressure or Static Pressure on either side without permanent deformation or loss of accuracy.
9	Adjustments	Internal – set point Differential adjustable feature
10	Process Connection	½ " NPT(M) bottom connected

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S.No.	Feature	Minimum Requirement
11	Switch Configuration	2 SPDT / 1 DPDT
12	Switch Rating	230 V, 5A AC / 220 V, 0.25 A DC/24 V, 2A DC
13	Switch Type	Snap acting, shock and vibration-proof
14	Cable Connection	½ " ET conduit connections or compression gland
15	Enclosure Class	Weather proof as per IP 65 with corrosion resistance coating.
16	Accuracy	1% of span up to 3Kg/cm2 0.5% of span for more than 3 Kg/cm2.
17	Repeatability	0.5% of span
18	Accessories	
a)		Snubber for pulsating fluid application.
b)		Tag Number, service engraved in SS tag plate
c)		Teflon back-up sheath protection, as required.
d)		i) Remote diaphragm seal with SS 316 armored capillary for typical application. MOC of seal material shall be as per process fluid requirement. ii) Silver coated diaphragm for corrosive services like chlorinated water.
e)		Retention ring and screws for surface mounting.
f)		3-way Gauge Cock (SS 316) for PS / 5-Valve Manifold (SS 316) for DPS.
g)		Mounting bracket / Clamp for 2 " pipe, bolt & nut.

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1. The pressure switches shall have sensing elements made of copper alloy or stainless steel sealed diaphragm and piston actuated for high pressure service and bellows for low pressure / vacuum service.
2. Low differential pressure switches for low static pressure ranges shall be diaphragm type with snap action switch elements.
3. Low differential pressure switches for high static pressure shall be elbows and torque tube type and snap – action switch elements and metric scale dial indicators.
4. For corrosive, viscous process fluids diaphragm sealed with completely filled inert liquid shall be used. Material of diaphragm and wetted parts shall be selected considering the nature of process fluid.
5. The sensing elements shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand at least 150 % the full scale pressure without any damage or permanent deformation.
6. Actuation set point, dead band shall be internally adjustable throughout the range with tamper proof facilities.
7. Electrical connection for the switch devices shall be suitable for plug in type connection.
8. Process connection shall be ½ inch NPT. Process piping connections shall include necessary union, nut, nipple, tail pipe, isolation valve and test connection to permit servicing, testing, calibration and removal of the instrument device.
9. Pressure switches shall be tested as per BS – 6134.

13.13 Conductivity Type Level Switch

Table 13.11
Specification for Conductivity Type Level Switch

S.No.	Feature	Minimum Requirement
1	Sensing elements	Conductivity type
2	Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
6	Probe length	As per requirement
7	Mounting	Flanged- on external cage
8	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry

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S.No.	Feature	Minimum Requirement
		contact
9	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
10	Enclosure	IP 65
11	Housing	Cast aluminum epoxy coated weather proof
12	Ambient Temperature	60 °C (max.)
13	Electrical Connection	Plug-in type
14	Cable connection	½ " NPT with cable gland
15	Set point	Adjustable
16	Accessories	All mounting accessories

13.14 Capacitance Type Level Switch

Table 13.12
Specification for Capacitance Type Level Switch

S.No.	Feature	Minimum Requirement
1	Type	Capacitance type
2	Probe	Rod or Suspended Electrode
3	Material	SS 316
4	Insulation	PTFE/PP/Kynar part/full as required
5	Repeatability	± 0.5 % of full range or better
6	Accuracy	± 0.5 % of full scale or better
7	Working temperature	As per process requirement
8	Probe length	As per requirement
9	Probe Mounting	1 ½ " Flanged
10	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry

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S.No.	Feature	Minimum Requirement
		contact
11	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
12	Enclosure	IP 65
13	Housing	Cast aluminum epoxy coated weather proof
14	Cable connection	½ " NPT with Cable gland
15	Ambient Temperature	60 °C (max.)
16	Electrical Connection	Plug-in type
17	Accessories	Counter flange, Cable gland, Prefab cable etc.
14	Set point	Adjustable
15	Accessories	All mounting accessories

13.15 Float/Displacer Type Level Switch

Table 13.13
Specification for Float/Displacer Type Level Switch

S.No.	Feature	Minimum Requirement
1	Type	Float/Displacer type
2	Float/Stem/Displacer Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
7	Process connection	As per requirement
8	Over-range proof	150% of max. design pressure
9	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact
10	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V

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S.No.	Feature	Minimum Requirement
		DC
11	Enclosure	IP 65
12	Hydro Test	Chamber – 100% at 1.5 times rated pressure or as per ANSI flange rating Float – 1.1 times of operating pressure
13	Electrical Connection	Plug-in socket
14	Accessories	All mounting accessories

1. Level Switch shall work on gland less magnetically coupled float or displacer operated mechanism having separate float chamber.
2. Float, stem and displacer shall be 316 stainless steel.
3. Level switch body, cage and process connections shall be designed to withstand the maximum pressure and temperature of the operating fluid.
4. A setting adjustment on the level set point of + / - 25 mm shall be used. The adjustment shall be made externally to the switch.
5. The accuracy & repeatability of the switch shall be within +/- 0.5 % of full-scale range. On – Off differential shall be adjustable.
6. Process connections of the cage shall be 25 NB male plain nipples connected through socket / welded isolation valves of adequate rating.
7. Level switch connections shall also include 15 NB test and drain connections to permit servicing, testing, calibration of the instrument.
8. The switching elements shall be snap-acting, shock-proof and vibration-proof. All switches shall have two electrically isolated SPDT contacts with provision of external adjustment of set points and dead bands. The contact ratings shall be 5 amps at 240 V AC 50 Hz or 0.25 amps at 220 V DC.
9. Switch enclosures shall be cast aluminium, weather-proof, NEMA -4X type with cable entry through compression type cable glands / ¾ "NPT conduit connections. Switches located in hazardous areas shall have dust-ignition-proof enclosure as per NEC article 500 provisions.

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13.16 Ultrasonic Level Transmitter

Table 13.14
Specification for Ultrasonic Transmitter

S.No.	Feature	Minimum Requirement
1	Application	Level measurement in silos, sump water level etc.
2	Medium	Coarse, hard solid materials like ash etc. Materials may be slowly falling through the detection range.
3	Type	Non contact Microprocessor based 2 wire type, HART protocol compatible Ultrasonic Transmitter
4	Principle	Time of flight
4	Sensor Material	Corrosion resistant material to suit individual application requirement.
5	False signal tolerance	Transmitter shall be capable of ignoring false echoes from internal tank / sumps obstructions such as pipes, heating coils or agitator blades. Also transmitters shall have adjustable damping circuitry.
7	Range	Capable of covering the complete level span of tank/vessel taking care of blocking distance, frequency, attenuation due to surface, obstructions, vapours etc.
8	Output	4 – 20 mA DC with 600 ohms load with HART compatibility.
9	Display	minimum 4 characters display with Integral keypad, access protected by user code.
10	Diagnostics	Loss of echo alarm etc.
11	Resolution	+/- 0.1 % of range or better
12	Accuracy	+/- 2 mm or 0.2% of span
13	Repeatability	3 mm or better
14	Operating temperature	0 to 60° C
15	Power supply	24 V DC + / - 10 %

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S.No.	Feature	Minimum Requirement
16	Mounting	Flanged connection at top of covers / side walls as per requirement.
17	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

1. The power and frequency of transmission for the transmitter shall be selected to assure a sufficient signal / noise ratio.
2. The transmitter shall be designed with an electronic circuit having the features such as temperature compensation, rejection of unnecessary echoes and noises and adjusting 'zero' and 'span'. It shall consist of sensors, electronic unit and accessories.

13.17

Guided Wave Radar Type Level Transmitter

Table 13.15
Specification for Guided Wave Radar Type Transmitter

S.No.	Feature	Minimum Requirement
1	Application	Level measurement of vessel under vacuum or low pressure application
3	Type	Guided wave radar
4	Principle	TDR (Time domain reflectometry)
5	Probe Material	SS 316
6	Accuracy	5 mm or better
7	Resolution	+/- 0.1 % of range or better
8	Signal Output	4 – 20 mA DC with 600 ohms load with HART compatibility
9	Power Supply	24 V DC + / - 10 %
10	Display	Integral

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S.No.	Feature	Minimum Requirement
11	Mounting	External cage type
12	Transmitter housing Protection Class	IP-65 with corrosion resistance coating
13	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

13.18 Flow Switch

Table 13.16
Specification for Flow Switch

S.No.	Feature	Minimum Requirement
1	Type	Vane actuated/Differential bellow type
2	Vane/bellow Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
7	Process connection	As per requirement
8	Over-range proof	150% of max. design pressure
9	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact, shock & vibration proof
10	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
11	Enclosure	Cast Aluminium/IP 65

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S.No.	Feature	Minimum Requirement
12	Cable connection	Compression type cable gland/ ½ " NPT Conduit connection
13	Electrical Connection	Plug-in socket
14	Accessories	All mounting accessories

13.19 Rotameter

Table 13.17
Specification for Rotameter

S.No.	Feature	Minimum Requirement
1	Type	Variable area Linear scale
2	Fluid media	Water/Oil
3	Float Material	SS 316
4	Accuracy	± 2 % of full scale or better
5	Working temperature	0 to 70°C
6	Process connection	As per requirement
7	Over-range proof	150% of max. design pressure
8	Enclosure	Transparent toughened glass/IP 65
9	Accessories	Flange, orifice in case of bypass Rotameter

Rotameter shall be used for low flow & low viscosity applications of liquid.

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13.20 Sight Glass Indicator (Flow Glass)

Table 13.18
Specification for Flow Glass

S.No.	Feature	Minimum Requirement
1	Application	Online observation of fluid flow in Pipeline
2	Type	Double window for pressurized pipe with rotary wheel for installation in horizontal or vertical pipeline. Full view for non-pressurized pipeline.
3	Size	Double window up to 12" and 600 lbs rating. Full view up to 6" and 150 lbs rating.
3	Body Material	SS 316
4	Glass	Pyrex tempered glass
	Others	Rotor & wetted parts shall be bronze All accessories shall be SS316
5	Protection class	IP-65
6	Connection	Screwed up to 50 NB size Flanged ANSI 150 RF – above 50 NB size
7	Accessories	Name plates, mating flanges with gasket, bolts & nuts etc.

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13.21 Flow Element
a) Orifice Plate

Table 13.19 A
Specification for Orifice Plate

S.No.	Feature	Minimum Requirement
1	Type	Concentric as per ASME PTC – 19.5 (Part III); ISA RP – 3.2, 960; BS – 1042; ISO 5167
2	Material	SS 316
3	Thickness	3 mm for main pipe diameter up to 300 mm and 6 mm for main pipe dia above 300 mm.
3	Beta ratio	0.34 to 0.7
4	Tapping's	Flanged weld neck 3 pairs of tappings.
5	Material of Branch Pipe	Same as main pipe
6	Root Valve type	Globe
7	Root Valve material	SS 316
8	Root Valve size	1"
9	Accessories	Root valves, flanges, vent / drain hole (as required)

- Each orifice plate shall be used with a handle on which the orifice diameter, pipe diameter and pressure tap distances are stamped. This information shall be so located that it can be read without removing the orifice plate from pipe line.
- The standard primary element shall be thin plate, square-edge concentric orifice plate mounted between a pair of weld-neck type orifice flanges with flange taps. The minimum pressure rating of flanges shall be 300 pounds ANSI. The material of the orifice plates shall be SS 316 in general. Orifice plates shall be not less than 3 mm thick for nominal pipe diameters up to and including 300 mm, and not less than 6 mm thick above 300 mm NB pipe.
- Quadrant edge or quarter circle orifice plates shall be used for highly viscous liquids and for pipe Reynolds Number below 10,000. Conical entrance type of orifice plates shall preferably be used for very highly viscous liquids up to Reynolds Number below 250. Vent and drain holes shall be used wherever necessary.

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4. Orifice diameter shall be selected, so that d/D ratio is between 0.20 to 0.70 for gas and steam and up to 0.75 for liquids.
5. Metering orifices shall not be installed in lines less than 1 ½" (40 mm) the lines shall be blown to the 1 ½" (40 mm) size for the meter run, keeping the d/D ratio within limits.
6. Restriction orifices and integral orifice transmitters do not require upstream or downstream straight pipe runs.
7. The orifice plate shall be supplied and fitted in conformity with ISO. When the pipe diameter is larger than the value specified in ISO, the restriction ratio shall be decided by extending the specific curve externally.
8. The length of straight pipe run required for metering accuracy shall be in conformity with ISO. When it is extremely difficult to comply with the standard, a minimum straight length of 10D (D = pipe inner diameter) on the upper stream and a minimum length of 5D on the downstream shall be considered.
9. All orifice plates shall be supplied with matching flanges of material and pressure rating not less than the rating of the associated pipe system.
10. For pipeline sizes of 500 mm and less, the orifice plates shall be an integral unit comprising of carrier ring assembly, tapping arrangement on both upstream as well down stream side. For line sizes more than 500 mm, the orifice plate shall be disc type. For disc type orifice plate, suitable corner tapping arrangement on both upstream as well as downstream side shall be used. All tapping arrangements shall be complete with a piece of impulse pipe line and a shut – off valve suitable for specified line pressure.
11. For steam applications, orifice plate shall be supplied with a pair of steam condensation chambers suitable for specified line pressure.
12. Data sheets, sizing calculation, fabrication & sheets for the elements shall be submitted for approval and finalization.

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b) Flow Nozzle

Table 13.19 B
Specification for Flow Nozzle

S.No.	Feature	Minimum Requirement
1	Type	Long Radius welded type ASME PTC 19.5 (Part III) or BS – 1042
2	Material	Same as Pipe material
3	Thickness	Suitable for intended application
3	Beta ratio	Around 0.7
4	Tapping's	D and D/2 (3 nos. tappings)
5	Material of Branch Pipe	Same as main pipe
6	Root Valve type	Globe
7	Root Valve material	SS 316
8	Root Valve size	1"
9	Accessories	Root Valves, Vent & Drain Hole

- The branch pipes for holding the flow nozzle shall also be furnished along with the flow nozzle.
- Flow nozzles in high pressure pipes shall be subject to a test according to DIN 50049, 3.1C, considering the technical guideline. The test of flow nozzles shall contain:
 - Check of drawings
 - X-ray testing of the circular bead or colour soaking or ultra-sonic testing
 - Test of sizes.
- Flow nozzle shall be used with a permanent mark indicating:
 - Measuring point number
 - Direction of flow
 - Plus and minus tapping
 - Material

Moreover, the actual inside pipe diameter "D" and the diameter of the flow nozzle shall be stated on the identification plate.

- The supplier shall provide the following documents:
 - Design drawings of the flow nozzle

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- b) Calculation documents
 - c) Fabrication, assembly and installation drawings
 - d) Test reports.
5. For measurements of steam, balancing vessels shall be used. Balancing vessels shall be used for flow measurement in steam system based on the differential pressure method to ensure a defined water column. The balance vessels shall be arranged on the same geodetic level. If this is not possible for design reasons, the level difference shall be taken into account during calibration
- c) **Venturi**

Table 13.20
Specification for Venturi

S.No.	Feature	Minimum Requirement
1	Design standard	BS 1042/ISO5167
2	Material	SS 316
3	Type	Fabricated Machine Cast
4	Mounting	Flanged
5	Root Valve type	Ball
6	Root Valve material	SS 316
7	Root Valve size	1/2"
8	Accessories	All required mounting accessories & piezometric ring with 4 nos. tapping's for choke removal & screwed cap/plug on the ring

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13.22 Control Valves

13.22.1 Introduction

The control valves and accessories equipment furnished by the Supplier shall be designed, constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Boiler & Pressure Vessel code, Indian Boiler Regulation (IBR) & ISA or acceptable equal standards.

13.22.2 Control Valve Design & Sizing

1. The design of all valve bodies shall meet the specification requirements and shall conform to the requirements of ANSI for dimensions, material thickness and material specification for their respective pressure classes.
2. The valve sizing shall be suitable for obtaining maximum flow conditions with valve opening at approximately 80% of total valve stem travel and minimum flow conditions with valve stem travel not less than 10% of total valve travel. All the valves shall be capable of handling at least 120% of the required maximum flow. Further, the valve stem travel range from minimum flow condition to maximum flow condition shall not be less than 50% of the total valve stem travel. The sizing shall be in accordance with the latest edition of ISA Handbook on control valves. While deciding the size of valves, Supplier shall ensure that valves outlet velocity does not exceed 8 m / sec. for liquid services, 150 m/sec. for steam services and 50% of sonic velocity for flashing services. Manufacturer shall furnish the sizing calculations clearly indicating the outlet velocity achieved with the valve size selected by him as well as noise calculations.
3. Control valves for steam and water applications shall be designed to prevent cavitations, wire drawing, flashing on the downstream side of valve and downstream piping. Thus for cavitations / flashing service, only valve with anti-cavitations trim shall be used. Detailed calculations to establish whether cavitations will occur or not for any given application shall be furnished.
4. Trim shall be multistage type having sufficient number of discrete pressure drop turns (stages) to ensure elimination of vibration, erosive – action, cavitations. Identify the number of pressure drop turns in the given equipment and shall also provide calculation demonstrating compliance to the trim exit velocity.
5. To prevent flow induced vibration and to protect the valve internals from foreign particles such as weld slag flow, direction shall be a flow to close (over the plug) configuration for liquid applications. To maximize noise attenuating benefits and to allow for constant fluid expansion, flow direction shall be under the plug for steam and gas applications.

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6. Control valves for application such as Feedwater Flow control shall have permissible leakage rate as per leakage class V. All other control valves such as low and high range feed control valves etc shall have leakage rate as per leakage class IV.
7. The control valve induced noise shall be limited to 85 dBA at 1 meter from the valve surface under actual operating conditions. The noise abatement shall be achieved by valve body and trim design and not by use of silencers.
8. The characteristic of the control valves shall be determined based on the application / service.
9. On supply air or electrical failure for pneumatic / electrical drive, the valve shall remain full closed, open or stay – put position as per process safety requirement.

13.22.3 Valve Construction

1. Proper selection of valve type and material of construction to meet operating requirement.
2. All valves shall be of globe body design and straightaway pattern with single or double port unless otherwise recommended by the manufacturer to be of angle body type. Rotary valve may alternatively be offered when pressure or pressure drops permit.
3. Valves with high lift cage guided plugs & quick charge trims shall be supplied.
4. Cast iron valves are not acceptable.
5. Bonnet joints for all control valves shall be of the flanged and bolted type for easy dis – assembly. Bonnet joints of internal threaded or union type will not be acceptable.
6. Plug shall be of one – piece construction either cast, forged or machined from solid bar stock. Plug shall be screwed and pinned to valve stems or shall be integral with the valve stems.
7. All valves connected to vacuum on down stream side shall be used with packing suitable for vacuum applications (e.g. double vee type chevron packing).
8. Valve characteristic shall match with the process characteristics.
9. Extension bonnets shall be used when the maximum temperature of flowing fluid is greater than 280 degree Celsius.
10. Flanged valves shall be rated at not less than ANSI pressure class of 300 lbs.
11. Teflon shall be used for valve gland packing to suit process requirement.
12. The valve body shall be marked to show direction of flow.

13.22.4 Valve Materials

1. The control valve body material shall be
 - a) Carbon steel as per ASTM – A216 GR WCB for non – corrosive, non – flashing and non – cavitations services below 275 deg c temperature like

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Auxiliary Steam flow to Deaerator, CRH flow to Deaerator, Condensate flow to Deaerator etc.

- b) Alloy steel as per ASTM – A217 GR WC 9 for severe flashing / cavitations services like low load and full load feed water control, HP and LP heaters emergency drains, Deaerator overflow drain to Hotwell etc.
 - c) Alloy steel as per ASTM A – 217 GR WC 6 for low flashing / cavitations services like HP heaters & LP heaters normal drain control, drain cooler normal level control, gland steam cooler minimum flow etc.
 - d) 316 SS for condensate service below 300 deg C like condensate normal and emergency make – up controls etc.
2. The control valve trim material shall be
- a) 17 – 4 PH SS for severe services listed under item D.1, 2nd point & 3rd point above
 - b) 316 SS for services listed at D.1, 4th point above and
 - c) 316 SS with stellite faced guide parts and bushings for remaining applications.

13.22.5 End Preparation

Valve body ends shall be either butt welded / socket welded, flanged or screwed. The welded ends wherever required shall be butt welded type as per ANSI B 16.25 for control valves of sizes 65 mm and above. For valves sizes 50 mm and below welded ends shall be socket welded as per ANSI B 16.11. Flanged ends wherever required shall be of ANSI pressure – temperature class equal to or greater than that of the control valve body.

13.22.6 Valve Actuator

1. The regulating control valves shall be furnished with pneumatic actuators. The supplier shall be responsible for proper selection and sizing of valve actuators in accordance with the pressure drop and maximum shut off pressure and leakage class requirements. The valve actuators shall be capable of operating at 60 °C continuously.
2. Valve actuators and stems shall be adequate to handle the unbalanced forces occurring under the specified flow conditions or the maximum differential pressure specified. An adequate allowance for stem force, at least 0.15 kg / cm² per linear millimeter of seating surface, shall be used in the selection of the actuator to ensure tight seating unless otherwise specified.
3. The travel time of the pneumatic actuators shall not exceed 10 seconds.
4. For quick opening / closing services (such as fuel oil shut – off valve), the actuator shall be pilot solenoid operated pneumatic drive; the rating of solenoid shall be 24 V DC.

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5. Selection of actuator shall be such that it meets the requirements of thrust / torque, stroke length, angular movement, full scale travel time, repeatability & accurate positioning for successful operation of final control element.
6. All the actuators shall have also provision for manual operation during emergency / maintenance along with graduated local position indicator.

13.22.7 Control Valve Accessory Devices

All control valve accessories such as air locks, hand wheels / hand-jacks, limit switches, SMART positioners, diffusers, external volume chambers, reversible pilot for positioners, tubing and air sets, solenoid valves and junction boxes etc. shall be used as per the requirements.

Table 13.21(i)
Specification for E-to-P converter

S.N	Feature	Minimum Requirement
1	Air Supply	1.5 Kg/Sq. cm
2	Input Signal	4-20 mA DC
3	Output Signal	0.2 to 1.0 Kg/ Sq. cm
4	Linearity	0.5 % of span or better
5	Hysteresis	0.1 % of span or better
6	Ambient Temperature Effect (-20 to +60 *C)	<0.2 % of span per Degree centigrade
7	Mounting	Close to Actuator
8	Protection class	IP-65
9	Enclosure	Die cast Aluminium
10	Drift	+/- 2% of set point per hour

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Table 13.21(ii)
Specification for Smart Positioners

S.No.	Feature	Minimum Requirement
1	Input	4-20 mA DC
2	Power Supply	24 V DC Loop powered
3	Type of Electronics	Microprocessor based with self diagnostic facility & digital communication by means of HART Protocol
4	Valve position sensing	Non-Contact type with 4-20 mA DC Output
5	Enclosure Type/Material	Weather & Dust proof to IP-65/ Die cast Aluminium
6	Ambient conditions	Suitable for - 30 to + 80 *C temperature & 0-95% Humidity
7	Operating Range	Suitable for Full range & Split Range operation
8	Modes of operation	Suitable for Direct & reverse valve action
9	Flow characteristics	Suitable for Linear & Equal percentage Characteristics
10	Fail safe/Freeze feature	Required
11	Air Capacity	Sufficient to handle the Valves Selected/Boosters to be supplied if required.
12	Air supply pressure	To suite the Air Supply Pressure / Quality available
13	Process Connection	1/4" NPT
14	Characteristic Deviation	< = 0.5% of span
15	Ambient Temperature effect	< = 0.01 %/Deg C or better
16	Configuration	Remote Calibration, Auto & Manual Calibration shall be possible
17	Cable Entry	½" NPT, Side or Bottom Entry to avoid

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S.No.	Feature	Minimum Requirement	
		water ingress	
18	Accessories	a)	Display with push buttons for configuration and Display on the positioner itself (Password Protected / Hardware Lock).
		b)	For Supply & Output Pressure, Filter Regulator and other accessories shall be used as on required basis for making system complete
		c)	Valves Mounting Assembly For Sliding Stem / Rotary / Single Acting / Double Acting on required basis

1. SMART positioner shall be a Double stage positioner. The first stage of the positioner shall be typically a flapper-nozzle that serves as a high-gain pre-amplifier. This sensitivity shall be maintained over a wide range of dynamic conditions. Second stage shall be a power amplifier that provides power to drive the actuator. Preferably this shall be a pneumatic relay. Spool Driven type SMART positioners are not preferred due to Higher Dead Band and Poor responsiveness. The SMART positioner shall have pressure sensors to measure the pneumatic outputs to the actuator.
2. The control algorithm for the positioner shall use feedback signal from the motion of the pneumatic relay beam instead of pressure feedback to minimize pneumatic related effects and for stable and smooth response of the control valve. The SMART positioner shall have user adjustable tuning sets to identify the optimum tuning for the total valve assembly. SMART Positioner with HART Communication facility shall communicate all the valve diagnostics to Plant DCS.

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Table 13.21(iii)
Specification for Air Filter Regulator (AFR)

S.No.	Feature	Minimum Requirement
1	Type	Constant Bleed type
2	Inlet Pressure	10 Kg/Sq. cm (maximum)
3	Output	Adjustable from 0-2 Kg/Sq. cm or 0-7 Kg/Sq. cm (Continuous) as required
4	Filter Element	5 microns
5	Filter Element Material	Phosphor Bronze
6	Bowl Material	Metallic
7	Drain	Automatic
8	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
9	Process connection	¼ " NPT
10	Accessories	All mounting accessories. 2" dial size Pressure gauge.

Table 13.21(iv)
Specification for Position Transmitter

S.No.	Feature	Minimum Requirement
1	Power Supply	24 V DC Loop powered
2	Type	Non-Contact/ LVDT type
3	Output	4-20 mA DC/ Linear
4	Accuracy	+/- 1%
5	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
6	Cable Entry	½ " NPT, Side or Bottom Entry to avoid water ingress.

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S.No.	Feature	Minimum Requirement
7	Accessories	All mounting accessories

Table 13.21(v)

Specification for Limit Switch (Non Contact Type)

S.No.	Feature	Minimum Requirement
1	Type	Non-contact type inductive Proximity/Namur type
2	Sensing distance	10 mm minimum
3	Hysteresis	Maximum 10% of sensing distance
4	Indicator	LED indication
5	Protection class	IP 67
6	Integral Cable	1 mtr.
7	Power supply	24 V DC/ 8 V DC
8	Mounting	Flush mounting with check nut
9	Other Feature	Explosion proof enclosures shall be used wherever required by the application. Shock & Vibration proof.

13.22.8 Test & Examination

- All valves shall be tested in accordance with the quality assurance programme agreed which shall meet the requirement of IBR and other applicable codes.
- The tests shall include but not but limited to the following:
 - Non-destructive test as per ANSI B – 16.34.
 - Hydrostatic shell test in accordance with ANSI B16.34 prior to seal leakage test.
 - Valve closure test and seal leakage test in accordance with ANSI B16.34 and as per the leakage class indicated under clause no. B.6.
 - Functional test: The fully assembled valves including actuators control devices and accessories shall be functionally tested to demonstrate times from open to close position.

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- e) All control valves shall be tested with the positioners for accuracy of positioning and reproducibility over the full range of travel.
 - f) CV Test: CV test shall be carried out as type test on each size, type and design of the valves as per AISA 75.02 standard.
 - g) Magnetic particle inspection shall be performed on all machined surfaces of valves having ASA rating of 1500 lbs ASA or greater. All carbon steel valves with 1500 lbs ASA or greater shall receive 100% radio graphic examination in accordance with ASTM – E71.
3. The certificate shall be in the prescribed forms III A & III C and shall be endorsed by an Inspection Authority recognized by the Indian Boiler Regulations.

13.22.9 Pneumatic Power Cylinder

Table 13.22
Specification for Pneumatic Power Cylinder

S.No.	Feature		Minimum Requirement
1	Applicable standard		ISO 6431
2	Mounting Type		Fixed Position mounting/ Trunion mounting
3	Material	Cylinder	Seamless Steel Tube
		Piston rod	Hard Chrome Plated Steel
		Tie rod	Stainless steel
		End Cover	Cast Iron
		Sealing	Polyurathane
4	Control Signal		4-20 mA DC signal to Smart positioner with HART protocol for modulating purpose. Solenoid valve operating on pneumatic line for open & closing purpose of ON-OFF Damper.
5	Supply Air		0-7 Kg/cm ²
6	Accuracy		Better than +/- 1%
7	Repeatability		Better than 0.5 % of full travel
8	Hysteresis		Less than +/- 0.2% of full travel
9	Dead Band		+/- 0.1%

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S.No.	Feature	Minimum Requirement
10	Selection	Based upon thrust/torque, stroke length, angular movement, full scale travel time, repeatability, space factor etc. Provision for air-to-open or air-to-close operation
11	Accessories	Air lock relay, hand wheel, AFR, Volume booster, Limit switch, Positioner, Solenoid valve, position transmitter & all required mounting accessories etc.
12	Fail safe operation	Stay put for regulating duty

13.23

Solenoid Valves

Table 13.23
Specification for Solenoid Valves

S.No.	Feature	Minimum Requirement
1	Operating Principle	Electromagnetic (noiseless), Pilot operated
2	Coil Voltage Rating	24 V DC (in general)/220 V DC/230 V AC/ 110 V AC as required
3	Ways	3 ways in general others as required
4	Port size	¼ " NPT all ports
5	Body	SS Bar stock/Brass
6	Trim	AISI 316 SS
7	Manual Operation	In built
8	Duty	Suitable for continuous Energisation
9	Sealing	Airtight & leak proof
10	Coil Enclosure	SS 316/Moulded type
11	Insulation class	Class H
12	Coil Casing	IP-67
13	Mounting	Suitable for mounting On pipe or in panel

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S.No.	Feature	Minimum Requirement
14	Cable connection	½ " NPT Cable gland
15	Accessories	Mounting Bracket, nuts, bolts etc.
16	Other Features	LED Indication

13.24 Dew Point Meter

Table 13.24
Specification for Dew Point Meter

S.No.	Feature	Minimum Requirement
1	Type	Sensor- Hyper Thin Film high capacitance Al2O3, Transmitter- Microprocessor based 2-wire loop powered
2	Accuracy	± 5.5°F (± 3°C)
3	Repeatability	± 0.9°F (± 0.5°C)
4	Storage temperature	-40°F to + 176°F (-40°C to + 80°C)
5	Local Indication	To be provided
6	Input Resolution	0.1°C dew point
7	Power Supply	24 VDC
8	Output	4 - 20mA
9	Enclosure material	Die – cast Aluminium
10	Enclosure protection	Weatherproof IP 65
11	Electrical connections	½ " NPT
12	Process connection	As per requirement
13	Accessories	All required mounting accessories.

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13.25 Speed Probe

Table 13.25
Specification for Speed Probe

S.N	Feature	Minimum Requirement
1	Type	Proximity type (inductive / NAMUR)
2	Frequency Response	0-10 KHz
3	Housing	SS 316/ Polyurethane tip
4	Sensing distance	10 mm minimum (2mm for embedded type)
5	Enclosure class	IP67
6	Power supply	24 V DC/8 V DC (for NAMUR)
7	Cable	Integral Cable 6 mtr.
8	Mounting	Flush with check nut
9	Accessories	Flexible conduit, Non-conductive mounting plates etc.

13.26 Speed Transmitter

Table 13.26
Specification for Speed Transmitter

S.No.	Feature	Minimum Requirement
1	Type	Microprocessor based Programmable
2	Enclosure Protection	IP-67
3	Accuracy	+/- 1 RPM
4	Power Supply	24 V DC
5	Range	Programmable
6	Resolution	0.1 RPM
7	Output	4-20 mA
8	Input signal	Pulse Input from Proximity Probe

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S.No.	Feature	Minimum Requirement
9	Display	LCD display

13.27 Flow/No Flow Detector Switch

Table 13.27
Specification for Flow/No Flow detector switch

S.No.	Feature	Minimum Requirement
1	Operating Principle	Microwave
2	Detection Range	Adjustable
3	Power Supply	230 V AC, 50 Hz
4	Housing	SS 316
5	Protection Class	IP 67
6	Output	Potential free contact output
7	Contact Rating	5A, 240 V AC; 0.5A, 220 VDC
8	Time delay for contact Changeover	Adjustable
9	Accessories	All required mounting accessories

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14. PROCESS CONNECTION PIPING

Installation and testing of all required material for completeness of impulse piping system, sample piping system and air piping system as per the requirements of this clause on as required basis for the connection of instruments and control equipment to the process and make the system complete.

Control and instrument piping & connections shall generally be designed in accordance with the following criteria and these criteria shall be closely co-ordinated with Mechanical Piping / Erector to fulfill the Mechanical Design Criteria also. This is a guideline for Piping design & selection.

1. Pressure connections and piping up to the root valves for all pressure indicators, pressure switches, pressure transmitters, etc., shall be as indicated for miscellaneous piping.
2. Temperature indicators, temperature controllers, temperature switches, temperature detectors, and test well connections shall be as follows:
 - a) Main steam -- 40 mm NPT.
 - b) Extraction steam -- 40 mm NPT.
 - c) Boiler feed water -- 32 mm NPT.
 - d) Reheat steam -- 40 mm NPT.
 - e) All others -- 19 mm NPT.
3. Draft pressure connections on steam generator walls and ducts shall be 50 mm pipe couplings.
4. Flow transmitter connections and piping up to the root valves shall be 25 mm for all piping except orifice flanges, where 15 mm piping and valves shall be used.
5. Level switch connections and piping up to root valves shall be 25mm.
6. Level controllers and level transmitters of the displacement type shall have connections and piping up to root valves of 50 mm.
7. Level controllers and level transmitters of the differential pressure type shall have connections and piping up to root valves of 25 mm.
8. Instrument columns at tanks and pressure vessels shall generally be 65 mm minimum.

14.1 Design Pressure and Temperature

Instrument primary piping design pressure and temperature shall be selected consistent with the requirements discussed in Mechanical Design Criteria of this specification, for the process pipe to which the instrument primary piping is connected. The following general criteria shall also apply:

Instrument primary piping for steam and other systems shall be designed for 1-½ times the maximum sustained process pressure and temperature (plus 20°C).

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14.2 Sizes of Instrument Primary Piping

Instrument primary piping shall not be smaller than the connection at the process pipe root valve and/or the following (metric sizes are nominal):-

1. 20 mm for pressure measurement piping with a design pressure equal to or less than 42.0 bar and a design temperature equal to or less than 400°C.
2. 25 mm for pressure measurement piping with a design pressure greater than 42.0 bars or a design temperature greater than 400°C.
3. Flow and level measurement by differential pressure shall also use primary piping conforming to the above requirements; however, flange tap connections may be of 13 mm size.
4. Float actuated level switch devices shall be supported on connecting piping not smaller than 25 mm.
5. Level controllers and transmitters of the displacement float type shall be supported on connecting piping not smaller than 50 mm.
6. Instrument columns for float actuated level switches and displacement float devices shall be piping of not less than 65 mm.
7. Primary piping internal diameter shall not be less than 8 mm between the process connection and instrument blow down valve.

14.3 Materials for Instrument Primary Piping

Material for instrument primary piping connecting to the root valve shall preferably be the same as that used in the process system to which it is connected. Higher strength materials may be substituted in the interest of standardization; however, welding procedures at the point of joining the instrument primary piping to the process piping must be appropriate to the combination of materials involved. Copper may be used only for compressed air services that use copper process piping.

14.4 Insulation of Instrument Primary Piping

Instrument primary piping connecting to high temperature systems, which might become hot enough to injure personnel during blow down of the instrument line, shall be insulated where such hazard exists. Insulation materials, exterior finish, and metal lagging shall conform to the standards adopted for the process piping.

All materials supplied shall be suitable for intended service, process operating conditions and type of instruments used and shall fully conform to the requirements of this specification.

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14.5 Process Connection Size

Size of tapping point, stub no and size of Root valves for different type of measurements. These shall be as follows:

Table 14.1
Process Connection Stub & Root valve

S.No.	Quantity of root valves (Nos.)	Size of stub and root valves	Service condition
A. Pressure and Differential pressure measurement			
1	2	25NB	> = 62 bar or 425degree C
2	1	15NB	< 62 bar and 425 degree C
B. Level Gauge and Switch			
1	2	25 NB	> = 62 bar or 425 degree C
2	1	25NB	< 62 bar and 425 degree C
C. Level Transmitter (Displacement Type)			
1	2	40NB	> = 62 bar or 425degree C
2	1	40NB	< 62 bar and 425 degree C
D. Stand pipe for Level measuring instrument			
1	2	80 NB	> = 62 bar or 425degree C
2	1	80 NB	< 62 bar and 425 degree C
E. Flow measurement			
1	2	25NB	> = 62 bar or 425degree C
F. Level measurement			
1	1	25NB	< 62 bar and 425 degree C
G. Sampling system measurement (system and water service)			
1	2	25 NB	> = 62 bar or 425 degree C
2	1	25 NB	< 62 bar and 425 degree C

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14.6 Impulse Piping, Tubing, Fitting, Valves & Valve Manifolds

All impulse pipes shall be of seamless type conforming to ANSI B36.10 for schedule numbers, sizes and dimensions etc. The material of the impulse pipe shall be same as that of main process pipe. For various applications specification of impulse pipe materials and associated fittings and valves shall be as given in Table –15.2 (Process Connection Piping).

Table 14.2
Process Connection piping

S.No.	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
1	Main steam/ Saturated steam	SCH.XX S 21.34m m OD	1.7 mm ODX 1.65HK	SS 316	ASTM-A-335-Gr-P-22 (alloy steel)	ASTM-A-182-Gr-F-22	ASTM-A-182-Gr-F-22
						9000 LBS	2500 SPL. Class
2	Hot reheat /extraction to HPH	SCH.80 21.34m m OD	12.7 mm ODX 1.65mm THK	SS 316	ASTM-A-335-Gr-P-22 (alloy steel)	ASTM-A-182-Gr-F-22	ASTM-A-182-Gr-F-22
						9000 LBS	2500 SPL. Class
3	Cold reheat / extraction / heater drains / condensat	SCH.80 21.34m m OD	12.7 mm ODX 1.65mm THK	SS 316	ASTM-A-106-Gr-B (carbon steel)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II

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S.No.	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
	e system; aux. steam					3000LBS	400LBS
4	Water system	SCH.80 21.34m m OD	12.7 mm ODX 1.65mm THK	SS316	ASTM-A-106-Gr-B (carbon steel)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
						3000LBS	400LBS
5.	Instrument air system	SCH.40 21.34m m OD(pipe through out)	12.7 mm ODX 1.65mm THK	SS316	IS 1239 Heavy Class	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
					(Galvanized)	3000LBS	150LBS
6.	Service air system	SCH.40 21.34m m OD	12.7 mm ODX 1.65mm THK	SS 316	IS 1239 Heavy Class	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
					(Black)	3000LBS	150LBS
7.	Vacuum	SCH.40 21.34m m OD	7 mm ODX1.65mm THK	SS 316	ASTM-A-106-Gr-B (carbon steel)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
						3000LBS	150LBS
8.	Make up water system	SCH.40 21.34m m OD	12.7 mm ODX1.65	SS 316	ASTM-A-312-TP-316	ASTM-A-182-Gr-IF6a	ASTM-A-182-Gr-IF6a

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S.No.	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
			mm THK		(SS)	3000LBS	150LBS

Notes:-

1. Impulse pipe thickness shall be selected as per ANSI B 36.10. based on the schedule indicated against each service.
2. Wherever impulse tubes are provided, all the fittings required for these shall be SS316.

The following guidelines shall also be considered along with the Table 9.2 for size, material and rating for impulse line/tube fittings and accessories:

a) Impulse line / tube fittings and accessories

1. Nipple shall be used for root valve size more then ½ inch and the nipple size shall be same as the root valve size. Reducer / adapter shall be used to suit instrument connection, where nipple, root valve size is more then ½ inch.
2. Bulk head fitting socket welded type to be provided at instrument rack / enclosure.

b) Fittings

1. All fittings except the last fitting connecting to the instrument shall be socket welded. The size of the fittings shall be same as the impulse line size.
2. The fitting connecting to the instrument shall have a size and thread to suit the instrument connection.

c) Drain

Drain shall be used for all water / steam and non-inflammable / non-corrosive fluids only.

d) Drain Valve

1. Two numbers of globe drain valves shall be used for process conditions of 425 degree C or 62 bar and higher.
2. One number globe drain valve shall be used for process conditions of less than 425 degree C and 62 bar.
3. The valve size shall be same as impulse piping / tubing size.

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e) Funnel with drain header

1. This shall be used in the racks for blowing / draining out the process fluid in the impulse tubings.
2. The size of drain header shall be 1"
3. When instruments are mounted local to the tapping point and are not mounted in rack, or panel or enclosure. The drains shall be connected to the nearest floor level or plant drain.

f) Instrument Valves

1. Type of the valve shall be needle valve with built in drain valve.
2. Sizing of the valve shall be ½".

g) Right / left threaded fittings

1. This shall be used for installation / removal of instruments without disturbing the tubing / piping.
2. A suitable adapter shall be used to install the instruments on ½" right-left threaded fittings.

h) A ½" vent line with a ½" isolation valve shall be used in the instrument rack for air and compressible fluids or other wise if the installation call for eg., for liquid service where the transmitter is located at a higher elevation than the tapping point.

Stainless steel tube shall be used inside enclosures and racks from tee connection to valve manifold and then to instrument. For high pressure/temperature applications the material shall be ASTM A 213 TP 316H and for other applications material shall be ASTM A 213 TP 316L. The wall thickness of the tube shall be in accordance with the ANSI B31.1 standard.

All fittings shall be forged steel and shall conform to ANSI B16.11. The material of forged tube fittings for shaped application (e.g. tee, elbow etc.) shall be ASTM A182 Gr. 316 H for high pressure/ temperature applications (as defined above) and ASTM A182 Gr. 316L for other applications. The material for bar stock tube fitting (for straight application) shall be 316 SS. Metal thickness in the fittings shall be adequate to provide actual bursting strength equal to or greater than those of the impulse pipe or SS tube, with which they are to be used.

The disc and seat ring materials of carbon steel and alloy steel valves shall be ASTM A-105 and ASTM A-182, Gr. F22, hard faced with stellite (minimum hardness - 350 BHN.) The surface finish of 16 RMS or greater is required in the area of stem packing. The valve design shall be such that the seats can be re-conditioned and stem and disc may be replaced without removing the valve body from the line.

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The valve manifolds shall be of 316 s Furnishing Recommended protection interlock logics stainless steel with pressure rating suitable for intended application. 2-valve manifold and 3 valve manifold shall be used for pressure measurements using pressure transmitters/ pressure switches and differential pressure transmitters/ switches respectively. 5-valve manifold shall be used for remaining applications like DP, flow and level measurements.

For Pressure/D.P gauges in fluid application two-way globe valve on each impulse line to the instrument and in air/flue gas application two way gate valve on each impulse line to the instrument shall be used near the instrument. These shall be in addition to the three way gauge cock provided along with the pressure/D.P gauges.

Table 14.3**Specification for Seamless SS Pipe**

S.No.	Property	Requirement
1	Reference	ASTM A-312 TP-316
2	Material Grade	TP-316
3	Type	Seamless/Plain end
4	Size	½ " NB
5	Schedule	40/60/80
6	Standard Length	5 metre

Table 14.4**Specification for Seamless SS Pipe Fittings**

S.No.	Property	Requirement
1	Reference	ASTM A-182 F-316
2	End Connection	Socket welded
3	Type	Forged conforming to ANSI B16.11
4	Size	½ " NB
5	Rating	3000/6000/9000 lbs
6	Type of Fittings	Reducing coupling, Male-Female reducer, Straight coupling, Equal Tee, Three Piece Union, Elbow, Cap etc.

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Table 14.5A

Specification for Seamless SS Tube (1/2")

S.No.	Property	Requirement
1	Reference	ASTM A-213 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	½" OD X 2.1 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness
8	Test	Flare, Hardness, Ball & Bubble test
9	Standard Length	5 metre

Table 14.5B

Specification for Seamless SS Tube (1/4")

S.No.	Property	Requirement
1	Reference	ASTM A-269 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	1/4" OD X 1.2 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness
8	Test	Flare, Hardness, Ball & Bubble test

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S.No.	Property	Requirement
9	Standard Length	5 metre

Table 14.6

Specification for Seamless SS Tube Fittings

S.No.	Property	Requirement
1	Reference	ASTM A-182
2	Material Grade	SS 316 forged
3	Type	Double ferrule double compression
4	Ferrule	SS 316
5	Size	To suit SS tubing & NPT end connection
6	Type of fittings	Male/Female connectors, elbow, Equal & Unequal Tee, Cross, Straight connector, bulk head unions, etc. as required to suit the installation.

Table 14.7

Specification for Instrument Valve Manifolds

S.No.	Property	Requirement
1	Type	Two valve manifold/Three Valve Manifold Five valve manifold
2	Mounting	Remote 2" pipe mounting
3	Construction	Single Block (Bar Stock)
4	Material	Forged body & bonnet AISI 316 SS
5	Ports	½" NPT
6	Rating	420 Kg/ cm2 at ambient
7	Packing	PTFE Wafer
8	Seat & Stem	AISI 316 SS
9	Plug	AISI 316 SS free to turn on stem/ 17-4 PH
10	Handle	AISI 316 SS
11	Connection	Straight
12	Accessories	Plug for all ports Mounting Bracket, nut, bolts etc.

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Table 14.8
Specification for Condensate Pot

S.No.	Property	Requirement
1	Reference	ASTM A 182 F22/ ASTM A105
2	Material	Alloy Steel/Carbon Steel as per application
3	Construction	Drilled Bar stock
4	End Connection	3 nos. ½" SW
5	Accessories	Vent Valve

14.7 Air Supply Piping

1. All pneumatic piping, fittings, valves, air filter cum regulator and other accessories required for instrument air for the various pneumatic devices/ instruments shall be used.
2. This shall include as a minimum air supply to pneumatically operated control valves, actuators, instruments, continuous and intermittent purging requirements of Local Instrument Enclosures (LIE) etc.
3. For individual supply line and control signal line to control valve, 1/4 inch size light drawn tempered copper tubing conforming to ASTM B75 shall be used. The thickness of copper tubing shall not be less than 0.065 inch and shall be PVC coated. The fittings to be used with copper tubes shall be of cast brass, screwed type.
4. All other air supply lines of 1/2 inch to 2 inch shall be of carbon steel hot dipped galvanized inside and outside as per IS-1239, heavy duty with threaded ends. The threads shall be as per ASA B.2.1. Fittings material shall be of forged carbon steel A234 Gr. WPB galvanized inside and outside, screwed as per ASA B2.1. Dimensions of fittings shall be as per ASA B16.11 of rating 3000 lbs.
5. Instrument air filter cum regulator set with mounting accessories shall be used for each pneumatic device requiring air supply. The filter regulators shall be suitable for 10 kg/ sq.cm max. inlet pressure. The filter shall be of size 5 microns and of material sintered bronze. The air set shall have 2 inch size pressure gauge and built in filter housing blow down valve. The end connection shall be as per the requirement.
6. All the isolation valves in the air supply line shall be gate valves as per ASTM B62 inside screw rising stem, screwed female ends as per ASA B2.1. Valve bonnet shall be union type & trim material shall be stainless steel, body rating 150 pounds ASA. The valve sizes shall be 1/2 inch to 2 inch.
7. Purge Air Connection for Air and Flue Gas Applications
 - a) The continuous purging with instrument air shall be done, for all air and flue gas measurements excepting instrument air and service air instruments, at the process source connection end. Necessary arrangements required for

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continuous purging shall be used inside all the air and flue gas local instrument enclosures.

- b) For intermittent purging with service air, necessary arrangements inside all the air and flue gas Local Instrument enclosures/racks shall be used. The SS three way valve provided in the SS tubing shall be used for isolating the transmitter and connecting the service air quick disconnect line.
- c) One air filter regulator, purge Rotameter and blow down device per instrument shall be used in the transmitter rack/enclosure.

Table 14.9

Specification for Instrument Air Header

S.No.	Property	Requirement	
		For Panel	For Field
1	Material	SS 316	SS 316
2	Inter Connection	2" NPT (M)	1" NPT (M)
3	Header Take-Off	SS 316	SS 316
4	Take-Off Connection	½" NPT (M)	½" NPT (M)
5	Take-Off Valve	½" Ball Valve SS 316	½" Ball Valve SS 316
6	Drain	½" Ball Valve SS 316 at the lowest point	½" Ball Valve SS 316 at the lowest point

Table 14.10

Specification for CS Pipe

S.No.	Property	Requirement
1	Reference	ASTM A-106 Gr. C
2	Material	Cold Drawn Seamless CS
3	Type	Seamless/ threaded ends as per ASA B2.1/ Hot dip Galvanised from Inside & outside as per IS-1239
4	Size	½" to 2" NB
5	Schedule	80/160
6	Standard Length	5 metre

Table 14.11

Specification for CS Pipe Fittings

S.No.	Property	Requirement
1	Reference	ASTM A-234/ ASA B16.11
2	Type	Forged/ hot dip galvanised from inside & outside
3	Size	½" to 2" (as required)

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S.No.	Property	Requirement
4	Rating	3000/6000/9000 lbs.
5	End Connection	Threaded as per ASA B2.1
6	Type of Fittings	Reducing Coupling, Male-Female reducer/ Straight Coupling/ Equal Tee/ Three piece Union/ Elbow/ Cap etc.

Table 14.12
Specification for CS Globe Valve

S.No.	Property	Requirement
1	Reference	ASTM A-105/ASTM B62
2	Type	Globe
3	Construction	Forged body cadmium plated
4	Rating	PN 40/PN 160/ PN 320/ PN 400
5	End Connection	Screwed Female ends as per ASA B2.1
6	Material	Body- Carbon steel Stem- Hardened Steel Plug- AISI 316 SS Seat- SS Stellite
7	Size	½ " to 2 " as required
8	Packing	Teflon/Grafoil as required
9	Hand wheel	CS
10	Yoke	ASTM A105
11	Design Standard	As per ANSI B16.34

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15. INSTRUMENTATION CABLES & ACCESSORIES

15.1 Specifications of Instrumentation Cables

15.1.1 Common Requirements

Table 15.1
Specification of Instrumentation Cables- Common Requirement

S.No.	Property	Requirement
1	Voltage grade	1100 V (Peak Value)
2	Codes and Standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6 , VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification
3	Continuous operation suitability	At 70 deg. C for all types of cables, while 205 deg C for Type-C cables
4	Progressive automatic on-line sequential marking of length in meters.	To be provided at every one meter on outer sheath.
5	Marking to read 'FRLS'	To be provided at every 5 meters on outer sheath except for type-C cable.
6	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet.
7	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8	Ovality at any cross-section	Not more than 1.0 mm
9	Others	a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name , insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacture to be provided. b) Cables shall be suitable for laying in conduits, duct, trenches, racks and underground-buried installation c) Repaired cables shall not be acceptable

15.1.2 Specific Requirements

Table 15.2
Specification of Instrumentation Cables- Specific Requirement

S.No.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
A.	Conductors				
i.	Cross section area				

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S.No.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
ii.	Conductor material	ANSI type KX	ANSI type SX	High conductivity annealed tin coated copper	ANSI type KX
iii.	Colour code	Yellow-red	Black-Red	As per VDE-0815	Yellow-red
iv.	Conductor Grade	As per ANSI MC 96.1		Electrolytic	As per ANSI MC 96.1
v.	No. & dia. of stands	7x0.3 Sq. mm (nom)			
vi.	No. of Pairs	2, 6	2	4, 8, 12, 16, 24, 48,	2
vii.	Max. conductor resistance per Km (in ohm) at 20 deg. C	As per ANSI MC 96.1		73.4 (loop)	As per ANSI MC 96.1
viii.	Reference Standard	As per ANSI MC 96.1		VDE 0815	As per ANSI MC 96.1
B.	Insulation				
i.	Material	PVC type YI 3 with FRLS properties			Teflon (i.e. extruded FEP)
ii.	Thickness in mm (Min/Nom/Max)	0.25 / 0.3 / 0.35			0.4 / 0.50
iii.	Volume Receptivity (Min) in ohm-cm	1x10 ¹⁴ at 20 deg. C & 1x 10 ¹¹ at 70 deg.			---
iv.	Voltage rating	1100 V peak operating voltage			
v.	Reference Standard	VDE 0207 Part 4			VDE 0207 part 6 & ASTM D 2116.
vi.	Core diameter above insulation	Suitable for cage clamp connector			
C.	Pairing & Twisting				
i.	Max. lay of pairs (mm)	50			
ii.	Single layer of numbered binder tape on each pair provided	Yes			
iii.	Unit formation of four pairs with	NA		Yes	NA

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S.No.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
	printing of no. of Unit provided				
iv.	Conductor / pair identification as per VDE0815	NA		To be provided	NA
D.	Shielding				
i.	Type of shielding	Al-Mylar tape			
ii.	Individual pair shielding	No		To be provided for Type-F cable	No
iii.	Minimum thickness of individual pair shielding	No		28 micron	No
iv.	Overall cable assembly shielding	To be provided			
v.	Minimum thickness of overall cable assembly shielding	55 micron			
vi.	Shielding coverage	100% with at least 20% overlap			
vii.	Drain wire provided for individual shield	NA		Yes (for F-type) 7 -strand 20 AWG (0.51 mm ²) annealed Tin coated copper	NA
viii.	Drain wire provided for overall shield	Yes (for F-type) 7 -strand 20 AWG (0.51 mm ²) annealed Tin coated copper			
E.	Fillers				
i.	Non-hygroscopic, flame retardant	To be provided			
F.	Outer Sheath				
i.	Material	Extruded PVC compound YM1 with FRLS properties			Teflon (i.e. extruded FRP)
ii.	Minimum thickness at any point	1.8mm			0.4 mm
iii.	Nominal Thickness at any point	> 1.8mm			0.5mm
iv.	Color	Blue			
v.	Resistant to water,	Required			

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S.No.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
	fungus, termite & rodent attack				
vi.	Oxygen index as per ASTM D-2863	Not less than 29%			NA
vii.	Temperature index as per ASTM D-2863	Not less than 250 deg. C			NA
viii.	Acid gas generation by weight as per IEC-60754-1	Maximum 20 %			NA
ix.	Smoke Density rating as per ASTM D-2843	Maximum 60% (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as ASTM D-2843)			NA
x.	Reference Standard	VDE 207 part 5			VDE 207 Part 6 & ASTM D 2116
xi	Armour	Galvanised steel wire armoured type conforming to IS-3975			
G.	Electrical Parameters				
i.	Mutual capacitance between Conductors. At 0.8KHz (Max.)	200 nF / Km		120 nF / Km for F type 1000 nF / Km for G-type	200 nF / Km
ii.	Insulation resistance (Min.)	100 M ohm / Km			
iii.	Cross talk Figure (min.) at 0.8 KHz	60 dB		60 dB	NA
iv.	Characteristics impedance (Max) At 1 KHz	NA		320 ohm for F type 340 ohm for G type	NA
v.	Attenuation Figure at 1 KHz	NA		1.2 dB / Km	NA
H.	Complete Cable				
i.	Complete Cable assembly	Shall pass Swedish chimney test as per SEN-SS 4241475 class F3.			NA
ii.	Flammability	Shall pass flammability test as per IEEE-383 read in conjunction to this			NA

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S.No.	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
		specification			
I.	Accessories				
i.	Cable accessories of flame retardant quality	Yes. (Accessories such as harnessing components, markers, bedding, cable jointer, binding tape etc.)			
J.	Cable Drum				
i.	Type	Non-returnable wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.			
ii.	Outermost layer covered with waterproof paper	Yes			
iii.	Painting	Entire surface to be painted			
iv.	Length	1000m + 5% for up to & including 12 pairs 500m + 5% for above 12 pairs			

15.1.3

Type Test

Table 15.3
Type Test Requirement for Cables

S.No.	Item	Test Requirement	Standard
1	Conductor (to be discuss)	Resistance Test Diameter test Tin coating test (drain wire)	VDE – 0815 IS – 10801
2	Insulation	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
3	Inner sheath	Loss of mass Heat shock Hot deformation Shrinkage Cold bend / Cold impact test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
4	Outer sheath	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472

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S.No.	Item	Test Requirement	Standard
		Hot deformation Shrinkage Bleeding & Blooming Colour fastness to water Cold bend / Cold impact test Oxygen Index test Smoke Density test Acid gas generation test	VDE – 0472 VDE – 0472 IS – 5831 IS – 5831 IS – 5831 ASTM D – 2863 ASTM D – 2843 IEC – 754 – I
5	Filters	Oxygen Index test Smoke Density test Acid gas generation test	ASTM D – 2863 ASTM D – 2843 IEC – 754 – 1
6	AL-MYLAR Shield	Continuity test Shield thickness Overlap test	Yes Yes Yes
7	Overall cable	Flammability Noise interference Dimensional checks Cross talk Mutual capacitance HV test Drain wire continuity	IEEE 383 & IEC – 332 IEEE -TRANSACTION IS – 10810 VDE – 0472 VDE – 0472 VDE – 0815

15.1.1 Routine Test

To be carried out by supplier during various stages of manufacture.

1. Insulation & jackets: All tests as per IS – 5831 except insulation resistance, voltage & spark test shall be as per BS – 5308, Part II
2. Armor test as per IS – 3975
3. Conductor resistance
4. Cable capacitance and L/R ratio.

15.1.2 Acceptance Test

These following tests shall be carried out as acceptance test:

1. Continuity test
2. Voltage test as per BS – 5308 Part II
3. Conductor resistance and drain wire resistance
4. Cable capacitance and L/R ratio test.
5. Tests for uniformity of galvanization of armor as per IS – 2633
6. Oxygen and temperature index test as per ASTM D – 2863
7. Dimensional checks for overall diameter and under armour / over armour diameter.

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8. Checking of drum length & overall length tolerances.

Immediately after completion of electrical tests, the ends of the cable shall be sealed to prevent ingress of moisture with suitable PVC / Rubber caps

15.2 Specifications of Optical Fibre Cables (OFC)

1. OFC shall be installed on cable tray, duct bank, cable trench installation as necessary. For outdoor applications the cable shall be armoured with Poly Ethylene sheathing. In all cases cable shall be routed through suitable grade HDPE permanently lubricated protection pipe as per IS-4984, IS-12235 & TEC.G/CDS-08/01 of suitable size @ 53% fill factor.
2. The optical fibre core shall be of ultrapure fused silica glass coated with UV cured acrylate suitable to withstand temperature of about 80 deg. Centigrade continuously.
3. OFC shall be 4 / 8 / 12 core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor / indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multi-mode fibres on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties & to be identified with the manufacturer's name, year of manufacture, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
4. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. steel central member, Loose buffer tube design, 4 fibres per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly or better material etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile 1000 N minimum. The compressive strength of cable shall be 3000N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 DegC to 70 DegC.
5. The splicing loss of any two fibres in any case shall not exceed 0.10 db/splice.
6. The total additional attenuation above the nominal attenuation due to regular splices, repair splices, connectors, temperature variation, ageing etc. shall be indicated.
7. Fibre coloring shall conform to EIA/TIA-598. The color-coding shall be permanent thus withstanding normal handling; e.g., during termination, testing, or cable relocation. Refer to EIA – 359 for color identification and coding.
8. Cables shall be designed & tested in accordance with ISO 11801, TIA-568 & ICEA 596 and Performance specifications shall be measured in accordance with the Fibre Optic test procedures(EIA/TIA -455 documents) test procedures of IEC-60793 & IEC-60794
9. The OFC shall generally conform to the following specifications.

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Table 15.4A
Specifications for Single Mode Optical Fibre

S.No.	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@1310 nm	0.4 dB/km
		@1550 nm	0.3 dB/km
2	Mode field Diameter	@1310 nm	9.2 ± 0.4 µm
		@1550 nm	10.4 ± 0.8 µm
3	Maximum Cable Cut-off Wavelength		1260 nm
4	Maximum Zero Dispersion Wavelength		1321.5 nm
5	Minimum Zero Dispersion Wavelength		1301.5 nm
6	Maximum Zero Dispersion Slope		0.092 ps/nm ² ·km
7	Maximum Polarization Mode Dispersion		0.2 ps/√km
8	Gigabit Ethernet Length 1000BASE-LX		2-5000 mtrs.
9	Ten Gigabit Ethernet Length	10GBASE-LX	2-10000 mtrs.
		10GBASE-LX4	2-10000 mtrs.
10	Maximum Core/cladding Concentricity Error		0.5 µm
11	Cladding Diameter		125.0 ± 1.0 µm
12	Cladding Non-circularity		1 %
13	Coating Diameter		245 ± 5 µm
14	Maximum Coating Concentricity Error		12.5 µm
15	Temperature Dependence (-60 to +85C)		0.05 dB/km
16	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		0.05 dB/km
17	Minimum Proof Test		100 kpsi
18	Bending Induced Attenuation (100 turns, 75mm diameter)		0.5 dB

Table 15.4B
Specifications for Multi Mode Optical Fibre

S.No.	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@850 nm	3 dB/km
		@1300 nm	0.7 dB/km
2	Overfilled Launch Bandwidth	@850 nm	200 MHz·km
		@1300 nm	500 MHz·km
3	Gigabit Ethernet Length	1000BASE-SX	2-300 mtrs.

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S.No.	Feature	Minimum Requirement
		1000BASE-LX
4	Ten Gigabit Ethernet Length	2-550 mtrs.
		10GBASE-SR
		2-33 mtrs.
		10GBASE-LX4
		2-300 mtrs.
5	Numerical Aperture	0.275 ± 0.015
6	Core Diameter	62.5 ± 3.0 µm
7	Maximum Core Non-circularity	6 %
8	Maximum Core/cladding Concentricity Error	3 µm
9	Cladding Diameter	125.0 ± 2.0 µm
10	Cladding Non-circularity	2 %
11	Coating Diameter	245 ± 10 µm
12	Maximum Coating Concentricity Error	12.5 µm
13	Temperature Dependence (-60 to +85C)	0.2 dB/km
14	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)	0.2 dB/km
15	Minimum Proof Test	100 kpsi
16	Bending Induced Attenuation (100 turns, 75mm diameter)	0.5 dB

10.The cables shall be supplied in non-returnable strong wooden (or alternatively steel) drums provided with lagging of adequate strength, constructed to protect the cable against any damage and displacement during transit, storage and subsequent handling and stringing operations in the field.

11.Test on Fibre optic cable:

Table 15.4C
Type Test Requirement for Fibre Optic Cables

S.No.	Test Requirement	Standard
A	Optical Characteristics of Fibres	
1	Attenuation	IEEE Std. 1138 IEEE STD. P1222 (EIA/TIA – 455-61,78A) (IEC 793-1-C1A,B,C)
2	Cut off wavelength	IEEE STD. 1138 IEEE STD P1222 (EIA-455-80, 170) (IEC-793-1-C7A,B)
3	Fibre Dispersion	IEEE STD. 1138 IEEE STD. P1222

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S.No.	Test Requirement	Standard
		(EIA/TIA-455-168A,169A,175A) (IEC-793-1-C5A,B,C)
4	Frequency Response	IEC-793-1-C2B
5	Mode Field Diameter	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-164A,165A,167A) (EIA-455-174) (IEC 793-1-C9A,B,C,D)
6	Temperature Cycling	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-69A) (IEC 793-1-D1)
B	Mechanical Characteristics of Fibres	
1	Abrasion	IEC 793-1-B4
2	Core Concentricity	IEC 793-1-A3
3	Macro Bending	EIA/TIA-455-62A (IEC 793-1-C11)
4	Micro Bending	IEC-793-1-C3
C	Proof Test	IEC-793-1-B1
D	Strippability	IEC 793-1-B6
E	Visual Examination	EIA/TIA-455-13 (IEC 793-1-B5)

15.3 Instrumentation Cable Interconnection & Termination Philosophy

The cable interconnection philosophy to be adopted shall be such that expensive grouping of signals by large scale use of field mounted Group Junction Boxes (JBs) at strategic locations. (Where large concentrations of signals are available, e.g. valves limit and torque switches, switchgear) is done and consequently cable with higher number of pairs are extensively used. The details of termination to be followed are mentioned in the following Table:

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Table 15.5
Instrumentation Cable Interconnection & Termination Philosophy

S.No.	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
1.	Limit, Torque switches of valves / dampers / drives (integral junction box)	Marshalling cubicle / Marshalling cum Termination Cubicle / Local group JB	Plug-in connector	Posts mount cage clamp type	G
2.	Transmitters, E/P converters, process actuated switches mounted in LIE / LIR	Integral junction box of LIE / LIR	Plug-in connector	Cage clamp (rail mount)	F, G
3.	RTD heads	Local junction Box	Plug-in connector	Cage clamp (Rail mount) type	F
4.	Thermocouples	Junction Box	Plug in connector	Cage clamp (Rail mount) type	A, B, C *
5.	Other Field Mounted Instrument	Local JB / Group JB	Plug in connector	Screwed, Cage clamp (Rail mount) type	F (For analog signals) G (For Binary Signals)
6.	Junction Box (For Thermocouples for interlock and protection)	Marshalling Cubicle / Marshalling cum Termination Cabinet	Cage clamp (Rail mount) type	Screwed, Cage clamp (Rail mount) type	A, C *. These signals shall preferably through 6 pair cable
7.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Group JB	Cage clamp (Rail mount) type	Cage clamp (Rail mount) type	F, G
8.	Local junction box,	Marshalling Cubical /	Cage clamp (Rail	Posts mount cage clamp	F, G

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S.No.	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
	Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Marshalling cum termination Cabinet	mount) type	type	
9.	Marshalling Cubical / Termination Cabinet	Electronic system cabinet	Cage clamp post mounted type	Plug-in connector / Other System as per manufacturer's Standard	Internal Wiring

Notes:

1. Normally 10% spare cores shall be used when the numbers of pairs of cables are more than four pairs.
2. For analog signals, individual pair shielding & overall shielding & for binary signals only overall shielding of instrumentation cables shall be used.
3. * For high temperature applications only.
4. Instrument Cabling for instruments / equipment of specialized / proprietary Control System shall be as per manufacturer's standard.

15.4

Terminal Blocks

1. All terminal blocks shall be rail mounted/post mounted, cage clamp type with high quality non-flammable insulating material of melamine suitable for working temperature of 105 deg. C. The terminal blocks in field mounted junction boxes, temperature transmitters, instrument enclosures/racks, etc. shall be suitable for cage clamp connections. The terminal blocks in Control Equipment Room logic / termination / marshalling cubicles shall be suitable for the post mounted cage clamp connection at the field input end. The terminal blocks for SG integral control system Input/ Output connections from/to SWGR/MCC, shall be used with built in test and disconnect facilities complete with plug, slide clamp, test socket etc.
2. All the terminal blocks shall be used complete with all required accessories including assembly rail, locking pin and section, end brackets, partitions, small partitions, test plug bolts and test plug (as specified above for SWGR connections), transparent covers, support brackets, distance sleeves, warning label, marking , etc.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams. At least 20% spare unused terminals shall be used everywhere including local junction boxes, instrument racks/enclosures,

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termination/marshalling cabinets, etc. All terminal blocks shall be numbered for identification and grouped according to the function. Engraved labels shall be used on the terminal blocks.

4. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
5. Internal wiring in factory pre-wired electronic equipment cabinets may be installed according to the applicable standards as to wire size and method of termination or internal equipment. Terminal blocks for connection of external circuits into factory pre-wired electronic equipment cabinets shall meet all the requirements as specified above.

15.5 Internal Panels, Cabinets, System Cabinet Wiring Philosophy

1. Internal panel/cabinet wiring shall be of multi-stranded copper conductor with FRLS PVC insulation without shield and outer sheath meeting the requirements of VDE 0815.
2. Wiring to door mounted devices shall be done by 19 strand copper wire provided with adequate loop lengths of hinge wire so that multiple door opening shall not cause fatigue breaking of the conductor.
3. All internal wires shall be used with Tag identification of printed type (partex labels) at both ends. All wire directly connected to trip devices shall be distinguished by one additional red color.
4. All external connection shall be made with one wire per termination point. Wires shall not be tapped or spliced between terminal points.
5. All floor slots of desk/Panels/cabinets used for cable entrance shall be used with removable gasketed gland plates and sealing material. Split type grommets shall be used for prefabricated cables.
6. All the special tools as may be required for solder less connection.
7. Tag identification for internal wires shall be printed (partex labels)
8. Wire sizes to be utilized for internal wiring shall be as per following table.

Table 15.6

Wire Size for Internal Wiring

S.No.	Application	Wire Size
1	Current (4-20mA), low voltage signals (48 V)	0.5 Sq. mm
2	Ammeter/ Voltmeter circuit, control switches etc. for electrical system.	1.5 Sq. mm
3	Power supply and internal illumination.	2.5 Sq. mm minimum (shall be as per load requirement)

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15.6 Cable Installation & Routing

1. All cable assigned to a particular duct/conduit shall be grouped and pulled in simultaneously using cable grips and suitable lubricants. Cables removed from one duct/conduit shall not be reused.
2. Cables shall be segregated as per IEEE Std. 422. In vertically stacked trays, the higher voltage cable shall not be in higher position and instrumentation cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other system shall be as follows:
 - a) From 11KV/6.6KV/3.3KV tray system - 900 mm
 - b) From 415KV tray system - 600 mm
 - c) From control cable tray system - 300 mm
3. Cables shall terminate in the enclosures through cables glands. All cable glands shall be properly gasketed. Fire proof sealing (to prevent ingress of dust entry and propagation of fire) shall be used for all floor slots used for cable entrance. Compression cable glands (double for armored and single for other cables) shall be used.
4. All cables shall be identified by Tag. Nos. provided in approved format at both the ends as well as at an interval of 5 meters.
5. Line voltage drop due to high resistance splices, terminal contacts, insulation resistance at terminal block, very long transmission line etc. shall be reduced as far as practicable.
6. The cables emanating from redundant equipment/devices shall be routed through different paths. The above segregation of cables & wiring for redundant equipment / devices shall be in accordance with IEEE-Std-422

15.7 Cable Laying

1. Cable shall be laid strictly in line with cable schedule. In general, the cable routing from the local instrument to JB shall be such that the cable go away from the hot zone.
2. Identification tags for cables.
Indelible tags to be provided at all terminations, on both sides of wall or floor crossing, on each conduit/duct/pipe entry/exit, and every 20 m in cable trench / tray.
3. Cable tray numbering and marking.
To be provided at every 10m and at each end of cables way & branch connection.
4. Joints for less than 250 Meters runs of cable shall not be permitted.
5. Buried cable protection

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With concrete slabs; Route markers at every 20 meters along the route & at every bend.

6. Road Crossings

Cables to pass through buried high density PE pipes encased in PCC. At least 300 mm clearance shall be used between.

- a) HT power & LT power cables,
- b) LT power & LT control cables,
- c) LT control & instrumentation cables,

Spacing between cables of same voltage grade shall be in accordance with the derating criteria adopted for cable sizing.

7. Segregation (physical isolation to prevent fire jumping)

- a) All cable associated with the unit shall be segregated from cables of other Units.
- b) Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire.

8. Cable clamping

All cables laid on trays shall be neatly dressed up & suitably clamped/tied to the tray. For cables in trefoil formation, trefoil clamps shall be used.

9. Optical fibre cables inside conduits shall be laid on cable trays wherever available and feasible. In areas where the same are required to be buried, the same shall be buried in separate trench approx. 1.6 meter depth, to be laid in 2" GI/rodent proof HDPE conduits covered with sand, brick and soil along the pipe line route.

10. While crossing roads- to be laid in GI/rodent proof HDPE conduits with sand filling at bottom and sand, soil filling at top with cement concrete;

While crossing canals/river- to be laid in GI/rodent proof HDPE conduits within Hume pipe.

15.8 Cable Accessories

1. Cables, which terminate in cabinets or draw out sections, shall have sufficient cable coils in the bottom of the cabinet to permit full withdrawal of draw out sections without disconnecting the cables. When prefabricated cables with factory connectors on both ends are longer than required, the excess cable shall be coiled in the bottom of one or both termination cabinets.
2. No splices shall be made in conductors for instrument and control circuits except where required at connections to devices equipped with factory installed pigtailed. Such splices shall be made only in approved splicing boxes of fitting with

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removable cover. The splices shall be made with sufficient slack left in the wire to permit withdrawal of the splice from the splicing boxes for ease of future disconnection of the splices. All exposed conductor or connector surfaces shall be covered with a minimum of three half-lapped layers of all weather vinyl plastic electrical tape. Taping shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the other insulation or connections requiring insulation.

3. Proper grounding of all equipments shall be done. Further, proper termination of cable shield shall be verified and the grounding of the same shall be coordinated so as to achieve grounding of all instrumentation cable shields at same potential. This shall be completed prior to system tests.
4. Take full care while laying/installing cables as recommended by cable manufacturers regarding pulling tensions and cable bends.

15.9

Cable Conduits

1. Conduits shall be generally used for interconnecting cables from field instruments to Local JB's. All unarmoured cables shall be installed in conduit. All rigid conduits, couplings and elbows shall be hot dipped galvanized rigid mild steel in accordance with IS: 9537 Part-I and Part-II. The conduit interior and exterior surfaces shall have continuous zinc coating with an overcoat of transparent enamel lacquer or zinc chromate. Flexible metal conduit shall be heat resistant lead coated steel, water leak, fire and rust proof. The temperature rating of flexible conduit shall be suitable for actual applications. The flexible metal conduit shall be constructed with interlocked corrosion resistant steel & manufactured in accordance with UL1 & NEC Article 348.
2. All grounding bushings within all enclosures shall be wired together and connected internally to the enclosure grounding lug or grounding bus with 8 AWG bare copper conductors. Conduit runs to individually mounted equipment shall be grounded to the cable tray grounding conductor with 12 AWG bare copper conductors.
3. All rigid conduit fittings shall conform to the requirements of IS: 2667. Galvanized steel fitting shall be used with steel conduit. All flexible conduit fittings shall be liquid tight, galvanized steel. The end fittings shall be compatible with the flexible conduit supplied.
4. All individually mounted equipment and devices shall be connected to the supply conduit, using not more than one meter of flexible conduit adjacent to the equipment or device. Flexible conduit shall be installed in all conduit runs, which are supported by both building steel and structures subject to vibration or thermal expansion. This shall include locations where conduit supported by building steel or foundation becomes supported by steam generator framing.

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5. Special areas, such as Control Rooms in which external noise is to be minimized, shall have flexible conduit in conduit runs where the runs cross from the main building framing to the Control Room framing.
6. Conduit supports shall be furnished and installed in accordance with these specifications. Support material shall comply with the requirements.
 - a) Hanger rods shall be 12 mm diameter galvanized threaded steel rods.
 - b) Single conduit support shall be one-hole cast straps and clamp backs. Multiple conduit bank supports shall be constructed of special galvanized support channels with associated conduit clips.
7. Conduit sealing, explosion proof, dust proof and other types of special fittings shall be used as required by these specifications and shall be consistent with the area and equipment with which they are installed. Fittings installed outdoors and in damp locations shall be sealed and gasketed. Hazardous area fittings and conduits sealing shall conform to NEC requirements for the area classification.
8. Double locknuts on all conduit terminations shall be used. Water tight conduit unions and rain tight conduit hubs shall be utilized for all the application which shall be exposed to weather. Moistures pockets shall be eliminated from conduits.
9. Conduits shall be securely fastened to all boxes and cabinets.

15.10 Cable Sub Trays & Support

1. The cable sub-trays and the supporting system, to be generally used between Local/Group JB's and the main cable trays. It is the assembly of section and associated fitting forming a rigid structural system used to support the cable from the equipment or instruction enclosure up to the main cable trays (trunk route). The material of cable tray shall be GI.
2. The covers on the cable sub-trays shall be used for protection of cables in areas where damage may occur from falling objects, welding spark, corrosive environment, etc. & shall be electrically continuous and solidly grounded. The cable trays shall not have sharp edges, burrs or projections injurious to the insulation or outer sheath of the cables.
3. The supporting arrangement of cable tray system shall be able to withstand the weight of the cable and cable tray system. The supporting interval shall not be more than the recommended span for the above loading for the type of cable tray selected. The tray shall not overhang by more than one meter from the support at the dead end. As far as practicable the cable sub-tray system shall be supported from one side only, in order to facilitate installation and maintenance of cables.
4. Install the estimated quantities and size of sub trays / troughs including all required fittings and adaptors on as required basis:

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Table 15.7
Specifications for Cable Tray

S.No.	Feature	Minimum Requirement
1	Material	Mild Steel as per IS-2062
2	Thickness	Not Less than 2 mm
3	Finish	Hot Dip galvanised as per IS-2629, 2633 & Zinc Coating as per IS-4579
4	Length	2.5 Mtr. +/- 10 mm
5	Width	W +/- 3mm
6	Inward Bend	25 mm
7	Coupler Plate	Thickness 2 mm, length 100 mm, Width 50 mm
8	Coupler plate material	MS with Hot dip galvanised
9	Nuts, Bolts, washer etc.	As required/ Hot dip galvanised
10	Cover	Dome Fixed type, Thickness 1.2 mm (Minimum)
11	Cover Material	Hot dip galvanised MS sheet

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16. SYSTEM CABINETS, PANELS & JUNCTION BOX**16.1 General Requirements**

1. All control panels, system cabinets, local panels and local instrument enclosures, racks shall be furnished fully wired with necessary provision for convenience outlets, internal lighting, grounding, ventilation, space heating, anti-vibration pads and accessories as per IS:5039 as required for completeness of the system.
2. All panels & cabinets shall be free standing type and have bottom entry for cables unless otherwise specified. The bottom of panels, cabinets, enclosures shall be sealed with bottom plate, compression cable glands and fire proof sealing material to prevent ingress of dust and propagation of fire. The Cabinets shall be designed for front & back access to components, terminals and wiring.
3. The cabinets shall be used with bottom glanding plate which shall be removable from inside and shall be used with sufficient no. of knockouts. The details of knockouts shall be used during detail engineering. All knockouts shall be used with pluggable grommets.
4. The cabinets shall be of max. 2200mm height including base channel. The base channel shall be of 100 ISMC. All cabinets shall be of same height. Construction shall be modular.
5. System & non-system cabinets shall have "look alike" appearance.
6. All electronic system cabinets shall be designed for 50 deg C operating under maximum ambient temperature without air conditioning system in service. Further cabinets, panels shall be so designed that temperature rise due to heat load does not exceed 10 deg. C above ambient temperature under all operating conditions. Necessary louvers, fans, limited packing density, adequate spacing between instruments, devices etc. shall be used to maintain temperature rise within permissible limits.
7. Panels, cabinets enclosures wiring shall be arranged to enable the removal of modules/instruments and devices without unduly disturbing them.
8. All panels, cabinets, enclosures interiors shall be illuminated with rapid start fluorescent strip fixtures with door actuated switches. Door switch terminals shall be shrouded. All illuminated lights shall be used with isolation switch in addition to door switch for maintenance & switching off when not required. Illumination light shall be used on both front & back sides if both sides are provided with equipments/instruments/terminal blocks requiring maintenance.
9. Sufficient number of power receptacles with disconnect switches shall be installed within panels, enclosure and racks.
10. The local instrument enclosures/racks shall be used locally for mounting of electronic transmitters and switches, etc.

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- 11.Exterior steel surface shall be sand blasted, ground smooth, filed, primed, sanded and smooth enamel painted to give a good finish subject to minimum paint thickness of 65-75 microns for sheet thickness of 3 mm and 50 microns for sheet thickness of 2mm. Minimum 2 coats of primer and two sprays of final finish colour shall be applied to all surfaces.
- 12.The colour of the panel's interior shall be brilliant white. External colour of the panels shall be as RAL 7032 for LIE/ LIR and RAL 7035 for control room system cabinets.
- 13.All panels, enclosures, system cabinets, marshalling cabinets shall be used with a minimum of 20% spare terminations and system cabinets shall be used with spare space for 20% additional modules fully wired with connectors etc. in excess of the total requirement of the system design when the cabinets are delivered. The spare space capacity shall be distributed evenly throughout the cabinets.

16.2 System Cabinets

Table 16.1
Specifications for System Cabinets

S.No.	Features	Minimum Requirements
1	Application	For housing Signal conditioning cards, input/output cards, processor cards, power supply units etc.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Anti vibration pad	Required, 15mm
9	Painting	Interior- Brilliant White Exterior- RAL 7035

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S.No.	Features	Minimum Requirements
10	Cabinet Dimension	To be decided during detail engineering
11	Grounding	M6 earthing stud shall be used
12	Ventilation	Fans & louvers with brass mesh required
13	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
14	Lifting arrangement	Removable lifting eyebolts shall be used

1. Beacon Lamps shall be used in each cabinet to indicate panel having fault condition.
2. The racks in system cabinets shall have provision along with plug in sockets/back plane to house accommodate the spare slots/modules as specified elsewhere.
3. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots & details of the card type/service shall be inscribed on this metal tag.
4. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
5. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
6. All cabinets shall have common key for locks.
7. Door shall have concealed type of hinges with 120 degree swing.
8. Door latches shall be of the three-point type to ensure tight closing.
9. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material.

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16.3 Marshalling Cabinets

Table 16.2
Specifications for Marshalling Cabinets

S.No.	Features	Minimum Requirements
1	Application	For termination of all cables originating from field.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Terminal Blocks	Rail mounted cage-clamp suitable for conductor size up to 2.5 mm ² & fused type with LED indication for power supply (24 VDC, 230 V AC, 110 V AC etc.) for instruments & equipments.
9	Anti vibration pad	Required, 15mm
10	Painting	Interior- Brilliant White Exterior- RAL 7035
11	Cabinet Dimension	To be decided during detail engineering
12	Grounding	M6 earthing stud shall be used
13	Ventilation	Fans & louvers with brass mesh required
14	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
15	Lifting arrangement	Removable lifting eyebolts shall be used

1. Separate Marshalling cabinets for the system shall be supplied for terminating all cables originating from the field and for distributing the signals to different functional panels and cubicles.
2. The terminal blocks shall be cage clamp type. Fused terminal blocks hinged at one end to facilitate easy isolation shall be used wherever necessary. All cabinets shall be used with spare terminals for the spare inputs/outputs as specified elsewhere in the specification. The type of terminals for terminations from cabinets/panels shall match with the pre fabricated cables and pins supplied.

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3. The terminals for field cables shall be arranged in a logical order of equipment/system wise.
4. The marshalling cabinets, the terminal blocks, the terminals and the electronic hardware if any, shall have identification numbers.
5. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
6. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
7. All cabinets shall have common key for locks.
8. Door shall have concealed type of hinges with 120 degree swing.
9. Door latches shall be of the three-point type to ensure tight closing.
10. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material

16.4 Local Instrument Enclosure & Racks

1. Transmitters and switches, devices, etc. mounted in the field shall be suitably grouped together and mounted in local instruments enclosures in case of open areas of the plant and in local instrument racks in case of covered areas. These local instrument enclosures and racks shall be furnished as per the project requirements.
2. The local instrument enclosures shall be constructed of 2 mm sheet plate and shall be of modular construction with one or more modules and two end assemblies bolted together to form an enclosure. Vibration dampeners shall be installed for supporting each enclosure. The internal layout shall be such that the impulse piping/ blow down lines are accessible from back doors of the enclosure and the transmitters etc. are accessible from front side for easy maintenance. Gaskets shall be used between all mating sections to achieve protection class of IP-65.
3. The local instrument racks shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be used with a canopy to protect the equipment mounted in racks from falling objects, water etc. The canopy shall not be less than 3 mm thick steel, and extended beyond the ends of the rack. Bulk heads, especially designed to provide isolation from process line vibration shall be used. The junction box for racks also shall conform to IP 65 protection class.
4. Provision for continuous purging arrangement is to be made for all air and flue gas applications.
5. Each transmitter enclosure housing instruments i.e. for air and flue gas applications, requiring purge air for continuous air purging shall be used with common purge air header, air filter regulators of sufficient capacity, required

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pressure gauges, valves, fittings, SS tubing and individual purge meters for each purge line etc. as required.

- The junction box of Local Instrument Enclosure & Racks shall be used with hinged type door, latch for locking & gland plates for cable entry. All terminals in junction box shall be of rail mounted cage clamp type suitable for conductor size up to 2.5 Sq. mm.

16.5 Local Junction Box

Table 16.3
Specifications for Junction Box

S.No.	Features	Minimum Requirements
1	No. of Ways	32 (2X16) with 20% spares terminals
2	Material & Thickness	3 mm thick Stainless steel
3	Protection class	IP-65 for outdoor/ IP 55 for Indoor
4	Cable entry	Bottom
5	Mounting	Suitable for Wall/column/structures mounting
6	Terminal Blocks	Rail mounted cage-clamp type suitable for conductor size up to 2.5 mm ²
7	Grounding	M6 earthing stud shall be used
8	Gland plate	Removable type
9	Door	Single Lockable door with gasket, able to open sideways, turnable hinge based, latch type lock without handle with common key.
10	Accessories	Tag plate, clamps, fixtures, bolts (SS), nuts (SS), Gasket (Neoprene), cable glands (SS), Lugs (Brass), Fire proof compound for sealing.

- All JB's for outdoor application shall be used with individual canopies to prevent ingress of water.
- All JB' shall have provision to add 10% additional TB's.

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3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams.
4. Separate Terminal blocks shall be used for Analog & Digital Signals & also for signals with different voltage levels.
5. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
6. Separate shield bus shall be used with screw connection for terminating cable shields.
7. All spare cable entries shall be used with plugs.
8. All wires in JB shall be neatly dressed & ferruled.
9. Double deck type terminal block shall not be used.

Table 16.4
Specifications for Cable Glands

S.No.	Features	Minimum Requirements
1	Type	Double compression
2	Entry Thread	½ " NPT
3	Material	Brass
4	Finish	Cadmium Plated
5	Protection	IP-54 or better
6	Accessories	Neoprene gasket, Locknut, Reducer etc.

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17. TIME SYNCHRONIZATION SYSTEM (MASTER & SLAVE CLOCK SYSTEM)*{TO BE DELETED, IF ALREADY PROCURED UNDER SG PACKAGE.}***17.1 General**

A Global Positioning Satellite (GPS) based Master Clock System shall be provided with the Plant DCS system. Necessary signal output for time synchronization from Master Clock System shall be made available to the TG control system to have common time reference.

1. The system shall be provided with a GPS based date insensitive master & slave clock system (common for the station) for time synchronization of all plant control systems & equipments.
2. The system shall be complete with receiving antennae (for receiving time from GPS), receiver and associated electronics, Redundant Master Clocks, Slave Clocks, interconnecting cables, cubicles, power supplies & any other accessories.
3. The master clock shall have adequate number of communication ports to provide independent time reference signals for the following applications.
 - All DCS system equipment including plant common systems.
 - SER systems.
 - All PLC based BOP & offsite plant control systems
 - Vibration monitoring system for Unit specific requirements and for plant utilities.
 - PADO system.
 - Computerised Maintenance Management system
 - Integrated CCTV Surveillance system
 - Management Information system
 - Station LAN Server
 - TG Integral control systems.
 - SG Integral control systems.
 - SG Flame monitoring & analysis system.
 - Any other equipment requiring time synchronising.
4. The following spare ports shall be as a minimum:
 - Spares for Hour Pulse
 - Spares for Minute Pulse
 - Spares for Second pulse
 - Spares for BCD real time output with one (1) second frequency
 - Spares for serial time code in IRIG-B format with one (10 second frequency.

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- Spares for serial time code in RS 232 C with one (1) minute frequency.

17.2 Design Requirements

1. The offered master clock system shall be a fully wired panel consisting of the following minimum items & shall be located in Equipment Room in CCR :
 - GPS Antenna
 - GPS Receiver
 - Signal Processing Unit
 - Local display unit
 - Power supply
 - All required cables, mounting accessories, cabinet for the processing electronics etc.
2. The system shall be designed in a 100% redundant configuration and shall include two master clock systems.
3. The Master Clock System shall receive the synchronizing pulses from the GPS system and form a common time reference for recording of any event, logs and reports, which may take place in any portion of the network distributed throughout the Plant. Global Positioning System, to which the Master Clock gets synchronised, shall be an absolute system to provide continuously 3 dimensional position fixing, velocity measurement and Time reference generation.
4. The master Clock shall be configured as Real Time Clock with display of time in 24 hrs format & it shall drive the slave display units. It shall be ensured that loss of any slave display unit does not affect the display of any other slave unit. The character size of slave display unit shall be minimum 100 mm LEDs (4''). Since the timing synchronization of many off-site facilities is being done through station LAN, the slave clocks may be alternatively driven by respective systems / sub-systems.
5. Accuracy of the master clock system shall be as follows:
 - PPS output : +/- 500 nano second or better.
 - IRIG-B output : +/- 200 micro second of UTC or better
6. All the cables for interconnection between Master Clock and Slave Clocks & other systems shall be provided. This shall include all signal cables, (minimum Type-G cable as per specification) as well as power supply cables.

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Table 17.1
Specifications for Master clock system

S.No.		Requirements
1	GPS Antenna type	Helical
2	Noise	Less than 6 dB
3	GPS Receiver	Micro processor based
4	Tracking method	Code/carrier tracking
5	Output data format	NEMA 0183 or equivalent
6	Communication speed	9600 BPS or better
7	Output rate	Every Second
8	Signal Processing unit	Micro processor based digital type
9	Reference	OCXO with stability of 1 PPM
10	Time accuracy	1 PPM

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18. UNINTERRUPTED POWER SUPPLY (UPS)

{TO BE DELETED, IF ALREADY PROCURED UNDER SG PACKAGE.}

18.1 General

This specification is intended to cover the *[design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning]* of UPS system complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [..] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

18.2 Scope of Supply

Redundant, 230 VAC Uninterrupted Power Supply (UPS) System for various C&I packages including the plant control system (DCS) consisting of 2x 100% capacity static inverters, 2 x 100% capacity static switches, Manual by-pass switch, 2x 100% capacity float-cum-boost chargers, Battery with accessories, Step-down transformer, Voltage Stabilizer, 2x 100% AC Power Distribution Boards etc. shall be provided. UPS shall be provided with all interconnecting cable between UPS equipment and battery, UPS system cabinets and enclosures etc.

UPS shall be provided with all equipment and accessories required for completeness of the system including any feeder distribution as required for protecting UPS equipment and connected inputs and outputs shall be furnished in line with the specification.

18.3 Technical requirements

1. The equipment furnished under this subsection of the specification shall meet the requirements of all applicable codes and standards including ANSI, NEMA, IEEE, NEC and IS.
2. The UPS equipment and the complete system shall have Surge Withstanding Capability (SWC) to meet the requirements of ANSI C 37.90a - IEEE Standard 472-1974.
3. The UPS shall be provided to cater to all the loads for systems, equipment and instruments requiring UPS supply. Spare feeders of at least 10% of the total number of feeders shall be built in.
4. The selection and selective co ordination of all the protecting devices including fuse free circuit breakers/ fuses shall conform to the requirements of National Electric Code NEC –1984 and other applicable codes and standards. The selectivity ratios of the fuses shall be such that there is a sufficient margin between the total electric energy of the upstream fuse. The selectivity ratio shall be not be less than 2:1 in any case.

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5. The following general requirements shall be met for ensuring proper branch and circuit protection-
 - a) The feeder fuse ampere rating and feeder conductor ampacity must be at least 100% of the non continuous load plus 125% of the continuous load as calculated per Article 220 (220-10 G) of NEC Code- 1984. The feeder conductor must be protected by a fuse not greater than the conductor ampacity.
 - b) Each ungrounded service entrance conductor shall have a fuse in series with a rating not higher than the ampacity of the conductor.
 - c) If secondary fuses are sized not greater than 125% of transformer secondary current, individual transformer fuses are not required in the primary, provided, the primary feeder fuses are not larger than 250% of the transformer rate primary current.
6. The UPS system shall be suitable for operation at ambient conditions indicated in the specification.

18.4 Functional requirements

1. The Uninterrupted Power Supply (UPS) system of continuous duty shall supply regulated, filtered and uninterrupted 230V, 50 Hz, single-phase power, within specified tolerances. Each of the UPS loads shall receive one feeder each from the AC Distribution Board of Inverter A& B. However, each inverter shall supply only 50% loads under normal conditions.
2. Each UPS System component shall be compatible for satisfactory and well coordinated operation with other related components as well as with the input and output systems.
3. The KVA rating of the UPS shall be guaranteed at 230VAC, 50 Hz, single phase output at 50 deg C ambient temperature and load factor of 0.8 lagging. In case, the standard UPS rating are applicable at an ambient temperature lower than 50 deg C, then derating factor of at least 1.5 % / deg C shall be considered. The Bidder shall demonstrate the above stated capacity at 50 Deg C during shop testing.

18.5 Normal Operation

1. During normal operation, UPS loads shall be supplied by both 100% capacity inverters each working at 50% load. The inverters shall receive power from DC source (Charger/Battery) and their static switches shall be in the respective "Inverter" position. In this mode the two inverters shall act as hot standby for each other.
2. Necessary paralleling networks shall be included to ensure equal load sharing by both inverters. The rating of the paralleling device / circuit shall be such that it does not act as a limiting factor on the fault clearing capability of the inverters

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individually and when working in parallel. Load sharing network details shall be provided to establish all functionalities including fuse clearance.

3. One inverter shall act as "Master", working on its internal oscillator and the other inverter shall follow by using the synchronising signal from master inverter for automatic control of its output frequency.

18.6 Emergency operation

In case of failure of any inverter, the static switch shall automatically transfer the UPS loads of faulty inverter (say Inverter-"A") to the healthy Inverter-"B" which shall start working at 100% capacity. Thus the feeding of UPS power is continued automatically to all loads connected to both inverters despite the failure of one inverter and the quality power supply to all UPS loads connected to both inverters shall be maintained without interruption. Isolation of faulty inverter shall be automatic and achieved in less than 4 mille seconds.

On inverter failure, the plant AC source is automatically brought in as the standby source to healthy Inverter working at 100% capacity. In this mode, the healthy Inverter shall get the synchronizing signal from the standby AC source.

Operation on internal oscillator and transfer/retransfer to standby source shall be as follows:

1. The output frequency of the healthy inverter shall be automatically synchronised with the plant stand-by AC source supplied through step down transformer and voltage stabilizer using synchronizing signal from the standby source. If the frequency of the standby source is beyond these limits, the inverter frequency control shall be automatically disconnected from stand-by synchronizing signal and the inverter shall maintain the output frequency at 50 Hz within + 0.1 percent under all conditions of load and input voltage by working on its own internal oscillators.
2. During operation on its own internal oscillator, the inverters shall continuously monitor the frequency of standby source. Upon restoration of proper frequency conditions of stand-by source, the inverter shall automatically start using stand-by source frequency as the synchronizing signal for inverter output frequency control.
3. During the operation of any inverter on its internal oscillator due to synchronizing frequency being beyond the specified limits, the transfer of static switch from "Inverter" to "Standby source" shall be inhibited.
4. While one of the inverters (healthy) is feeding 100% load and the AC source is acting as standby, and in case this inverter also fails, the 100% load shall be automatically transferred from inverter to standby AC source through static switch, provided the standby source is synchronized to the inverter (synchronous transfer). However, such transfers shall be inhibited during operation of inverter on its internal oscillator due to standby AC source frequency being beyond the

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synchronization limits. Asynchronous transfer of inverter loads to standby AC source with a beak, on inverter failure shall be envisaged.

5. Retransfer of loads from standby AC source to inverter shall be automatic or manual as pre selected by the operator and shall be accomplished only after synchronism of the inverter output with the standby source has been automatically accomplished.
6. The manual bypass switch shall have the provision for fully by-passing the UPS system and connecting all UPS loads to the standby AC source.

18.7 Static inverters and auxiliary equipment

The static inverters shall be solid state type employing silicon controlled rectifiers or power transistors and other solid state devices to convert direct current power to essentially sinusoidal alternating current power as per this specification. Ferro resonant type inverters shall not be acceptable. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, surge suppression network, automatic synchronisation etc. as specified herein. Inverter shall be of continuous duty. Natural convection or forced cooling using redundant fans shall be used. Equipment shall be designed for operation with full load even with cooling fans failure / non-availability.

18.7.1 Inverter Capacity

Each static inverter shall have the following minimum capabilities. Continuous full load rating: meeting specification stipulations Over load capacity: 125% of full load rating for 10 minutes and 200% for 10 seconds minimum and 300% for 4ms minimum for all specified input voltages.

The inverter shall have sufficient I₂t capability to clear a slow acting HRC fuse having a continuous current rating equal to at least 20% of the continuous full load current rating of the inverter, while feeding 100% rated loads of the inverter.

Voltage regulation: $\pm 1\%$ for 0-100% load at all input voltage and all power factors.

Step load pick up: Upon transfer of full load, the inverter output voltage shall not drop below 85% of nominal voltage during the first half cycle after transfer and 90% of nominal voltage in the next half cycle. The recovery to within $\pm 1\%$ of voltage shall be in less than 50 milliseconds.

The Bidder shall indicate the maximum current rating (in Amps) of slow acting HRC fuse which can be cleared by the proposed inverters upon a branch circuit or bus fault. This shall also be accompanied by calculations and test data.

18.7.2 Input / Output Voltage

The inverters shall be fed from Battery and chargers which do not feed any other

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loads. Input voltage shall be nominal DC output voltage of battery and charger of range from final voltage after discharge of battery to maximum DC bus voltage during equalize charging of battery. The inverter shall also be capable of working satisfactorily meeting all specification requirements with only the chargers connected to its input without battery in circuit. Filtering on the input of the inverters shall be furnished as required to operate with the output ripple of the chargers. Each inverter shall include equipment necessary to protect itself from damage resulting from excursions, loss or restoration of DC input voltage and synchronizing voltage. The inverter output voltage shall be 230V AC, 50 hz, single phase. Total harmonic content shall be 4% (max) and harmonic content of any single harmonic shall not exceed 3%. The inverter efficiency at 100% load and 0.8 pf shall be minimum 85% and at 50% load and 0.8 pf shall be minimum 80%.

18.7.3 Over loads, Short Circuits and Load loss

1. The inverters shall be provided with suitable fuses at the input and output which shall permit proper co-ordination with other protective devices and at the same time protect the inverter against damage due to internal faults. All necessary equipment shall be provided to protect the inverters against over loads, short circuits and 100% loss of load. The inverter shall be self protecting against damage if energized with full load connected. All the fuses used in inverter power & control circuits shall be fast acting type, operating in less than 5 ms.
2. The inverter shall be provided with current limiting circuitry which shall limit the output current to a value which will not damage the inverter or blow its fuses.
3. The inverter shall have sufficient I_{2t} capability to prevent damage to itself until short circuit conditions on the output are cleared.
4. Each inverter shall be capable of operation with non linear loads. Bidder shall furnish details of non linearity for the loads. Output waveform of the inverters) shall remain within specified limits when operating with non linear loads at 100 percent rated load.
5. The inverters shall be self protecting against all AC and DC transients, voltage surges and steady state abnormal voltages and current likely to be encountered in utility power station.

18.7.4 Automatic Synchronization

1. Inverter equipment shall include stable solid state oscillator devices designed to automatically maintain the inverter output in phase and in synchronism with the standby AC source. The frequency regulation shall be automatic within +/- 0.1% for all conditions of inputs, loads and temperature occurring simultaneously or in any combination.
2. Facility shall be provided for automatic transfer to internal oscillator operation when the standby source frequency is not within the synchronization limits.

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3. Provision shall be made for step less adjustment of synch disconnect frequency range from 50 Hz +/- 0.5 Hz to 50 Hz +/- 2 Hz.
4. Automatic adjustment of phase relationship between inverter output and standby AC source shall be gradual, at a controlled slew rate which shall not exceed one Hz per second.
5. The inverter shall normally work on the internal oscillator with either of the two inverters as master synchronizer and the other following it. Suitable selector facility shall be provided to select the master. When any one inverter fails the healthy inverter gets the synchronizing signal from the standby A.C. source.

The DC input current shall never exceed the full load current except for a short circuit within the inverter. This limitation applies to transient as well as steady state currents and includes inrush currents upon initial energisation of the UPS, load energisation, short circuits external to the inverter etc. For any value of the load and load power factor drawn by the equipment served, the inverter shall not impose on DC source any voltage oscillations in excess of 5 volts (RMS total, all frequencies) or any current oscillations in excess of 3 percent (RMS total, all frequencies) of the DC current at full load.

18.7.5 Static inverter auxiliary equipment

In addition to the inverter equipment specified above, auxiliary equipment shall be furnished with each static inverter as follows:

1. Output ammeter, Output voltmeter, Output KVA meter, Input voltmeter, Frequency meter, Power factor meter, Inverter ON-OFF switch, Alarm Reset Push Button etc. of one number each shall be provided on the front panel of the inverter enclosures.
2. Indicating lights shall be furnished on front of the UPS panels. For those abnormal conditions which could be of a momentary nature, the indicating lights shall remain energized and the contact remain closed until cleared by a reset push button on the panel.
3. The following indications shall be provided as a minimum i.e. DC voltage to the Inverter Low/ High, Loss of DC input to the inverter, Inverter output voltage High/ low, Inverter failure, Standby AC source failure, Inverter synchronized with standby AC source in case of failure of the other inverter, Inverter feeding 100% UPS load, Standby AC source feeding 100% UPS loads, Fan failure and temperature high etc.
4. In addition to the above indications, the Bidder shall furnish electrically independent, potential free contacts for each of the above conditions. These contacts shall be rated for 0.5 Amps, 220 Volts DC and shall be wired to the terminal blocks.

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5. The 4-20 mA signals for Inverter A & B output voltages, output currents, output frequency etc shall be furnished.

18.8 Static Transfer Switches And Auxiliary Equipment

The static transfer switches shall be provided to perform the following functions

1. To transfer the load automatically between the Inverter to the standby inverter as described under automatic synchronization.
2. To transfer UPS load under manual control from standby AC source to inverter when placing the UPS System in service and from inverter to standby AC source when taking the UPS out of service.
3. The static transfer switches shall have two modes of operation namely automatic and manual.
4. The static transfer switches shall use silicon controlled rectifiers and other static devices required for automatic transfer of load from Inverter to Standby source and vice versa.
5. The static switches shall be provided with the requirements specified herein including the following:

- | | | |
|----|-----------------------------|---|
| a) | Capacity(continuous) | Continuous full load capacity of the inverter. |
| b) | Capacity (overload) | As per overload capacity of inverter indicated in the specification |
| c) | Capacity (Peak) | 1000% of continuous rating for 5 cycles. |
| d) | Transfer Time | 1/4 cycle maximum. (The transition shall be "make before break". Voltage failure shall be sensed at the output of static switch |
| e) | Voltage Rating (Nominal) | 230 Volts, 50 Hz, single phase. |
| f) | Transient Voltage Tolerance | 340 Volts peak above the normal line voltage. |
| g) | Ambient temperature | 50 deg C max. |
| h) | Cooling | Natural or forced circulation, using redundant fans. |

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i) Duty Continuous

6. The transfer of static switch from normal "Inverter" position to "Stand-by" position shall be initiated by Inverter failure and UPS system trouble, Static switch output voltage failure, over current or manual push button operation.

The UPS bus shall be monitored by two voltage detectors. One fast acting circuit shall be used for detecting a complete and instantaneous voltage loss while the other slower acting averaging circuit with adjustable trip level shall be employed to detect voltage deviation beyond selected limits. Both voltage detector circuits shall automatically initiate operation of static transfer switch.

UPS bus current shall be continuously monitored by a current monitoring detector. This detector shall operate the static transfer switch when the load current exceeds the overload rating of any inverter. The detector shall rest when the load current falls below the rated current of the inverter resulting in retransfer of static switch with inverter position.

The static switch shall automatically transfer the load from inverter to stand-by AC source when the maximum I_{2t} capability of the inverter is reached or when the inverter output voltage drops below 90%.

Over current transfer limit shall be continuously adjustable from inverter continuous rating to inverter current limit rating.

7. Transfer Inhibit of static switch shall be under the following conditions:

Automatic or manual synchronous transfer of load from inverter to stand-by AC source or vice versa, shall be inhibited when the inverter frequency is not synchronized to the alternate source. However, asynchronous transfer facility under such condition shall be provided.

Transfer resulting from overload shall be inhibited when the standby AC source is not available. In this case the load fed by the inverter shall be automatically disconnected.

8. Static transfer switches shall be provided with necessary protective devices (circuit breakers) both in "Normal" as well as "Stand by" position.
9. The static switches shall be furnished with contacts to alarm failure of the alternate source or opening of any fuse protecting the static switches.
10. Auxiliary equipment for static transfer switch
11. Following auxiliary equipment shall be furnished with each static transfer switch a minimum:

- a) Red indicating Light to indicate switch in "Normal" position, Green indicating Light to indicate switch in "Standby" position, White indicating Light to indicate "Normal" and "Standby", power sources in synchronism, Push-button to simulate normal AC UPS power failure (sensed at static switch output) to

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test the satisfactory working of static switch, transfer labeled "Transfer Test", Push-button for manual retransfer of static switch to "Normal" position, Push-button for manual transfer from normal to alternate source, Light to indicate standby AC source voltage deviation high, Light to indicate voltage transfer enabled, Light to indicate voltage transfer disabled etc shall be provided on the front of the enclosure.

- b) Two (2) number each of NO contact for static switch transfer to "Standby" position and standby source voltage deviation $> \pm 2\%$ from normal shall be provided within the static transfer switch enclosure.

18.8.1 Manual by-pass switch

1. The manual by-pass switch shall be used to isolate any static switch from its load and stand-by power supply and to take the static switch out of service without power interruption to the load. In doing so, the manual by-pass switch shall connect both load buses to a single inverter. The manual bypass switch shall provide the facility for by passing the entire UPS system during the operation of the UPS in the option of the operator.
2. The manual bypass switch shall have "make before break" contacts to ensure continuous supply to UPS loads during the operation of the same.
3. The manual bypass switch shall be rated for 600 Volts, 50 Hz, single phase operation. It shall have continuous load carrying capacity equal to full load inverter current and necessary short term load carrying and interrupting capacity to meet the requirements of the UPS system.
4. Another bypass and disconnect devices shall be envisaged as required for orderly start up, shut down and maintenance of UPS system and system components.
5. The manual by-pass switch and required disconnect devices shall be furnished duly mounted and wired in enclosure.

18.8.2 Float-cum-boost chargers and auxiliary equipment

1. Two 100% capacity chargers shall be furnished for the UPS system. Each charger shall confirm to the following requirements.
2. Each charger furnished for UPS system shall be adequately rated to ensure that any one shall meet full DC load of UPS system operating at 100 % rating plus recharge the fully discharged UPS batteries.
3. The chargers shall be served from a 415 volt, 50 Hz, 3 phase system. The chargers shall maintain the output voltage within plus and minus 0.5 % from no load to full load, with an input power supply deviation in voltage level of $\pm 10\%$ and input power supply deviation in frequency of $\pm 5\%$ and with both deviations present in any combination.
4. In addition to supplying DC power for inverters, the chargers shall be designed to charge a fully discharged battery without over loading or causing over voltage or

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without causing interrupting operation of AC or DC circuit breakers for the entire range of intended operating regimes. Suitable solid state electronic circuits shall be provided to ensure that the charging current is voltage regulated and current limited. After the battery is recharged the charger shall maintain the battery at full charge until the next emergency operation when the UPS battery is again required to provide DC power.

5. Float and equalizing controls shall have an adjustment range of $\pm 5\%$ continuous (without steps).
6. The chargers shall be self-regulating, solid state, silicon controlled, full-wave rectifier type designed for single and parallel operation with the battery specified. The chargers shall be designed for automatic load sharing during parallel operation.
7. The charger shall be current limited at 125% of full load to reduce output voltage for charger circuit protection and for protection of battery from overcharge. The current limit shall be continuously adjustable from 80% to 125%.
8. All necessary equipment and devices shall be provided to protect the charger from short circuits, transient voltages, surges, load and supply fluctuations including sudden loss of input or load.
9. The charger shall have a slow walk-in circuit which shall prevent application of full load DC current in less than 10 seconds after AC power is energized.
10. The minimum full load efficiency at nominal input and float output shall be 90% or better. The output regulation, ripple content and power factor shall meet the requirements of UPS system offered.

18.9 Battery Charger Auxiliary Equipment

Following auxiliary equipment shall be furnished for battery charger a minimum:

1. AC Voltmeter, DC Voltmeter, AC Ammeter, DC Ammeter, Charger On-Off push buttons, Potentiometers (one "Float Voltage Adjust" and one "Equalizing Voltage Adjust", both with manual adjustment knobs, the settings of these knobs, shall be independent of each other), Selector Switch for float charge / Equalizing charge, Charging rate setter, Selector switch and lights for ground fault detector, Indicating lights with proper actuating devices, Circuitry and legend etc shall be furnished on the front of the panel of the charger enclosure.
2. Indications such as Failure of input AC supply, Charger failure, System on battery operation, Battery equalize timer 'on', Low battery voltage, DC ground fault, Redundant fan failure and temperature high (if provided), Charger fuse failure, Low DC output voltage, High DC output voltage etc.
3. One set of independent potential free contacts rated for 0.5 amps, 220 volt DC shall be furnished for the alarms above and wired to terminal block for use of alarm annunciation system.

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18.10 Ground Detector System

Each charger shall be furnished with a ground detector system consisting of a relay and a centre tapped resistor. The resistor shall be connected between the positive bus and the negative bus. The relay coil shall be connected to resistor and ground. The relay shall be furnished with one normally open and one normally closed contact wired to terminal blocks for connection to external circuits.

Two indicating lights and one three position spring return to centre selector switch mounted on front of charger cabinet shall be provided for each ground detector system.

18.11 UPS Battery

1. The battery shall be heavy duty Nickel-cadmium type and shall have sufficient Amp-hour capacity to supply 100% full load current of UPS for one hour. The Ni-cd battery shall conform to IS: 10918 and shall be sized according to IEEE Std. 1115.
2. The battery shall be high discharge performance type to withstand discharge/charge cycles throughout life without loss of capacity. In battery sizing calculation, Bidder shall also take into account a minimum voltage drop of 2.5 volts from battery room to the inverter input.
3. Battery sizing calculations, supporting curves/data etc. with the proposal to demonstrate that the proposed battery capacity meets the above specification shall be furnished. Various correction factors such as capacity factor, temperature derating factor (at a minimum electrolyte temperature of 4°C), design margin shall be take in to account as per data below:

Table 18.1
Battery Sizing Correction Factors

S.No.	Features	Minimum Requirements
1	Temperature derating factor (At an electrolyte temperature of 40C)	(Td)
2	Design margin	20% = 1.2
3	Capacity factor (KT) (For discharge duration of 1 hr. & end cell voltage of 1.1 volts)	AH capacity of chosen cell /(discharge current in amp for chosen cell Corresponding to 1 hour) x Float correction factor.
4	The UPS battery shall be furnished as specified herein and shall meet following requirements:	

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i)	Nominal Voltage	As per the requirement of nominal DC voltage level at the input of the inverters.
ii)	Ambient temperature	50 ° C max.
iii)	Specific gravity, full charge	1.19 ± 0.01
iv)	Voltage per cell	
	Nominal	1.2 V
	Floating	1.40 V to 1.42V
	Boost	1.53 V to 1.67V
	End cell voltage	1.1 Volts

18.12 Battery Accessories

2 nos. of Hydrometer along with syringes suitable for vent holes in different cells, Thermometers, Specific gravity correction chart, Wall mounted type holder made of teak wood for hydrometer & thermometer, Cell testing voltmeter (3-0-3V), Acid/Alkali mixing jar 2 nos. Rubber apron, Rubber gloves, Set of spanners, Goggles (industrial) Instruction Card, Variable metallic resistor & shunt, Inter cell connectors, Suitable terminal lugs for cables, Two tier teakwood battery rack, Jack for lifting the cells etc shall be provided as accessories and fittings of the Batteries and auxiliaries.

18.12.1 Step-down transformer & voltage stabilizer

One 415 Volt, 3 phase to 240 Volt, single phase transformer along with associated voltage stabilizer shall be furnished.

This transformer and stabilizer combination shall convert 415 Volt +/- 10% plant auxiliary AC supply to 230V, +/- 2% single phase standby AC Power, which shall serve as UPS system back up supply source.

The transformer and stabilizer shall be sized for 100 % UPS load and shall co-ordinate with the largest branch circuit protection device for feeder short circuit current without sacrificing voltage regulation. The voltage stabilizer shall employ silicon solid state circuitry and shall maintain a stabilized voltage for 0 -100% load with input voltage variations as indicated above.

The stabilizer shall meet the following characteristics as a minimum. Fast rate of correction - within 5 cycle; Output distortion - less than 5% under worst conditions; Efficiency shall be better than 94%; No load losses less than 5%.

18.12.2 AC Distribution Boards

Panel boards for distribution of continuous AC power to essential loads shall be dead-front type panel boards rated for 600 V, AC service. Sheet steel thickness shall be 3 mm for load bearing member and 1.6 mm for other members. The hinged panel board front shall cover the fuses and wiring gutter but not the switch

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handles. The hinged front and switch handles shall be covered by the enclosure-door.

Each panel board shall be constructed for 2 wire, single phase distribution with solid neutral bar. Phase and neutral bars shall be of copper. Rating of the main lugs shall be equal to the rated continuous full load current of each inverter. Type of enclosure shall be IP 42 as a minimum.

Each panel board shall have one fused disconnect switch of adequate rating for incoming feeder for AC Bus and requisite single pole, suitably rated disconnect switch branch circuit devices. Fused switches shall be equipped with arc quenchers, visible blades and quick-make quick-break operating mechanisms. The number of feeders and rating of each feeder shall be to suit the individual load requirements.

The AC distribution board and components thereof shall be from the latest proven product range of a qualified manufacturer. However, 25% spare feeders with fuses of each rating shall be provided.

18.12.3 Wiring and interconnections

All interconnections required from input to output terminals or outgoing inverter, transfer switches and distribution board equipment shall be provided within the enclosures in accordance with the manufacturer's proven practice, applicable international standards and good engineering practice. Internal wiring in factory pre-wired electronic systems cabinets may be installed according to the standard practice as to wire size, insulation and method of termination on internal equipment. Wiring for external circuits including all alarm contacts shall be brought to grouped terminal blocks located for convenient connection for external circuits entering from top or bottom.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-II
SECTION-II, PART-D
DETAILED TECHNICAL SPECIFICATION-CIVIL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

TURBO GENERATOR & AUXILIARIES (PACKAGE NUMBER: R&M-SP-02)

VOLUME-II, SECTION-II, PART-D DETAILED TECHNICAL SPECIFICATION - CIVIL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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1. CIVIL, STRUCTURAL & ARCHITECTURAL WORKS- DESIGN & EXECUTION CRITERIA

1.1 Introduction

This specification covers the design, preparation of general arrangement, construction as well as fabrication drawings, supply of all labour as well as materials and construction of all civil, structural as well as architectural work on EPC basis for Renovation and Modernisation of turbine generator (TG) and associated structures for the existing [Name of project...] Thermal Power Project. The renovated unit shall be capable of producing the output of [210/215/220/250] MW. Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope shall be as per Volume-II, Section-I, CIVIL SCOPE OF WORK.

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2. [BUILDINGS & STRUCTURES]

Design and construction of new buildings, structures, foundations etc. as well as repairing / retrofitting of existing buildings, structures, foundations shall take into account requirement for operation and maintenance of all equipments and its users. The buildings will have good architectural features. The surrounding areas shall be properly micro levelled and graded. The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials fittings and finishes.

- *Due consideration shall be given for adequate natural lighting and ventilation for both plant and non-plant buildings.*
- *Retrofitting / repair works / new constructions shall not cause damage to the existing structures. The temporary supports shall not be allowed on the existing structures for any of these works unless the loads are minor and may not cause any damage to any existing structure. However in such a case Bidder shall take approval from the Owner/Consultant prior to initiating the work.*
- *Internal finishes shall be provided with latest available materials approved by Owner/Consultant with due consideration of the functional aspect of the area.*
- *External finishes shall be provided with latest materials approved by Owner/Consultant for improving the aesthetics.*
- *The orientation of the important buildings shall be in line with the existing site condition and function as such.*
- *Each building shall have its own identity. However, a total homogeneity shall be maintained in the design of all buildings.*
- *Adequate frontage shall be provided to all important buildings to create a better visual impact.*
- *All other civil and structural buildings shall be developed in conjunction with the above aspects.*

All Civil, Structural and Architectural works of the following systems shall be covered under this package.

- a) Main Power House Building*
- b) TG Deck, Columns and Foundation*
- c) Electrical Control Building*
- d) Service Building*
- e) DG Building*

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- f) Air Washer Building*
- g) CPU Regeneration Building*
- h) ACW Pump house*
- i) Cable & Pipe rack in Steam Turbine Generator Area*
- j) Any building inadvertently left out in the above list, however required for proper functioning of the power plant as per system requirement stipulated under Mechanical & Electrical section of this specification shall also be included.]*

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3. DESIGN REQUIREMENTS

3.1 Location

Geographical location of the plant site is approximately between [11°34'00" N] to [11°35'00" N], Latitude and [79°26'00" E] to [79°27'00" E], Longitude.

3.2 Ground Condition

Subsurface **condition**: The natural ground surface level approximately varies from [60 m to 74.5 m] from MSL.

[The soil profile in the plant area can be broadly classified into 3 layers namely laterite, cemented sand and cemented silt in general as per detail soil investigation report. Top soil upto a depth ranging from 0.4 m to 0.75 m is entirely non-uniform. The underlying layer is laterite whose depth varies from 4.0 m to 5.5 m followed by deep layers of cemented silt and cemented sand].

The ground water table (GWT) at finished ground level shall be considered for foundation design purposes.

The detailed soil investigation report conducted for plant shall be made available to Bidder for required replacement / refurbishment / retrofitting of Foundations, if any.

Bidder is advised to carefully study the content of detailed Soil investigation report for the existing type of foundations and design of new ones.

The type, size, depth of the foundation shall be based on the detail soil investigation **report** provided by OWNER.

3.3 Climatic Condition

a) Temperature

Maximum : [...] °C

Minimum : [...] °C

For design purpose, maximum temperature to be considered: [50.0] °C

Minimum temperature to be considered: [.....] °C

b) Rain fall

Minimum : [...] mm in May]

Maximum : [.....mm in October]

Peak hourly rain fall: [...]mm] (corresponding to 50 years return period.)

[Note: Maximum per day rainfall as per weather report has been considered conservatively as peak hourly rain fall which will be used for drainage system design etc.]

Annual average: [.....mm tomm & average mm]

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3.4 Seismic Zone

The site is located in [Zone II] as per IS: 1893-2002. Zone factor shall be [0.10]. Importance factor shall be considered as [1.75].

3.5 Wind Zone

The site is located in wind speed zone [... m/s] as per IS: 875 (Part 3)-1987.

3.6 Loads and Load Combinations

All new structures shall be designed and old structures requiring modification shall be checked for the most critical combinations of dead loads, imposed loads, equipment loads, wind loads, seismic loads, temperature loads, forces developed due to differential settlement and any other loading conditions which can occur during the design life of the facility.

(a) Dead Loads

Dead loads consist of the weights of the complete structure with finishes, fixtures, partitions, wall panels and all existing / modified / replaced equipments of semi-permanent nature including storage structures partitions, roofing, piping, cable trays, bus ducts etc. The content of storage structures etc. shall be measured at full capacity for this purpose.

The piping loads (for empty, operating and test conditions), cable tray loads and the contents of the storage structures shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing load for uplift.

The following unit weight of material shall be considered for computation of loads. Loads given in IS: 875 (part-I) shall be made use of for material not listed below.

Table 2.1
Weights of Material

Material	Unit weight (kN/m ³)
Plain cement concrete	24.0
Reinforced cement concrete	25.0
Structural steel	78.5
Brick work	19.0
Cement plaster	21.0
Floor Finish	24.0
[Coal]	12.6

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(b) Superimposed Live Load (SILL)

Listed below is the minimum SILL for the areas involved. Floors and supporting members subjected to heavy equipment live loads shall be designed on the basis of the equipment loads specified by vendor or specifically defined SILL whichever is greater.

The specific minimum floor SILL is listed below:

Table 2.2
Superimposed Live Load (SILL).

S.No	Description	SILL Value
a)	Roof	
	• Flat accessible roof	1.5 kN/m ²
	• Flat accessible roof with HVAC equipments, etc.	5 kN/m ²
	• Flat inaccessible roof	0.75 kN/m ²
	• Sloped Roof	As per code IS: 875 (Part-2)
b)	Turbine building	
	• Ground Floor	
	- General Area	25 kN/m ²
	- Heavy equipment storage area	50 kN/m ²
	• Operating Floor	
	- Rotor removal area	30 kN/m ² Beams shall also be checked for ½ the rotor load at the center of the beam
	- Equipment laydown area	30 kN/m ²
	- Other areas (Corridors etc.)	15 kN/m ²
	Heater bay floor	10 kN/m ²
	Deaerator floor	10 kN/m ²
	Precast concrete covers	12 kN/m ²
	Mezzanine Floors	10 kN/m ²
	Platform around deaerator	10 kN/m ²
	Floor around feed water tank	20 kN/m ²
c)	Main control building/ Electrical building	
	• Control Room Floor	10 kN/m ²
	• MCC Room	15 kN/m ²
	• Cable vault Floor	5 kN/m ²
	• Battery Rooms	20 kN/m ²
	• AHU, AC & ventilation plant floors	10 kN/m ²

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S.No	Description	SILL Value
	• Switchgear room	15 kN/m ²
	• PLCC, relay room	15 kN/m ²
d)	All other building floors & Stairs	5 kN/m ²
e)	Equipment Load	As applicable
f)	Tunnels under road, culverts & its allied structures including Concrete pipes	Class "A" / Class "70R" as per IRC standard whichever is higher / load due to bull dozers
g)	Underground basement, tunnel	Surcharge of 10 KN/m ²
h)	Vehicular traffic	Surcharge of 20 KN/m ²
i)	Covers for Channels	Surcharge of 10 KN/m ²
j)	Other areas	
	• RCC floors (Offices, laboratories, conference rooms and general floors)	5 kN/m ²
	• Balconies	5 kN/m ²
	• Chequered plate / gratings	5 kN/m ²
	• Walkways	3 kN/m ²
	• Toilets	2 kN/m ²

- In addition to LL, Hung loads for electrical, ventilation & air conditioning minimum of 0.5 kN/m² shall be considered.
- Load of 1 kN/m² shall be considered as hung load for piping unless otherwise mentioned. However, the actual loads will be as furnished by the supplier. The stringent most will be followed.
- For other areas LL shall be considered as per IS: 875 (Part-2).

(c) Seismic Load

The proposed plant is located in Seismic [Zone-I] as per IS: 1893, Seismic force on the structures will be considered accordingly.

Turbine Building shall be designed by Response spectrum method. Minimum extraction of modes shall be as per Clause 7.8.4.2 of IS- 1893 Part I, 2002.

(d) Wind Load

The proposed plant is located in Wind Speed Zone of [50 m/s] as per IS: 875 (Part 3). The wind force on the structures will be considered as follows:

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Table 2.3
Wind Speeds

Description	Wind Speed
Basic Wind Speed Vb (at 10m above mean ground level)	[50 m/sec]
Risk coefficient K1 (for 100 years)	[1.07]
Category of terrain	[Category 1]
Factor K2	As per IS: 875
Topography factor K3	As per IS: 875

For the design of structures, wind force on Equipment, supported on frame including all fixtures, piping, staircase, ladder, etc, shall be considered.

Design of structures shall be checked for the condition of wind load with gust factor.

(e) Earth Pressure Loads

For earth pressure the worst condition with dry / submerged and active, passive or at rest shall be considered. The pressure coefficient shall be adopted as recommended in Soil Report or for the backfill material used.

(f) Temperature Loads

The total temperature variation shall be considered as 2/3rd of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the average between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50 % of the total considered temperature variation with temperature load applied with positive and negative sense.

For design purpose average maximum annual variation shall be taken as [+50°C] to +5°C.

Coefficient of thermal expansion of steel shall be taken as per IS: 800 where the value is given as 12x10-6/°C. Coefficient for thermal expansion for concrete shall be taken as per IS: 456.

(g) Thermal Loads (during operating condition)

When thermal loads (such as produced by temperature changes in piping, equipment and structures) results in friction between equipment and supports (exchangers) or piping and supports, the friction force will be taken as the

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operating load on the support multiplied by the applicable friction coefficient given below:

**Table 2.4
Thermal Loads**

Description	Value
Surfaces	Friction coefficient
Rolling supports	0.05
Steel to steel	0.30 (longitudinal) and 0.10 (lateral)
Concrete to steel	0.30

(h) Equipment Loads

Static and dynamic loads of major existing / modified / replaced equipments shall be based on the manufacturer's data of the specified equipments and shall be considered in design in addition to the live load.

Equipments to be tested for hydraulic test, tanks and piping design loading shall include hydraulic test loading. Weight of equipments, ducts, tanks, pipes, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads applicable.

(i) Cranes, Hoists, Monorail and Elevator loads

All lifting beams and monorails shall have their design loads increased for impact factor. Loads for overhead cranes, hoists, monorails and elevators shall be taken as per IS: 875.

100 % of the lifted load including elevator live load plus the cab weight shall be considered for the elevator support beam design. Pedestals in elevator pits shall be designed assuming impact factor as per IS codes.

(j) Vibration and Noise

The design shall ensure that vibrations from any moving machinery transmitted from its immediate foundations to adjacent buildings or areas of the same building shall be suppressed in accordance with the recommendations of relevant codes of practice.

(k) Other Loads

- Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance loads, creep and shrinkage shall also be considered in design of all structures.

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- Roof girders / trusses in the service / maintenance bay of Turbine building shall be designed for crane erection loads.
- Columns in turbine building near transformer yard shall also be designed to support tension due to strung conductors and shield wire, if the conductors are connected to the Turbine building columns.
- Dust loads

All buildings / structures shall be designed for a dust load of 1 kN/m² for flat roof and 0.5 kN/m² for sloped roof.

- Construction/ Erection/Maintenance Loads

The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing as far as possible. However, construction or access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

- Future Loads

Loads from future expansion shall be considered when so directed by the Owner/Consultant. Future loads may include any of the loads listed above.

- Surge Loads

Surge loads may occur in some vessels or equipment. In such cases, the magnitude and direction of the load shall be given by the equipment supplier.

(I) Basic Load Cases

Following basic loads shall be considered for analysis and design:

Dead load	:	DL
Superimposed dead load	:	SIDL
Self weight of permanent equipment	:	EL
Steam piping (Static & Dynamic) & other piping loads	:	PL
Cable loads	:	CL
Live load on floor / walkway	:	LL
Superimposed live load	:	SILL
Live load on roof	:	LLR
Seismic load	:	SL
Wind load	:	WL
Load due to soil pressure	:	SP
Load due to surcharge	:	SCL

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Load due to hydrostatic pressure	: HP
Load due to temperature	: TL
Hoist, monorail loads	: MR1
Crane loads	: CRL
Special loads	: SPL

(m) Load Combinations

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load combinations shall be taken as per IS: 456, IS: 800 & IS: 875 (all parts) and other relevant IS codes.

Wind and seismic forces shall not be considered to act simultaneously.

Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loading.

(n) Load Combinations for underground structures

- For the design of sub structure only liquid pressure from inside and no earth pressure and ground water Pressure and surcharge pressure from outside (applicable only to the Structures which are liable to be filled with water or any other liquid) shall be checked.
- For the design of sub structure combination of earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside shall be applied.

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4. EARTHWORK AND ROCKWORK

4.1 General

This section applies to all earth and rockwork required for the replacement / refurbishment / retrofitting of existing foundations or construction of new buildings foundations (if any), any types of structure and burying service lines in the ground.

The Bidder shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the detailed soil investigation and of the available information and instruction given in writing by the Owner/Consultant.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Owner/Consultant. All necessary precautions shall be taken to cause the minimum possible alteration or disturbance to the other existing foundations, material lying under and adjacent to the excavation final lines.

4.2 Fill Materials

The fill materials used and source are to be examined and approved. Excavation materials can be used if they fulfil the requirements.

a) Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials, which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas etc.

b) Ordinary fill shall have the following properties:

- Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.
- The intention is to use ordinary fill for non-built areas.

c) Special fill:

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- Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks.

4.3 Excavation

The works shall be excavated either by hand or by use of excavating plant and tools acceptable to the Owner/Consultant.

Last 300 mm shall be excavated by hand tools only to ensure that natural conditions of soil at foundation level should not be disturbed. In case if over excavation has been done, the depth of soil over excavated shall be filled with M10 Grade concrete and no earth filling shall be allowed to fill over excavated earth.

Also, excavation by hand may be required close to existing installations, existing foundations and/or underground services, but subject to special instruction of the Owner/Consultant.

The Bidder shall carry out all kind of earth and rockwork for the following particular works as defined hereafter (where applicable):-

- i) Clearing and grubbing
- ii) Excavation of topsoil
- iii) Open cut excavation
- iv) Backfilling
- v) Safety precaution during earthwork
- vi) Mining or underground excavation (if required)
- vii) Grading
- viii) Replacement of material
- ix) Trench excavation for service lines
- x) Embankments
- xi) Archaeological findings

4.4 Safety Precautions

The Bidder shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc shall be to the Bidder's debit. The additional moving of soil resulting from such damages will not be paid for.

4.5 Over Excavation

Bidder shall ensure that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

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4.6 Stockpiles and Disposal

Excavated material from the works selected by the Owner/Consultant for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on site as directed by the Owner/Consultant.

Distance of stockpiling of excavated material from the pit edge shall be minimum 1.5 meters or half of the depth of the pit whichever is higher. The Bidder shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Owner and shall not be permanently deposited elsewhere. The Bidder shall trim and form the edges of spoil to profiles and levels as directed by the Owner/Consultant.

The placing of materials within the waste disposal areas shall be made in layers not exceeding 0.50 m in thickness in order to obtain an appreciable degree of compaction by means of transportation equipment and/or if required by appropriate compaction equipment.

All traffic to or from the waste disposal areas shall run over the surface of such areas in order to achieve compaction.

4.7 Preparation of Foundation

All earth surfaces, against which concrete is to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Owner/Consultant and then protected by means of a lean concrete layer, 7.5 cm or PCC thickness as shown in the design drawings, whichever is greater. No concrete is to be poured until formation is inspected and approved by the Owner/Consultant.

No structural concrete shall be poured against earth surface. Shuttering shall be used at sides and PCC shall be provided below foundations.

4.8 Backfilling

Foundations and structures shall be backfilled with approved material compacted in layers not exceeding 150 mm by suitable equipment upto the required designed levels. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Owner/Consultant.

Density requirements as per standard Proctor Test shall be in accordance with relevant parts of IS: 2720 and all tests shall be made by/on under the supervision of Owner/Consultant at Bidder's own expenses, at optimum moisture content:

- a) Backfilling of foundations and under grade slabs - 98%
- b) Under roadways and parking areas - 98%

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c) Embankment

- 95%

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Owner/Consultant after compaction tests have been made.

Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the sub-grade.

Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Owner/Consultant.

4.9 Soil Replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange. The suitability of soil for its use for filling shall be as per provisions of Indian Standards.

Prior to the commencement of work, three samples shall be taken from the anticipated borrow area and tested in respect of IS: 2720 or Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

These three samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of not more than 15 cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for watering of soils.

The fill material shall be compacted by vibratory roller (min. weight 20T.). However for small compaction works such as small patches etc., comparatively low weight compactors or other compaction methods may be used after taking approval from Owner / Consultant. The minimum required degree of compaction should be as defined under "Tests and Properties". One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Owner/Consultant. The Bidder shall either provide all required laboratory facilities and staff to perform the tests or he shall co-operate with an experienced soil testing laboratory, subject to the approval of the Owner/Consultant.

Filling work may be continued in case all tests performed show satisfactory results.

4.10 Protection of Existing Utilities and Services

During modification/rehabilitation of existing structures or construction of new structures, the Bidder shall provide all protection for existing utilities and services as may be required by his modification and construction operations.

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Permanent protection of certain items shall be as included under other sections or as instructed by the Owner/Consultant.

In addition to the requirements as specified, herein the Bidder shall comply with the following requirements:

- a) Use all necessary precautionary and protective measures required to maintain existing structures, utilities, services and appurtenances that must be kept in operation. In particular, the Bidder shall take adequate measures to prevent undermining of existing structures and utilities/services presently in service.
- b) Protect existing or new utilities and services where required by the Bidder's operations and/or as directed by the Owner/Consultant. The Bidder shall be responsible for bracing and supporting existing structures, utilities and services to prevent settlement, displacement or damage.

4.11 Dust Control

The Bidder shall use all means necessary to control dust on roads, dismantling/demolition and modification areas, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

4.12 Dewatering during Construction

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the detail soil investigation and/or information given in writing by the Owner/Consultant.

Ground water control for keeping the construction pits dry shall be included in the Bidder's scope of work.

The method and technique shall be based on the IS: 3764.

The scope of supply includes removal of all equipment, plants, pipes, machinery, etc for modification /rehabilitation of existing foundations and re-installation of all equipment, plants, pipes, machinery, etc and its removal after completion including operation & maintenance of the equipment during the construction period.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that alterations and extensions can be made at any time throughout the operating time, if necessary. Reserve units shall be kept ready for service when failure of any of the installed units occurs.

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The Bidder has to consider the possibility of a temporary failure of any pump, diesel engine and/or the electric power service and shall install emergency power units with sufficient capacity to feed the necessary power to the installed unit at the moment of failure. The Bidder shall submit to the Owner/Consultant, the detailed method of the envisaged pumping system for dewatering, the pump capacity and the standby reserve units. The Bidder shall adjust the system if required by the Owner/Consultant.

The Bidder must ensure that any dewatering works will not cause any interference to his own work and to those of other Bidders working elsewhere on site. Any damage occurring during the above mentioned period should then be made good by the Bidder at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least [0.50] m below the foundation level.

4.13 Equipments

All equipments, instruments, machineries, tools, pipelines, etc required for execution of the water control shall be kept in good working condition throughout the operation period.

4.14 Execution

The Bidder shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to the Owner/Consultant for information and checking every working day. For that purpose, the lowering of the water table shall be controlled by piezometers. The numbers and position of them shall be submitted to the Owner/Consultant's approval. The Bidder shall provide and maintain these piezometers at his own expenses during the dewatering works or as long as the Owner/Consultant requires it.

Pump operations shall not be stopped nor pipes, channels and equipment for dewatering and water control removed or altered in any way, except with the express permission of the Owner/Consultant. The Owner/Consultant will stipulate the time of removal. Until then, the pumps and water drainage facilities shall be kept in proper working order without extra payment being granted.

Pump sumps and channels:

Provision of pump sumps and channels of the dimensions required for each particular case shall include all necessary excavation of any kind of soil above and under water, backfill and consolidation, sheeting, bracing, stiffening, sealing, scaffolding accesses, as well as the disposal of water and all auxiliary works.

Routing of channels or pipes for discharge water shall be such as not to impede or obstruct any of the other works and/or operations.

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The same shall be applicable for pump sumps. Prior to the determination of any arrangement of pump sumps, the Owner/Consultant's approval shall be obtained.

Routing and location of water discharge lines shall be submitted to the relevant authorities and to the Owner/Consultant's approval.

Difficulties during dewatering:

The Bidder shall consider all difficulties and additional work due to the presence of unexpected ground water during subsequent construction work. Where it is possible to keep off or divert such water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from Owner/Consultant has been obtained.

Ready for service condition:

The Bidder shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by the Owner/Consultant in this matter shall be carried out immediately.

Leakage:

Blockouts and pipe connections through structures and their closure, proper grouting of joints, etc or repairs in the event of leakage shall be the responsibility of the Bidder.

Piezometers:

The ground water lowering effect is to be checked by piezometers in unfavourable positions (e.g. in the middle of the building pit) before starting the excavation. The piezometers are to be installed at unfavourable positions or in more permeable layers (in stratified sub-soil) below the bottom of the excavation. They serve to check whether or not the water pressure (head) has been sufficiently reduced in those layers below the bottom of the excavation, which are more permeable. Security against hydrostatic uplift is to be demonstrated by calculation.

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5. REINFORCED CONCRETE STRUCTURES AND FOUNDATIONS

5.1. General

All structures, building foundations, machines / equipment foundation, water retaining structures, trenches, pits, etc. shall be checked / designed as per latest relevant IS codes in general. Construction in general shall follow provisions of IS: 456 and IS: 3370 for normal and water retaining structures respectively.

5.2. Design Methodology

a) General

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456.

IS: 11384 shall be followed for design of steel concrete composite beam.

For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

b) Foundation and Underground Structures

Type of foundation system, i.e. isolated, strip, raft shall be decided based on the loading arrangement, load intensity and soil strata. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

Foundation system adopted shall ensure that settlement / relative settlement is as per provision of IS: 1904 and other Indian Standards. However, the settlement shall be restricted to a lower value, if necessary as per the system requirement.

All foundation including machine / equipment foundations shall be of RCC construction. All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian standards IS: 2974 and IS: 456. Raft foundations shall be designed as per IS: 2950.

All foundations shall be treated as per the guidelines prescribed in IS 456: 2000 against sulphate/other aggressive chemicals if found present in soil or as per the requirements of detail Geotechnical Investigation Report.

For design of underground structures, subsoil water level shall be assumed at Finished Ground level. All underground pits, tunnels, basements, cable and pipe trenches, etc. shall be designed as leak proof RCC structure, where depth of ground water table so warrants. In case of leakage in the above structures injection grouting method shall be applied to repair the structure according to

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the requirement of IS: 6494. Effects of uplift and reduction in bearing capacity due to underground water table shall also be considered.

For Subsoil conditions, Average ground water table, Foundation system, Earth Pressure Coefficient, refer to detail geo-technical investigation report of the site.

The soil conditions met during the foundation works especially in the foundation level are to be checked by the Bidder's soil Engineer, recorded and compared with previous known or investigated results. If essential differences occur, which could be detrimental to the structures, the Bidder has to inform the Owner/Consultant and to propose further measures. Foundation works in such areas are to be continued only after approval of such measures by the Owner/Consultant

If there is any doubt about the soil quality or if discrepancies appear with regard to the previous decisions or investigations stated by the Owner/Consultant, then additional measures are to be taken after consulting the Owner/Consultant (e.g. additional excavation and lean concrete fill)

Allowable settlements, elastic plus consolidation, shall be limited as follows: -

- i) Total settlement : 38 mm
- ii) Differential settlement : 6 mm

Foundations for equipment shall be designed to meet the total and differential settlement established by the equipment manufacturer if they are more stringent than the allowable settlements listed above. Foundations for buildings shall be designed to meet the total and differential settlement as required for the building function if they are more stringent than the allowable settlements listed above.

c) Settlement and Expansion Joints

Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS: 8009 – "Code of Practice for calculation of settlement of foundation".

d) Foundations at Different Depths

Foundations at different levels should be based beyond a load-spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure)

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of the higher-level structures on the lower ones must be taken into consideration.

e) Replacement

If unsuitable soils are encountered below the grade slabs or basement floor, they are to be replaced by suitable layer wise compacted material down to the good bearing soil.

Materials and compaction method as well as quality control are described in clause 'Earth and Rockworks' of this section. Selected fill is to be employed below all grade paving and basement floors.

f) [Liquid Retaining Structures]

RCC water retaining structure like storage tanks shall be leak proof and designed as un-cracked section in accordance with IS: 3370 (Part 1 to IV) by working stress method. However the parts of such structures not coming in contact with liquid may be designed according to IS: 456.

Water channels and substructure of pump houses shall be designed as cracked section with steel stresses as per IS: 3370 (Part 1 to IV) by working stress method and limiting crack width to 0.2 mm.

All water retaining / storage structures shall be designed assuming liquid upto the height of wall irrespective of provision of any over flow arrangement. No pressure relieving devices shall be permitted in underground structures.

In all liquid retaining structures, PVC water bar shall be provided at each construction / expansion joint. The sequence of construction shall also be specified on drawings showing construction joints.

The walls shall be designed for a surcharge load of 2000 Kg/m² or actual whichever is higher.

Liquid Retaining Structure shall be checked for two loading conditions. With water inside up to operating level and no earth fill outside or water in one compartment and no water in the other compartment (where two compartments are provided).

Base slab / raft of all liquid retaining structure shall be designed to withstand the uplift pressure.]

g) Modification of the existing foundation (as required) for the new equipment supplied

The new equipment shall be supported on an RCC deck which in turn shall be supported over steel helical springs and viscous dampers. The steel helical springs and viscous dampers shall be supported over structural steel beams which in turn shall rest over columns. The columns shall be supported over foundation. The modification of existing foundation may involve partial to full

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dismantling and reconstruction of new foundation as per design & constraints of space.

Precautions shall be taken not to disturb the basic building structure & other foundation and it shall be ensured that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

The contractor shall be responsible for maintaining all safety norms including the stability of existing structures. Any propping, shoring and under pinning required to this effect shall be put in place before the dismantling work is undertaken.

Wherever any existing concrete member is required to be partially dismantled, a coat of epoxy paint shall be applied to the exposed reinforcement and the cut surface of concrete shall be built up by providing 40 mm thick concrete with wire mesh.

h) Machine Foundations

General

Design of equipment foundation for block type machine foundation (if any) shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in mind the existing structural arrangement and space limitation.

The design of machine / equipment foundation shall be as per IS: 456 and IS: 2974. The provisions of DIN 4024 shall also be followed for machine foundations. All machine / equipment foundations and structures subject to vibrations shall be suitably proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

For the foundations supporting minor equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining part of building and other foundations. Joints at floor/ slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitable to ensure integral action.

The extent of foundation shall be based on the general arrangement of the equipment and the design requirement. However minimum width of any

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foundation shall not be less than one meter. Water table has to be considered at finished ground level for design of all foundations.

Suitable arrangement shall be made for prevention of transmission of vibration from the proposed foundation to the nearby structure/ foundation/ paving slab.

All design calculations and drawings shall be submitted to Owner for approval.

In case any modification to any existing nearby structural steel bracing/support system/ concrete work is required, the contractor shall check the adequacy of the design of the existing structures for the new loads. Suitable modification to the existing structure as required shall be carried out by the contractor.

Loose pockets if any found below the foundation shall be removed and filled up with PCC of grade M10.

Loads

All static and dynamic forces / loads which equipment supplier considers applicable shall be considered for analysis and design of machine foundations.

Foundation Sizing

The outline plan dimensions of foundations as given by the machine supplier will be adopted. The height of foundation will be selected after taking into consideration soil strata and operating level of the machine. The eccentricity of common CG of machine and foundation with respect to the centroid of base area should not exceed 5 % of the corresponding base dimensions of foundation. Partial contact between the foundation and soil strata shall be considered wherever applicable. The footing will be checked for minimum contact area of 80 % and maximum bearing pressure will be calculated for the actual contact area only.

Analysis and Design

The minimum grade of reinforced cement concrete shall be M25, unless specified otherwise.

The analysis and design of machine foundations will be carried out to ensure the following:

- Compliance with the manufacturer's requirements and relevant standards
- No resonance phenomenon of a disturbing nature to machine operation should exist at the normal running speed
- Calculations to be performed for dynamic as well as static cases for reinforced concrete block type pedestal
- Soil bearing capacities
- Deep foundation capacities
- Lateral earth pressures
- Allowable settlements

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- Structure, equipment and environmental loadings
- Equipment performance criteria
- Access and maintenance requirements
- Temporary construction loadings

The foundation will be designed for the most critical combinations of forces and moments, resulting from all possible combinations of the various loading from the equipment system. The foundation sections will be sized and reinforced adequately for bending moments and shear stresses and uplift.

The foundation shall be checked for overturning, sliding and uplift as per relevant IS Codes. The foundation will be checked for overturning with minimum and maximum vertical loads.

For analysis of machine foundation following data will be furnished by the equipment manufacturer:

- Loading diagram showing static and dynamic loads and points of application of loads
- Operating speed of machine
- Weight of rotating parts, maximum eccentricity of rotating mass from the geometric axis of rotation
- Location of C.G. of machines in all three axis
- Mass moment of inertia
- Allowable amplitude / velocity of vibration at machine bearing points
- Temperatures at various areas during operation

While designing following aspects shall also be taken care of:

- All dynamic foundations shall be isolated from building foundations. The isolation gap shall be of minimum 25 mm.
- Natural frequencies of structures and components shall be away from running speed of equipment by at least 20 % generally but for important ones it shall be away by at least 30 %.
- For design of foundation of large fans etc., provision shall be kept in the foundation for addition of mass / area for retaining of the foundations if required at a later date

However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral loads shall be 1.5
- Factor of safety against sliding shall be 1.5
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5. Uplift check shall be carried out during construction stage also.

For miscellaneous machines, most suitable type of foundation shall be provided. Foundation for pumps, and minor rotating equipment etc., are usually in the form of solid block foundations, resting on the ground or on a floor of the

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building. At such machine supports, floor may be thickened and extra reinforcement may be provided. Also the machines, which are almost vibration free, light to moderately heavy, may be supported in the above manner. Rubber or neoprene pads under some of these machines to reduce transmission of vibrations to the supporting floor will be provided if required.

All block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456. Suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining foundations.

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25°C when placed. For maintaining the temperature of 25°C in the top decks of machine foundations, crushed ice shall be used in mixing water.

Non-Shrink Grout for Equipment Foundations

Special non-shrinking grout of approved make shall be provided in strict accordance with the manufacturer's instructions / specifications. Ready mix non-shrink grout of GP2 brand or equivalent, of approved make shall be used for base grouting of major rotating equipments.

i) Increase in Stresses

Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

Bearing capacity of the soil shall be allowed to be increased by 25 % under seismic/ wind load condition.

j) Elevated Foundations

Design of all equipment foundations shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in view the existing structural arrangement and space limitation. Adequacy of the design of the existing structures, for the new loads shall be, checked by the contractor. Suitable modification as required shall be carried out by the Contractor and complete design for the same shall be furnished to owner for approval. Where ever new columns/foundation is required the same shall be designed and constructed by the contractor as per relevant Indian Standard Code.

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For the foundations of the all equipments details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic forces as per IS:1893. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Design of RCC foundations/as well as structures, checking of design of existing structure shall be carried out by working stress method. A fatigue factor of 2.0 shall be considered for dynamic forces.

The foundation general arrangement shall be such that the spring units are placed over the structural steel beams. The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The vibration amplitudes at the bearing locations shall not exceed the limits as per VDI 2060 or limits specified by the machine supplier whichever is more stringent. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

The grade of concrete for the top deck shall be M35.

k) Steel Helical Springs and Viscous Dampers

The supporting structural beam and columns shall be designed for the loads transferred through springs and all other loads such as piping loads, seismic loads as per IS:1893. The stiffness of the beams supporting the springs shall be at least 10 times the stiffness of the springs supported over it along both vertical and horizontal direction.

The scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implied for the successful completion of the work for which these specifications are intended.

Scope of work of the bidder shall include manufacturing, testing, supply, transport to site, pre-stressing, erection, supervision of erection, release of pre-stress, alignment, commissioning etc of Steel helical springs and viscous dampers:

- Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
- Frames for pre-stressing of spring elements.
- Suitable hydraulic jack system including electric pumps, high- pressure tubes etc. required for the installation, alignment etc, of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.
- Any other items which may be required for the complete installation and satisfactory commissioning of the spring system.

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Supervision of complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

The steel helical springs and viscous dampers supplied should be of proven make. The bidder or his sub-contractor should have designed spring supported machine foundations, manufactured, supplied and installed steel helical springs and viscous dampers (conforming to DIN 2096 & DIN2089) and viscous dampers (providing damping resistance in all three planes) for not less than 2 (two) machine foundations of heavy rotating machine systems.

The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of units.

All design calculations and drawings shall be submitted to Owner for approval.

5.3. Stability of Structures

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like underground storage tanks, pits, trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For the purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area of the base slab shall be taken in to consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS: 456 and other latest relevant IS codes. However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum
- Factor of safety against sliding shall be 1.5 minimum
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

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In cases where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

5.4. Minimum Thickness of Concrete Structural Elements

The following minimum thickness shall be followed:

Table 2.5
Minimum Thickness of Concrete

S.No	Description	Thickness, mm
a)	Suspended floor / slab / walkways /canopy slabs, etc.	125
b)	Ground floor slab (non-suspended)	150
c)	Water Retaining slabs / walls	200
d)	Cable/pipe trenches/underground pits/Laundry walls and base slab	125
e)	All footings (including raft foundations)	300
f)	Parapets	125
g)	Sunshades	75 at edge
h)	Precast louvers / fins	50
i)	Precast trench cover slabs / floor slabs / louvers	75
j)	Paving	100
k)	Basement walls and base slab	200
l)	Underground tank:	
	Below ground water table	200
	Above ground water table	150

From fire resistance point of view minimum cover to reinforced concrete members shall be as per Table 16A of IS: 456.

5.5. Minimum Heights for Pedestal of Steel Columns

Pedestals to Steel Columns for building structures:

Top of RCC foundations (pedestals) shall normally be kept at a minimum [250 mm] above finished floor level (FFL) unless specified otherwise. Foundation levels for columns shall be decided to accommodate underground services, pits, trenches, etc.

Stair and ladder pedestal shall be kept [200 mm] above the finished floor level.

Pedestals to Steel Columns for Equipment structures:

a) Equipment in open area : as required [(300 mm min)]

b) Equipment in covered area : as required [(150 mm min)]

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c) Structures and equipment

Supplied by vendor : as per vendor's data subject to minimum as specified above.

5.6. Minimum heights for encasement of steel columns

In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following:

- a) Open area : [300 mm] above paved level
- b) Covered area : [150 mm] above FFL

5.7. Concrete Works

i) General Description, Proportions and Mixing

Mix Design

At the commencement of the contract the Bidder shall make preliminary tests to determine the proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling and placing and when concrete hardens, it shall have the required strength, durability and surface finish. The Bidder shall get approval of Owner/Consultant to such proportions before he starts concreting. However, such approval shall not relieve the Bidder of his responsibility to produce concrete having compressive strengths as laid down in the foregoing Table.

No departure from the approved proportions will be permitted during the works unless and until the Owner/Consultant gives written authorisation for any change in proportion. The Owner/Consultant shall have authority at any time to check whether the mixing of concrete is being carried out according to the approved proportions.

For the all major and important R.C. works and for all special works, the design of mixes shall be made by the Bidder at his own cost, for each grade of concrete as well as for various workability. The design of mixes shall be made according to I.S. 10262 or any other approved standard methods.

The concrete made by designing the mix is termed hereinafter as "Design Mix Concrete".

The cement content for various grades of concrete shall be based on design mix. However, irrespective of requirement of cement found out from design mix, cement content of concrete shall not be reduced below the quantities specified as under.

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Grade of concrete	Minimum cement content per Cu.m finished concrete
M-15	290 kg
M-20	320 kg
M-25	380 kg
M-30	not less than 400 kg
M-35	not less than 400 kg

Water Cement Ratio

Where a particular water cement ratio is stipulated in the design or drawing along with the characteristic grade of concrete the design of mix shall be carried out by adjusting the other variable factors to obtain the characteristic strength of concrete with stipulated water cement ratio.

In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, such as water retaining structures, basements, underground premises, tunnels, pump houses, pre-stressed structure, thin precast members etc. the water cement ratio shall be kept low and preferably not exceeding 0.45.

The water cement ratio, as achieved in the Mix Design, or as specified in the drawings shall be adhered to strictly and shall not be varied without the permission of the Owner/Consultant.

Workability

The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling & placing so that after compaction it becomes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

The workability of fresh concrete at the place of batching/mixing shall be measured by compacting factor test and at the place of disposition by means of slump test. During the finalisation of Trial Mixes, the relationship between compacting factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS:1199.

Normally, in the condition of low water cement ratio as well as for medium/high workability, the workability shall be achieved by increasing the cement content, in consistent with added water.

In cases where the cement content is to be limited to reduce the heat of hydration, and the water/cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of plasticiser or air entraining agent. In such cases the method of mixing and dosage of the plasticiser/air entraining

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agent shall be according to the manufacturer's specification and with the approval of the Owner/Consultant.

The usual limits of consistency for various types of structures are given below:

Limits of consistency

Degree of Workability	Slump in mm with Standard - Cone		Use for which concrete is suitable as per IS : 1199
	Minimum	Maximum	
Very low	0.0	25.0	Large mass concrete structure with heavy compaction equipment, roads and the like.
Low	25.0	50.0	Uncongested wide and shallow R.C.C structures
Medium	25.0	75.0	Deep but wide R.C.C structures with congestion of reinforcement and inserts
High	75.0	125.0	Very narrow and deep R.C.C structures with congestion due to reinforcement and Inserts

Durability

The durability of concrete, depending on the exposure condition, is to be taken into account while designing the mix. For given aggregates, the cement content should be sufficient to make sufficiently low water cement ratio and Appendix A of IS: 456 shall be taken as guideline for durability considerations.

Minimum fire rating of 2 hours shall be considered where fire hazard is expected and accordingly minimum cover shall be taken as per Table 16 A of IS: 456. For structures below ground level which are exposed to sulphate attack, requirement of cement shall be as per Table 5 of IS: 456. Intermixing of different grades of concrete in the same structure shall not be allowed in a particular element.

Mix design concrete shall be used for all areas other than plain concrete work used for lean concrete, screeds and backfill.

The following minimum grades of concrete as per IS: 456 shall generally be used for the type of structures noted against each grade.

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Table 2.6
Grades of Concrete

Concrete mix/Grade	Type of structure
1:5:10	Fill concrete
1:4:8	Blinding layer below foundations, trenches and underground structures, foundation below brick wall, etc. Minimum thickness of layer shall be 75 mm
M15	Plinth protection work around buildings
M25	Base plate encasement, encasement of structural steel work, all RCC paving work, ground floor slabs, cable and pipe trenches, precast concrete work etc.
M30	All RCC structures and equipment foundations, super structure, grade beams, columns, roof slabs and all underground RCC structures, cable and pipe rack foundation, pedestals, etc. water retaining structures below and above ground, TG foundations, etc.

Inter mixing of different grade of concrete in the same structure shall not be allowed normally.

ii) Trial Mixes

- Before concreting commences, the Bidder shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation. Only materials which the Bidder intends to use for concreting (including all admixtures) shall be used in the trial mixes.
- Test cubes from trial mixes shall be made and tested in accordance with IS: 516.
- As per IS: 456 and IS: 516, three separate batches of concrete should be made, workability of each batch determined and three test cubes shall be made from each batch for each age (e.g. for 7 and 28 days) at which tests are required. The strength shall conform to target mean strength as per IS: 456 – Requirements for design mixes.
- The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength and if the average strength of the nine cubes is not less than recommended by IS: 456 and IS: 516, trial mixes.

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iii) Quality and Testing

Not more than 5% of the test results may fall below the 28 days specified strength. Making and curing of test specimens shall be in accordance with relevant IS: 456, IS: 516 and IS: 1199.

All mixes can only be placed following approval by the Owner/Consultant. The mean strength shall exceed the characteristic strength by a margin of 1.65 times the standard deviation expected from the batching plant. However, no standard deviation less than 3.5 N/mm² shall be used as a basis for designing a mix.

iv) Trial Mixes and Field Tests

Sufficient laboratory trial mixes shall be prepared to show that concrete complies fully with the specified performance criteria. The following tests are to be included:

- Air content < 1%
- Slump: Piles 170 + 25 mm, regular work 80 + 20 mm as per IS: 1199
- Fresh and hardened concrete densities
- Field trial mixes shall be carried out under full-scale site conditions as per IS: 4925 (for structural concrete only).
- Where directed by the Owner/Consultant, concrete incorporating reinforcement details shall be cored to assess stratification of mixes. Cores of 150 x 200 mm (diameter and length) shall be used.
- Each trial mix shall have 9 x (150 x 150 x 150 mm) cubes taken to measure 24 hours/7 days and 28 day compressive strengths. These trials shall be run for three consecutive days (for structural concrete only).
- At least 3 x sets of field trials shall be tested according to the provisions laid down in laboratory testing.
- The average 28 day characteristic strength for trial mixes shall be as per IS: 456. Failure to comply shall result in the mix having to be re-designed.
- All test results shall have to be complied before approval can be given.

v) Consistency of Concrete

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be

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checked by slump tests measured in accordance with IS: 1199 and shall not exceed the values given in clause 7.1 of IS: 456-2000.

vi) Mixing of Concrete

- The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way and shall comply with the requirements of IS: 456, IS: 1791 and IS: 12119.
- The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than 2 (two) minutes after all the materials and water are in the drum.
- Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

vii) Laboratory

The Bidder shall establish and maintain a field laboratory on the site and this laboratory shall be available at all time to the owner.

The laboratory must have qualified technicians to carry out all tests and must be adequately equipped to ensure that all necessary testing work can be carried out in compliance with the standards.

5.8. Strength of Concrete

i) Testing of fresh concrete by means of test cubes

- a) All test cubes shall be made and tested for compressive strength in accordance with IS: 456, IS: 516 and IS: 1199.
- b) The minimum required strength for different classes of concrete shall be as shown in clause "General description and proportions and mixing" here above.
- c) The grade of concrete required will depend partly on the particular use and the characteristic strength needed to provide the structure with adequate ultimate strength and partly on the exposure conditions and the cover provided to any reinforcement.
- d) A minimum of four test samples (of six test cubes each) shall be taken on each concreting day (from the same mix) and for at least each 40 m³ of concrete mixed. At least one sample shall be taken for each shift.
- e) For columns, beams and cantilevers seven (7) cubes for every 15 m³ of concrete poured shall be taken. The concrete for test samples shall be

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taken directly from the concrete mixer and shall be handled (vibrated etc) under similar conditions to those prevailing during the construction. The moulds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.

- f) The strength level of each type and each strength concrete will be evaluated separately and the concrete strength will be considered satisfactory if:
- Compressive strength: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-
 - The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column 2 of table 11 of IS: 456.
 - Any individual test result complies with the appropriate limits in column 3 of table 11 of IS: 456.
 - Flexural strength: When both the following conditions are met, the concrete complies with the specified flexural strength:-
 - The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm².
 - The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm².
- g) If the results are less than those specified, the Owner must suspend all concreting work and order further tests. Any concrete found not to comply with the specification shall be broken out and replaced to the satisfaction of the owner.
- h) The Bidder shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

ii) Testing of concrete in structures

- a) The types of tests described hereinafter are applicable to the finished parts of the structures. They may be used in routine inspection and for quality control.
- b) Type of tests:
- Cutting cores: The procedure used shall comply with the requirements of IS: 516 or an approved equivalent standard.
 - Gamma radiography: The testing shall be carried out in accordance with the requirement of IS: 13311, part 1 or equivalent.
 - Ultrasonic test: Such tests may be used to obtain approximate indications of the strength of the concrete in the structures (IS: 13311, part 1).

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- Electromagnetic cover measuring devices: Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design (IS: 13311, part 1).
 - Rebound hammer test: Such tests may be used to obtain approximate indications of the strength of the concrete (Ref. IS: 13311, part 2).
 - Load tests of structures or parts of structures: If the results of the above mentioned check tests show that the quality of the materials is inadequate or if other defects are revealed, the owner may require a loading test to be made.
- c) For the purpose of testing floors, roofs and similar structures and their supports, the test load shall be equivalent to the sum of the characteristic dead load and one-and-a quarter times (1.25 times) the characteristic imposed load for a period of 24 hours which the works or part thereof to be tested have been designed.
- d) Wherever certain procedures for testing of parts in structures are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Owner/Consultant.
- e) If within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under superimposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.
- f) If the result of the test is not satisfactory, the Owner/Consultant shall instruct that the part of the works concerned be taken down or cut and reconstructed to comply with this specification. The Bidder shall at his own cost take down or cut out and reconstruct the defective work.
- g) The Owner/Consultant may require other tests to be made. Number of samples, tests and types will be as per Owner requirements.
- h) All the costs for the above mentioned tests shall be borne by the Bidder.

5.9. Materials

a) Storage of materials

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Storage of materials shall conform to IS-4082 "Recommendation on stacking and storage of construction materials and components at site". Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Bidder.

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b) Cement

OPC/PPC Cement of reputed make conforming to relevant codes, shall be used for all Concreting works and the certificate of manufacturer shall be furnished with each batch. Cement used shall be ordinary Portland cement unless the chemical nature of the soil warrants special cement for structures below ground level.

Sampling and Testing of Cement

- All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties as required by relevant IS: 8112 for grade 43 and IS-12330 for sulphate resistant cement.
- The manufacturer's test certificate will normally be accepted as proof of compliance with the specification, but the Owner may order further tests of a character specified in the appropriate Indian standards. The confirmatory tests are to be conducted by a recognized quality control organization. The Bidder shall bear all expenses required for the preparation, dispatch, and tests of the samples. In case the results of such tests show any sample to be inferior to specifications, the whole consignment from which the sample was taken shall not be used and shall be immediately removed from the site.

Delivery and Storage of Cement

- The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture, date of original loading, destinations en-route, date of unloading, intended date of delivery to site.
- The Bidder shall obtain and provide to the owner the manufacturer's average test certificate for each consignment of cement to the works.
- The certificates shall be provided before the consignments are required for use and shall show the chemical composition and physical properties determined in accordance with the relevant standard.
- Samples shall be taken from each consignment of cement and tested as directed by the owner in an approved independent laboratory.
- Consignments shall be used in the order in which they were delivered.
- Bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the owner before any cement is delivered to site.
- Each consignment of cement shall be separately stored for ease of access, identification, inspection and sampling. Sufficient stocks shall

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be maintained on site to ensure the proper progress of the works and the stock holdings shall be to the approval of the owner.

- No cement from any consignment shall be used in permanent works without the approval of the owner.
- Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter or which has been contaminated or is otherwise unsatisfactory in the opinion of the Owner/Consultant will be rejected and shall be removed from site without delay.
- The Bidder shall be responsible for satisfying himself that the performance characteristics of cement are not such as to necessitate excessive cement content or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete notwithstanding apparent compliance with this specification.

c) Reinforcing steel

General

Reinforcing steel used in reinforced concrete shall comply with the following standards:-

Deformed bars shall be of grade Fe500 and conform to IS: 1786.

Mild steel shall conform to IS: 432.

Mesh reinforcement shall conform to IS: 1566.

Binding wire

Binding wire for general use shall be annealed wire 16/18/20 BWG conforming to IS 280. The number of strands shall be as per IS specification.

Reinforcement supports

- Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing; supporting, and fastening the reinforcement.
- Spacers shall be cast from concrete of the same quality as that in which they will be embedded.
- Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.
- Binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the Bidder shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

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Certificates

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analyzed and the date of such tests and analyses and that such tests and analyses comply in all respects with the standards. The following tests shall be carried out on reinforcement:-

- Cast analysis
- Carbon equivalent value
- Tensile strength, yield stress, elongation
- Bend test
- Bond classification
- Chemical analysis

Stock of reinforcing steel

In order to ensure due progress of the works, the Bidder shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted as satisfactory by the Owner/Consultant.

Rejection

The owner at his discretion may order random testing of the reinforcement steel and in the event of any failed test reject the entire lot notwithstanding the manufacturer's or coating applicator's certificates.

The Bidder shall remove all rejected reinforcing steel from the site without delay at his own expense.

Storage

All bars for reinforcement and steel fabric reinforcement shall be stored on the site under cover on timber or concrete supports suitably spaced and of sufficient height to keep the steel not less than 150 mm clear of the ground.

Bar-bending Schedules

The Bidder shall prepare bar bending schedules based on the detailed reinforcement drawings. These shall be presented to the Owner/Consultant for review. The Bidder is fully responsible for their completeness and correctness in every way nor shall any claim for extra cost or time be allowed on the grounds of errors or discrepancies which may arise between drawings and schedules.

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d) Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. pH value of water shall not be less than 6.

Only potable water shall be used. Tests and quality of water shall be in accordance with IS: 456 or equivalent.

e) Aggregates

General

The aggregates for concrete shall be crushed natural rock subject to Owner's approval.

The aggregate to be used in the work shall be supplied from an established pit or quarry.

The concrete supplier shall obtain from the aggregate producer, or otherwise provide current test, examination, and inspection reports performed and certified by an approved laboratory for submittal to the Owner/Consultant.

As a minimum, this information shall include the following items:-

- **Item 1**

A comprehensive description, with current photographs of the pit or quarry, including but not limited to, identification by name and location, type of deposit, age, potential reserves, primary products by size including average gradation based on previous six (6) months production and the range for each sieve size; mining methods, process equipment, quality control organization and laboratory; the primary and alternate means of product transportation; listing of primary and secondary users of the product.

- **Item 2**

Petrographic examination in accordance with IS: 2386 (Part-8) and ASTM C-295 performed by a qualified concrete aggregate petrographer. This report shall be based on material produced and examined within the previous six (6) months and must be representative of the current production.

- **Item 3**

Coarse aggregate shall be sampled from current production in accordance with IS: 2386 (Part 1 to 8). Three [20 mm, 10 mm & 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:

IS 2386(Part 1): Methods of test for aggregates for cement: Part 1
Particle size and shape (Amendments 3)

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- IS 2386(Part 2): Methods of test for aggregates for concrete: Part 2 Estimation of deleterious materials and organic impurities (Amendment 1)
- IS 2386(Part 3): Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking
- IS 2386(Part 4): Methods of test for aggregates for concrete: Part 4 Mechanical properties (Amendments 3)
- IS 2386(Part 5): Methods of test for aggregates for concrete: Part 5 Soundness
- IS 2386(Part 6): Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregates (Amendments 2)
- IS 2386(Part 7): Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity
- IS 2386(Part 8): Methods of test for aggregates for concrete: Part 8 Petrographic examination
- ASTM C-295 Standard guide for petrographic examination of aggregates for concrete

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the Owner/Consultant shall meet the requirements of IS: 383 and IS: 456.

Testing is to be carried out at the following intervals:

Table 2.7
Grades of Concrete

Type	Coarse Agg.	Fine Agg.
Grading	Daily	Daily
Specific Gravity	7 days	7 days
Magn Sulphate soundness	30 days	-
Clay, Silt and dust content	Daily	Daily
Shape (elongation and flakiness)	3.5 days	-
Los Angeles Abrasion	Initial stage only	Initial stage only
Moisture content	2 days	Daily
Drying shrinkage	Initial only	Initial only
Organic impurities	30 days	30 days
10% fines value for concrete	7 days	-

Combined grading shall also be done on a daily basis.

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Storage and handling of aggregates

- Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent wind blown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.
- Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect against wind blown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.
- Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.
- Rescreening Coarse Aggregate: Rescreening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If rescreening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.
- Natural or manufactured sand shall be allowed to drain until it has reached somewhat uniform moisture content before it is used.

Fine Aggregate

Fine aggregate source shall be manufactured crushed stone or river sand, excluding fines, which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone nor 4% for natural sand.

The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

Crushed Stone Sand

- i) Concrete subject to abrasion 1% by weight
- ii) All other concrete 3% by weight

There shall be no clay or fine silt present.

The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on an IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

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Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS: 383.

The grading of the aggregates should be such as to produce a concrete of the specified proportions, which will work readily into position without segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of silt adhering to the aggregate is found to be unacceptably high.

Coarse Aggregate

Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The unit weight of the coarse aggregate shall not be less than 2.5 t/m³. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm² when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

Samples of aggregates shall be submitted to the Owner/Consultant, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the Owner/Consultant have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

f) Concrete additives

Use of Concrete Additives

Concrete additives approved by the Owner/Consultant shall be used to improve consistency, workability, quality and strength of the concrete.

Chemical admixtures manufacturer shall provide certified test reports from qualified independent laboratories showing actual test results indicating material that complies in all respects with the applicable specification.

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Admixtures used in concrete shall conform to the appropriate specification and requirements as indicated below:-

- Air entraining admixtures shall conform to IS: 9103.
- Water reducing and retarding admixtures shall conform to IS: 9103. Accelerating admixtures shall not be used.
- High range water reducers shall be naphthalene-sulfonated polymer based material. No admixtures containing chlorides shall be used.
- Chemical admixture suppliers shall provide certified test reports with each shipment indicating compliance with the appropriate specification. The test reports shall include the chloride content of the admixture, specific gravity and solids content.
- Fibers: Polypropylene fibers shall be collated, fibrillated polypropylene fiber of approved manufacture.
- Admixtures used in production of concrete shall be the same as used in establishing the required concrete mix and shall be used in accordance with the manufacturer's directions.
- Liquid admixtures shall be stored in such a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations

Accelerating and Retarding Additives

Such additives shall only be used in case of necessity and after obtaining the written approval of the Owner/Consultant.

Plasticizers and Air entraining Additives

Plasticizers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Owner/Consultant and in accordance with the manufacturer's instructions.

5.10. Dismantling/Demolishing and Modification in PCC&RCC

- The dismantling implies, carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of a structure. This includes chipping work, cutting of reinforcement, making holes/opening etc. in concrete members, according to the required shape, size and profile at all elevations.
- The term demolition implies, taking up or down or breaking up of a structure/member, in part or full, as specified or shown in the drawings or as directed by Engineer.
- In a structural member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as directed by the Engineer.

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- All material obtained from the demolition/dismantling work shall be property of the Owner, unless otherwise specified.
- All serviceable materials obtained, shall be separated out and stacked properly upto a lead of [500 meter] or shall be returned to OWNER's stores and all unserviceable materials, rubbish etc., shall be disposed off as directed by the Engineer, upto a lead of [2kms].
- The dismantling / demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process or work.
- Necessary propping, shoring and under pinning shall be provided for safety of adjoining work or property which is to be left intact, before dismantling/demolishing work.
- All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall be taken to keep the dust nuisance down. Safety requirements stipulated in IS: 4130 shall also be followed.
- As and where necessary, the dismantled/demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Engineer. Wherever required, temporary enclosures shall be erected to minimize the dust or moisture infiltration.
- Wherever fresh concrete is laid over old concrete, to ensure proper bond between old concrete and fresh concrete, the surface of old concrete shall be thoroughly cleared by removing all loose particles and coat of epoxy paint shall be applied.

5.11. Minimum Cover to Foundation Bolts

Minimum distance from the centre line of foundation / anchor bolt to edge of pedestal shall be the maximum of the following:

Clear distance from the edge of base plate / base frames to the outer edge of the pedestal shall be minimum 50 mm

Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm

Clear distance from the edge of sleeve or anchor plate to the edge of pedestal shall be 75 mm

5.12. Miscellaneous Requirements

Fillets at the junction of roof and vertical walls shall be provided with cast in-situ cement concrete 1:2:4 (nominal mix) followed by 12 mm thick 1:4 cement mortar.

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A screed layer not less than 100 mm thick of cast in-situ concrete of nominal mix 1:3:6 shall be provided below all water retaining structures. A sliding layer of craft paper or bitumen paper shall be provided over the screed layer to destroy the bond between screed and base slab.

Plywood formwork shall be used for all water retaining / conveying structures and for all over ground concrete works. For other areas steel/ plywood formwork shall be used.

Unless specified 20 mm and down graded aggregates shall be used for all structural concrete works. However 40 mm and down graded aggregates may also be used under special conditions for foundation.

Tolerance for formed and concrete dimension shall be as per IS: 456.

5.13. Major Equipment Foundation

Special requirements for concreting of major equipment foundations shall be as given below:

Coarse Aggregates

Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali aggregate reaction. Materials, which contain high percentage of reactive silica, shall not be used. In exceptional cases of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations, which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundations).

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25° C when placed. For maintaining the temperature of 25° C in the top deck of machine foundations, crushed ice shall be used in mixing water.

Admixture

Plasticizer cum retarder/accelerating type admixture shall generally be added to the concrete for promoting workability in addition to retarding / accelerating setting time for mass concreting work. The Bidder shall submit the mixing proportion/report after conducting the design mix as per the relevant codes and standards. The slump of concrete shall generally be in the range given below:

TG Top deck	: 150mm to 200mm
BFP	: 100mm to 150mm
Block foundation	: 100mm to 150mm
Column	: 100mm to 150mm

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Formwork

Plywood formwork shall be used for the top deck of all machine foundations and also for columns of TG foundation. Any other type of formwork required to be used may be permitted subject to prior approval of the owner after submission of the required data.

Scheme for Concreting

Batching plants shall be mobilized for all RCC works. Concrete pump shall be mobilized for TG raft, TG Top deck, BFP Deck etc. Arrangements for stand-by Plant and Equipments shall also be made.

Placing of Concrete

Base mat as well as top deck of machine Foundations shall be cast in a single pour. However the BIDDER shall submit method statements for various structures and shall get the prior approval from the OWNER/CONSULTANT before placing the concrete.

Ultrasonic Testing

Ultrasonic pulse velocity test shall be carried out for the top deck of all machine foundations to ascertain the homogeneity and integrity of concrete. In addition, additional cubes (at the rate of one cube per 150 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values. Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the BIDDER shall rectify the defects suitably using cement / epoxy grout etc.

5.14. Transport of Concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods, which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The Concrete shall be transported by transit mixers of adequate capacity. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Owner/Consultant.

The Bidder shall obtain permission well in advance of any concrete pour.

5.15. Concreting Operations

Inspection prior to Concreting

All concreting methods shall be subject to the approval of the Owner/Consultant.

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Concrete placing shall not be started until the Owner/Consultant has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

Placing of Concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The Bidder shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

The temperature of concrete shall not exceed 40°C measured at discharge into the works.

The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable differential temperature between any two points in the same element is 15°C. Additional temperature control measures during construction (such as the use of insulated formwork) will be required. Bidder to prepare a process control chart and method statement verifying measures to achieve these requirements.

Temperature monitoring of concrete work is required where:

The minimum dimension of any casting is 0.8 metres or more, or otherwise instructed by the Owner/Consultant.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours time shall be subject to the same treatment as the construction joints.

Concrete shall not be dropped into place from a height exceeding 1.5 metres. Trunking and chutes to Owner/Consultant's approval shall be used for any concrete to be deposited from a height exceeding 1.5 m.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

5.16. Compaction and mechanical vibration of concrete

As concrete is being placed it shall be compacted by mechanical vibrators complying with IS: 2505, IS: 2506, IS: 2514 & IS: 4656, to obtain a dense material free from honeycombing, free from water and air holes.

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The Bidder shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation/bleeding caused, but complete compaction of the concrete is achieved.

5.17. Finish of concrete

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

5.18. Construction, expansion and contraction joints

Construction joints

The number of construction joints should be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subject to agreement between the Owner/Consultant and the Bidder before any work commences. Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Concrete should not be allowed to run to a featheredge and vertical joints should be formed against a stop board.

The top surface of a layer of concrete should be level and reasonably flat unless design considerations make this undesirable. Joint lines should be so arranged that they coincide with features of the finished work.

If a kicker (i.e. a starter stub) is used it should be at least 70 mm high and carefully constructed. The kicker must be incorporated with the previous concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

The maximum horizontal length of wall to be poured in one operation in any one direction is 7.5 metres. A period of 7 days to be allowed between adjacent pours except where water stops are provided when this can be reduced with Owner/Consultant's approval. Alternatively a gap of 600 mm width shall be left between adjacent pours and filled after 7 days from the date of formation subject to Owner/Consultant's approval.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is

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exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible a vibrator should be used.

Where the Owner/Consultant considers that special preparation is necessary, i.e. for an in-situ structural connection, preparation should be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush, which is sufficient to remove the outer mortar skin and expose the larger aggregate. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking of hardened surfaces should be avoided.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.

Joints shall be straight and vertical, except where otherwise specified, and concrete surfaces on both sides of the joint shall be flush. Where necessary, water stoppers of a type approved by the Owner/Consultant shall be embedded in the concrete. The water stopper should be made of high quality material, which must obtain its resilience through the service life of the structure for the double function of movement and sealing. The surface of water stoppers should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints the water stopper should be provided with anchor parts. The cross-section of the water stoppers should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

All joints between structural steel and concrete parts shall be sealed by a suitable permanent flexible compound.

5.19. Concreting at night

When approval is given to carry out concreting operations (under control of the Owner/Consultant) at night or in places where daylight is excluded, the Bidder has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

5.20. Protective measures for concrete

In general, the cover of rebars shall be as per IS: 456 taking into account the site conditions. However, the minimum concrete cover shall not be less than:

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Concrete parts above ground (external surface)	: 40 mm
Concrete exposed to underground & groundwater	: 50 mm
Isolated footings	: 50 mm
Raft	: 75 mm
Slabs	: 25 mm
Beams	: 25 mm
Columns	: 40 mm

Immediately after the compaction of the concrete has been finished, the Bidder shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constant moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Owner/Consultant. Where formwork cannot be removed within 24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Owner/Consultant's approval to the use of a particular curing compound and to the method of application will only be given after the Bidder has completed satisfactory site trials and a sample panel has stood for at least 28 days.

Where large sections of concrete are poured, special precautions to the approval of the Owner/Consultant shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete.

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind, however light, shall be allowed on concrete which has not properly set and the Bidder shall prevent any load to be imposed on the concrete structures until it has been declared by the Owner/Consultant to be ready to carry loads.

5.21. Concrete with Special Properties

General requirements

The pre-condition for obtaining concrete with special properties is that it should be made with the appropriate composition, that it is placed in such a way that segregation does not occur and further that it is fully compacted and given appropriate curing.

Waterproof concrete

This concrete must meet the provisions of IS: 3370. Waterproof concrete must be sufficiently dense (impermeable).

Waterproofing and protection of underground concrete structures

Water aggressive to concrete should be kept away from the fresh concrete.

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Concrete, which is exposed for a prolonged period to “very severe” chemical attack, must be protected against direct access of the aggressive substances.

The protection, which is to be laid as protection to all concrete surfaces in contact with the ground, shall consist of an approved waterproofing membrane. The membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane.

Such membranes shall be PVC sheets of minimum 0.35 mm thickness with knobs of Maxlock.

The waterproof membranes shall be installed in strict accordance with manufacturer’s instructions.

The membranes shall extend 15 cm above ground level.

When setting forms and reinforcing steel caution shall be exercised to avoid damage to the impervious membrane. The surface of the impervious membrane extending outside the forms shall be protected during subsequent operations.

Any puncture or damaged areas shall be cleaned and patched according to manufacturer’s instructions.

Concrete with high wearing resistance

Concrete which is exposed to severe mechanical action, e.g., due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, should possess high wearing resistance and correspond at least to grade M30.

The aggregate upto 4 mm size should consist predominantly of quartz or materials of at least equal hardness; the coarser particles should consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action, it will be necessary to use special hard materials. The particles of all types of aggregate should have a moderately rough surface and be of compact shape. The combined aggregate should be as coarsely graded as possible.

Furthermore, the concrete should be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete should be kept moist for at least 7 days after placing.

Finishing of formed surfaces

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that shall be covered with earth backfill. Exterior surfaces that shall be exposed above grade and all interior surfaces, except those not usually exposed to view shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

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Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed. The resulting recesses shall be cleaned, wetted, and filled with patching mortar. Patches on rubbed surfaces shall match the texture of the adjacent concrete.

Finishing of unformed surfaces

No surface treatment shall be required for buried or permanently submerged concrete. As a minimum, unformed surfaces shall be finished by screeding and floating. Surfaces requiring a trowelled finish shall be finished by screeding, floating, and trowelling.

Float finished and screeded surfaces shall be finished to provide a flat profile within a 6 mm deviation as measured from a 3 m straightedge. Trowel finished surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 3 mm when measured from a 3 m straightedge.

Screeding

Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

Floating

The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and colour.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

Trowelling

The exposed portions of the tops of equipment bases, tops of interior curbs, and the surfaces of interior slabs not receiving a separate finish shall receive a steel trowel finish. Trowelling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Trowelling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

Surfaces to be covered with neoprene-hypalon coatings shall be lightly trowelled but not burnished.

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Brooming

Brooming shall follow the float finish for exterior surfaces where a nonslip surface is required. Brooming shall be done with an acceptable steel or fiber broom not less than 450 mm wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1.5 mm and 3 mm deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

Aggregate Exposure

Surface mortar shall be removed and the aggregate exposed from surfaces that shall be covered with mortar, concrete, or grout at a later time.

Edging

Unless specified otherwise, exposed edges of floated or troweled surfaces shall be edged with a tool having a 6 mm corner radius.

Finishing mortar

Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 102 kilograms of concrete sand to one sack of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 50 mm.

Separate finishes

Certain slabs surfaces shall be finished with a separate concrete finish or floor covering.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances. Low areas shall be filled. High spots shall be ground slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 3 mm from a 3 m straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the drawings or a float finished surface set 3 mm low and levelled with trowel finished fill material.

Surfaces that receive a mortar set quarry tile, ceramic tile, or vitrified finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 6 mm as measured from a 3 m straightedge.

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5.22. Formwork

Design and construction

For stability and type of formwork and support framing used, IS: 14687 is to be observed.

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section) "Dimensional Tolerances".

The Bidder shall submit in sufficient time in advance for the approval of the Owner/Consultant the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Particular attention must be paid to the formwork supports and braces to avoid any slip when the concrete is poured.

Materials for formwork

Forms shall be constructed from steel or from sound timber well seasoned and free from shakes. Plywood lining for forms shall be of timber, which is resin-bonded and water repellent.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete. Where a slope exceeds 1 V: 2 ½ H, formwork shall be provided for the top of the concrete faces and anchored to prevent flotation.

The details of fair-faced concrete facades have to be to the satisfaction of the Owner/Consultant. The concrete surface for facades has to be absolutely stainless and all efforts have to be taken to achieve this. All the proposed formwork shall be properly designed before its usage.

Grading of formwork and of finished concrete surfaces

Quality of formwork, materials to be used and treatments of surface are graded according to the finish of the concrete surface as given in IS: 14687.

The type and treatment of the formwork lining (plywood, metal, plastics, etc) should be appropriate to the grade of concrete finish required.

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Preparation and inspection of formwork

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces, which are not oiled, shall be wetted thoroughly to prevent warping.

Erection and placing of formwork

All formwork shall be erected and placed in accordance with the construction drawings approved by the Owner/Consultant. Shuttering shall be true to line and braced and struttred to prevent deformation under weight and pressure of the wet concrete, live loads, wind and other forces. The deflections shall not exceed 3 mm.

The formwork for beams and slabs shall be erected so that the form on the sides of the beams and of the soffits of slabs can be removed without disturbing the beam soffit.

If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Wherever necessary, panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc shall be fixed to the formwork carefully.

Panels shall be put together to ensure a perfect fit at the joint and fixed in both directions.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on the drawings as "Fair-faced Formwork".

Where concrete surfaces are covered (non-exposed surfaces), the formwork shall be referred to and marked as "Sawn Formwork".

Internal spacers and ties, if any, shall be so arranged that after removing of the forms no holes shall extend through the concrete, in the case of watertight concrete or to be closed by plastic plugs and epoxy mortar in all other cases.

All formwork will be inspected and approved by the Owner/Consultant before concrete placing commences but this shall not relieve the Bidder of any of his responsibilities under the contract.

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Striking of formwork

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

In accordance with IS: 456 clause 11.3.1, the striking period for cast in-situ concrete under certain conditions may be taken as follows: -

Table 2.8
Formwork

Type of Formwork	Minimum period before striking formwork
Vertical formwork to columns, walls, beams	16 to 24 hours
Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs:	
1) Spanning upto 4.5 m	7 days
2) Spanning over 4.5 m	14 days
Props to beams and arches:	
1) Spanning upto 6 m	14 days
2) Spanning over 6 m	21 days

Special care is necessary in the case of components, which have to carry nearly the full-calculated load as soon as the formwork is struck.

Columns, piers and walls are to be struck before the beams and slabs supported by them. Scaffolds, formwork supports and self-supporting floor formwork are to be carefully lowered by releasing the devices.

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

To keep deflections through creep and shrinkage to a small amount, auxiliary supports should be left in place or immediately repositioned after striking.

5.23. Water stoppers

Water stoppers shall be of PVC or equivalent and shall be eye-letted with a minimum 25 cm width. Type and manufacturer shall be submitted to the Owner/Consultant's approval.

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All intersection pieces shall be prefabricated by the manufacturer and only welding of butt-joints in running lengths will be allowed to be carried out on the site.

The site welding of butt-joints shall be executed by using the manufacturer's purpose-made electrically heated jig and work shall be done by competent and trained personnel only. The manufacturer's instructions shall be carefully observed.

The wings of the water stoppers shall be formed with corrugations or bulbs to achieve a good bond. Moreover, the water stoppers shall conform to the following requirements:-

- The tensile strength not less than 10 N/sq.mm when tested.
- The ultimate elongation shall not be less than 22% when tested.
- The tear resistance shall not be less than 2 N/sq.mm when tested.
- The material shall not crack when tested.
- Under accelerated elongation, the tensile strength shall not be less than 8 N/sq.mm and the ultimate elongation shall not be less than 200%.

The water stoppers shall be installed so that they are securely held in position during the placing of concrete, which shall be fully and properly compacted around the water stoppers to prevent voids or porous areas. Adequate clearance between the reinforcement and all the water stoppers shall be kept to permit proper compaction of concrete.

No holes or nailing shall be made through any water stopper for fixing purposes. Jointing by lapping two pieces of water stoppers shall not be permitted.

The free edges of water stoppers shall at all times be protected from direct sunlight.

5.24. Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed and if required the concrete may be protected for few more days as per the design mix / approved methodology.

Trowelled surfaces except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane-curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

Water curing

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application

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shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water may be interrupted for surface rubbing. The concrete surface shall not be permitted to dry.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap and kept saturated for the remainder of the curing period.

Membrane curing

Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at coverage of not more than 7.4 sqm/litre. Membrane curing shall not be used on surfaces that shall be covered at a later date with mortar, concrete, damp proofing, tile, or any coating. Membrane curing shall not be used on cast-in-place concrete bases for field-erected tanks. Membrane curing will be permitted only after prior approval of the OWNER/CONSULTANT.

Floor sealer

All concrete floors shall be given two coats of clear floor sealer in addition to that applied as membrane curing compound. The first coat shall be applied at the end of the curing period before any traffic is permitted on the floor. The second coat shall be applied after the floor has been cleaned in preparation for the final inspection. Floor sealer shall be applied in strict accordance with the manufacturer's recommendations.

5.25. Waterproofing/Damp proofing

A waterproofing seal shall be provided for all below grade structures where applicable by external tanking with PVC sheets of 1.0 mm thickness with knobs for membrane type waterproofing. In addition, joints in deep underground structures shall be provided with structural waterproofing.

Damp-proof course 40 mm thick, consisting of cement concrete 1:2:4, with admixture of approved water-proofing compound shall be laid at plinth level for walls of all buildings for protection of super-structure against moisture and dampness.

5.26. Repair of damaged and defective concrete

Concrete after its final setting shall be inspected by the Owner/Consultant and any cracks, honeycomb areas, segregations, etc shall be marked. No repairs shall be carried out until directed by the Owner/Consultant.

Surface defects in formed concrete shall be repaired to the satisfaction of the Construction Manager within 24 hours. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 25 mm shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the concrete is placed.

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Defective concrete shall be replaced within 48 hours after the forms have been removed.

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6. PRESSURE GROUTING

The work shall consist of drilling grout holes, exploratory holes and check holes, pressure testing, pressure washing, and injecting suspension grout under pressure, and shall include furnishing of all materials, labor, and equipment as described and specified.

6.1. Materials

a) Cement

Portland cement shall contain less than 0.6 percent alkali.

b) Aggregate

Aggregate shall be non reactive and shall be washed before use. When sources of aggregate are changed, test reports shall be provided for the material from the new source prior to commencing grout work. Fine aggregate shall be sand or crushed stone.

c) Admixtures

Admixtures shall be compatible with the grout and shall comply with the manufacturer's recommendations. Admixtures shall be added to the grout mix separately.

Water Reducing Retarder: Water reducing retarder shall comply with relevant Indian standard or as approved by Owner.

Lubricant: Lubricant additive for cement pressure grouting shall be Intrusion Prepakt Intrusion Aid, Sika Intraplast N, or as approved by Owner.

d) Water

Water for washing aggregate, for mixing and for curing shall be potable, shall not contain more than 1000 mg/l of chlorides as Cl, nor more than 1300 mg/l of sulfates as SO₄, and shall not contain impurities which may change the setting time by more than 25 percent or a reduction of more than 5 percent of the compressive strength of the grout at 14 days when compared to the results for grout made with distilled water.

e) Grout

Drypack Grout

Drypack grout shall be a mixture of approximately one part cement, 1.5 parts sand, water reducing retarder and sufficient water to make a stiff workable mix, branded Dry Pack or approved equal.

Cement Grout

Cement grout shall be a mixture of one part cement, two parts sand proportioned by volume admixtures for pressure grouting and sufficient water to form a workable mix.

Nonshrink Grout:

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- Non-shrink expansive flowable grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticiser admixture shall be added in the grout. For grouting of base of machine foundation high strength ready mixed non-shrink flowable grout shall be used.
- Type and grade of grouting for structural columns and equipment bases shall be as indicated. Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M 30.
- Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipment. For secondary posts, stair and ladder base, etc. grouting shall not be less than 25 mm thick.

Special grout, where specified on the drawings, shall be provided in strict accordance with the manufacturer's instructions/specifications. Pre-mixed Grout Conbextra GP-2 of 'FOSROC' make or equivalent of crushing strength 650 kg/cm² for major equipment foundations and Conbextra GP-1 or equivalent having crushing strength of 450 kg/cm² for other foundations where concrete grade M30 or higher is provided

- Forms and shims used to obtain adequate clearance shall not be removed and the anchor bolts shall not be tightened for at least three days after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and edge of the foundation shall be finished smooth to allow drainage away from the base. Attachment of interconnecting piping of machinery and complete load transfer of machinery shall not be done before the bolts are tightened. During this period, grouting work shall be properly cured using rags/gunny bags.

In view of extremely small proportion (about 0.01% by weight of cement) of the aluminium powder required, it is necessary to take all precautions to ensure thorough mixing. It is advisable to mix the blend of aluminium powder thoroughly with sand and cement before water is added because aluminium powder has a tendency to float on water.

- Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement: 1 admixture: 1 sand), or as per manufacturer's instructions.

Pre-mixed non-shrinking grout shall be used as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

Epoxy Grout for Crack Repair and Dowel Anchorage

Except for applications involving pressure grouting or crack injection, epoxy shall be a high modulus, moisture insensitive, two components, 100 percent solids, thermosetting modified polyamid epoxy compound. The material shall

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equal which is capable of not sagging in horizontal or overhead anchoring applications.

Epoxy for applications involving pressure grouting or crack injection, shall be a high modulus, moisture insensitive, two components, injection grade, 100 percent solids blend of epoxy resin compounds. The material shall equal which is capable of achieving complete penetration of hairline and larger cracks.

Polymer Concrete for Resurfacing and Patching

Polymer concrete shall consist of a liquid binder and dry aggregate mixed together to make a flowable mortar. The liquid binder shall be a chemical and oil resistant, stress relieved, low modulus, moisture insensitive, two component epoxy resin compound. The binder material shall equal with a consistency similar to light weight oil for proper mixing with the aggregate. The aggregate shall be oven dry, kept in sealed packages until the time of mixing and be of size and consistency compatible with recommendations of the manufacturer of the liquid binder for the intended application.

Adhesive Resin for Dowel Anchorage:

Pneumatically operated caulk gun and automatically mixed at nozzle. Subject to compliance with one of the following: HIT RE500-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-2322), HIT-HY 150 MAX-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-3013), SET-XP Adhesive Anchoring Systems, Simpson Strong-Tie Co. (ICC ESR-2508).

6.2. Pressure Grouting Equipment

Pressure grouting equipment shall include a mixer and holdover agitator tanks designed to place grout at pressures up to 0.345N/mm^2 (50 psi). Gauges indicating grouting pressure shall be provided and the mixer shall be equipped with a meter capable of indicating to within 0.003 m^3 the volume of grout placed.

6.3. Execution

Bonding compounds for use with grout is to be provided and installed per the manufacturer's recommendations.

a) Drypack Grout

Drypack grout is to be used for built-up surfaces, setting miscellaneous metal items and minor repairs.

Surfaces required to be built-up with drypack grout are to be roughened by brushing, cleaned and coated with the bonding compound before application of grout. The grout is to be applied to the required thickness.

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b) Cement Grout

Cement grout is to be used for filling nonbearing portions of equipment pads and pressure grouting.

Except for the specialized requirements for pressure grouting, grout is to be mixed and placed in the same manner as cast-in-place concrete. Grout is to be mixed for at least one minute and diluted grout is to be agitated until placed.

c) Non-shrink Grout

Nonshrink, nonmetallic aggregate grout is to be used under equipment, bearing plates and column base plates. Nonshrink, metallic aggregate grout is to be used under rotating equipment where high strength and fatigue are of concern, to grout anchor bolts and to grout reinforcing steel. Grout is to be placed and cured in accordance with the manufacturer's recommendations.

Holes required for grouting shall be blown clean with compressed air and are to be free of dust or standing water. Horizontal holes for grouting are to be drilled at a slight downward angle and with the inserted dowel or bolt bent to match.

d) Epoxy Grout

Epoxy grout shall be used for repairing cracks by pressure grouting or gravity, repairing structural concrete and may be used for setting dowels or bolts in holes. Concrete is to be primed in accordance with the grout manufacturer's recommendations.

The use of epoxy grout must comply with the following restrictions:

- Limited to areas where exposure, on an intermittent or continuous basis, to acid, chlorine gas or to machine or diesel oils, is extremely unlikely.
- Limited to applications where exposure to fire or to concrete temperatures above the product heat deflection temperature or 120 deg F (40 deg C)(whichever is less) is extremely unlikely. Overhead applications are not allowed.
- Holes for the anchors shall be drilled (not cored), shall be blown clean with compressed air and shall be free of dust or standing water.
- The anchor type, size and embedment depth shall be as shown on the drawings and the anchor must be installed in accordance with the manufacturer's recommendations.
- The anchor must not be loaded until after the full curing period has elapsed.

e) Pressure Grouting

Prior to grouting, cracks and holes to be grouted shall be washed clean. Washing is not required for grouting soil voids. Once started, grouting shall be continuous until completed. In case of a mechanical failure or other

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stoppage of the work, the grout equipment shall be washed out sufficiently to ensure that fresh only grout is pumped when the work is restarted.

After grouting is completed, the Contractor shall remove the grouting plant and all related parts, equipment, and supplies from the site, including unused materials and waste.

6.4. Field Quality Control

- The Testing Laboratory will Develop and utilize an effective method of field marking anchor and dowel test locations and results.
- Testing of grout mixes for conformance to manufacturer's specified strength: The independent testing laboratory shall take four test samples of each day's grout mix and test grout mix samples at 7 and 28 days. Test reports shall be submitted to the Owner for review.
- Test 25 % of reinforcing steel dowels installed with adhesive resin on a given day in tension using pullout procedure. Test to 80% of specified yield strength of the dowel with special inspection. Dowels specifically noted on the drawings as "No test required" do not require tension testing.
- If the failure rate of dowels exceeds 10 percent, testing will be increased to 100 percent of that day's installation of similar anchors or dowels. Testing will be reduced to 25 % of that day's installation when the failure rate is reduced to 10 percent or less. Failed dowels will be replaced at no additional cost to the Owner. The Contractor will produce daily reports of all testing activities; copies of daily reports will be submitted to the Owner in a timely manner.

6.5. Submittal

- Manufacturer's data shall be provided for bonding compounds, dry pack, non-shrink, pressure grout, retardants, epoxy grout, polymer concrete.
- Test reports, accompanied by a manufacturer's statement that previously tested material is of similar type, quality, and manufacture as that which is proposed for use on this projects, shall be submitted for Cement, Aggregates, Retardants, Bonding compounds and Epoxy resin
- The Contractor's testing laboratory shall provide evidence of correction of deficiencies noted in the inspection report before materials specified in this section are delivered to the job site.

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7. Retrofitting Works

7.1. General

- a) The Work shall, in general, conform to other works/items specified in this Specification.
 - If the specifications for any item are not available in in this Specification cited above, relevant BIS Specifications should be followed.
 - In case BIS Specifications are also not available, the decision of Engineer-in-Charge given in writing based on acceptable sound engineering practice and local usage shall be final and binding on the contractor.
- b) The work will be carried out in accordance with the architectural and structural drawings to be approved by Owner. The structural and architectural drawings shall have to be properly correlated before executing the work.
- c) For items where so desired, samples shall be prepared before starting the particular items of work for prior approval of the Owner and nothing extra shall be payable on this account.
- d) Materials brought at site of work shall not be used in the work before getting satisfactory Mandatory test results.
 - Equivalents for the various materials and the materials of approved make shall be got approved from the Owner in writing before using them on the work.
- e) The contractor shall submit the required documents regarding the genuineness of materials used such as manufacturer's certification that the firm has manufactured the supplied materials.
- f) The contractor shall get approved from the Owner the storage space for epoxy/polymer/patented/other manufacture of materials to ensure that the storage temperature is maintained between 5° C and 38° C unless recommended otherwise by the manufacturer.
- g) Contractor shall comply with manufacturer recommendations so as to comply with environmental conditions under which the repair materials may be applied.
- h) The contractor shall employ Principal Technical Representative & skilled site workers who shall have adequate qualifications and experience for the proper execution of such works and already performed works of this kind with success.
- i) Contractor shall advise all workers working with epoxies to avoid contact with eyes and skin, inhalation of vapours, and ingestion. Necessary protective and safety equipments in the form of hand gloves, welders' goggles, shall be provided by the contractor and used on site.

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- j) Care shall be taken to ensure that vibrations are well within acceptable limits for structural safety and users of the building.
- k) For the execution of protection and repair works, properly maintained plant and equipment permitting adequate treatment of the concrete substrate, proper execution of the work and determination of the required properties of the construction materials and construction measures must be present on the construction site.
- l) To ensure efficient and effective functioning, all plant and equipment must be checked on-site and at field material testing laboratory prior to first use and at appropriate intervals thereafter.

7.2. Chipping of Unsound/Weak Concrete Material

a) Purpose

To remove weak, loose or carbonated concrete over an area from its surface with pneumatically operated or power driven tools by chiselling, chipping etc.

b) Materials and T&P

Power or pneumatically driven chisel, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator (0.2% phenolphthalein solution) with pH range at least up to 10.5 and clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support to relieve the structural member of stress and strains.

Step-2: Scaffolding, if necessary for the exterior members, shall be done for working upon the area.

Step-3: Working Platforms for interior members, if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if necessary.

Step-5: Mark off the area to be repaired using straight lines between corners. The marked area shall have 90° corners with the sides parallel or normal to the direction of the reinforcement. The marked boundaries for the repair area should be a minimum of 50 mm outside the perimeter of the spall. For a single spall, the repair area should have a minimum width of 100mm in any direction. If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair.

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Step-6: Cut shall be made along the marked boundary, normal-to-the surface. It should be made with a diamond cutter blade. However, when diamond cutting is not practical, the normal cut can be made with a power driven chisel. Minimum depth of cut shall be 10 mm. In situations where the diamond saw could cut into the reinforcing steel due to inadequate concrete cover, the boundary edge should be formed manually by means of chisel and impact hammers. A cover meter could be used to estimate the depth of cover.

Step-7: Chipping to remove all the unsound and weak concrete material shall be done carefully from the damaged portions of structural members by adopting mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

e) **Tolerance**

The chipping tolerances shall be ± 5 mm.

f) **Chiselling**

Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer. Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm Mechanical Milling (single drum, rotary cutter head with Tungsten-carbide bits) is applicable for large areas where the concrete cover is to be removed. Care must be taken to avoid contact with the reinforcing steel as both the reinforcement and the cutter drum could be damaged. Rounded And Feathered Edges should be hand cut to form normal-to-the-surface boundaries. All the edges and cavities shall be square shouldered.

Step-8: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on concrete in contact and in the immediate vicinity of reinforcement soon after its chipping. As otherwise, chipped concrete surface in contact with air is likely to get carbonated soon after its coming in contact with atmospheric carbon dioxide.

Step-9: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, in case the concrete in contact and in immediate vicinity of the reinforcement is carbonated.

Step-10: Inspection and soundness testing, after concrete removal & cleaning, for weaknesses and delamination of exposed surfaces shall be visually carried out. If required, additional removal will be done.

Step-11: Cleaning of debris and dust shall be carried out from within the chiselled/ chipped area and its disposal as per direction of the Engineer-in-Charge.

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7.3. Removing concrete all around reinforcement including from its behind

a) Purpose

To create an average clear air gap equal to nominal size of coarse aggregate plus 5 mm all around embedded reinforcement, in contact with carbonated concrete for rust removal & passivating its surface with fresh alkaline passivating coat and concrete/ mortar.

b) Materials and T&P

Power or pneumatically driven chiselling, abrading, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator i.e. 0.2% solution of phenolphthalein indicator for pH range preferably up to 11.5 or at least up to 10.5, clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support, if not done already, to relieve the structural member of stress and strains.

Step-2: Scaffolding & working platforms for the exterior members, if not already done and if necessary, shall be erected for working upon the area.

Step-3: Working Platforms for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if not already done and if necessary.

Step-5: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on freshly chipped concrete in contact and in the immediate vicinity of reinforcement.

Step-6: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, if the concrete in contact and in immediate vicinity of the reinforcement is carbonated. The concrete around reinforcement shall be removed so as to have a near uniform air gap of about 5 mm plus the nominal size of coarse aggregate to be used in repair concrete/mortar. However, the air gap shall not be less than 15 mm in any case. Power/pneumatic driven tools/chisels shall be used for such portions of carbonated concrete around reinforcement, which could not be removed manually, to achieve a near uniform required air gap all around including behind the reinforcement. Power Driven Chisels/Hammers are normally applicable for chiselling smaller depths up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger depth in excess of 50 mm.

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Step-7: Cleaning of debris and dust shall be carried out from within the chiselled /chipped area and its disposal as per direction of the Engineer-in-Charge.

7.4. Cleaning reinforcement of total rust including from behind reinforcement

a) Materials and T&P

Chiselling, abrading, chipping, hammering, wire brushes, paint brush, abrading cloth, etc hand tools complete with accessories, tested and approved chemical rust remover.

b) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

c) Procedure

Step-1: Cleaning by manual method-

Remove the rust manually from all round the surface along the length of reinforcement, using hand tools like chisels, hammers, wire brushes, abrading cloth/paper, etc. This shall be continued manually along the length of the rusted reinforcement till such time that the steel surface is cleared of all rust that could be removed manually.

Step-2: Cleaning by chemicals –

Remove the Rust by using tested chemicals, if directed by Engineer-in-Charge, due to unsatisfactory results of manual rust removal. Chemical rust remover shall be brush applied over the reinforcement surface thoroughly all around the circumference and along the full length of rusted reinforcement. After 24 hours (or as prescribed by manufacturer) of its application, the surface shall be cleaned with wire brush and all loose particles removed. It shall be washed with water thoroughly and allowed to dry.

7.5. Cleaning Reinforcement and exposed concrete surface of loose and foreign material by means of sand blasting

a) Purpose

Clean the prepared concrete surface of all-loose, lightly sticking materials including the foreign materials, loose concrete, aggregates etc to provide a good bond with the applied repair material and clean the reinforcement surface of any minor rust remaining after manual and chemical cleaning to achieve shining bright metal.

b) Materials and T&P

Coarse sand conforming to Zone I or II as per IS: 383, Air compressor of a minimum 35 Kilowatt capacity, spray gun for sand, all related accessories for sand blasting, hand tools like wire brushes, chisels, etc

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c) **Testing of Materials and T&P**

The sand shall be tested to conform to the specification.

The air compressor shall be tested to perform to the required standards as laid down in specifications of shotcreting.

d) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

e) **Procedure**

Step-1: Specified tested coarse sand shall be collected at site in required quantity for sand blasting.

Step-2: Make available mechanical power driven air compressor in working condition at site with all required accessories for carrying out sand blasting as well as air blasting operations.

Step-3: Coarse sand shall be sprayed under pressure over the exposed surface so as remove all loose and foreign material and to cause an intense abrading of the reinforcement and removal of rust from entire surface of reinforcement to achieve shining bright surface. The sand blasted surface shall be subsequently cleaned with oil free air blast.

7.6. Providing drilling and inserting nipples along crack lines

a) **Purpose**

To fix injection nipples and seal the remaining portion of honey combed or cracked concrete /masonry for grout injection.

b) **Materials and T&P**

12 mm diameter approved PVC/aluminium /Galvanised Iron nipples, Chisel, hammer, power driven tool for chase cutting & drilling, hand operated blow out pump, sealing putty of polyester/epoxy/polymer modified mortar etc. and all related accessories and materials.

c) **Testing**

The sealing putty and the nipples shall be tested to conform to the manufacturers specifications. The power driven tools shall be test driven and their drill/cutting bits shall be tested for effectiveness before taking up the repair operation.

d) **Procedure**

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Personnel, Supervision, Product delivery, Storage and Handling etc.

Step-2: Identify the Cracks and mark the area for injection grouting.

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Step-3: Prop & support the structural member, if required, to relieve it of stress and strains.

Step-4: Open up cracked surface by making 'V' notch or groove of size 12 mm x 12mm.

Step-5: Remove plaster, if required, to identify and mark the honey combed area.

Step-6: Drill holes at least 25 mm diameter and 40mm deep along crack lines at spacing of 300 mm or thickness of the structural member, whichever is less. In honey combed area @ 9 nos per sqm. as directed by Engineer-in-Charge and up to 30 mm to 40 mm depth.

Step-7: Remove coarse debris and dust in opened up cracks and drilled holes by blowing oil free compressed air, if available with air compressor, otherwise with hand operated blow out pump. Concrete surfaces required to be grouted shall be free from all loose and unsound materials by means of mechanical abrasion using stiff wire brushes, after removing all loose areas with chisel and hammer. Area shall be made free from any deleterious materials, such as oil dust dirt etc. by means of oil free jet of compressed air. All prepared concrete surfaces shall be thoroughly inspected and got approved by the contractor.

Step-8: Insert 12mm dia specified injection nipples in holes drilled along crack lines and fix them by sealing only its sides with epoxy or polymer modified mortar.

Step-9: Seal the crack or the honey combed surface between the nipples by polymer modified mortar as may be approved by Engineer-in charge. The polymer used shall be of approved grade and applied as per specifications mentioned separately elsewhere. The polymer-modified mortar shall be moist cured for 1-3 days and allowed to gain strength before actual grouting commences.

7.7. Sealing of cracks by injection of advance grout

a) Purpose

To inject the specified grout into honeycombed or cracked concrete/ masonry

b) Materials and T&P:

Cement, sand. Water and admixture for cementitious grout shall be as per clause 5 of this specification.

Polymer: It shall be as specified and shall conform to ASTM-C-1059.

Hand/power operated grouting pressure pump/gun with pressure gauge. The grouting equipment shall be capable of supplying, mixing, stirring and pumping grout to the satisfaction of the Owner. The equipment shall have the capacity to inject grout at a pressure upto 7 kg per square centimeter

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measured at the grout connections. It shall be capable of mixing and pumping of cement sand grout 1:2 with water cement ratio ranging from 0.5 to 1.

Air compressor with all related accessories for carrying compressed air to the required location. Hand operated blow out pump may be allowed by Owner for small crack depths/areas.

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing, Spray equipment/brush for application of polymer modified/ bonding cement slurry

c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured material (e.g. specified resin, hardener, polymer, cement, etc as may be required) shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: If directed by Owner, collect random samples of materials for test and send to approved laboratories so as to ensure that they satisfy the physical and mechanical properties. The grout pump and the pressure gauge shall be tested before taking up the repair operation.

Step-4: Identify the Cracks and mark the area for injection grouting.

Step-5: Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

- Prop & support the structural member to relieve it of stress and strains.
- Provide grouting nipples.

Step-6: Blow the compressed air followed by washing with water through nipples located at the highest level and downwards to ensure removal of even fine dust particles from the cracked surface, which could obstruct the free flow of grout material and impede its bonding with cracked surface (and drying with air blast wherever epoxy injection grout is to be used).

Step-7: Saturate the cracked surface in the vicinity of crack/honeycombed concrete/ masonry with water (but without excess water), only if the cementitious grout is to be injected. Otherwise, this step may be skipped.

Step-8: Prepare the injection grout as specified under clause 5 of this specification.

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Step-9: Inject the approved & specified grout into the cracks by means of suitable gun or pump at a pressure of 1- 2 kg./cm² for epoxy grout and 4-7 kg./cm² for cementitious grout. In case of vertical cracks injection shall be started at the lowest nipple and continued until the injected grout begins to flow out at the next higher nipple. Whereas in other cases of horizontal locations, the injection shall be started from one nipple and continued until the injected grout begins to flow out at the other nipple.

The first nipple shall then be closed off and injection continued at the second until the grout flows out at the third. The process shall be repeated until the whole of the crack has been sealed. As soon as the system is cured, the nipples shall be cut.

In case of Honeycombed Area, each grout hole shall be grouted individually. Grouting pressures to be used in the work will vary with the conditions encountered and different areas and the pressure used shall be between 1 to 4 kg/cm². The sequence of injection shall be as per the direction of Engineer-in-Charge.

7.8. Providing and inserting shear key bars

a) Purpose

Shear key bars are used for providing a structural connection of the applied repair material with the substrate/parent surface for transfer of forces occurring at the interface.

b) Materials and T&P:

Epoxy cartridges and specified lengths and diameter of steel reinforcement.

Standard Power driven drilling/hammering equipment, Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

c) Procedure

Step 1: Mark the locations of shear keys and get the same approved for structural connection from the Owner.

Step 2: Drill holes to specified depth and diameter in concrete at marked locations for the specified dia of shear key bars.

Step 3: The drilled hole in dry state shall be cleaned with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump.

Step 4: Inject epoxy from the foil pack with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards.

Step 5: Insert the reinforcing bar and allow the epoxy adhesive to cure.

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7.9. Reinforcement for RCC works etc.

a) Purpose

To provide reinforcement in repair concrete for structural purposes, controlling effects of thermal variation or holding shotcrete/gunite material in position. The reinforcement material may comprise specified grade and quality with or without zinc coating.

b) Material & T&P:

Specified reinforcing material, necessary hand or power driven tools for cutting, bending, binding, transportation, handling and placement etc. Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

c) Procedure

The general requirements, placing in position, measurement etc. shall be generally followed as in clause 4 of this specifications excepting those specifications provided in the following clauses.

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Testing of Material: The requisite number of test specimens of specified reinforcing material shall be collected from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements before use on the work.

Step-3: Execution:

The required reinforcement as per approved detailed drawings in the form of round bars or welded wire fabric in such a way so as to cause the least interference with placement of repair material.

d) Overlaps:

Lapped reinforcing bars shall not be tied together. They shall be separated by at least 50 mm wherever possible. Wire mesh shall be lapped by 1-1/2 squares in all direction. Minimum requirement of lap length of bars shall be as specified in I.S. 456.

e) Clearance around reinforcement:

Sufficient clearance shall be provided around the existing exposed and additional reinforcement to permit complete encasement with sound repair material.

f) Cover:

Minimum cover to reinforcement shall be as specified under clause 4 or as per I.S. 456. As far as possible the bars shall be arranged so as to permit shooting from opposite side.

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g) **Fixing:**

Reinforcement shall be fixed to existing shear key bars and depth gauges driven into the concrete with wires and secured rigidly so that the vibration resulting from the deposition of repair material shall not impair or displace them.

h) **Where Guniting /shotcrete to be done in more than one layer**

In such cases, the additional reinforcement should be so fixed that it is encased in succeeding layer. No additional reinforcement is required to be fixed in first layer of guniting.

Mesh reinforcement shall be fixed in the manner so that it is firmly held at least 12 mm away from the parent concrete surface as well as from the final finished surface. It shall be ensured that it is stiffened enough and cannot belly out during the guniting / jacketing / concrete overlays with consequent lack of cover. It shall be done by tying with parent concrete surface through shear key bars or depth gauges. GI-wire mesh fabric will add sacrificial "Zinc" coating & shall reduce corrosion process in the reinforcement. The wire mesh spacing shall be as specified in the drawings.

7.10. Alkaline Passivating bond coat over Reinforcement

a) **Purpose**

To protect steel reinforcement with a passivating alkaline layer provided all around its circumference along the length with strong adhesive to bond with applied repair concrete or mortar.

b) **Materials and T&P:**

Specified alkaline passivating & bonding materials e.g. CPCC material, epoxy, epoxy phenolic IPN-RB or specified polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, mechanical mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882.

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

Patented materials e.g. CPCC or epoxy-phenolic IPN-RB as per licensee's specifications

c) **Execution:**

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life

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so permits. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: Prepare the surface for treatment.

Step-4: Thoroughly inspect all the concrete surfaces prior to applications of passivating/ bond coat and get approved from the Engineer-in-Charge.

Step-5: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-6: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),

Mechanical blender for mixing

Brush for application of specified and approved passivating/bond coat.

Step-7: Material Mixing: Components of the passivating/ bond coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-8: Material Application: The alkaline passivating & bonding material shall be applied to prepared reinforcement substrate after tying in new reinforcement wherever specified in the form of bars or welded wire fabric. It shall be applied to reinforcement surfaces by stiff nylon bristle brush. The coating material shall be worked well all round the periphery and along its exposed length using a stiff brush ensuring that no pinholes are remaining. The second coat, if required, the same shall be applied as per manufacturer's recommendation after the first coat is touch dry.

7.11. Bonding coat for hardened concrete with repair concrete/shotcrete/cement mortar

a) Purpose

To provide adequately strong adhesion of parent concrete with applied repair concrete or mortar.

b) Materials and T&P

Specified bonding materials e.g. epoxy or polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, spray gun, mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

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c) Execution

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer- in-Charge Full quantity shall be worked out as theoretically required for consumption in the whole work

Step-3: Prepare the surface for treatment.

Step-4: Saturate the surface with water but shall be free of excess surface water, debris and dust, where cementitious bond coat is to be applied. Otherwise, surface to remain dry and clean of debris and dust.

Step-5: Thoroughly inspect all the concrete surfaces prior to applications of adhesive and get approved from the Engineer-in-Charge.

Step-6: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-7: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing Spray equipment, brush for application of epoxy, polymer modified, bonding cement slurry.

Step-8 Bond Coat Mixing: Components of the bonding coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-9 Bond coat application for jacket concrete/ shotcrete/ Mortar placement: The specified adhesive shall be applied to concrete surface at atmospheric temperatures below 40°C for epoxy adhesive and below 30°C for polymer modified cement or cement-sand slurry adhesive. Bonding coat shall be applied by spray equipment or stiff nylon bristle brush as approved by Engineer-in-Charge. The bonding material shall be worked well into the surface of the parent body ensuring that no pinholes are visible.

Polymer modified bonding cement slurry shall be applied to a thickness not in excess of 2 mm.

If necessary, a second coat shall be applied at right angles to the first to ensure complete coverage and absence of pin holes.

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All concrete surface shall be well protected beyond limits of surface receiving adhesive against spillage.

Step-10 Repair Material Application: Fresh plastic concrete/ shotcrete/ mortar shall be applied while adhesive is still tacky and well within the pot-life/ setting period. If adhesive cures to the extent of losing its tack or has set before plastic concrete/shotcrete/mortar is placed, the same shall be removed or slightly abraded and second coat of adhesive applied. Freshly placed plastic concrete shall be thoroughly consolidated to ensure full bonding of new concrete with the substrate.

d) Bond of repair with parent concrete:

Evaluate bonding of fresh concrete/ shotcrete/ mortar to existing concrete after the fresh material has cured for not less than 7 days by sounding and tapping fresh concrete with a blunt metal instrument to the satisfaction of Engineer-in-charge. Suspect inadequate bonding, if a hollow sound is detected in any area. In case of conflicted location contractor shall extract one core from the repaired surface area at the end of 28 days.

Conduct one core test at random for checking the bond, for every 100 square metre or part thereof. The contractor shall core each area after 28 days of application of concreting/ shotcreting/ repair mortar application for determination of bonding adequacy.

Core drilling shall be done through applied repair material and into the existing concrete. Core diameter shall be not less than three times the nominal size of the coarse aggregate used in repair material or as required by the Engineer-in-Charge. Length of cylindrical cores shall preferably be twice the core diameter or twice the thickness of applied repair material or as instructed by Engineer-in-Charge but in any case not less than the dia of the core.

Cores shall be visually inspected by Engineer-in-Charge for evidence of poor workmanship.

Cores shall be tested in tension to evaluate the quality of bond between new concrete/shotcrete/mortar and the parent concrete. If the failure is in the parent concrete the bond of new repair material shall be deemed to be satisfactory.

Failure at the bond line or in the repair material shall be concluded as lack of proper bond or inadequate strength of repair mortar

Dismantle such areas of work failed in bond or repair material and re-prepare the surface after chipping off new concrete/mortar work and abrading the epoxy/ polymer/cement slurry interface. Nothing for testing concrete for bond between old and new concrete shall be paid separately.

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7.12. Curing of RCC Surfaces etc

a) Purpose

To ensure satisfactory hydration of cement by retaining or replenishing the mixing water lost due to natural drying and evaporation process for a specified period through exposed cementitious surfaces of the freshly placed cement mortar/ concrete.

b) General

Importance of wet curing to all items of work involving use of cement can not be over emphasised. Any surface experiencing discontinuity of dampness of surface with any patch having dried out during the specified period of curing, it shall be prominently marked with lime or other suitable prominent colour.

c) Materials and T&P:

Curing compound, brush or hand operated spraying gun and all other related accessories for application on Concrete/Plastered Surface.

d) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified manufactured material shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out theoretically for consumption in the whole work.

Step-3

• Moist Curing:

Cover all exposed surface of concrete, when the concrete begins to harden i.e. two to three hours after compaction with moist gunny bags or any other material approved by the Owner.

Keep the exposed surfaces continuously damp after its final setting (i.e. after a maximum of 8 hours of concreting) by ponding with a sheet of water or by covering with a layer of sacks, canvass, hessian or similar water absorbent materials constantly kept wet by water sprinkling for at least 7 days, where ordinary portland cement is used and 10 days, where portland pozzolana cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as per manufacturer's recommendations or as directed by the Owner.

• Using Curing compound:

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Testing of Materials:

It must be ensured that curing compound should neither affect the strength nor the surface of concrete. It shall not leave any undesirable stains on surface to affect the bond of plaster or other finishes to be applied later. It should be soluble in water, so that it can be removed by splashing or washing with water without scrubbing the surface.

Test for Efficacy:

The testing of curing compounds shall be done from each lot of curing compound received at site by casting two sets of 15 cm cubes with each set having 6 cubes. One set shall be moist cured by covering with damp gunny bags and subsequently by immersing under water and the other set by applying curing compound on top after 2 to 3 hours of casting and subsequently on de-moulding apply on the remaining faces all around. The cubes shall be kept in an environment similar to which the actual structure is exposed for a period of 7 days after its casting. Three concrete cubes each from both sets shall be tested after 7 days for their crushing strength as per standard test procedure. The average crushing strength of cubes cured with curing compound shall be not less than 95% of the crushing strength of cubes cured under damp or immersion curing.

Test for Staining:

The set of three sample cubes applied with curing compound, remaining after 7-day cube crushing strength test, shall be washed with water with soft brush scrubbing with nylon bristles and allowed to dry for a period of seven days in an atmosphere with relative humidity not exceeding 40% at ambient temperature. The other set of three cubes cured for seven days under damp or immersion conditions shall also be kept for another seven days under identical humidity and temperature conditions. The surface of the two sets of such cubes shall be compared by closely observing for any visible stain and texture that may detrimentally affect its bond with subsequently applied plain plaster or aesthetic appearance. Such observations shall be recorded in three categories as no effect, slight effect and moderate effect. The curing compound shall be considered as acceptable in the 'no effect' category and unacceptable in the 'moderate' category. The decision of Engineer-in-Charge, which shall be final and binding, based on the likely use of finished surface of concrete/plaster shall determine the acceptability of the 'slight effect' category.

Concrete curing compounds, after testing satisfactorily for efficacy, may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing within two to three hours of casting and well within an hour of removal of formwork.

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7.13. Engineered Steel Tubular double Scaffolding System

a) Purpose

To provide a scaffolding system with adjustable working platforms on the exterior of the building for the workmen to work upon any part of the area to be accessed safely and with ease for surface preparation, application of repairs and construction activity.

b) Materials

The standard proprietary tubular double scaffolding system of repute with all accessories, working platforms etc.

c) Design

It shall be designed for all the incidental dead, live and wind loads as per IS: 875 in steel tubular sections as per general design considerations governed by IS:800. The design of the scaffolding system shall cater to the safety features for the workmen.

d) Fabrication and Erection

Fabrication and erection shall be done as per the design brief and installation instructions of the proprietary firm. It shall be maintained in functional condition for the work duration.

7.14. Temporary barricading using angle iron verticals and sheet panels

a) Purpose

To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work.

b) Materials

Available Corrugated G.I. Sheet minimum 24 G thick; Framing structural material at least MS Angle iron of size [40x40x5mm] or equivalent.

c) Fabrication & Erection

Size of framing panel shall be decided depending upon site conditions and these could be approximately 2.0 metres long with height as 1.8 metre.

It shall be made up at least of two verticals, each with additional length of about 600 mm for fixing in to ground firmly and two horizontals equal to the length of panel.

It shall be made up by cutting the structural sections to size, shear punching holes in verticals and horizontals for nuts and bolts or making other suitable provision for receiving CGI sheet or other specified panelling material and connection of panel with adjoining panels.

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Fabrication of frame of an individual panel shall be by welding at corners, welding MS plate at base of verticals or any other acceptable practice approved by Engineer-in-charge.

G. I sheet or other specified panelling material shall be suitably fixed. It shall preferably be done by means of nuts and bolts at its ends spaced at about 300 mm c/c transversely and at about 600 c/c longitudinally along corrugations. The corrugations of CGI sheet shall run along the shorter span of the panel.

In case of newly fabricated panels, these shall be painted with red oxide zinc chromate primer on steel work and approved primer on other material and at least one coat of paint of approved shade. In case of used panels, one coat of paint of approved shade shall be applied over the existing paint. The portion of verticals to be embedded in ground shall be suitably protected against rusting by painting it with bitumen or other suitable paint.

The fabricated panels shall be suitably fixed vertically and firmly in to the ground to the satisfaction of Engineer-in charge by maintaining a uniform height of about 1.8 metres above GL and connecting each panel with the adjoining panels with nut and bolts or other suitable means.

Suitable provision of frame/posts in the openings provided in barricading shall be made for receiving door shutter at locations as approved by Engineer-in-Charge.

7.15. Temporary protective fabric screens

a) Purpose

To protect passersby from falling debris and also to protect the workmen and structure being repaired against direct exposure to sun.

b) Materials:

For screening purpose jute cloth, woven PVC cloth, geo-textile or wire-mesh as specified and approved by Engineer-in-Charge shall be used, which shall conform to their relevant BIS Code. Screen materials shall be fixed by suitable means comprising of M.S.Flats/ J-bolts /nails/clamps, etc with washer or any other suitable means on frames of existing scaffolding etc.

c) Procedure

Scaffolding, if required, comprising of verticals, horizontals and diagonal bracings of steel tubes shall be fixed over ground which is payable separately.

One end of the screening material, brought to site in looms/rolls, shall be properly fixed over top horizontal member with suitable means and suspended so as to cover the required area.

The vertical fall of screen shall be suitably fixed/firmed up at intermediate levels so as to keep it in position during the work duration.

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Next strip of the screening material shall be fixed with its sides stitched or suitably jointed or lapped with the previous ones as approved by Engineer-in-charge.

Spacing of frame member of scaffolding shall be so selected that the sagging of screen shall not hinder the repair process.

The contractor shall maintain the protective screens in acceptable conditions for the entire work duration as required by the Owner.

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8. CONCRETE RETROFITTING METHODS

In selecting the retrofitting method, the current status of the existing concrete structure as determined through inspection, the performance of the structure, the performance required of the structure after retrofitting, the conditions for retrofitting construction work, the ease of maintenance, economy and other factors shall be considered.

At the stage of selecting the retrofitting method, the current status of the existing structure and its performance shall be obtained, and the performance required for the structure after retrofitting and the conditions for retrofitting work shall be determined. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors.

Various retrofitting methods listed below shall be used for retrofitting objective:

8.1 Retrofitting of concrete members

a) Continuous fiber reinforced plate bonding construction method:

Bonding continuous fiber reinforced plates to the surface of the existing structure to restore or improve load-carrying capacity

b) Continuous fiber reinforced plate jacketing construction method:

Jacketing with continuous fiber reinforced plates around the periphery of the existing structure to restore or improve load-carrying capacity and deformation characteristics

c) Prestressed concrete jacketing construction method:

Placing pre-stressing wires and pre-stressing stranded steel wires in place of lateral ties around the periphery of existing member sections and using mortar and concrete to bond them in order to reinforce the structure. To increase the restraining effect of the inner concrete, the pre-stressing steel is generally stressed during placement.

d) Pre-stressing introduction (internal cable) construction method:

Using internal cables for the existing concrete members to provide pre-stressing and restore or improve the load-carrying capacity of the members.

e) Repaving method:

Replacing some or all of the existing concrete members with new members through the use of precast members or concreting on site to restore or improve load-carrying capacity.

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8.2 Retrofitting as a structural body

a) Beam (girder) addition method:

Adding beams between the main girders of the existing reinforced concrete deck to reduce the deck span and restore or improve the load-carrying capacity of the reinforced concrete deck.

b) Seismic wall addition method:

Placing new reinforced concrete walls between existing reinforced concrete rigid-frame bridge piers and bonding them to form a continuous unit in order to restore or improve the load-carrying capacity as a structural body.

c) Support point addition method:

Supporting the intermediate sections of the beams and other existing concrete members with new members to reduce the span of the members in order to restore or improve the load-carrying capacity as a structure.

d) Seismic isolation method:

Using seismic isolation bearings and the like to reduce the seismic energy applied to the structure in order to improve its various performance values during an earthquake.

8.3 Foundation retrofitting

a) Underground wall (beam) addition method:

Connecting the foundations with cast-in-site diaphragm walls and underground connecting beams to distribute stress and ensure the stability of the entire system.

b) Pile/footing addition construction method:

When pile foundations are damaged or there is residual displacement, adding piles or footings to increase the load-carrying capacity of the foundation.

c) Foundation improvement method:

Improving the ground around the foundation with cement improvement materials to improve the ground bearing capacity and horizontal foundation resistance. Also prevents excessive pore water pressure and liquefaction.

d) Steel sheet-pile coffering construction method:

Placing sheet-piles around the periphery of the footings and bonding them to the footings to improve bearing capacity and horizontal resistance.

e) Foundation compacting method:

When insufficient foundation bearing capacity is a concern due to scouring or the like, using concrete or the like to compact the ground around the foundation in order to restore bearing capacity.

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8.4 Repair of cracks and missing sections

a) **Cracks fill method:**

Forcing low viscosity resin and ultra-fine cement into the cracks in existing concrete members to seal the cracks.

b) **Fill method:**

Filling cracks, rock pockets, cavities, peeling and other small-scale missing sections in existing concrete members with resin and mortar to repair sections.

c) **Section repair method:**

Removing deteriorated or damaged portions of existing concrete members and then restoring these members to their original sectional status using materials with excellent bonding to existing concrete.

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9. Shoring and Underpinning

9.1 Material and Equipment

- a) The contractor shall furnish all materials, tools, equipment, facilities and services as required for providing the necessary shoring and underpinning work and facilities. Jack and jacking equipment shall be more than adequate for the imposed loads and shall be provided with calibrated gauges.
- b) Shoring and bracing materials
Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles, and accessories as required.
- c) Lagging and sheeting material
Provide heavy timber boards, planking or sheeting as required. Lagging board shall be secured in place by steel H-piles, with boards inserted between the H-flanges.
- d) Underpinning Pier
An excavation pit, provided generally by manual excavation, which is carried to a pre-selected bearing surface and then filled with concrete to provide supplementary foundation support for the underpinning structure.
- e) Concrete
Refer clause 4 of this specification for concrete requirements.
- f) Grout
Refer to Clause 5 of this specification for Non-Shrink Grout requirements.
- g) Structural Steel
Refer to Clause 9 of this specification for Structural steel requirements

9.2 Execution

- a) Detection of Movement
 - For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding improvements to be monitored. Settlement markers shall be capable of being read to an accuracy of 1.52mm.
 - Take and record readings not less than once per week during performance of the work until the permanent structures is complete to the ground level.
 - Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.
 - Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks or longer if movement persists, and report the results to the Engineer.

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- The detection of movement shall be performed by a qualified licensed land surveyor or civil engineer.

9.3 Shoring and Underpinning

- Existing footings, foundations, pile caps, grade beams, retaining walls, or pavement which may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement.
- Provide soldier piling, lagging and sheeting, tie-backs, slurry diaphragm wall, and cementitious grouting, as required, to hold back earth at excavations and as required to prevent cave-ins and earth sloughs.
- Footings, foundations, pile caps, grade beams, retaining walls, or pavements which have been undermined by earthwork and pile-driving operations shall be filled and supported with concrete extended to undisturbed bearing earth or bedrock.
- Concrete may be placed as a stiff mix of minimum slump (dry pack), or concrete may be pneumatically placed (shotcrete), or concrete may be placed by conventional methods with concrete formed to hold it in proper position.

9.4 Concrete Piers, Walls and Pile caps

- Install concrete underpinning piers, walls, and pile caps as indicated, with the bottom at the indicated or bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed.
- Where earth forms are indicated, install waterproof building paper or board between the earth and concrete to prevent water loss from the fresh concrete.
- Do not remove support of existing structure until concrete piers, walls, or pile caps have attained design strength.

9.5 Piles and Caissons

- Install pipe pile shells or drilled shafts at locations indicated, and extend from underside of existing footings to indicated elevations, plus additional penetration if required to develop the design working load of the pile or caisson.
- Distribute jacking reactions over the existing structure in a manner that will not overstress or deflect the existing structure.
- Weld splices where indicated. Provide watertight welds capable of developing the full strength of the pile or caisson. Align splices to ensure the

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straightness of the pile from top to tip. Use outside sleeves and backup rings as necessary.

- Where the pile tip is below the ground-water table, maintain the elevation of the water inside the shell at approximately the elevation of the ground-water table during installation of the shell.
- After installation of the shell, apply the full design-working load to the empty pile shell and maintain until there is no measurable settlement over a one hour period.
- Maintain the excavation within the pile shell approximately 12 inches above the tip during driving, and dewater pile shells prior to filling with concrete in a manner which will prevent loss of earth or soil at the tip. An earth plug may be left in the pile tip or a concrete plug may be placed and cured prior to dewatering pile shells.
- After load testing to the design load, dewatering, and inspection of the shell by the Engineer, fill accepted pile shells with concrete in the presence of the Engineer. Keep an accurate record of the volume of concrete deposited in each pile. Deficiencies revealed by comparing the volume of the inside of the pile with the volume of placed concrete will be cause for rejection of the pile or correction of the deficiency.
- Securely wedge in place with steel wedges those piles that have satisfied the load-testing requirements. Weld and encase in concrete all wedges, plates, wedging struts and piles, as indicated or required.
- Following completion of load transfer of underpinned structures, fill the underpinning pits with concrete as indicated. Provide reinforcement, shear keys, dowels, and water stops as indicated or required. Place concrete to within 3 inches of the underside of the existing foundation. After three days, dry pack the space between the foundation and concrete.

9.6 Load testing of piles and acceptance criteria

- After the concrete within the pile or shaft has set for at least 24 hours, test each pile or pier by jacking to a load equal to 150 percent of the design-working load of the pile. Maintain the load until there is no measurable settlement of the pile over a one-hour period.
- Load-test piles in sequences and groupings that will minimize or eliminate eccentric loadings on the existing foundation and piles.
- Piles will be rejected and shall be retested if, in the opinion of the Engineer, there is a danger of unequal loading.
- Should the existing structure fail to furnish sufficient reaction to installed underpinning piles to the test loads specified, provide additional reaction to prevent damage to, and movement of, the structure during installation of

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piles, and to obtain specified underpinning test loads. The additional reaction shall not detrimentally affect the structure.

- Maximum out-of-plumb tolerance for installed piles: two percent.
- Maximum offset of top of pile from the design center: 3 inches.

9.7 Fill and backfill

Provide engineered fill and backfill in accordance with Clause 3 of this specification, after acceptance of the underpinning by the Owner.

9.8 Temporary Supports

Install temporary supports where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work.

9.9 Restoration

Restore existing structures to conditions equivalent to those existing prior to the start of shoring and underpinning work, including repair of any settlement-related damage.

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10. STRUCTURAL STEEL WORK

Design of structural steel work shall include generally but not be limited to the steel constructions listed below:

- Steel building structure and open structures including beams, columns, bracings, supporting structures for floors, roof slabs, cladding etc.
- Hoist & monorail supporting beams etc.
- Platforms and walkways
- Ladders, staircases, handrails, etc.

10.1 Design

(a) General

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However where large cut outs are to be provided in the floor slabs horizontal floor bracing shall be provided. Grating / Chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support and horizontal bracing shall be provided as required in such cases.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimize vibration, avoid resonance and maintain alignment and level.

(b) Design of structure

The Design of steel structures shall be done by Working stress or Limit state method, in accordance with the provisions of IS: 800 and other relevant IS codes as applicable to specific structures. Basic consideration for structural framing shall be stability, rigidity, building usage, ease of fabrication / erection and overall economy. Additional bracings / moment connections shall be used to assure stability of structures. Structure shall be designed such that the surfaces of all parts shall be accessible for inspection, cleaning, painting and maintenance. Most of steel superstructure shall be designed as simple space frame structures. Simple space frame design utilizes single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Large span built-up girders shall be single web plate girders of welded construction with bearing and intermediate stiffeners. For lifting / monorails beams ISMB sections shall be preferred and the bottom flange of all beams shall be checked separately for distortion and reinforced suitably if required.

Columns shall be designed to support the load combination which results in maximum interaction ratio. Exterior columns shall be designed to resist moments

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due to wind & seismic. Columns shall also be designed to resist moments caused by discontinuous vertical bracing or non-concentric bracing work points. Column base can be fixed or pinned. Lateral forces shall be resisted by rigid jointed moment connections in rigid frame design. For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension, etc.) use 90 % of the column dead load and no live load. Uplift forces from vertical bracing and Wind uplift on the roof shall be included where applicable.

Permissible stresses for different members shall not be allowed to exceed by 33.33 % under wind and seismic conditions. However, members who shall be designed primarily to resist wind load such as bracing members, no increase in permissible stresses will be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. All anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself. No anchor pockets in foundation shall be allowed. Design of base plates shall be based on design pressure on foundation which shall not exceed the following:

Pedestal in concrete grade M30 7.50 N/mm²

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A coefficient of friction of 0.30 shall be used in conjunction with the minimum column load. If the horizontal shear force exceeds the frictional resistance force or if the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Anchor bolts are not assumed to resist any horizontal shear force. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Static analysis of overhead conveyor galleries upto a span of 24 m is allowed. However dynamic analysis shall be carried out for overhead conveyor galleries exceeding 24 m span.

For equipments, the bolt shall be either embedded or placed inside the pedestal and grouted with non-shrink grout.

The following criteria shall be followed for posting loads on the design drawings. For vertical beam reactions, the load shall be posted whenever the value exceeds the maximum allowable uniform distributed load. For axial loads in floor beams, the actual horizontal load which the beam end connection must resist shall be posted for each end of the beam. Note that this value may be different for opposite end of the same beam. For truss members, only one member force shall be noted for each member.

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(c) Permissible deflections

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

• Vertical deflection

a) For beams supporting dynamic equipment	Span / 500
b) For beams supporting floors / masonry	Span / 325
c) For beams supporting pipes (pipe racks)	Span / 400
d) For roofing and cladding components	Span / 250
e) For gratings and chequered plates	Span / 200 subject to a maximum of 6 mm

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

For manually operated cranes and monorails : Span / 500

For electric overhead cranes

- i) Up to 50 t capacity : Span / 750
- ii) Over 50 t capacity : Span / 1000

• Horizontal deflections

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	Height / 325
b)	Multistoried building (without crane load)	Height / 500
c)	Pipe rack columns	Height / 200
d)	Open Structures	Height / 200
e)	Crane gantry girder due to surge	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail due to action of crane surge load only	Height / 2500 limited to level maximum of 10 mm
g)	Open gantry columns at crane rail level due to action of crane surge load only	Height / 4000 limited to maximum of 10 mm

Provisions of IS: 800 and relevant latest IS Codes shall be followed for limiting deflections of structural elements not listed above.

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(d) Minimum thickness and size of steel elements

• **Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgement in each instance.

Trusses, purlins, girts and bracing	6 mm
Columns and beams	8 mm
Gussets	8 mm
Stiffeners	8 mm
Base plate	10 mm
Chequered plates	6 mm o/p
Grating flats	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc shall be 6 mm.

• **Minimum Sizes**

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

(e) Slenderness and depth ratios

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

Truss	1 / 10
Rolled beams and girders for Ordinary floors and rafters	1 / 24
Supporting floor beams for vibrating Machines / equipments	1 / 15
Roof purlins and girts	1 / 45
Gable columns	1 / 30

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(f) Design of Connections

Welding will be done in accordance with the recommendations of IS: 816 and IS: 9595.

Shear connections will be designed for 75 % of section strength for rolled sections and 80 % of section strength for built up section or rolled section with cover plates. Designed shear force shall be more than actual shear. Moment connections between beam and column will be designed for 100 % of moment capacity of the beam section.

All butt welds will be full penetration butt welds.

Size of fillet weld for flange to web connection for built up section will be as follows:

- i) Able to take full shear capacity or actual shear whichever is more for box section
- ii) Able to take 80 % of full shear capacity or actual shear (if indicated in drawings) or shall be 0.5 times of the web thickness whichever is more. For I-section Weld will be double fillet
- iii) All welds will be continuous. The minimum size of the fillet weld will be 6 mm as per relevant IS code

Connection of vertical bracings with connecting members will be designed for full tensile capacity of the bracings. The connection between top flange & web of built-up girder will be full penetration butt weld & for bottom flange, connection may be fillet weld.

Connection of base plate & gusset members with the columns will be done considering that total load gets transferred through weld.

Splicing

All splicing work will be full strength. Field splicing will be done with web / flange cover plates. For, exceptional cases the field splicing will be designed for 50 % of load carried by the cover plates and remaining 50 % load through full penetration butt weld. Shop splicing for all sections other than rolled will be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections will be carried out using web and flange cover plate. For design efficiency of site weld shall be considered as 80 %.

Insert plates

Insert plates shall be designed / checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall also be checked. Lugs using steel bars shall preferably be fillet welded to the plate to transfer full strength of the lug.

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10.2 Fabrication

(a) General

Fabrication drawings shall be prepared according to the provision of IS: 800, IS: 813, IS: 816, IS: 9595, IS: 1367 and IS: 9178.

The work to be provided by the Bidder, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following:

- i) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on design drawings submitted by the Bidder and approved by the Owner/Consultant.
- ii) To submit revised design with calculations and detailed fabrication (drawings in case any substitution of the designed sections are to be made.
- iii) To submit design calculations for joints and connections developed by the Bidder along with detailed fabrication drawings.
- iv) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding \ electrodes for field connections. The field connection materials supplied by the Bidder shall be to the extent of actual requirement plus 10 % (ten percent).
- v) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- vi) Suitably mark, bundle and pack for transport all fabricated materials.
- vii) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

(b) Conformity with Design

Except where the standard connection details are furnished, the Bidder shall design all connections, supply and fabricate all steelwork and furnish all connection materials, Shear connectors / shear lugs on the beams in accordance with the approved drawings and / or as instructed by the Owner/Consultant Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and / or as approved by the Owner/Consultant. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

(c) Quality control

The Bidder shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all

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work shall be performed in accordance with this specification. In addition to the Bidder's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Owner/Consultant. As far as possible, all inspection by the Owner/Consultant shall be made at the Bidder's fabrication shop whether located at Site or elsewhere. The Bidder shall co-operate with the Owner/Consultant in permitting access for inspection to all places where work shall be done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Bidder.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

- a) Steel Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
- b) Bolts, Nuts Manufacturer's certificate, dimension & Washers checks, material testing.
- c) Electrodes Manufacturer's certificate, thickness and quality of flux coating.
- d) Welders .Qualifying Tests
- e) Welding sets Performance Tests
- f) Welds Inspection, X-ray, Ultrasonic tests
- g) Paints Manufacturer's certificate, physical Inspection reports
- h) Galvanizing Tests in accordance with IS: 2633 and IS: 4759.

(d) Materials

If desired by the Owner/Consultant, Test Certificates of materials supplied by the Bidder in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Owner/Consultant, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

Materials for main and secondary members shall be selected in line with good engineering practice and shall be arranged within any structure with due regard for maintenance of the structure and Plant and Equipment supported or sheltered by the Structure and also with regard to corrosion.

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pitting, rusts, etc. that may impair their strength, durability and appearance.

All rolled steel shall conform to the requirements of the Indian Standards.

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- i) Structural Steel will conform to IS: 2062 Grade-A for rolled steel members or plates up to 20 mm thickness.
- ii) For plates above 20 mm thickness and welded construction, steel conforming to IS: 2062 Grade-B will be used.

(e) Workmanship

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of IS: 800 and other relevant Indian Standards or equivalent.

Straightening Material

Rollled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed as per IS:1852. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

Cutting

Cutting shall be affected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Owner/Consultant.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

Planning of Edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Owner/Consultant.

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Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end, but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

Bolted construction

All bolts and nuts shall conform to the requirements of IS: 1367.

Field connections shall preferably be bolted connections unless specified otherwise. Weld connections at site shall be avoided.

High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter unless designated otherwise. High strength bolts shall be installed as bearing type joint except where loads are reversible. Bearing Type connection (H.T. bolts Grade 8.8) shall be used for all removable type connections. Bolts will be tightened to develop the required pre-tension during their installation.

All erection bolts shall be of minimum 16 mm diameter of property class 4.6 conforming to IS: 1367 unless specified otherwise.

Holes for bolts shall not be more than 1.5 mm for bolt of diameter equal or lesser than 25 mm and shall not be more than 2 mm for bolt of diameter greater than 25 mm.

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

Assembly

Drifting to enlarge un-matching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the

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metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted nor damaged and shall be so prepared that the specified cambers, if any, are maintained.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Owner/Consultant.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or locknut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

Welded Construction

Welding shall be in accordance with relevant Indian Standards. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817. All shop connections shall be welded type.

Preparation of Material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears, Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than 20C.

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

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In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Owner/Consultant, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Consultant.

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding shall be started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

No welding shall normally be done on parent material at a temperature below (-) 50C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 50C and 00C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 200C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

Submerged arc welding process shall be used for welding longitudinal fillet welds (connecting flanges with web) and longitudinal / transverse butt joints for fabrication of columns, framing beams and all other built up members unless manual arc welding is specifically required. All electrodes, flux, bare wire etc will

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be procured from approved manufacturers. All butt welds in beams, girders & columns will be of full penetration. All butt welds will be radio-graphically or ultrasonically tested as per relevant IS codes and standard practice. The base wire electrodes for submerged arc welding will conform to IS: 7280. The combination of wire and flux will satisfy requirements of IS: 3613.

Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the Owner/Consultant.

Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-buttressed over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2 mm.

Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

Miscellaneous

- Lacing bars

The ends of lacing bars shall be neat and free from burrs.

- Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

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- **Bearing Plates**

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

- **Architectural Clearances**

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

- **Shop Connections**

- All shop connections shall be welded as specified on the Drawings.
- Certain connections, specified to be shop connections, may be changed to field connections if desired by the Owner/Consultant for convenience of erection and the Bidder will have to make the desired changes at no extra cost to the Owner.

- **Shop Erection**

The steelwork shall be temporarily shop-erected complete or as directed by the Owner/Consultant so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

(f) Shop Painting

All fabricated steel material, except those galvanized or to be embedded in concrete, shall receive paint coatings as specified below. All paints shall be of approved brand and shade as per the Owner's requirement.

Steel surface, which is to paint, shall thoroughly be cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by wire brush & if required by sand blasting prior to actual surface preparation. The surface shall be cleaned to grade ST-2.5 as per SIS05-5900 or as per IS: 1477 (Part -I).

All steel structures shall receive two primer coats and two finish coats of painting. After fabrication the first coat of primer shall be immediately given over the prepared steel surface. The second coat of primer shall be applied over the dried first primer coat. Two finish coats shall be applied over the primer coats before dispatch of structure at site.

Primer paint shall be red oxide zinc chromate conforming to IS: 2074. Dry film thickness of each coat shall be 50 microns. Adequate care should be taken such that the surface does not possess a slick finish to which paint may not adhere properly. Top coat shall consist of two coats of HB Synthetic enamel of approved shade and colour with glossy finish and DFT as 75 microns (total). Thus the total DFT of painting including that of primer coats shall not be less than 175 microns.

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Following care shall be taken while painting:

- i) Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.
- ii) Surfaces inaccessible after assembly shall receive two coats of primer prior to assembling.
- iii) Surfaces inaccessible after erection, including top surfaces of floor beams supporting gratings or chequered plate, shall receive one additional coat of finish paint over and above number of coats specified above before erection.
- iv) Portion of steel member embedded / to be encased in concrete shall not be painted.
- v) Areas / Surfaces subjected to chemical attacks shall be painted with acid resistant paint.
- vi) Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

(g) Inspection, testing and acceptance criteria

Unless specified otherwise, inspection to all work shall be made by the Owner/Consultant at the place of manufacture prior to delivery. The Owner / Consultant shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification. The Bidder shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Owner/Consultant to carry out inspection and / or tests in accordance with the Contract.

The Bidder shall guarantee compliance with the provisions of this Specification.

The Bidder shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Bidder shall get the specimens tested in a laboratory approved by the Owner/Consultant and submit to the Owner/Consultant the test results in triplicate within 3 (three) days after completion of the test.

Steel

All steel supplied by the Bidder shall conform to the relevant Indian Standards, except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to

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be used by the Owner/Consultant, random samples of materials will be taken from each unidentified lot of 50 ton or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be borne by the Bidder.

All material shall be free from all imperfections like mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

All raw steel plate of thickness more than 20 mm supplied by the Bidder shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Owner/Consultant:

- i) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.
- ii) If the results of the tests in (i) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (i) or as directed by the Owner/Consultant.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Owner/Consultant requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Bidder. If the plates in the fabricated item are found to be laminated, the component will be rejected.

Welding

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Owner may ask for at least one test-destructive or non-destructive including X-ray, ultrasonic test or similar, the cost of which shall be borne by the Bidder. In the event of further tests as may be desired by the Owner. The cost of such test shall be borne by the Bidder if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Owner / Consultant shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

Bolts, nuts and washers

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Owner/Consultant and shall conform to the relevant Indian Standards. If desired by the Owner/Consultant, representative samples of these materials may have

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- i) Name of the Bidder
- ii) Number and date of the Contract
- iii) Name of the office placing the contract
- iv) Nomenclature of stores
- v) A schedule of parts or pieces, giving the parts or piece number with
- vi) Tolerance

The tolerance on the dimension of the individual rolled steel components shall be as specified in IS: 1852. The tolerances on straightness, length etc. of various fabricated components (such as beams, girders, columns, etc) of the steel structures (other than steel railway and road bridges structure) subjected to dynamic loading (like wind, seismic etc.) and thin walled constructions (like box girders) shall be as specified in IS: 7215.

10.3 Erection

(a) General

The work to be provided for by the Bidder, unless otherwise specified in the Bid, shall include but not be limited to the following:

- i) The Bidder shall provide all transport equipment, lifting equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- ii) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Bidder shall pay all demurrage and / or wharfage charges etc. on account of default on his part.
- iii) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the Owner/Consultant. If necessary, suitable temporary approach roads to be built for transportation of fabricated steel structures.
- iv) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Owner/Consultant. The Bidder shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- v) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Owner/Consultant.

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- vi) Touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Bidder free of cost to the Owner.
- vii) All minor modifications of the fabricated steel structures as directed by the Owner/Consultant including but not limited to the following:
 - Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
 - Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
 - Reaming of holes for use of higher size bolt if required.
 - Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Owner/Consultant.
 - Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
 - Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
 - Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
 - Carry out tests in accordance with this Specification if directed.

(b) Conformity with design

The Bidder will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and / or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and / or the instructions of the Owner/Consultant. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and / or the instructions of the Owner/Consultant.

(c) Storage of materials

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site.

(d) Yard

The Bidder will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have

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proper facilities like, drainage, lighting, suitable access, trailers and other heavy equipments. The yard shall be fenced all round with security / arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

The Bidder should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. All of which shall be carried out by the Bidder at his own cost as directed by the Owner.

(e) Covered Store

All field connection materials, paints, etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Bidder.

(f) Workmanship

Erection Plant and equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Owner/Consultant.

Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Owner/Consultant. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

Temporary bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure Installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Bidder in respect of temporary bracings and guys shall cease when the structural steel is once located plumbed levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Owner/Consultant.

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The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Bidder to take out the materials from the project site. The Owner may remove and return the materials in good condition to the Bidder without any charge if they have been left in place under other agreed arrangement.

Temporary floors for buildings

It shall be the responsibility of the Bidder to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and / or by-laws of state, Municipal or other local authorities.

Setting out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Owner/Consultant. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Bidder shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations.

He shall remain responsible for correct positioning. For heavy columns, etc. the Bidder shall set proper screed bars if desired by the Owner/Consultant, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

Drifting

Correction of minor misfits of bolts will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to

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enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

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11. ARCHITECTURAL WORKS

The architectural design concept of buildings shall be evolved considering the functional, technical and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes. To achieve above objective Bidder shall employ a qualified architect / architectural firm to carry out all designs and hold all other architectural responsibilities for the project.

The Bidder shall obtain and be conversant with all laws, by-laws and regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The Bidder shall provide the drawings and documents for such statutory approvals.

11.1 General

The architectural services shall cover finishing work of new buildings and modernised existing buildings/structures, included under the specification starting from masonry work, partition walls, cladding walls, roof protection, finishing of walls, floors and ceilings, false ceiling as required potable water system, sanitation etc.

During execution of the contract, the Bidder shall take approval from the Owner, for all building materials and finish items (e.g. floor tiles, doors, and windows, paints etc.) to be used for the contract by submitting samples and/or product literature as appropriate.

Finishing works including material used for renovation/modernisation work shall be matched with the finishing of existing structures to make similarity in architectural view of new and existing structures.

11.2 Finishes

All exposed surfaces shall be clean and smooth and members shall be sized to give a pleasing appearance. The Finishes for all Structures and Buildings shall meet the functional requirements and shall be as per the approved Finishing Schedule. However, the finishing schedule shall be pre-approved by the Owner/Consultant.

11.3 Design Requirements

(a) Architectural Concepts

- All buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to all

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buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

- Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipments, exposed structural elements, piping, trestles, bus ducts and other service elements.
- Overall emphasis shall be on developing an eco-friendly architecture, merging with the nature with its own sustainable energy management systems.
- The scheme shall be conceptually finalized in totality including that of equipments so that the proper co-ordination with other agencies can be taken up at appropriate time.

(b) Architectural Design

- Natural light shall be used to the maximum extent. For adequate light and ventilation, National Building Code recommendation shall be followed.
- Entrance canopies, chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.
- All the buildings shall be architecturally designed to meet the National Building Code.
- Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect Statutory requirement and any clearances from local authority may be required to be met with, wherever essential. The Architect Consultant shall be of national - International repute having experience in similar kind of works. The consultant shall evolve the design philosophy and shall present it in the form of presentation drawings, prospective views, 3-D Models & detail drawings.
- A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving plant technology and architectural & civil engineering for a smooth control hierarchy and man machine interface.

The Bidder shall develop the architectural layout of all the buildings listed in this document as per the final approved equipment disposition and other layout considerations indicated elsewhere in this specification. These drawings shall need the approval of the Owner/Consultant before construction. The Bidder shall also have to submit perspective views if so desired by the Owner/Consultant at no expenditure to the Owner. Approval from statutory authorities, e.g. Factories Inspector, Explosives Inspector, Loss Prevention Association of India / Tariff

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Advisory Committee etc. shall be the responsibility of the Bidder without any obligation of the Owner.

The entire complex shall have an architectural character and style of its own and shall be visually and functionally integrated with the existing landscape. The Bidder must visit the site and have a feel of the overall environment, so that a harmonious as well as integrated architectural concept of the proposed phase of development is achieved. Special care must be taken to enhance the visual and technological quality of development by adopting updated technology, materials, finish etc.

11.4 Guideline for Architectural Works

11.4.1 Roof Insulation and Ventilation

Wherever required the roof of buildings shall be insulated with foam concrete. For ventilation requirements relevant section of the specification shall be referred.

11.4.2 Roof Waterproofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size 230x230x18 mm laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

11.4.3 Brick/stone masonry and parapet wall

All masonry works shall be designed in accordance with IS: 1597, IS: 1905, IS: 2212, IS: 4326 and other relevant IS codes as applicable. Structural design of load bearing and non-load bearing walls constructed with solid or perforated burnt clay bricks or concrete blocks shall be in accordance with criteria specified by National Building Code of India.

All walls shall be non-load bearing infill panel walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change rooms, first aid rooms and toilets, which may be half brick thick.

Minimum 50 kg/sq.cm compressive strength brick shall be used for non-load bearing super structure brickwork. Cement sand mortar 1:6 for one brick thick wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided to reinforce the wall where required.

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All brickwork shall be plastered as per specification.

Even where metal cladding is specified, for initial [3 m] height from the ground level, minimum one brick thick masonry wall shall be provided.

All up stands and parapet walls on roof shall be of RCC construction, minimum height of parapet walls shall be [1050 mm] and a minimum thickness of [125 mm].

11.4.4 Cement based polymer modified mortar

a) Purpose

To carry out structural repairs to prepared patches of spalled concrete with an alkaline impervious repair material comprised of polymer admixed cement-sand mortar.

b) Materials and T&P

Polymers in emulsion or powder forms as may be specified conforming to ASTM C1059, Ordinary Portland Cement of 43 grade conforming to relevant BIS code, Sand conforming to Zone-II or Zone-III grade of IS: 383, Mixing water conforming to IS: 456-2000, mortar mixer with mechanical water dozer, spatulas, trowels, etc.

c) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified polymers shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 Testing of Material: The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less). These are to be tested for conformance to the specified requirements before use on the work. Polymer modified cement mortar with cement: sand proportion by weight as (1:3) shall have the following properties

Minimum compressive strength -20N/sq.mm after 28 days at 27oC

Step-4: Identify and mark the area for Polymer modified mortar repair.

Step-5 Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

Prop & support the structural member to relieve it of stress and strains.

Removal of existing surface plaster/treatment shall be done.

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Chipping unsound/weak concrete material shall be done.

Removing concrete all around embedded rusted reinforcement shall be done.

Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done.

Sealing the cracked or honeycombed concrete with injection grouting shall be done.

Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate, which may also be used as depth measuring gauge.

Additional fresh reinforcement, if required, shall be tied with required overlaps or welded.

The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically.

Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done.

Step-6: Clean the dust and saturate the prepared surface of concrete and reinforcement with a clean oil free air blast and water fit for construction.

Step-7: Inspection of concrete surface prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-8: Alignment & thickness Control- Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-9: Apply Passivating & bonding coat over the cleaned existing and new reinforcement.

Step-10: Apply bond coat on the cleaned concrete substrate.

Step-11: Mix and Prepare Polymer Modified Mortar to have a uniform consistency and texture by adding cement sand and polymer as weigh batched ingredients of the design mix, a specified proportion of water through water dozer.

Use of prepacked ready to use components supplied by manufacturers in containers may be allowed subject to approval of Owner. In case where prepacked ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

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Plastering with cement based polymer modified mortar shall be done immediately after applying the bonding slurry to the prepared surfaces, preferably in coats of approximately 10mm thickness as greater thickness may lead to delamination/collapse. However, coats shall be applied in fairly rapid successions within 15 to 30 minutes. After applications of mortar the surface shall be finished using a wooden float.

Step-12: Moist cure the polymer modified mortar surface for 1-3 days followed by air curing at ambient temperature or as per manufacturer's specification, if specified otherwise. Use of flowing water or ponding of water shall not be done for curing. Steam curing shall not be permitted.

Step-13: Test the Surface of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

d) Inspection & Quality control

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing stoppage of work during low temperatures (minimum working temperature being 8°C in most of the polymer modified mortar or as per manufacturer direction) and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 28 days of mortar application. The cores shall be examined for evidence of poor workmanship by the Owner, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall dismantle such areas of work as required by the Owner and re-do the same after re-preparing the surface by chipping off mortar work and abrading the bonding slurry interface.

11.4.5 Partition Wall

All intermediate walls shall be full brick thick wall in 1:6 cement sand mortar. Half brick thick wall in 1:4 cement: sand mortar with [2 nos. 6 mm] diameter rod in every fourth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area.

11.4.6 Metal cladding

a) Permanent colour coated sandwiched insulated metal cladding system

Trough zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 180 gm / sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film

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Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanised M.S. sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanising shall not be less than 180 gm / sq. m.

The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanised steel sheet of grade 375 as per IS: 277. Inner sheet shall be fixed at the rate not more than 0.75 m centre to centre to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS: 8183, having a density of 32 kg / cu. m for glass wool & 48 kg / cu. m for rock wool.

b) Permanent colour coated (non-insulated) metal cladding system

Trough zinc-aluminium alloy coated not less than 180 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability.

c) Flashings, Cap, Trim Closures etc.

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

11.4.7 Plastering

On the exterior wall & rough side of interior brick wall [18 mm] thick minimum with cement-sand mortar in two layers shall be applied. Where external finish will require rich plastering for special finish plaster shall be of 1:4/1:3.

Interior wall: [12 mm] thick with 1:4 cement-sand mortars

Ceiling: [6 mm] thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

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11.4.8 Removal of plaster manually from masonry or concrete surface using chisel and hammer and disposal of debris etc

a) Purpose

For removal of all type of loose /delaminated /damaged/weak cement plaster from surface of masonry or concrete.

a) Procedure

Step-1: Safety shall be ensured in accordance with contract conditions and specifications.

Step-2: Provide double scaffolding, protective screens etc.

Step-3: Existing plaster to be to be identified for removal by tapping all areas and its boundary shall be marked with a colour marking (in an optimal rectangular shape), which shall be approved by Engineer-in-Charge.

Step-4: Make a cut normal to the surface all along the boundaries with power driven cutters. The depth of cut shall not exceed the thickness of plaster.

Step-5: Remove the plaster manually with the help of chisel and hammers to completely expose the parent masonry or concrete surface, so as not to have any traces of such plaster left behind.

11.4.9 False ceiling and under deck insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the under side of the roof / floor slab of the air-conditioned areas based on the functional requirement. Aluminium false ceiling system shall comprise of [84 mm] wide [12.5 mm] deep closed type plain panels of approved colour, roll formed out of [0.5 mm] thick corrosion resistant aluminium alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, AC ducts etc. Suitable M.S channel (minimum ISMC100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc.

Bidder shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire detectors, fire protection sprinklers etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the Owner approves the layout. Under deck insulation shall comprise of [50 mm] thick resin bonded mineral wool insulation mat conforming to IS:8183. This mat shall be backed with [0.05 mm] thick aluminium foil and [24 Gx25 mm] wire mesh netting. These shall be fixed to ceiling or wall as the case may be with [100x50x6 mm] slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at [600 mm c/c and 14 G] steel wire drawn through slots and fixed to wire netting.

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11.4.10 Doors

- Generally hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas.
- Solid core factory made wooden flush doors in hard wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.
- Special areas like control rooms and other special area shall be provided with minimum 15 micron pre-coated Le. colour anodised aluminium glazed partitions with air lock facilities having two sets of doors.
- Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard and also to all fire exists as per TAC requirement.
- Doors shall be provided at appropriate location to prevent dust ingress from outside.
- FRP Doors with FRP Frames shall be provided for all the toilet doors.
- Weather stripping shall be provided to all outside doors as well as air-conditioned areas and all other doors where dust-free environment is required.

11.4.11 Rolling shutters

Rolling steel shutters conforming to IS: 6248 will be used for large openings where frequent use is not envisaged. Unless noted otherwise, main entry doors of width and height to suit the requirements. Rolling shutters with area up to 8 m2 shall be pull and push type hand operated, while above 8 m2 shall be pull and push type with ball bearings (Electrically operated) as per IS specification.

11.4.12 Windows & Ventilators

In all buildings, full glazed windows and ventilators in minimum [15 micron] colour anodized aluminium window frame shall be provided with [4 to 6 mm] thick (depending on the size of panel) clear float glass and [6 mm] thick clear wired/laminated glass where required from safety point of view. Structural glazing may be considered as an important facade element.

The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Glass thickness and member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Bidder before execution.

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11.4.13 Plywood Covering Panels to Cover Windows etc. During repairs

a) Purpose

To protect the finished items against their spoiling/damage to finishes during the process of carrying out repairs in a building. The items could include finished windows, doors, glass curtain wall or other such items.

b) Materials:

Wooden Battens of size 50mm X 50mm (approximately) or as approved by Engineer-in-charge, free from warping, cracks etc. made from locally available timber.

Plywood of suitable thickness, preferably 6 mm thick, as approved by Engineer-in-Charge.

Nails, screws etc. as per requirement.

c) Fabrication:

Size of covering panels shall be more than the size of windows etc. to be shielded/ protected, enough to be fixed to the walls without damaging the windows etc.

Wooden battens shall be cut approximately to the size of panels of windows etc. to be protected. The joints of the wooden framework shall be lap joint or as approved by Engineer-in-Charge.

Where the panel size is more than 2 square metres or as specified by the Engineer-in-Charge, the stiffening shall be done with batten backing to impart stiffness enough to provide rigidity against undue deflection due to impact of falling debris, self load, etc.

Plywood shall be fixed with nails/screws over the batten frames. The spacing of nails/screws shall be about 300mm c/c or as may be required at site.

d) Fixing:

The plywood covering panel shall be suitably fixed without damaging the windows etc. being protected by such panels with nails/screws fixed in walls strong enough to resist the forces likely to be imparted during repair work. It shall be done in such a manner that it can be removed with ease without damaging the covered windows etc. after completion of repairs.

e) Removal:

After completion of work, the covering panels shall be removed carefully, so as not to cause any damage to windows etc. covered. The damages, if any, shall be made good.

11.4.14 Facilities in Buildings

Adequate toilet and drinking water facilities shall be provided for personnel working in each building. Each building shall have toilet facilities both for Gents

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and Ladies. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.

However minimum 1 Water Closet, 1 washbasin, 1 urinal shall be provided in each toilet.

Each floor shall have drinking water facility connected through water purification system like Aquaguard or similar approved make.

11.4.15 Glazing & Glazed Partition

- Glazing in Control room between AC. and non-AC. areas shall be insulating glass consisting of [two 6 mm] thick toughened float glass sheet hermetically sealed and separated by [12 mm] gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.
- [4 mm] thick ground glass shall be provided for toilets.
- Glazing between two AC. areas shall be with 6 mm thick clear float glass.
- All glazing shall be in aluminium frame.
- [6mm] thick Wired / laminated glass shall be used for windows / ventilators at higher level for safety.
- [24mm] thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with [12mm] air gap & hermetically sealed shall be mounted on [15 micron] coloured anodised aluminium frame suitable for structural glazing system.

11.4.16 Sealant

Silicon sealant or polyurethane sealant shall be used in all expansion joints exposed to weather. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water-lightness.

11.4.17 Damp Proof Course

[40 mm thick 1:1.5:3] concrete with waterproofing admixture. Water proofing compound shall be of Zydex, SIKa, or similar approved.

11.4.18 Plinth Protection

Minimum [1000 mm] wide and minimum [100 mm] thick M 15-grade concrete plinth protection along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be provided. The plinth protection shall be laid over prepared sub-grade and base formed with locally available broken laterite stone to thickness of [150 mm].

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11.4.19 Painting

- Exterior Masonry Surface : Buildings shall be finished with [Acrylic Emulsion pain] as per IS specification with approved colour and scheme.
- Exterior Steel Work : Anti-corrosive synthetic enamel paint over [anti corrosive primer].
- All Woodwork: [Synthetic paint over a coat of primer].
- All Internal Steel Work : [Synthetic enamel over a coat of primer].
- Interior Office Spaces Rooms, All AC Areas : Acrylic emulsion paint over [2 mm] control thick plaster of paris punning.
- Balance areas: As indicated in finish schedule in this document.
- Fire Door: Post Office red shade shall be provided.

11.4.20 Flooring

Unless and otherwise specified, the nominal total thickness of floor finish shall be [50 mm] including under bed and topping. The flooring shall be laid on already matured concrete base. The under bed for floors shall consist of minimum grade of M 15 with stone chips [12.5 mm] downgraded as coarse aggregates. The under bed shall be provided appropriate slope towards catch pit for floor drainage.

- **False Flooring System**

Removable type false flooring system shall be provided wherever required (computer rooms etc.). RCC floor slab will be sunk to a depth [800 mm], which shall be height of the false floor system. The flooring shall consist of fire resistant phenol formaldehyde bonded particle board panels [600x600x35 mm] size, mounted on steel pedestals of adjustable height and supporting steel grid system to provide under floor space. [2 mm] thick flexible anti-static PVC topping on top and PVC strip edging on sides of each panel shall be provided.

- **PVC Floor Finish**

Two mm thick PVC as per IS: 3462 and laid as per IS: 5318 over concrete under bed of [48 mm] shall be provided in electronic cubicle rooms, conference room, etc. PVC tiles shall ensure anti static surface.

- **Vitrified ceramic Tiles**

Heavy duty vitrified ceramic tiles of appropriate thickness and of minimum size [600 mm x 600 mm] of approved shade & colour shall be provided for control room as per relevant code and manufacturer's specification over concrete bedding to result in an overall thickness of [50 mm].

- **IPS Flooring**

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IPS (cement concrete flooring) with metallic floor hardener topping [12 mm] thick with a total thickness of [50 mm] shall be provided in maintenance and unloading area, ground floors, floor of pump house, permanent stores and other plant building areas where heavy duty flooring is required.

IPS flooring with non-metallic floor hardener shall be provided in all MCC and switchgear rooms, which are not air-conditioned.

IPS flooring shall also be provided in areas, which are not provided with any special finish. Areas which are likely to be subjected to oil spillage shall be provided with two coats of oil resistant painting over IPS floor finish. If required, Bidder has to use floor hardeners at appropriate locations.

- **Heavy Duty Ceramic Tiles**

Heavy duty vitrified ceramic tiles with suitable finish shall be used in toilets, pantry, dining hall of canteen, locker rooms etc. The tiles shall be minimum of [300 x 300 x 7 mm] of approved shade, brand and colour.

- **Acid / Alkali Resisting Tiles**

Battery rooms and other areas coming into contact with acid / alkali vapours or fumes shall be given acid / alkali resistant tiles [25 mm] thick, jointed with acid / alkali resistant cement slurry. Bedding shall comprise of potassium silicate mortar conforming to IS: 4832 (Part-I) and resin based mortar like epoxy for jointing. Total thickness of flooring shall be [50 mm].

- **Integral Floor Finish**

For cable vaults floor finish integral to the concrete base shall be provided as per IS: 2571.

11.4.21 Miscellaneous

PVC nosing shall be provided for edge protection of R.C.C. stair treads.

Angles [50x50x6 mm] (minimum) with lugs shall be provided for edge protection of cutouts / openings in floor slabs, edge of drains covering gratings, edge of R.C.C cable / pipe trenches of any other place where breakage of edges / corners is expected.

Floors of switchgear rooms shall have embedded steel channel suitable for easy movement of breaker panel.

11.4.22 Skirting/DADO

- [150 mm] skirting matching with floor finish shall be provided in all areas unless specified otherwise elsewhere.
- Toilets and locker rooms shall be provided with dado of [2100 mm] high with glazed tiles of minimum 5 mm thickness generally as per IS: 777.
- For battery room and other areas coming in contact with acid / alkali spillage / fume, dado of acid / alkali resistant tiling as per IS: 4457 shall be provided

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to a height of [2100 mm] set in potassium silicate mortar and joints pointed with resin bonded mortar

- Staircase wall shall be given dado of vitrified tiles of approved colour and shade to a height of [2100 mm] or as per approved drawings.

11.4.23 Roof access

All roofs shall be provided with access thorough a staircase / cage ladder. Minimum [1000 mm] wide access path shall be provided with suitable tiles to approach equipment on roof.

11.4.24 Roof Drains

Roof drains design criteria

Minimum diameter of the pipe shall be [150 mm]. The roof drains shall be sized for the roof area runoff for a maximum rainfall per hour at site.

Detailed specification is mentioned elsewhere in this specification.

Roof Drainage and Water Proofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size [230x230x18 mm] laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

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12. GENERAL REQUIREMENTS

12.1 Roof

All the buildings having R.C.C slabs over structural steel framing are provided with troughed metal sheet decking which acts as permanent shuttering. These sheets shall meet the general requirements of IS: 14246 and shall conform to class 3 for durability. The sheeting shall be permanently colour coated galvanised M.S. troughed metal sheet decking of approved profile with minimum base metal thickness of 0.8 mm and minimum trough depth of 38 mm. Silicon modified polyester painting shall be used for permanent coating over galvanised surface with minimum rate of galvanising of 180 gm of zinc per sq. m. Dry film thickness of colour coating shall be at least 20 micron.

Roof of all buildings having R.C.C. framework shall have cast in-situ R.C.C. slab with conventional shuttering.

Structural steel roofing wherever required shall be of permanently colour coated galvanised M.S troughed metal sheet of approved profile. Minimum base metal thickness shall be 0.8 mm. The rate of zinc consumption for galvanising shall be 275 gm/sq. m. The external face shall have permanent colour coating of PVF 2 paint of minimum DFT of 20 microns and inner surface shall be coated with silicon modified polyester paint with DFT of 20 microns

12.2 Waterproofing of underground structures

All underground structures like basements, pump houses, water retaining structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sq.m (minimum) for water/ damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that waterproofing grouting can be injected later in case of leakage.

12.3 Anti-termite treatment/Anti-weed treatment

Pre-constructional anti termite treatment shall be given to all buildings as per IS: 6313 and other relevant Indian Standards.

Reservoirs shall be given an anti-weed treatment of approved quality and quantity as per the manufacturer's specification. Anti weed treatment shall be carried out before carrying out the lining work.

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13. GENERAL CIVIL WORKS AND CONSTRUCTION TOLERANCES

13.1 Basic requirements for all civil works

Design requirements

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Owner/Consultant.

- Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers (whichever is less).
- The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable nor troublesome to personnel and will not cause damage to the machine or structure.
- The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating plant.
- The differences between frequencies and the dynamic analysis of the superstructures and foundations shall be in accordance with the relevant design standard.
- The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.
- Throughout the works all floor slabs above rooms containing electrical equipment shall be watertight. No drainpipes or water pipes are permitted to pass through these rooms.
- All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Owner/Consultant and shall comply strictly with the tests prescribed hereinafter or, where tests are not laid down in this specification, with the requirements of the latest issue of the relevant Indian, American, British, German Standards or other Standards approved by the Owner/Consultant.
- Samples of all materials proposed to be used in the works may be called for at any time by the Owner/Consultant.

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- The work shall be carried out by competent personnel skilled in their various trades.
- Before commencing the works, the Bidder shall ascertain the locations and nature of all existing underground services and shall take every possible precaution against any damage occurring to them or interference therewith, during the execution of the works.
- Suitable access to the roofs of the buildings by means of steel stairs shall be provided for maintenance and repair of any installation.
- All rooms with fire hazard shall be provided with suitable emergency exists.
- Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles, which will be used (cars, forklifts, trucks/trailers etc) to reach up to the point of unloading of the equipment.
- Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms, at all levels using suitable stair wells and suitable electric hoists. The dimensions of rooms, stairwells, doors, etc shall be designed to suit the a.m. transport concept.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.

13.2 Basic requirements during construction

Basic Cleaning

Basic cleaning includes all floors, walls, ceilings, built-in fittings and equipment, including the furnishings. The basic cleaning operation must result in a degree of cleanness, which permits the fully equipped buildings and rooms and associated outdoor installations and secured surfaces to be taken over without complaint.

Advertising boards and stickers, temporary protective coatings and claddings, remains and splashes of paint, must be removed with water or suitable solvents. Dust and other dirt must be completely removed from all wall and floor surfaces, as well as from all furniture.

Windows and mirrors must be cleaned so that they are completely clear and without streaks.

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Perlator gauges, showerheads, odour traps and floor drains of the sanitary installations must be cleaned and the fittings and bright pipe work must be spotlessly polished.

Petrol and oil separators must be emptied, cleaned and refilled if necessary during basic cleaning.

Lamps, including dishes, lighting units and tubes, switches and sockets as well as bases and skirting boards, doors with frames and glazing, windows, window seats and other furniture and fittings must be included in the basic cleaning operation.

Initial Equipment

The specification is drawn up on the assumption that the scope of the initial equipment and consumption materials is to be provided complete in every respect; everything required for the use and care of the installations must be supplied, even if this is not expressly specified in the documentation.

Bidder shall ensure that during excavation ground water level shall be lowered by at least 0.50 m below the founding level adopting appropriate method of dewatering. Lean concrete below foundation shall be laid soon after excavation with minimum loss of time.

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14. STANDARDS, CODES AND REFERENCES

14.1 General

The Design of the Steel Structural Works shall be prepared and presented in accordance with IS codes. In absence of guidelines of specific items in the IS codes, International codes viz., American, BS, DIN or Australian code shall be used. All the Indian Standards referred to shall be the latest revision (including all amendments issued thereto) on the date of opening of the price bid. The Standards adopted shall be clearly stated in the calculations.

The Design shall comply with the current Local Authority Building Regulations (National Building Code) where appropriate. Subject to the agreement of the Owner, other International / Foreign National Standards, and, International / Foreign National Standard Codes of Practice, may be used.

To the extent that the Design shall include materials, methods or workmanship to be incorporated into the works, they shall be selected and incorporated into the design in accordance with the recommendations and requirements of the following (as appropriate in order of precedence but not mutually exclusive):

Statutory requirements

The Contract provisions

Bureau of Indian Standard Codes of Practice

International / Foreign National Standards

Agreement Certification for Materials

Manufacturer's recommendations for materials

Competent Trade Association recommendation

Engineering judgment

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

Where British / American / DIN or other codes and standards are referred to in this document, equivalent Indian Standards may be substituted if available.

Materials supplied from India shall follow the Indian Standard Specifications.

Field and laboratory testing procedures for materials follow Indian Standard Specifications.

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14.2 Codes for Loads

- IS: 875 : Code of Practice for design loads (other than earthquake) for Buildings and structures (All parts)
- IS: 1911 : Schedule of unit weights of building materials
- IS: 1893 (Part 1) : Criteria for earthquake resistant design of structure – General provisions and buildings
- IS: 1893 (Part 4) : Criteria for earthquake resistant design of structure – Industrial structures including stack-like structures

14.3 Codes for RCC

- IS: 456 : Plain and reinforced concrete - Code of Practice
- IS: 2974 : Code of Practice for design and construction of machine foundations
- IS: 2911 : Code of Practice for design and construction of pile foundation
- IS: 4326 : Code of Practice for earthquake resistant design and construction of buildings
- IS: 5525 : Recommendation for detailing of reinforced concrete works
- IS: 1786 : Specification for high strength deformed steel bars and wires for concrete reinforcement

14.4 Codes for Structural Steel

- IS: 800 : Code of Practice for general construction in steel
- IS: 801 : Code of practice for use of cold-formed light gauge steel structural members in general building construction
- IS: 806 : Code of Practice for use of steel tubes in general building construction
- IS: 808 : Dimensions for hot rolled steel beam, column channel and angle section
- IS: 812 : Glossary of terms relating to welding & cutting of metals
- IS: 813 : Scheme of symbols for welding
- IS: 814 : Covered electrodes for manual metal arc welding of carbon and carbon manganese steel - Specification
- IS: 815 : Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel
- IS: 816 : Code of Practice for use of metal arc welding for general construction in mild steel
- IS: 817 : Training of welders - Code of practice (Part 1 & 2)
- IS: 818 : Code of practice for safety and health requirements in

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- electric and gas welding and cutting operation.
- IS: 819 : Code of practice for resistance spot welding for light assemblies in mild welding
- IS: 822 : Code of practice for inspection of welds.
- IS: 1182 : Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
- IS: 1200 : Method of measurement of building and civil engineering works
- IS: 1161 : Steel tubes for structural purpose
- IS: 1363 : Indian standard- Hexagonal head bolts, screws and nuts of product grade C
- IS: 1367 : Technical supply condition for threaded fasteners
- IS: 1477 : Code of practice for painting of ferrous metal in building
- IS: 1852 : Specification for rolling and cutting tolerance for hot-rolled steel products
- IS: 2062 : Structural steel (fusion welding quality)
- IS: 2074 : Ready mixed paint, air drying, red oxide zinc-chrome, priming
- IS: 2645 : Specification for integral cement waterproofing compound
- IS: 2932 : Specification for enamel, synthetic exterior type –I
- IS: 3613 : Acceptance tests for Wire flux combination of submerged arc welding
- IS: 3757 : Specification for high strength structural bolts
- IS: 4000 : Code of practice for High Strength bolts in steel structures
- IS: 7205 : Safety code for erection of structural steel work
- IS: 7215 : Specification for Tolerances for fabrication of steel structures
- IS: 7280 : Specification for Bare wire electrodes for submerged arc welding of structural steel
- IS: 8640 : Recommendations for dimensional parameters for industrial building
- IS: 9178 : Criteria for design of steel bins for storage of bulk material (All parts)
- IS: 9595 : For Metal arc welding of carbon and carbon manganese steel - Recommendation
- IS: 11592 : Conveyor galleries
- IS: 12843 : Tolerances for erection of steel structures

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14.5 Miscellaneous Codes

IS: 919	:	ISO system of limits and fits
IS: 1038	:	Specification for steel doors, windows and ventilators
IS: 1172	:	Code of basic requirements for water supply, drainage and sanitation
IS: 1346	:	Code of Practice for water proofing of roofs with bitumen felts
IS: 1742	:	Code of Practice for building drainage
IS: 1905	:	Code of Practice for structural use of unreinforced masonry
IS: 2210	:	Criteria for design of reinforced concrete shell structures and folded plates
IS: 2633	:	Method for testing uniformity of coating on Zinc Coated Articles
IS: 3067	:	Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
IS: 4759	:	Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products
IS: 10440	:	Code of Practice for construction of reinforced brick and reinforced brick concrete floors and roofs
IS: 13592	:	Un-plasticized polyvinyl chloride (UPVC) Injection molded fittings for soil & waste discharge system for inside and outside buildings including ventilation and rail water system specification
IS: 15658	:	Precast concrete blocks for paving
SP: 6	:	Handbook for structural engineers - All parts
SP: 7	:	National Building Code of India
SP: 16	:	Design Aids for reinforced concrete to IS: 456-1978
SP: 20	:	Handbook on masonry design and construction
SP: 22	:	Explanatory handbooks on codes for earthquake engineering (IS: 1893-1975 and IS: 4326-1976)
SP: 24	:	Explanatory handbooks on Indian Standard code of Practice for plain and reinforced concrete
SP: 25	:	Handbook on causes and prevention of cracks in buildings
SP: 32	:	Handbook on functional requirements of industrial buildings
SP: 34	:	Handbook of concrete reinforcement and detailing (SCIP)
TAC	:	Traffic Advisory Committee
-	:	Indian Explosive Act
-	:	Indian Factory Act and State Factory Act

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- : Indian Electricity Act

Any statutory codes / standards / regulations other than listed above, as may be applicable, shall be followed.

Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in this document, the latest editions of the codes and standards given below shall also apply:

- a) Japanese Industrial Standards (JIS).
- b) American National Standards Institute (ANSI).
- c) American Society of Testing and Materials (ASTM).
- d) American Society of Mechanical Engineers (ASME).
- e) International Organization for Standardization (ISO).
- f) American Welding Society (AWS).
- g) National Electrical Manufacturers Association (NEMA).
- h) National Fire Protection Association (NFPA).
- i) International Electro-Technical Commission (IEC).
- j) German national codes (DIN)
- k) Expansion Joint Manufacturers Association (EJMA)

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-III
PART-A
TECHNICAL SCHEDULES-MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
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Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
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2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
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6. Forms and Schedules

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

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{Only the Applicable portion of the Data Sheet based on the scope of work as firmed up in Section-I, Volume-II should be retained and the remaining portion should be deleted. The scope of work in Section-I, Volume-II is based on Residual Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA) Report.}

Sl. No.	Item description	Technical Requirement			
1.0	Turbine – Performance Data				
(a)	Manufacturer				
(b)	Type and description				
(c)	No. of Cylinders				
1.1	Steam Parameters at Various Load	VWO	100% MCR	80% MCR	60% MCR
(a)	Main steam pressure before stop valve, {Kg/Sq.cm (a)}				
	Main steam temperature before stop valve, (Deg.C)				
	Pressure of steam at inlet to reheat stop valves {Kg/Sq.cm (a)}				
	Temperature of steam at inlet to reheat stop valve, (Deg.C)				
	Speed (rpm)				
(b)	Extraction pressure (Kg/cm ²)				
	1st extraction				
	2nd extraction				
	3rd extraction				
	4th extraction				
	5th extraction				
	6th extraction				
(c)	Steam Flow data, tonnes/hr. (Corresponding to constant pressure operation)	VWO	100% MCR	80% MCR	60% MCR
	Main steam throttle flow				
	Reheat steam flow				

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Sl. No.	Item description	Technical Requirement
	1st extraction	
	2nd extraction	
	3rd extraction	
	4th extraction	
	5th extraction	
	6th extraction	
	7th extraction	
	Exhaust flow to condenser	
(d)	Condenser vacuum (Kg/cm ²)	
(e)	Rated output (MW)	MCR(0%MU) MCR(3%MU) VWO(3%MU)
	-Turbo generator rated output with design extraction flow (MW)	
	-Turbo generator rated output with no extraction flow (MW)	
	-Turbo generator rated output with no extraction flow to HP heater (MW)	
(f)	Minimum continuous steam flow through turbine at rated speed, (Tonnes/hr)	
(g)	Power generated during minimum steam flow (MW)	
(h)	Maximum flow passing ability of turbine with valve wide open condition (tonnes/hr).	
(i)	Maximum continuous capacity of turbine with VWO (MW)	
(j)	Maximum allowable sustained pressure before turbine stop valve (kg/cm ²)	
(k)	Allowable time for the above	
	On any occasion (minutes)	
	Total (hrs) in a year.	
(l)	Maximum momentary pressure before turbine stop valve {kg/cm ² (a)}	
(m)	Maximum allowable temperature before turbine stop valve (Deg.C)	
(n)	Allowable time for the above	

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Sl. No.	Item description	Technical Requirement
	On any occasion (minutes)	
	Total (hrs) in a year.	
(o)	Maximum allowable temperature before reheat stop valve (Deg.C)	
(p)	Allowable time for the above	
	On any occasion (minutes)	
	Total (hrs) in a year.	
2.0	Turbine – Layout Data	
(a)	Total turbine-generator block length (mm)	
(b)	Total turbine-generator block width (mm)	
(c)	Total weight (only)	
	- Turbine-Generator combined (Tonnes)	
	- HP Turbine (Tonnes)	
	- IP Turbine (Tonnes)	
	- LP Turbine (Tonnes)	
	- Generator (Tonnes)	
(d)	Weight of heaviest piece during erection other than generator stator (tonnes)	
(e)	Weight of generator stator (tonnes)	
(f)	Weight of following (tonnes) :	
	- Generator rotor	
	Upper casing with diaphragms	
	- HP Turbine	
	- IP Turbine	
	- LP Turbine	
	Turbine rotor	HP IP LP
(g)	Weight & name of single heaviest pieces required to be lifted during routine maintenance	
(h)	Distance required for rotor pulling beyond the turbine-generator block	
	- Straight pull (mm)	

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Sl. No.	Item description	Technical Requirement		
	- Canting horizontally (mm)			
	- Main hook			
	- Auxiliary hook			
(i)	Proposed equipment plan layout drawing for			
	- Ground floor enclosed			
	- Mezzanine floor enclosed			
	- Operating floor enclosed			
	- General cross section			
3.0	Turbine – Design Data			
	General			
(a)	Last stages annulus area (total) (sq.m.)			
(b)	Last stage blade length and pitch dia. (mm)			
(c)	Critical speed of (rpm)			
	- Turbine rotor			
	- Generator rotor			
	- Combined critical speed			
(d)	Rotor Detail	HP	IP	LP
	- No. of stages			
	- Method of construction			
	- Diameter of the tips of the first row of blade			
	- Diameter of the tips of the last row of blade			
	- Special protection against erosion due to moisture impingement, as applicable for LP Turbine Blades			
	- Maximum wetness of steam that can be tolerated continuously by LP blading without affecting normal life (indicate life considered)			
	Maximum allowable temperature at LP turbine exhaust hood			
	Set value for exhaust hood spray valve to			

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Sl. No.	Item description	Technical Requirement
	open	
	Coast-down time after turbine trip With vacuum - With vacuum breakers opened	
(e)	Material of construction	
	<i>Turbine Casings</i>	
	(i) HP outer casing / barrel casing	
	(ii) HP inner casing and blade carriers	
	(iii) IP inner casing	
	(iv) IP outer casing	
	(v) LP outer casing	
	(vi) LP inner casings and blade carriers	
	Turbine Shaft	
	<i>Moving Blades</i>	
	(i) Turbine first stages	
	(ii) Turbine other stages i) ____ to ____ ii) ____ to ____	
	<i>Fixed Blades</i>	
	(i) Turbine first stages	
	(ii) Turbine other stages i) ____ to ____ ii) ____ to ____	
	<i>Casing Joint bolts</i>	
	<u>Shaft Couplings bolts</u>	
	<u>Sealing Strips</u> - Casing - Fixed blades - Rotor	
	<u>CRH valves</u>	
	(i) Valve body	
	(ii) Valve spindle	
	(iii) Valve seat	
	<u>Extraction valve</u>	

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Sl. No.	Item description	Technical Requirement
	(i) Valve body	
	(ii) Valve spindle	
	iii) Valve seat	
	Gland steam condenser (i) Shell (ii) Tube (iii) Tube sheet	
	Gland steam exhauster (i) Impeller (ii) Shaft (iii) Casing	
	Main oil tank	
	Main oil pump (i) Shaft (ii) Impeller/runner (iii) Casing	
	Auxiliary oil pump (i) Shaft (ii) Impeller/runner (iii) Casing	
	Turning gear (i) Nozzle (ii) Runner blades	
	Jacking oil pump (i) Shaft (iii) Runner/impeller (iii) Casing	
	Control oil pump (if provided) (i) Shaft (ii) Impeller/runner (iii) Casing	
	Oil cooler (i) Shell (ii) Tube	

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Sl. No.	Item description	Technical Requirement
	Lube oil piping from oil cooler to turbine bearings	
	(i) MOT oil filter housing (ii) Filter element	
	(i) Duplex filter housing (ii) Filter element	
	Oil vapour extractor (i) Shaft (ii) Impeller (iii) Casing	
	Centrifuge (i) Casing (ii) Shaft (iii) Bowl and internals	
	Oil Heater (i) Shell (ii) Tube (iii) Heating element	
	Polishing filter (i) Element (ii) Vessel	
	Central oil storage (i) Tank (ii) Pumps (iii) Shaft (iv) Runner/impeller (v) Casing	
	Lube oil conditioning equipment <u>Pumps</u> (i) Shaft (ii) Impeller (iii) Casing	
	Flash tank (i) Shell (ii) Nozzle	

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Sl. No.	Item description	Technical Requirement
(f)	External Connection	
	- Main steam	
	- Cold reheat	
	- Hot reheat	
	- 1st extraction	
	- 2nd extraction	
	- 3rd extraction	
	- 4th extraction	
	- 5 th extraction	
	- 6 th extraction	
	- 7 th extraction	
	Inter stage drains	
	Outlet connection	
(g)	Thermal insulation for Turbine	
	(i) Insulated Material	
	Type of insulated material	
	Insulation as per standard	
	(ii) Cladding	
	Material of Sheet	
	Thickness of Sheet	
	(iii) Noise Level of TG Set	
(h)	Permissible forces & moment at turbine connection flange	HP IP LP
	Forces in kgs. -Fx-(Axis of turbine rotor)+/- : -Fy-(Vertical) +/- : -Fz-(Lateral) +/-	
	Moment in kg-m -Mx +/- : -Mz +/- : -Mz +/- :	
(i)	Turbine Movements	

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Sl. No.	Item description	Technical Requirement
	- Location of turbine anchor point	
(j)	Design pressure and temperature	
	- Valve chest	
	- Casing	
(k)	Maximum noise level at (dBA)	
(l)	Bearing	
	Journal bearings <ul style="list-style-type: none"> - No. - Size - Type - Optimum operating temp. - Lining material 	
	Thrust bearings <ul style="list-style-type: none"> - No. - Size - Type - Optimum operating temp. - Lining material - High wear or failure detector 	
(m)	Coupling <ul style="list-style-type: none"> - No. - Location - Size - Type - No. & size of bolts - Material & ultimate strength of bolts 	
(n)	Casing bolts <ul style="list-style-type: none"> - Type - Number - Diameter, mm - Kinds of threads - Material of bolts - Steam heating of bolts - Allowable stress at 500 Deg.C 	

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Sl. No.	Item description	Technical Requirement
	- Heat of bolts provided (Y/N)	
(o)	Exhaust hood relief diaphragm <ul style="list-style-type: none"> - Type - Number - Bursting pressure (Kg/cm2) - Material of construction 	
(p)	Maximum peak to peak vibration (microns) <ul style="list-style-type: none"> - Turbine bearing housing - Exciter bearing housing - Shaft 	
(q)	Turbine suitable for no. of starts & stops for the life cycle of the plant as specified (Y/N)	
(r)	Turbine safety & supervisory instruments and interlocks furnished as specified (Y/N)	
4.0	Turbine – Control & Protection	
(a)	Main Governor	
	- Type	
	- Steady state speed regulation	
	Steady state incremental speed regulation <ul style="list-style-type: none"> - First 15% of rated power - Last 10% of rated power - Other power output 	
	- Speed regulator dead band	
	- Governing range	
(b)	Emergency over speed governor	
	- Type	
	- No. of independent devices	
	- Set operating speed	
	- Range of adjustment	
	-No of actuation signaling contacts provided	
	- Is arrangement for testing with unit in operation (on-load test) provided?	

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Sl. No.	Item description	Technical Requirement
(c)	Motor operated speed changer	
	- Type	
	- Synchronizing range	
	- Type of motor	
	- Range of adjustment of load	
(d)	Load limit device	
	- Type	
	- Type of drive motor	
	- Motor voltage & KW	
	- Is both remote and local position indication furnished?	
	- Range of adjustment of load limit	
	- Suitable for remote operation	
(e)	Initial pressure regulator	
	- Type	
	- Set pressure of operation	
(f)	Vacuum unloading device (if provided as part of EHG)	
	- Type	
	- Set value of condenser pressure for operation	
(g)	Control valves for governor	
	- Type	
	- No. & size	
	- Materials - Valves internals Wear surface protection	
	- Type of sealing	
(h)	<u>On-load throw-off :</u>	
	- Temporary speed rise (TSR)	
	- Permanent speed rise	
	- Range of adjustability of speeder gear	

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Sl. No.	Item description	Technical Requirement
(i)	<u>Specific conditions under which Turbine trips:</u>	
	Thrust bearing excess wear trip	
	Condenser very low vacuum trip	
	Lube oil pressure very low trip	
	Control oil pressure very low trip	
	Relative vibration high trip	
	Main steam temperature high trip	
	High exhaust hood temperature trip	
	Top and bottom casing differential temperature high trip	
	HP exhaust steam temperature high trip	
	Bearing metal temperature high trip	
	Is manual trip from control room and local provided?	
	Turbine Shaft vibration very high trip	
	Is manual trip lever provided on turbine front pedestal	
	Load limitations, in percent of rated load, if any, for testing of full closure of <ul style="list-style-type: none"> - Main stop valves - HP Turbine governing valve - Interceptor valve 	
(j)	Main stop & throttle valve	Stop Valve Control Valve
	-Capacity of Valve	
	- No. & size	
	- Type & method of actuation	
	- No. of limit switches	
	- Opening through full travel	
	- Closing through full travel	
	- Provision for on-load testing	
	- Permanent strainer type & strainer material	
	- Valve Material	

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Sl. No.	Item description	Technical Requirement
	<ul style="list-style-type: none"> - Valve body - Valve internal - Valve seats 	
	- Type of sealing	
(k)	Reheat stop & interceptor valve	Stop Valve Control Valve
	- Capacity of Valve	
	- No. & size	
	- Type & method of actuation	
	- No. of limit switches	
	- Opening through full travel	
	- Closing through full travel	
	- Provision for on-load testing	
	- Permanent strainer type & strainer material	
	- Valve Material <ul style="list-style-type: none"> - Valve body - Valve internal - Valve seats 	
	-- Provision for remote operation	
	-- Type of sealing	
(l)	- Extraction valves	
	- No. & size	
	- Type	
	- Actuation system	
	- Provision for on-load testing	
	- Valve Material <ul style="list-style-type: none"> - Valve body - Valve internal - Valve seats 	
5.0	Turning Gear	
(a)	Type	<u>Either Hydraulic or Motorized</u>
(b)	No.	

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Sl. No.	Item description	Technical Requirement
(c)	Method of engagement	<u>Automatic</u>
(d)	Method of disengagement	<u>Automatic</u>
(e)	Drive motor (kW)	
(f)	Is Hand barring facility provided?	
(g)	Turbine rotor speed on turning gear drive	
(h)	Furnished sensing element and other devices as required for remote indication of turning gear engaging & disengaging	
6.0	Turbine Supervisory Instruments	
(a)	Bearing vibration (amplitude & velocity)	
	Type of sensing element	
	Type of Signal	
(b)	Axial shift of rotor	
	Type of sensing element	
	Type of Signal	
(c)	Casing & differential expansion	
	Type of sensing element	
	Type of Signal	
(d)	Shaft eccentricity	
	Type of sensing element	
	Type of Signal	
(e)	Control valve position	
	Type of sensing element	
	Type of Signal	
(f)	Turbine speed	
	Type of sensing element	
	Type of Signal	
(g)	Turbine acceleration	
	Type of sensing element	
	Type of Signal	
(h)	Metal temperature	

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Sl. No.	Item description	Technical Requirement
	Type of sensing element	
	Type of Signal	
7.0	Turbine Maintenance Schedule	
(a)	Interval of minor maintenance (year) (without opening the casing)	
	Maintenance work to carried out	
(b)	Interval of major overhaul (year)	
	Maintenance work to carried out	
8.0	HP & LP Bypass System	HP LP Bypass Bypass
(a)	Capacity of system	
	Opening through full travel	
	Closing through full travel	
(b)	Pressure reducing valve	
	- Type	
	- No. & size	
	- Actuation type	
	Material - Valve body - Valve seat - Valve internals	
(c)	Desuperheater	
	- Type	
	- Size	
	- Spray quantity at different load	
	- Spray water pressure	
(d)	Type of pressure control	
(e)	Type of temperature control	
(f)	Oil Supply Unit	
	- Type	
	- No of pumps	
	- Capacity of the tank	

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Sl. No.	Item description	Technical Requirement
	- Method of purification of oil	
	- No. and capacity of accumulators	
9.0	Turbine - Gland Sealing System	
(a)	Type of shaft seal	
(b)	Type of seal ring	
(c)	Sources of gland sealing steam	
	- During normal operation	
	- During low load operation (indicate range of load also)	
(d)	- Minimum condensate flow required through gland steam condenser	
(e)	Automatic seal regulator	
	- Quantity of sealing system (Kg/hr)	
	- Pressure of sealing steam (Kg/cm ²)	
	- Seal steam pressure regulator	
	- Point of steam tapping	
(f)	Gland steam condenser	
	- Type	
	- Capacity	
	- Maximum condensate flow considered for design (tonnes/hr)	
	- Water velocity (maximum) in tubes (m/sec)	
	- Tube side design pressure (Kg/cm ²)	
	- Condensate pressure drop (Kg/cm ²)	
	- Heat transfer surface (m ²)	
	- Tube size & materials used	
(g)	Exhauster gland steam condenser	
	- Capacity	
	- Type	
	- Number	
	- Drive motor (KW)	
(h)	Gland sealing system capable for operating	

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Sl. No.	Item description	Technical Requirement
	with gland steam condenser out of service for condenser	
i)	Flash tanks - Number - Type - Size - Are distributors provided?	
10.0	Turbine - Lubrication System	
(a)	Oil Reservoir	
	Capacity (liters)	
	Size	
	Level indicator with alarm Yes/No	
	Internal strainers	
	Relief access doors	
	Operating pressure (Kg/cm ²)	
	Mountings	
	Permissible suspended particle size	
	Permissible water content in oil	
(b)	Oil reservoir vapour extractors	
	Number	
	Type	
	Capacity	
	Drive motor (KW)	
	Speed	
	Mountings	
	Lube oil moisture eliminator provided?	
(c)	Overflow type sight flow indicator	
	Number	
	Type	
(d)	Shaft driven main oil pump	
	Type	
	No.	

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Sl. No.	Item description	Technical Requirement
	Capacity	
	Suction head {kg/cm2(g)}	
	Discharge pressure {kg/cm2(g)}	
	Method of providing positive suction	
(e)	Injector/Booster Pump(If provided)	
	Number	
	Type	
	Capacity	
	Suction head {kg/cm2(g)}	
	Discharge pressure {kg/cm2(g)}	
	Type of drive	
	Driving oil quantity (lit./min.)	
	Driving oil pressure {(kg./cm2 (g))}	
(f)	A.C. Motor driven auxiliary oil pump	
	Number	
	Type	
	Capacity	
	Suction head {kg/cm2(g)}	
	Discharge pressure {kg/cm2(g)}	
	Drive motor rating (KW)	
	Speed	
(g)	D.C. Motor driven emergency oil pump	
	Number	
	Type	
	Capacity	
	Suction head {kg/cm2(g)}	
	Discharge pressure {kg/cm2(g)}	
	Drive motor (kW)	
	Type & speed	
	Voltage	
	Insulation class	

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Sl. No.	Item description	Technical Requirement
	Temperature rise over ambient	
	Starting torque and current	
(h)	Jacking oil pump	
	Number	
	Type	
	Capacity	
	Suction head {kg/cm2(g)}	
	Discharge pressure {kg/cm2(g)}	
	Drive motor rating (KW)	
	Speed	
(i)	Oil cooler	
	Number, working/standby	
	Type	
	Capacity of oil (Lit/min.)	
	Cooling water requirement Quantity (liters/min.)	
	Pressure drop across cooler, (kg/cm2) - Water side - Oil side	
	Maximum permissible cooling water temperature at inlet, Deg.C	
	Water temperature rise, Deg.C	
	Oil inlet temperature, Deg.C	
	Oil outlet temperature, Deg.C	
	Tube size and material	
	Mountings	
(j)	Oil strainer	
	Number	
	Type	
	Mesh Size	
	location	

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Sl. No.	Item description	Technical Requirement
	Is removable during operation ?	
	Material	
k	Duplex oil filter - Type - Capacity - Mesh Size - Filtration type - Maximum allowable differential pressure	
(l)	Pressure & Temperature switches for interlocking, signaling and protection (oil system)	
	Number	
	Set point & adjustment range	
	Contact type and ratings	
	Location	
(m)	Is an oil sight flow indicator at all bearings provided?	
(n)	Oil piping, hangers, etc. Furnished as specified ?	
(o)	Oil sight flow indicators at all bearings provided ?	
(p)	Complete specification of the lubricating oil	
(q)	Total oil in the system (Litres)	
	Oil make up quantity/periodicity	
	Normal lube oil pressure	
	Degree of cleanliness to be maintained for the lube oil for satisfactory operation	
11.0	Control Oil System(if applicable)	
(a)	Control fluid tank	
	Capacity (litres)	
	Size	
	Level indicator with alarm	
	Internal strainers (if any)	

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Sl. No.	Item description	Technical Requirement
	Relief access doors	
	Operating pressure (Kg/cm ²)	
	Mountings	
(b)	Material	
	Tank	
	Piping	
(c)	A.C. Motor driven Control oil pump	
	Number	
	Type	
	Capacity	
	Suction head {kg/cm ² (g)}	
	Discharge pressure {kg/cm ² (g)}	
	Drive motor (KW)	
	Speed	
(d)	Control oil cooler	
	Number, working/standby	
	Type	
	Capacity of oil (Lit/min.)	
	Cooling water requirement - Quantity (liters/min.) - Quality	
	Pressure drop across cooler, (kg/cm ²) - Water side - Oil side	
	Maximum permissible cooling water temperature at inlet, Deg.C	
	Water temperature rise, Deg.C	
	Oil inlet temperature, Deg.C	
	Oil outlet temperature, Deg.C	
	Tube size and material	
	Mountings	

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Sl. No.	Item description	Technical Requirement
(e)	Control oil strainer	
	Number	
	Type	
	Mesh Size	
	Material	
	location	
	Is removable during operation?	
(f)	Pressure & Temperature switches for interlocking, signaling and protection (oil system)	
	Number	
	Set point & adjustment range	
	Contact type and ratings	
	Location	
(g)	Control oil piping, hangers, etc. Furnished as specified ?	
	Complete specification of the control oil	
	Total oil in the system (Litres)	
	Oil make up quantity/periodicity	
	Normal control oil pressure	
	Degree of cleanliness to be maintained for the control oil for satisfactory operation	
12.0	CONDENSATE SYSTEM	
12.1	Condenser	
(a)	Manufacturer	
(b)	Type	
(c)	Performance data at rated condition	
	Flow in tonnes/hr. of - Exhaust suction steam to condenser at TG MCR - Drain from heaters : - System make-up : - Drain from gland steam condenser	

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Sl. No.	Item description	Technical Requirement
	Enthalpy in kCal/kg. of - Steam from turbine : - Drain from heaters : - System make-up : - Drain from gland steam condenser	
	Heat rejected to circulating water at design flow (kCal/kg.)	
	Condenser pressure {kg/cm2(a)}	
	Inlet circulating water design temperature (deg. C)	
	Cleanliness factor used	
	Temperature of the steam- air mixture at the outlet of air removal zone (deg. C)	
	Temperature of condensate at hot well outlet, (deg. C)	
	Maximum free oxygen content in the condensate coming out of the hot well (CC/litre)	
	Specify code followed for performance calculations	
	Water velocity in tube (m/sec.)	
	Total cooling water flow (m3/hr.)	
	Total friction loss across condenser (C.W inlet flange to C.W. outlet flange), MLC	
	Pressure drop across terminal point	
(d)	Design Particulars	
	No. of passes	
	Arrangement with respect to turbine axis	
(e)	Condensing surface (Sq.m.)	
(f)	Shell	
	Design pressure {kg/cm2 (g)}	
	Design temperature (deg.C)	
	Thickness of plates (mm)	
	Nozzles provided in the shell	

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Sl. No.	Item description	Technical Requirement
	Expansion joints provided in the shell	
(g)	Water boxes	
	Type of water boxes	
	Design pressure, kg/cm2(g)	
	Design temperature, deg.C	
	Code used for water box design	
	Shape	
	Method of attaching water boxes to shell	
	Size of C.W. connection - Inlet nozzles, mm : - outlet nozzles, mm	
	Drilling standard for C.W. inlet and outlet flanges as specified	
	Suitable drain and vent connection complete with necessary no. of valves provided for all water box compartments ?	
	Access doors in the water boxes provided as specified ?	
	Air liberated at the outlet water box during operation under design conditions, NM3/min.	
	Are water boxes divided?	
	Are water box manhole covers hinged for quick opening ?	
	Are safety guards provided in the CW connections which run vertically down from water boxes to prevent personnel from falling in?	
(h)	Tube Support Plates	
	No. of tube support plates :	
	Spacing, mm	
	Thickness, mm	
	Tube holes size & chamfer, mm	
(i)	Tube Sheet	
	Thickness, mm	

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Sl. No.	Item description	Technical Requirement
	Suitable painting provided on the water box side of the tube sheet?	
	Area of tube sheet drilled, %	
(j)	Tubes	
	Manufacturer	
	O.D. and gauge in air cooling zone	
	O.D. and gauge in condensing zone	
	Total no. of tubes in air cooling zone	
	Total no. of tubes in condensing zone	
	Effective tube length, m	
	Actual length, metres	
	Tolerances on the O.D. and the wall thickness	
	All the tubes individually tested at hydrostatic pressure ?	
	All the tubes checked for cracks and other defects ultrasonically at the shop?	
	Method of tube to tube sheet joint	
	Tubes self draining on shut-down	
(k)	Hot wells	
	Material thickness	
	Capacity at normal operating level, kgs,	
	Normal operating level (from the bottom of hot well), m	
	Suitable arrangement for prevention of under cooling provided ?	
	No. and size of condensate outlet nozzles	
	Drilling standard for condensate outlet nozzles	
	Strainers at condensate outlet provided	
	Necessary no. of nozzle connection provided	
	Level instruments provided	

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Sl. No.	Item description	Technical Requirement
	Access doors for hot well provided	
	Is screen provided at the outlet of hot well (suction to condensate extraction pump)?	
	Method of dispersing drains, make-up water etc., into condenser	
	Whether steam throw-off device is provided for bypass steam entry into condenser	
	Are Bosses for anodes of cathodic protection provided?	
(l)	Condenser supports and neck expansion joints	
	Type of supports	
	Total no. of supports	
	Provision for adjustment of supports provided	
	Load on each support, kg	
	Manufacturer and type of expansion joint	
	Type of connection at the ends of the expansion joint (flanged or welded)	
	Protection against steam erosion on the internal surface of the expansion joint	
(m)	Connections and Baffling	
	All piping connections provided as specified?	
	Drilling standards for flanged connections	
	Necessary steam distribution and impingement baffling provided?	
(n)	Material Specification	
	<ul style="list-style-type: none"> - Condenser shell - Hot well - Water boxes - Tube support plates - Tube sheets - Tubes - Impingement baffles 	

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Sl. No.	Item description	Technical Requirement
	<ul style="list-style-type: none"> - Stay rods - Bolts & Nuts - Shell expansion joint - Neck expansion joint - Water box gaskets - Internal steam dump piping - Water box lining & thickness of lining - Tubes sheet paint & thickness 	
(o)	Forces and reactions	
	Maximum loading at the turbine flange, kgs.	
	Operating load on the condenser feet, kgs.	
	Maximum load on the condenser feet kgs.	
	Operating load on the condenser feet, kgs.	
(p)	Weight and Dimensions	
	Weight of shell and water boxes (empty),tonnes	
	Total weight of tubes tonnes	
	Weight of heaviest piece to be handled during transportation and erection, tonnes	
(q)	Size of tube sheet	
	Width, m	
	Height, m	
(r)	Size of hot-well	
	Length, m	
	Width , m	
	Height, m	
(s)	Depth of water box	
	At the bottom, m	
	At the top, m	
(t)	Width of water box, m	
12.2	CONDENSATE EXTRACTION PUMP	
(a)	Manufacturer	
(b)	Model No	

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Sl. No.	Item description	Technical Requirement
(c)	Nos. provided	
(d)	Performance data under rated condition	
	Capacity, tonnes/hr	
	Discharge pressure, kg/cm2(g)	
	Suction pressure {kg,cm2(a)}	
	Temperature at pump suction,deg.C	
	Total pump head, MLC	
	Required NPSH static head at pump suction considering minimum hotwell level, MLC : - at design point - at run out point	
	NPSH available at minimum hot well level	
	Total head loss in the suction line, MLC	
	Speed, rpm	
	Efficiency, %	
	Drive power required under design condition, kW	
	Motor rating, KW	
	Specific speed - First stage - Other stages	
	Shut-off discharge pressure, {kg/cm2(g)}	
	Minimum permissible flow for continuous operation (m ³ /hr)	
	Recirculation control	
	Type	
	Manufacturer	
	Minimum flow required	
	Maximum temperature rise under minimum flow operation, deg.C	
	Cooling water requirement - Flow, m3/hr : - Inlet temperature, deg.C :	

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Sl. No.	Item description	Technical Requirement
	<ul style="list-style-type: none"> - Temperature rise, deg.C : - Supply pressure, kg/cm2(g) 	
	Pump vibration limit, <ul style="list-style-type: none"> - Amplitude in microns (peak to peak) : - Velocity , mm / sec. : 	
	Pump noise level	
(e)	Design and Construction	
	Basic type	
	No. of stages	
	Pump rotating assembly <ul style="list-style-type: none"> - Moment of inertia of assembly, (kg-cm2) : - Diameter of impeller, mm : - Shaft diameter, mm : - Pump shaft length, mm : - Method of fastening impellers to shaft 	
(f)	Suction connection	
	Size, mm	
	Rating of flanges (lb class)	
	Drilling standard	
	Facing	
	Max. allowable thrust, kg	
	Max. allowable moment kg.m	
(g)	Discharge connection	
	Size, mm	
	Rating of flanges (lb class)	
	Drilling standard	
	Facing	
	Maximum allowable thrust kg.	
	Maximum allowable moment, kg.m	
(h)	Maximum reverse runaway speed, rpm	
(i)	Critical speeds, rpm	

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Sl. No.	Item description	Technical Requirement
(j)	Pump Bearing	
	Manufacturer	
	Type	
	Catalogue no	
(k)	Thrust bearing	
	Manufacturer	
	Type	
	Catalogues no	
	Provided on the pump or the drive motor	
(l)	Material of Construction	
	Casing	
	Impeller	
	Shaft	
	Shaft Sleeve	
	Wearing Ring	
	Diffuser	
	Base Plate	
	Radial Bearing	
	Thrust Bearing	
12.3	CONDENSER ON-LINE TUBE CLEANING SYSTEM	
(a)	Balls	
	- Type of balls	
	- Materials	
	- Size	
	- Manufacturer	
	- No. of balls per charge	
	- Average flow rate of balls	
(b)	Ball Recirculating Pump	
	- Type	
	- Capacity	

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Sl. No.	Item description	Technical Requirement
	- Motor rating	
	- Speed	
	- Head	
(c)	Strainer	
	- Type	
	- Nos	
	Material of Strainer - Shell - Internal parts	
(d)	Ball collector	
	Material - Cylinder - Internal parts	
(e)	Materials	
	Casing	
	Impeller	
	Shaft	
	Shaft sleeves	
	Wearing rings	
	Shaft seals	
	Pump can	
	Coupling	
	Bolts & nuts	
	Gaskets	
	Suction strainer	
(f)	Weight	
	Completely assembled pump, kg	
	Rotating assembly, kg	
	Motor, kg	
	Total shipping weight, kg.	
(g)	Dimensions	

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Sl. No.	Item description	Technical Requirement
	Overall length, mm	
	Overall width, mm	
	Overall height, mm	
	Length of pump can, mm	
	O.D. of pump can, mm	
	Required pit dimension	
12.4	CONDENSER AIR EVACUATION SYSTEM	
12.4.1	VACUUM PUMP, AS APPLICABLE	
(a)	Make & Model	
(b)	Numbers offered	
(c)	Numbers working	
(d)	Size and type	
(e)	Design code	
(f)	Capacity in free air delivered at standard conditions with pump operating at saturated inlet conditions of 25.4 mm/hg (abs) and at design back pressure, Cub.Nm/hr.	
(g)	Suction pressure, mm Hg.(abs)	
(h)	Suction temperature, Deg.C.	
(i)	Suction line pressure drop mm Hg.	
(j)	Power Required at Pump	
	- 25.4 mm Hg pump pressure, KW	
	- Condenser design pressure, KW	
(k)	Cooling water required for sealant heat exchanger, Cub.m/hr.	
(l)	Design TTD Deg.C.	
(m)	Design TTD of heat exchanger, Deg.C.	
(n)	Volume of condenser and turbine steam space to be evacuated as basis of pump design	
(o)	Time to evacuate the above volume under standard conditions (21.1 Deg.C. & 1.033 kg/Sq.cm. (abs)	

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Sl. No.	Item description	Technical Requirement
(u)	Relief Valve	
	Manufacturer	
	Model No.	
	Size (mm)	
	Relieving capacity (m3/hr)	
	Setting (kg/cm2g)	
(v)	Motor	
	- Make	
	-Speed	
	- Rating, KW	
	- Rated voltage, KV	
(w)	Weight of each pump motor unit, kg	
(x)	Material of pump motor unit	
	- Casing	
	- Shaft	
	- Impeller	
	- Shaft sleeves	
	- Cooler tubes	
(y)	Weight & Dimensions	
	- Total weight of each vacuum pump & drive assembly including base plate, Tonnes	
	- Individual Pump, Tonnes	
	- Motor, Tonnes	
12.4.2	AIR EJECTORS, AS APLICABLE	
(a)	Starting Ejector	
	Number	
	Type	
	Capacity	
	Working steam pressure	
	Steam temp.	

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Sl. No.	Item description	Technical Requirement
	Steam Consumption	
(b)	Main Air Ejector	
	Type	
	Working steam pressure	
	Capacity	
	Steam temp.	
	Steam Consumption	
13.0	NOT USED	
14.0	DEAERATOR AND FEED WATER STORAGE TANK	
14.1	Deaerator Heater	
14.1.1	General	
a)	Type of deaerating feed water heater	
b)	Number of deaerating feedwater heater(s) per steam turbine unit (No.)	
c)	Manufacturer	
14.1.2	Design Conditions	
a)	Feed water outflow (T/H)	
b)	Temp. of deaerated water(⁰ C)	
c)	Condensate inflow (T/H)	
d)	Temp. of condensate inflow (⁰ C)	
e)	Heating steam quantity, (T/H)	
f)	Heating steam pressure, (Kg/cm ²)	
g)	Heating steam temperature, (⁰ C)	
h)	Steam / flashed drains into deaerator	
i)	Steam / flashed drains into deaerating feedwater storage tank	
j)	Deaerating heater operating pressure (kg/cm ²)	
k)	Pegging steam pressure at low loads / part loads	

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Sl. No.	Item description	Technical Requirement
l)	Pegging steam temperature at low loads / part loads	
m)	Load range as percent of TG MCR for pegging steam	
n)	Whether heating steam rakes are provided in deaerating feed water storage tank, if applicable?	
o)	Is a separate, initial heating steam rake provided? (if applicable)	
p)	Design pressure for Deaerator, (kg/cm ²)	
q)	Design temperature for Deaerator (deg C)	
r)	Design Pressure for Feed Water Storage Tank (kg/cm ²)	
s)	Design Temperature for Feed Water Storage Tank (DegC)	
t)	Design temperature, (°C)	
14.1.3	Sprayer Assembly Details	
a)	Number of sprayer assemblies	
b)	Sprayer assembly type	
c)	Manufacturer of sprayer assembly	
d)	Condensate flow through each spray assembly (T/H)	
e)	Pressure drop under design condensate flow	
f)	Material of sprayer assembly	
g)	Material of splash plate	
h)	Material of Spray valve assembly	
14.1.4	Tray Details (If applicable)	
a)	Construction	
b)	Tray thickness, mm	
c)	Number of horizontal trays in one stack and number of stacks (No.)	
d)	Total number of trays	

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Sl. No.	Item description	Technical Requirement
e)	Material	
14.1.5	Vent System Details	
a)	Deaerating feedwater heater vent steam flow	
b)	Number of uncontrolled vents (No.)	
c)	Number of controlled vents (No.)	
14.1.6	Construction details of Feed Water Storage Tank	
a)	Length of storage tank, mm	
b)	Diameter storage tank, mm	
c)	Internal diameter, mm	
d)	Overall length, mm	
e)	Shell plate thickness, mm	
f)	Domed head thickness, mm	
g)	Normal level capacity, m ³	
h)	High high level capacity, m ³	
i)	Low low level capacity, m ³	
j)	Total capacity, m ³	
k)	Empty weight, kg	
l)	Flooded weight, Kg	
m)	Operation weight, kg	
n)	Hydraulic test weight, kg	
o)	Corrosion allowance, mm	
14.1.7	Deaerator Details	
a)	Material of shell	
b)	Whether any portion of shell is clad?	
14.1.8	Feed Water Storage Tank Details	
a)	Supports for feed water storage tank	
b)	(a) Sliding type, (No.)	
c)	(b) Fixed type, (No.)	
d)	No of Manholes	

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e)	Material of shell and dished ends	
f)	Material of splash plates	
g)	Material of baffles	
h)	Material of steam pipes	
i)	Material of Internal bolting	
j)	Material of Gaskets	
k)	Material of Bolts and Nuts	
l)	Are Gauge glass and other instruments as desired provided?	
m)	Safety valve	
	Capacity	
	Setting pressure range	
	Material	
	• Body	
	• Trim	
	• Spring	
n)	Is Overflow arrangement provided ?	
o)	Is vacuum breaking valve provided ?	

14.2	REGENERATIVE SYSTEM	HP Heaters	LP Heaters
(Separate Data Sheet Shall be Provided for Each Heater)			
14.2.1	General		
a)	Model no.		
b)	Heater manufacturer		
c)	Type		
d)	Orientation		
e)	Type of extraction		
f)	Number of tube passes		
14.2.2	Design Data		
a)	Heat balance diagram number		
b)	Shell Side Data		
	Design pressure - kg/cm ²		
	Design vacuum - mm Hg (abs)		

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	Design flow normal, m ³ /hr Abnormal, m ³ /hr		
	Test pressure Shell Skirt (kg/cm ²)		
	Design temperature Shell Skirt (°C)		
	Fouling resistance (hr.m ²)		
c)	Tube Side Data		
	Design pressure (Kg/cm ²)		
	Test pressure (Kg/cm ²)		
	Design temperature (°C)		
	Fouling resistance, (hr.m ² C/Kcal)		
	Feed water/Condensate velocity through tubes at average operating temperature, (m/sec.)		
d)	Desuperheating Section		
	LMTD, (°C)		
	Heat Transfer Coefficient (kCal/hr.m ² °C)		
	Heat transfer surface, (m ²)		
e)	Condensing Section		
	LMTD, (°C)		
	Heat Transfer Coefficient (Kcal/hr.m ² °C)		
	Heat transfer surface, (m ²)		
f)	Drain Cooling Section		
	LMTD		
	Heat Transfer Coefficient		
	Heat transfer surface		
	Whether heater is designed to handle additional thermal and hydraulic loads during abnormal operating conditions as specified		
14.2.3	Drain cooler for LP heater 1		
14.2.3.1	General		
a)	Model no.		

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b)	Manufacturer	
c)	Type	
d)	Orientation	
e)	Number of tube passes	
14.2.3.2	Design Data	
a)	Heat balance diagram number	
b)	Shell Side Data	
i)	Design pressure, (Kg/cm ²)	
ii)	Design vacuum, (mmHg)	
iii)	Test pressure <u>Skirt</u> (Kg/cm ²) Shell	
iv)	Design temperature <u>Skirt</u> (°C) Shell	
v)	Fouling resistance (hr.m ² °C/Kcal)	
c)	Tube Side Data	
i)	Design pressure (Kg/cm ²)	
ii)	Test pressure (Kg/cm ²)	
iii)	Design temperature (°C)	
iv)	Fouling resistance (hr.m ² °C/Kcal)	
v)	Condensate velocity through tubes at average operating temperature (m/sec.)	
14.2.4	Construction Features	HP Heaters LP Heaters
a)	Shell	
i)	Outside diameter (OD) - (mm)	
ii)	Thickness - (mm)	
iii)	Overall length of heater - (mm)	
iv)	Type of joint between shell and tube sheet	
v)	Type of joint between tube sheet and channel	
vi)	Type of joint between tube and tube sheet	

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b)	Tubes		
i)	Tube type		
ii)	Total number of tubes		
iii)	Tube OD		
iv)	Tube thickness (mm)		
v)	Effective length of tubes (mm)		
vi)	Tube Sheet thickness (mm)		
vii)	Minimum cladding thickness_in tube sheet		
c)	Channel		
i)	Type		
ii)	Shape		
iii)	Removable partition		
iv)	Channel pass partition plates thickness (m.m.)		
v)	Shell Relief Valves		
vi)	Channel Relief Valves		
vii)	Is gauge glass and other instruments provided		
d)	Corrosion allowance		
i)	Channel side excluding tubes		
ii)	Shell		
iii)	Tubes		
e)	Drain Cooler for LPH1		
i)	Shell a) Outside diameter, (m.m.) b) Thickness, (m.m.)		
ii)	Tube a) type b) total numbe c) O.D and thickness d) Length of tubes		
iii)	Channel		

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	a) Type b) Shape c) Type of joint between tube sheet and channel		
14.2.5	<u>Materials of Construction</u> (Indicate to which standard it conforms to)	HP Heaters	LP Heaters
a)	Shell		
b)	Shell skirt		
c)	Shell cover		
d)	Shroud of desuperheating zone		
e)	Shroud of drain cooling zone		
f)	Shell flange		
g)	Cross baffles		
h)	Support plates		
i)	Tie rods		
j)	Spacers		
k)	Shell nozzles		
l)	Shell nozzles flanges		
m)	Tubes		
n)	Tube sheet		
o)	Tube sheet cladding material		
p)	Channel cover		
q)	Access cover		
r)	Channel pass partition plate		
s)	Channel nozzles		
t)	Gaskets		
u)	Steam side		
v)	Water side		
w)	Bolting material		
x)	Bolts		
y)	Nuts		
z)	Drain Cooler for LPH1		

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	a) Shell b) Tube c) Channel d) Tube sheet	
15.0	BOILER FEED PUMPS	
a)	General	
		<div>Main BFP</div> <div>Booster Pump</div>
i)	Model No.	
ii)	Type	
iii)	Manufacturer	
iv)	Number of BFP sets per STG unit Nos.	
v)	Liquid handled	
b)	Design and Performance Data	<div>Main BFP</div> <div>Booster Pump</div>
i)	Design temperature of feed water °C	
ii)	Rated capacity, m ³ /hr	
iii)	Inlet flow, m ³ /hr	
iv)	Minimum flow through the pump m ³ /hr	
v)	Run out flow (one pump at design speed) m ³ /hr	
vi)	Frequency range for the operation of the pump under rated flow	
vii)	Suction pressure at rated capacity kg/cm ²	
viii)	Discharge pressure at rated capacity kg/cm ²	
ix)	Total dynamic head at rated speed and capacity, mwc	
x)	Interconnecting pipe losses including flow measuring device mwc	
xi)	Maximum shut off head, mwc	
xii)	NPSH required	

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	(a) At design flow, mwc		
	(b) At best efficiency point, mwc		
	(c) At runout flow (one pump at design speed), mwc		
	(d) during transient operation mwc		
xiii)	Efficiency at design point, %		
xiv)	Power input to pump set (main pump, booster pump and lube oil pumps) at rated flow & head		
xv)	Suction specific speed, US Units		
xvi)	Critical speeds for pump & motor assembly, RPM		
xvii)	Vibration - based on double amplitude at shaft near bearing housing at fundamental and its multiple, frequencies, Microns		
xviii)	Type of coupling between :		
	a) Motor and hydro coupling		
	b) Motor and booster pump		
	c) Hydro coupling and BFP		
	Oil recommended		
c)	Cooling water requirement, Cu.m/hr		
d)	Noise level, dB A		
e)	Maximum speed of BFP unit during reverse rotation due to back flow of water, Rpm		
f)	Permissible variation in load sharing between pumps (%)		
g)	Recirculation control i) Type ii) Manufacturer iii) Temperature raise when pump is operating under recirculation only °C Minimum flow required t/hr		

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h)	Construction Features of Boiler Feed Pump	Main Pump	Booster Pump
i)	Casing type		
ii)	Type of impeller		
iii)	Impeller arrangement		
iv)	Number of stages		
v)	Shaft seal		
vi)	Cooling arrangement of seal		
vii)	Journal bearings, type		
viii)	Thrust bearing, type		
ix)	Type of axial balancing device		
x)	BFP suction strainer		
xi)	(a) Type		
xii)	(b) Strainer mesh size, coarse / fine		
xiii)	Type of foundation		
i)	<u>Materials of Construction</u> (Indicate to which standard it conforms to)	Main Pump	Booster Pump
i)	Inner casing		
ii)	Outer casing		
iii)	Impellers		
iv)	Diffusers / Volute		
v)	Casing wearing rings material / hardness (BHN)		
vi)	Impeller wearing rings material / hardness (BHN)		
vii)	Shaft		
viii)	Shaft nuts		
ix)	Shaft sleeves		
x)	Shaft sleeve nuts		
xi)	Stuffing box		
xii)	Stuffing box bushing		

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xiii)	Balancing device		
xiv)	Pressure bolting studs		
xv)	Nuts		
xvi)	Base plate		
xvii)	Suction and Discharge nozzle		
xviii)	Suction strainer mesh		
xix)	Hydraulic Coupling		
	a) Coupling wheels		
	b) Coupling wheel casing		
	c) Scoop tube		
15.1	Lubricating Oil System for each BFP		
a)	Oil tank storage capacity		
b)	Oil cooler		
i)	Type		
ii)	Shell material		
iii)	Channel material		
iv)	Tube sheet material		
v)	Tube material		
c)	Duplex oil Filter		
i)	Type		
ii)	Make		
iii)	Material		
	• Casing		
	• Filtering element		
d)	Oil pumps		
i)	Numbers		
ii)	Type		
iii)	Design capacity		
iv)	Total head		
v)	Material		
	(a) Casing		

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	(b) Impeller	
	(c) Shaft	
15.2	Hydraulic coupling for each BFP	
a)	Manufacturer	
b)	Input motor speed RPM	
c)	Gear ratio	
d)	Primary start-up speed	
e)	Full load slip %	
f)	Secondary speed (maximum)	
g)	Power loss in hydraulic coupling KW	
h)	Overall efficiency of the Hydraulic coupling (%)	
i)	Number of bearings / type	
j)	Performance :	
	i) Slip between impeller and runner at normal load %	
	ii) Maximum possible slip between impeller and runner at design ratings of driven equipment %	
k)	Scoop tube min. position to start the unit %	
l)	Oil Recommended	
m)	Filter type and make	
n)	Oil tank storage capacity (Litres)	
o)	Working oil cooler	
	i) Type	
	ii) Shell material	
	iii) Channel material	
	iv) Tube sheet material	
	v) Tube material	

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p)	Cooling water requirement	
q)	Hydraulic coupling scoop tube actuator	
	i) Make	
	ii) Type	
16.0	Chemical Dosing System	
16.1	Hydrazine Solution Tanks	
(a)	Numbers provided	
(b)	Capacity (litres)	
(c)	Approximate size, (dia. x height)	
(d)	Material of construction and thickness of plate	
(e)	Tank provided with all required Connections as specified?	
(f)	Details of Inside/Outside paintings	
16.2	Ammonia Solution Tanks	
(a)	Numbers provided	
(b)	Capacity (litres)	
(c)	Approximate size (dia. x height)	
(d)	Material of construction and thickness of plate	
(e)	Tank provided with all required connections as specified ?	
(f)	Details of Inside/Outside paintings	
16.3	Low Pressure Pumps	Hydrazine Solution Ammonia Solution
(a)	Type and manufacturer, model no.	
(b)	Numbers provided	
(c)	Rated discharge (litres/min.)	
(d)	Discharge pressure {kg/sq.cm (g)}	
(e)	Maximum stroke length	
(f)	Stroke per minute	

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(g)	Size of suction connection	
(h)	Size of discharge connection	
(i)	Details of capacity adjustment	
(j)	Materials of construction	
	- Pump body	
	- Pump head	
	- Plunger	
	- Discharge and suction valves	
	- Stuffing box	
16.4	Drive Motor for L.P. Feed Pumps	
(a)	Numbers offered	
(b)	Motor rating (KW)	
(c)	Motor R.P.M.	
(d)	Voltage, phase, frequency	
16.5	Piping and Valves	
(a)	Piping	
	- Size, OD x thickness in mm	
	- Material (specify standard)	
(b)	Valves	
	- Type and make	
	- Size	
	- Type of ends	
	- Materials of construction for body and trim	
(c)	Strainers	
	- Number offered and make	
	- Size, mm, screen & mesh size	
	- Material of construction of body and strainer	
16.6	Foundation bolts, nuts etc. as required for anchoring the equipment provided?	
16.7	Weight Data (Kgs.)	

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(a)	Tank empty	
(b)	Tank flooded	
(c)	Pump with drive	
	- LP pumps	
16.8	Pump characteristic curve provided Yes/No	
17.0	Utility/Service Requirement	
17.1	Auxiliary steam	
(a)	List of consumers	
(b)	Total requirement (kg/hr)	
(c)	Peak flow rate (kg/hr)	
(d)	Pressure (ksca)	
(e)	Temperature (deg C)	
17.2	Cooling Water	
(a)	List of consumers	
(b)	Total requirement (cu m /hr)	
(c)	Peak flow rate (cu m /hr)	
(d)	Pressure, supply/return (ksca)	
(e)	Temperature, supply/return (deg C)	
17.3	Service Air	
(a)	Total requirement (N cu m /hr)	
(b)	Peak flow rate (N cu m /hr)	
(c)	Pressure (ksca)	
17.4	Instrument Air	
(a)	Total requirement, (N cu m/hr)	
(b)	Peak flow rate (N cu m/hr)	
(c)	Pressure (ksca)	
(d)	Other utilities and services e.g. nitrogen lubricants, grease, etc. (Bidder to specify and indicated consumption data as above).	
18.0	Central Oil Storage and Purification System	

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18.1	Performance Data	
(a)	Rated capacity, litres/hr.	.
(b)	Guaranteed size of solids in the purified oil at the effluent of the polishing filter at rated capacity, microns, (specify also the maximum water content in %)	
(c)	Guaranteed size of solids in the oil at the outlet of the centrifuge but head of the polishing filter at rated capacity, microns (Specify also the maximum water content in %)	
(d)	Guaranteed percentage of oil drained through heavy phase drain	
(e)	Centrifuging temperature, deg.C	
(f)	Oil pump	Clean oil Pump Dirty oil Pump
i)	Type	
ii)	Manufacturer	
iii)	Capacity, lit/min	
iv)	Total head, Kg/cm ²	
v)	Maximum permissible suction lift at rated capacity, MLC	
vi)	Pump speed, rpm	
vii)	Power required at the rated operating conditions, KW	
viii)	Efficiency of the pump at the operating condition	
ix)	Drive motor rating	
x)	Relief valve <ul style="list-style-type: none"> - capacity, lit/min - setting pressure range 	
xi)	Material of construction <ul style="list-style-type: none"> - casing - runner/impeller - shaft - relief valve 	

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xii)	Bearing <ul style="list-style-type: none"> - number - type & make 	
(g)	Centrifuge	
i)	Manufacturer	
ii)	Type & model no.	
iii)	Bowl capacity, lit.	
iv)	Bowl diameter, mm	
v)	Sped of the centrifuge, rpm	
vi)	Motor, kw	
vii)	Drive details	
viii)	Belt guard provided?	
ix)	Bearing <ul style="list-style-type: none"> - type & no. - type of lubrication needed - make & model no. 	
x)	Method of balancing <ul style="list-style-type: none"> - static - dynamic 	
xi)	Heavy phase drain through anti-flood tanks (Yes/No)	
xii)	Method of signaling loss of water seal in centrifuge and/or excessive water in oil and/or choking of heavy phase drain pipe	
xiii)	Materials of construction <ul style="list-style-type: none"> - casing - bowl & internals - shaft 	
(h)	Oil heater	
i)	Manufacturer	
ii)	Type & model no.	
iii)	Rated capacity, lit/hr.	
iv)	Design oil inlet temp., deg.C	
v)	Water bath	

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	<ul style="list-style-type: none"> - dimension, mm - water content, lit. - gauge glass provided (Y/N) - type of insulation 	
vi)	Heating element <ul style="list-style-type: none"> - no. & ratings, kw - material and type of construction heating element - power supply - no. of thermostat & cut 'in' & cut 'out' temp. of each thermostat 	
vii)	Materials of construction <ul style="list-style-type: none"> - shell - tubes - heater element - sheathing material 	
(i)	Polishing filter	
i)	Manufacturer	
ii)	Type & model no.	
iii)	Rated capacity, lit/hr	
iv)	Pressure drop at rated capacity, kg/cm ² <ul style="list-style-type: none"> - normal - maximum 	
v)	Filter surface, m ²	
vi)	Filter elements <ul style="list-style-type: none"> - type - material - reusable after cleaning 	
vii)	Filter vessel <ul style="list-style-type: none"> - O.D., mm - Height, mm - Plate thickness, mm - Relief valve capacity - Design pressure, kg/cm² - Material of construction 	

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LII-GETS12021-G-00129-002	03	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-A	[52]	15.01.2016

(j)	Central oil storage tank	Dirty Oil Tank	Clean Oil Tank
i)	Capacity, lit.		
ii)	No. of compartment		
iii)	Overall dimension		
iv)	Floating suction details		
v)	Level gauge details		
(k)	Weight data, kg		
i)	Pump with drives <ul style="list-style-type: none"> - clean oil pump - dirty oil pump 		
ii)	Centrifuge unit		
iii)	Oil heater		
iv)	Polishing filter		
(l)	Plate heat exchanger (If provided)		
i)	Type		
ii)	Design code	CW water side	DM water side
iii)	Flow rate, m ³ /hr		
iv)	Inlet temp. deg.C		
v)	Temp. rise, deg.C		
vi)	Pressure drop, kg/cm ²		
vii)	Material of construction <ul style="list-style-type: none"> - plate - gaskets 		
(m)	Requirement of auxiliary cooling water		
i)	Normal, m ³ /hr		
ii)	Maximum, m ³ /hr		
(n)	Requirement of service air & instrument air		
i)	Normal, Nm ³ /min		
ii)	Maximum, Nm ³ /min		
19.0	ACW & DMCW System:		

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LII-GETS12021-G-00129-002	03	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-A	[53]	15.01.2016

1.	Auxiliary Cooling water requirement for TG & SG Auxiliaries	
2.	DM Cooling Water requirement for TG Auxiliaries	
19.1	DMCW Pumps	
i)	Designation	
ii)	Number offered	
iii)	Design capacity, m ³ /hr.	
iv)	Differential head, mlc	
v)	Shut-off head, mlc	
vi)	Hydrostatic test pressure, kg/cm ² (g)	
vii)	Number of stages	
viii)	Pump efficiency at duty point, %	
ix)	Pump speed, rpm	
x)	Pump bkw, kw	
xi)	Power input to driver at duty point, kw	
xii)	NPSH required, mwc	
xiii)	Driver efficiency, %	
xiv)	Suction nozzle	
xv)	Size, mm	
xvi)	Discharge nozzle	
xvii)	Size, mm	
xviii)	Type of coupling	
xix)	Minimum capacity for continuous operation, m ³ /hr.	
xx)	External water requirement for sealing & cooling	
xxi)	Weight of bare pump, kg	
xxii)	Weight of driver, kg	
xxiii)	Weight of common base plate , kg	
xxiv)	Moment of inertia of pump rotor, kg-m ²	

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LII-GETS12021-G-00129-002	03	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-A	[54]	15.01.2016

xxv)	Motor rating	
xxvi)	Materials of construction- as per data sheet -a	
19.2	Plate type Heat Exchangers	
i)	Quantity required	
ii)	Location	
iii)	Operation	
iv)	Design code	
v)	Fluid circulated	
vi)	Flow rate , kg/hr (10% margin for primary side flow and 20% margin for secondary side flow are to be considered)	
vii)	Heat exchanged	
viii)	Operating temperature	
ix)	Normal operating pressure	
x)	Design pressure	
xi)	Maximum allowable pressure drop including in nozzle	
xii)	Minimum hydrostatic test Pressure	
xiii)	Maximum differential pressure between hot fluid & cold fluid sides	
xiv)	Design temperature	
xv)	Overall fouling resistance (minimum) to be considered	
xvi)	Design margin on frame to accommodate additional plates	
xvii)	Seismic design criteria, if any	
xviii)	Flange drilling standard	
xix)	MATERIAL OF CONSTRUCTION	
a)	Heat transfer plates	
b)	Compression/fixed plates	
c)	Guide rail	

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d)	Support beam/column	
e)	Tie bolts and nuts	
f)	Plate gaskets	
g)	Nozzles: (a) Hot fluid side (b) Cold fluid side	
h)	Nozzle gaskets	
i)	Nozzle flanges/counter flanges	
j)	Hot fluid side	
k)	Cold fluid side	
l)	Nozzle flange bolts/nuts	
20.0	Condensate Storage Tank (CST)	
i)	Numbers provided	
ii)	Capacity (effective)	
iii)	Type of tank	
iv)	Design pressure	
v)	Design temperature	
vi)	Material of construction	
vii)	Shell	
viii)	Nozzle	
ix)	Nozzle end connections provided	
x)	Valves	
xi)	Valve end connections	
xii)	Protection provided	
xiii)	Internal surface of the tank	
xiv)	External surface of the tank	
xv)	Details of nozzles provided on the tank (Bidder to list the nozzles with service)	
xvi)	Type of ladder provided for the CST	
xvii)	Details of level switches provided	
21.0	DM Make up Pumps to Condenser	

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LII-GETS12021-G-00129-002	03	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-A	[56]	15.01.2016

i)	Type of pump	
ii)	Number of pumps	
iii)	Capacity of each pump, M3/hr	
iv)	Discharge pressure, Kg/cm2	
v)	Suction pressure, Kg/cm2	
vi)	Total pump head , Mwc	
vii)	Motor rating, Kw	
viii)	Type of bearing	
ix)	Type of lubrication	
x)	Type of seal	
xi)	Type of coupling	
xii)	No. Of stages	
xiii)	Speed	
xiv)	Material a) Casing b) Impeller c) Shaft d) Shaft sleeves e) Wearing rings	

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LII-GETS12021-G-00129-002	03	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-A	[57]	15.01.2016



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-III
PART-B
TECHNICAL SCHEDULES-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
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	---	Part-D	Not Used

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LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-B	[i]	25.09.2014

VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-B	[ii]	25.09.2014

VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-B	[iii]	25.09.2014

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

TURBO GENERATOR & AUXILIARIES (PACKAGE NUMBER: R&M-SP-02)

VOLUME-III, PART-B TECHNICAL SCHEDULES-ELECTRICAL (TO BE FILLED BY BIDDER)

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

Document Number	Rev No.	Description	Page No.	Date of Issue
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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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{Only the Applicable portion of the Data Sheet based on the scope of work as firmed up in Section-I, Volume-II should be retained and the remaining portion should be deleted. The scope of work in Section-I, Volume-II is based on Residual Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA) Report.}

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1.0 GENERATOR & ACCESSORIES

SL No.	DESCRIPTION	UNIT	DATA
1	Manufacturer's Name		
2	Maximum continuous output	KVA	
a)	*at rated Hydrogen pr.		
b)	(At MCR)	MW	
c)	condition		
3	Rated terminal voltage	KV	
4	Rated stator current	Amps	
5	Rated frequency	Hertz	
6	Rated power factor		
7	Rotor current at MCR	Amps	
8	Rotor voltage at MCR	Volts	
9	Maximum continuous permissible variation range in :		
a)	Rated terminal voltage %		
b)	Rated frequency %		
c)	Combined permissible % variation of frequency and voltage		
10	Number of		
a)	Phases		
b)	Number of parallel paths/phase		
c)	Line terminals brought out		
d)	Neutral terminals brought out		
	Space provided between generator leads to mount bushing current transformers (Yes/No)		
11	Compliance with IEC standard No		
12	Generator efficiency at:		
	a) 100% load		
	b) 80% load		
	c) 80% load		
	d) 40% load		
	e) 25% load		
13	Performance data for short circuit ratio corresponding to maximum capability		

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SL No.	DESCRIPTION	UNIT	DATA
14	Permissible tolerance in SCR		
15	Regulation at :		
	a) Unity power factor		
	b) 0.85 lag power factor		
16	Rated Hydrogen pressure:	Kg/cm ² (gauge)	
17	Rated cooling water pressure	Kg/cm ² (gauge)	
18	Cooling water flow at normal load	m ³ /hr	
19	Basic impulse insulation withstand voltage of stator winding with respect to earth (for standard wave shape of 1.2/50 micro sec.)	KV (peak)	
20	Symmetrical run short circuit current with generator isolated initial saturated value and sustained value		
	a) 3 phase	KA	
	b) Single phase to neutral	KA	
21	3 phase short circuit withstand time for	Secs	
22	Saturation factor		
23	Waveform factor		
24	Permissible unbalanced loading subject to rated current not being exceeded in any phase		
	a) Maximum continuous negative phase sequence current I ₂	amps	
	b) Minimum value of I ₂ ² t for transient operation under system fault conditions (where t in seconds)		
25	Maximum permissible capacitive loading at full load	MVAR	
26	Maximum capacitive loading for stability at rated voltage and zero power factor	MVAR	
27	Generator reactance, per unit at rated KV and MVA		
28	Direct axis synchronous reactance X _d		
29	Quadrature synchronous reactance X _q		
30	Direct axis transient reactance X' _d		
31	Quadrature axis transient X' _q		
32	Direct axis sub-transient reactance X'' _d		
33	Quadrature axis sub-transient reactance, X'' _q		

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SL No.	DESCRIPTION	UNIT	DATA
34	Negative phase sequence reactance, X2		
35	Zero phase sequence reactance X ₀		
36	Potier reactance X _p		
37	Leakage reactance X _L		
	a) Combined		
	b) stator		
	c) Damper		
38	Permissible tolerance in all %(+) guaranteed reactance values		
39	Effective winding capacitance to earth		
40	Permissible tolerance in all %(+) guaranteed reactance values		
41	Effective winding capacitance to earth		
	a) Per Phase Micro farad		
	b) All phases connected together Micro farad		
42	Effective surge impedance to neutral per phase	Ohms	
43	Synchronous impedance	Ohms	
	a) Harmonics voltage generated by the generator at 100%, 75%, 50%, 25% and no load		
	b) X/R ratio from fundamental to 20th harmonic		
	c) Harmonic impedance at each harmonic upto 20 th harmonic		
	d) Permissible current at each harmonic other than fundamental.		
44	Armature resistance per phase at:		
	a) 25 deg. C	Ohms	
	b) 75 deg. C	Ohms	
45	Field resistance per phase at :		
	a) 25 deg. C	Ohms	
	b) 75 deg. C	Ohms	
46	Effective negative sequence resistance		
47	Time constants		
48	Direct axis open circuit TIME CONSTANT T' _{do}	Sec.	

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SL No.	DESCRIPTION	UNIT	DATA
49	Direct axis 3 phase transient short circuit time constant T'd3	Sec.	
50	Direct axis 2 phase transient short circuit time constant T'd2	Sec.	
51	Direct axis 1 phase transient short circuit time constant T'd1	Sec.	
52	Direct axis sub-transient short circuit time constant d"	Sec.	
53	A-periodic 3 phase short circuit time constant Ta3	Sec.	
54	A-periodic 2 phase short circuit time constant Ta2	Sec.	
55	A-periodic 1 phase short circuit time constant Ta1	Sec.	
56	Armature winding short circuit time constant Ta	Sec.	
57	Quadrature axis transient open circuit time constant T'qo	Sec.	
58	Direct axis transient short circuit time constant T'd	Sec.	
59	Direct axis sub-transient open circuit time constant T"do	Sec.	
60	Quadrature axis sub-transient open circuit time constant T"q0	Sec.	
61	Quadrature axis sub-transient short circuit time constant T"q	Sec.	
62	Direct axis open circuit excitation winding time constant Tfd0	Sec.	
63	Direct axis open circuit equivalent damper circuit time constant Tkdo	Sec.	
64	Direct axis short circuit excitation winding time constant Tfd	Sec.	
65	Direct axis short circuit equivalent damper winding time constant Tkd	Sec.	
66	Acceleration time Tj	Sec.	
67	Stored energy constant H	KW sec/KVA	
68	Maximum temperature with the secondary cooling water inlet temperature as 34 deg C		
69	Maximum absolute temperatures when generator delivers 660 MW at 0.85 p.f. at its terminals.		
	a) Stator windings	Deg. C	
	b) Stator core		
	i) In contact with insulated winding	Deg. C	
	ii) Not in contact with insulated winding	Deg. C	
70	Stator teeth temperature	Deg. C	

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SL No.	DESCRIPTION	UNIT	DATA
71	Rotor windings	Deg. C	
72	Mechanical parts in contact with or adjacent to insulation	Deg. C	
73	Damper winding	Deg. C	
74	Rotor surface	Deg. C	
75	Other miscellaneous parts	Deg. C	
76	Cooled gas	Deg. C	
77	Hot gas in the stator and rotor	Deg. C	
78	Water to inlet of gas/air cooler	Deg. C	
79	Water at outlet of gas/air cooler	Deg. C	
80	Maximum absolute temperatures when generator delivers maximum capability of the turbine (with VWO, HP heaters out, over-pressure conditions etc.) at 0.85 p.f. at its terminals		
81	Generator losses, also indicate where one loss components is included in the another one. Give curves for various losses Vs. load as above at different hydrogen pressure.		
82	No load loss		
	a) Iron loss	KW	
	b) Rotor copper loss	KW	
83	Full load loss		
	a) Iron loss	KW	
	b) Stator copper loss	KW	
	c) Stray load loss	KW	
	d) Rotor copper loss	KW	
	e) Friction and windage loss	KW	
	f) Mechanical losses including bearing losses	KW	
	g) Exciter and exciter rheostat losses	KW	
	h) Collector brush contact losses	KW	
	i) Rotary rectifier losses	KW	
	j) Fan loss	KW	
	k) Shaft seal loss	KW	
	l) Eddy current loss	KW	
	m) Total loss at full load	KW	

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SL No.	DESCRIPTION	UNIT	DATA
	n) Any other loss (indicate)	KW	
	Dissipation losses in		
	a) Hydrogen/Air cooler		
	b) Seal oil cooler		
	c) Exciter air cooler		
	d) Excitation system panels		
84	ADDITIONAL DATA:		
	Permissible overload and duration		
	"Rapid defluxing" time and the technique used.		
	Surge capacitor requirement for the generator must be stated with reasons.		
	What provisions are made for automatic generator runback (turbine control point set back) and loss of cooling?		
	To what power level is runback required and what time is allowed for runback		
	Furnish permissible volts/HZ vs time characteristic of the generator		
	Describe your standard practice in coordinating connection of isolated phase bus duct to generator main leads		
	Have you furnished any generator of this rating with Brushless excitation system		
	Furnish the no-load saturation and zero Power-factor saturation curve for AC exciter used for brushless excitation system, if proposed. Details of Generator rotor winding temperature monitoring system and rotor winding earth fault detection system		
	Furnish detailed literature for the excitation system proposed for the generator including		
	a) Performance (transient and steady state) characteristics		
	b) Initial high response characteristics		
	c) Initial high response characteristics		
	d) Exciter ratings (where applicable)		
	e) Performance record as per relevant clause of specs.		
	f) List of instruments provided		
	Describe the performance characteristics of voltage		

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SL No.	DESCRIPTION	UNIT	DATA
	regulator, proposed for this generator.		
	Provide dimensioned general arrangement drawings for the following equipment:		
	a) Seal oil tank		
	b) Hydrogen Coolers		
	Details of generator neutral grounding system		
	Furnish the schematic diagram of excitation system, giving its controls & interface with automatic voltage regulation.		
	Type of Cooling		
	a) Stator winding		
	b) Stator Core		
	c) Rotor		
	Rated Output	MW	
	Transient rise of voltage on sudden rejection of full load at rated power factor		
	a) With AVR	P.U.	
	b) Without AVR	P.U.	
	Zero sequence Resistance		
	Inertia constant H	KW-Sec/KVA	
	a) Generator & Exciter		
	b) Complete turbine generator unit		
	Short circuit current	P.U.	
	Sub transient current		
	a) On 3 phase short circuit		
	b) on 2 phase short circuit		
	c) on 1 phase short circuit		
	Transient current		
	a) On 3 phase short circuit		
	b) on 2 phase short circuit		
	c) On 1 phase short circuit		
	Steady state current		
	a) On 3 phase short circuit		

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SL No.	DESCRIPTION	UNIT	DATA
	b) on 2 phase short circuit		
	c) On 1 phase short circuit		
	Whether specified earth fault current and duration as per specification (Yes/No)		
	Indicate values of earth current and duration		
	Voltage regulation under conditions of rated speed voltage & output (%)		
	a) at 0.8 power factor lag		
	b) at unity power factor		
	c) at 0.90 power factor load		
	Maximum continuous kva capacity of generator		
	- With one cooler out of operation		
	Maximum inductive capacity	KVAR	
	Excitation requirements at		
	a) Rated load		
	b) No load		
	c) At maximum capacitive load (at Zero active power		
	d) Under field forcing condition		
	Short circuit torque as a ratio of full load torque		
	Fly wheel moment (GD ²) of generator + exciter	Kg m2	
	Capacity of space heaters at 415 V where applicable	KW	
	Number, type and rating of CT's and PT's used exclusively for EHG and generator excitation system		
	Design and construction features		
	Stator Core		
	a) Type of spring mounting		
	b) Grade of sheet steel (Thickness & loss figure)		
	Stator Windings		
	a) Type and Class of insulation		
	b) Resistance per phase at 20 deg. C	Ohm	
	c) Capacitance per phase (i)		
	d) Dielectric Test Voltage Value	KV	

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SL No.	DESCRIPTION	UNIT	DATA
	e) Impulse voltage strength peak	KV	
	f) Is the winding transposed in the ends?		
	Terminals		
	a) No. of terminals brought out		
	b) Type of cooling of terminals and connectors		
	c) Type of terminal bushings		
	d) Number of distributed multi ratio bushing CT's & relaying accuracy class that is accommodated in the bushing furnished		
	e) Dielectric Test Voltage-KV		
	f) Impulse Voltage strength-KV		
	Rotor		
	a) Material of rotor forging		
	b) Material of retaining ring forging		
	c) Material of rotor wedge		
	d) Type of retaining ring mounting		
	e) material of Damper winding		
	f) Over speed Test Value and duration		
	Rotor Winding		
	a) Class & Type of insulation		
	b) Turns per pole		
	c) Resistance at 20 °C (ohms)		
	d) Dielectric Test Voltage value	KV	
	Bearing		
	a) Type of bearing (Pedestal/End Shield)		
	b) Oil quantity per bearing (m3/hr)		
	c) Oil pressure	(kg/cm2)	
	d) Grade of Oil		
	Shaft Seal		
	a) Type of seal		
	b) Pressure of Seal oil	(kg/cm2)	
	c) Grade of oil		

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SL No.	DESCRIPTION	UNIT	DATA
	d) Quantity of oil per seal	(m3/hr)	
	Gas/Air Coolers		
	a) Number of Coolers		
	b) Material of:		
	i) Tubes		
	ii) Fins		
	c) Material of tube plate		
	d) Quantity of cooling water required/ cooler	m3/hr	
	e) material of water boxes		
	f) Pressure drop across cooler on water side (m.w.c)		
	AUTOMATIC VOLTAGE REGULATORS		
	a) Manufacturer		
	b) Type		
	c) Power supply to the regulator (Volts)		
	d) Range of generator voltage adjustment(%)		
	i) in auto position		
	ii) in manual position		
	e) Frequency range of operation	Hz	
	f) temperature range of operation	Deg.C	
	g) Accuracy (%)		
	h) Dead band		
	i) Excitation system response time with AVR (The time for the generator field voltage to attain 95% of the difference between field forcing voltage and rated field voltage with 5% drop in generator terminal voltage and generator at rated MVA)		
	j) Time required for generator terminal voltage to get restored to within 2% of the nominal preset value when subject to sudden loss of rated output.		
	BRUSHLESS EXCITATION SYSTEM		
	Pilot exciter		
	a) Manufacturer		
	b) Type		

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SL No.	DESCRIPTION	UNIT	DATA
	c) Type of drive		
	d) Normal Speed	Rpm	
	e) Rated Voltage	Volts	
	f) Rate frequency	Amp	
	g) Rated current	Amp	
	h) Type of insulation		
	Rectifier for pilot exciter		
	a) Manufacturer		
	b) Type		
	c) Rated rectifier voltage	Volts	
	d) Rated rectifier current	Amp	
	e) Ceiling rectifier current	Amp	
	f) Ceiling rectified current	Amp	
	g) Total number of rectifier cells per parallel path of a bridge		
	h) Number of parallel paths per bridge arm		
	i) No. of bridge arms		
	j) Maximum peak inverse voltage rating of a cell	Volts	
	k) Method of over voltage protection		
	l) Maximum number of bridges/rectifier cells without which the rectifier can give output corresponding to generator MCR		
	Main Exciter		
	a) Manufacturer		
	b) Type		
	c) Type of drive		
	d) Normal Speed	rpm	
	e) Rated rectifier voltage	Volts	
	f) Rated rectified current	Amp	
	g) Ceiling rectified voltage	Volts	
	h) Ceiling rectified current	Amp	
	i) Exciter field voltage with manual control (rectified)		
	i) Maximum	Volts	

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SL No.	DESCRIPTION	UNIT	DATA
	ii) Minimum	Volts	
	j) Field current at generator MCR and rated power factor lagging	Amp	
	k) nominal exciter response ratio		
	l) Class of insulation		
	m) Insulation material on rotor winding		
	n) insulation material on field winding		
	o) Type of end winding support		
	p) Maximum temperature with secondary cooling water temperature of 31 deg. C		
	i) Exciter stator winding in contact with insulation		
	ii) Exciter stator winding not in contact with insulation		
	iii) Rotor winding		
	Exciter rectifier assembly		
	a) Manufacturer		
	b) Type of rectifier		
	c) Total number of rectifier cells per ring		
	d) Number of parallel paths per bridge arm		
	e) Number of bridge arms		
	f) Maximum number of rectifier cells/bridge without which the rectifier can give output corresponding to generator MCR		
	g) Maximum peak inverse voltage rating of cell	Volts	
	h) Number of rectifier cells in series in each bridge arms		
	i) Method of overvoltage protection		
	j) Overload rating of the rectifier cell		
	k) Ceiling output voltage of rectifier assembly	Volts	
	l) Ceiling output current of rectifier assembly	amp	
	m) Maximum junction temperature of rectifier cells		
	n) Method of mounting cells to cooling fins		
	o) Make and type of cooling fins		
	p) Type of visual indication provided for faulty rectifier cells		
	Air/Water Coolers (For Exciter)		

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SL No.	DESCRIPTION	UNIT	DATA
	a) Number of Coolers		
	b) Material of		
	i) Tubes		
	ii) Fins		
	c) Material of tube plates		
	d) Material of water boxes		
	e) Quantity of circulating water required per cooler	m ³ /hr	
	f) Maximum allowable water temperature	deg.C	
	g) Pressure drop across the cooler on water side	mwc	
	GAS SYSTEM		
	a) Volume of Hydrogen space in generator	m ³	
	b) Cooling gas flow	m ³ /min	
	c) Volume of CO ₂ at NTP required for displacing air	m ³	
	d) Volume of CO ₂ at NTP required for displacing hydrogen	m ³	
	e) Volume of H ₂ at NTP required for displacing carbon-di-oxide and to bring the casing to the rated pressure	m ³	
	f) Purity of H ₂ required	%	
	i) Normal		
	ii) Minimum allowable		
	g) Leakage of H ₂ by volume at NTP per day at rated H ₂ pressure in the generator		
	h) Is Nitrogen required to displace CO ₂ in the generator		
	i) Volume of air at NTP required to displace CO ₂	m ³	
	j) Requirement of compressed air for gas tightness test		
	k) No. of cylinders proposed to be furnished		
	i) Hydrogen		
	ii) Carbon dioxide		
	iii) Nitrogen (if required)		
	l) Standards to which the cylinders conform		
	i) Hydrogen		
	ii) Carbon dioxide		
	iii) Nitrogen (if required)		

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SL No.	DESCRIPTION	UNIT	DATA
	m) Internal volume of the cylinder		
	i) Hydrogen		
	ii) Carbon dioxide		
	iii) Nitrogen (if system require)		
	SEAL OIL SYSTEM		
	Seal Oil Pump Motor Set		
	a) Type		
	b) Numbers		
	c) Capacity	m3/hr	
	d) Discharge pressure (gauge)	kg/cm2	
	e) Shut-off Head	mwc	
	f) Size of motor	KW	
	Vapour extraction unit		
	(in seal oil drain) on air side stream		
	a) Type		
	b) Capacity	m3/hr	
	c) Size of motor	KW	
	Vapour extractor motor set		
	a) Type		
	b) Numbers		
	c) Capacity		
	d) Discharge pressure		
	e) Shut-off head		
	f) Seal oil flow and pressure required for normal operation		
	MAIN WEIGHTS :		
	a) Heaviest lift of generator stator with trunnions etc.		
	b) Weight of complete generator stator	Tonnes	
	c) Weight of complete rotor	Tonnes	
	d) Weight of complete generator	Tonnes	
	e) Weight of lifting beam assembly	Tonnes	
	Critical speeds for Generator + exciter (if any)	rpm	

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SL No.	DESCRIPTION	UNIT	DATA
	a) First		
	b) Second		
	c) Third		
	Motors (rated above 50 kW) (attach separate data sheet for separate motors)		
	Equipment driven by motor		
	Rated output for 50 °C ambient air/31 °C cooling water temperature	kw	
	Temperature rise at rated output conditions as in item 2.40.02 above	deg.C	
	Class and type of insulation		
	Rated voltage	Volts	
	Efficiency at rated output	%	
	Power factor at rated output		
	Rated current	amp.	
	Locked Rotor kVA (Indicate the Rated output kW upper limit)		
	Upper limit of locked rotor current	amp.	
	Whether motor is capable of two successive hot starts with the driven equipment coupled	Yes/No	
	Rated speed	rpm	
	Rated torque		
	Starting torque		
	Pull out torque		
	Applicable standard to which motor generally conforms		
	Manufacturer		
	Type of enclosure, degree of protection and method of cooling		
	Type of terminal box for stator leads		
	Bearing type		
	Rotor Earth fault protection		
	Whether for single earth fault or for both single and double earth fault		
	Make		

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SL No.	DESCRIPTION	UNIT	DATA
	Type		
	Range		
	Requirement of auxiliary supply		
	a. Voltage		
	b. AC/DC		
	c. Frequency		
	d. VA		
	Shaft current relay with CT		
	CT Dia		
	CT Ratio		
	CT VA and Accuracy		
	Core weight		
	Core dimension		
	Core material		
	Relay make and type		
	Relay range		
	Exciter Field Breaker		
	a) Manufacturer		
	b) Type		
	c) Rated DC voltage		
	d) Rated continuous current at 50 °C design ambient		
	e) Short time rating		
	f) No. of main poles		
	g) Material of main poles		
	h) No. of arcing contacts		
	i) Material of arcing contacts		
	j) Type & material of arcing chutes		
	k) Closing coil voltage with operating voltage range		
	l) Tripping coil voltage with operating voltage range		
	Exciter Field discharge resistance		
	a) Manufacture		

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SL No.	DESCRIPTION	UNIT	DATA
	b) Type		
	c) Material		
	d) Current rating		
	e) Power rating		
	Enclosure		
	a) Type of enclosure		
	b) Degree of protection		
	c) Type & thickness of sheet steel		
	d) Overall dimensions		
	e) Weight		
	CONTROL PANEL		
	CONTROL PANEL/DESK (furnish data separately for each control panel/desk)		
	Control panel/Desk (Service)		
	Tentative dimensions control panel/desk	mm	
	Detail of components	Make & Type	
	Contactors (Furnish details for AC & DC separately)		
	Timers (Furnish details for AC & DC separately)		
	Relay (Furnish details for AC & DC Relays separately)		
	Control switch		
	Push button		
	Ammeter/voltmeter selector switches		
	Indicating lamps		
	Space heater		
	Terminal blocks		
	Indicating Instruments		
	Wires		
	Panel		
	Annunciator		
	Whether detail write-up of the scheme furnished	Yes/No	
	Details of mimic diagram		

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SL No.	DESCRIPTION	UNIT	DATA
85	Manufacturer's Name		
86	Maximum continuous output	KVA	
a)	*at rated Hydrogen pr.		
b)	(At MCR)	MW	
c)	condition		
87	Rated terminal voltage	KV	
88	Rated stator current	Amps	
89	Rated frequency	Hertz	
90	Rated power factor		
91	Rotor current at MCR	Amps	
92	Rotor voltage at MCR	Volts	
93	Maximum continuous permissible variation range in :		
a)	Rated terminal voltage %		
b)	Rated frequency %		
c)	Combined permissible % variation of frequency and voltage		
94	Number of		
e)	Phases		
f)	Number of parallel paths/phase		
g)	Line terminals brought out		
h)	Neutral terminals brought out		
	Space provided between generator leads to mount bushing current transformers (Yes/No)		
95	Compliance with IEC standard No		
96	Generator efficiency at:		
	a) 100% load		
	b) 80% load		
	c) 80% load		
	d) 40% load		
	e) 25% load		
97	Performance data for short circuit ratio corresponding to maximum capability		
98	Permissible tolerance in SCR		

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SL No.	DESCRIPTION	UNIT	DATA
99	Regulation at :		
	a) Unity power factor		
	b) 0.85 lag power factor		
100	Rated Hydrogen pressure:	Kg/cm ² (gauge)	
101	Rated cooling water pressure	Kg/cm ² (gauge)	
102	Cooling water flow at normal load	m ³ /hr	
103	Basic impulse insulation withstand voltage of stator winding with respect to earth (for standard wave shape of 1.2/50 micro sec.)	KV (peak)	
104	Symmetrical run short circuit current with generator isolated initial saturated value and sustained value		
	a) 3 phase	KA	
	b) Single phase to neutral	KA	
105	3 phase short circuit withstand time for	Secs	
106	Saturation factor		
107	Waveform factor		
108	Permissible unbalanced loading subject to rated current not being exceeded in any phase		
	a) Maximum continuous negative phase sequence current I ₂	amps	
	b) Minimum value of I ₂ ² t for transient operation under system fault conditions (where t in seconds)		
109	Maximum permissible capacitive loading at full load	MVAR	
110	Maximum capacitive loading for stability at rated voltage and zero power factor	MVAR	
111	Generator reactance, per unit at rated KV and MVA		
112	Direct axis synchronous reactance X _d		
113	Quadrature synchronous reactance X _q		
114	Direct axis transient reactance X' _d		
115	Quadrature axis transient X' _q		
116	Direct axis sub-transient reactance X'' _d		
117	Quadrature axis sub-transient reactance, X'' _q		
118	Negative phase sequence reactance, X ₂		

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SL No.	DESCRIPTION	UNIT	DATA
119	Zero phase sequence reactance X_0		
120	Potier reactance X_p		
121	Leakage reactance X_L		
	a) Combined		
	b) stator		
	c) Damper		
122	Permissible tolerance in all $\%(+)$ guaranteed reactance values		
123	Effective winding capacitance to earth		
124	Permissible tolerance in all $\%(+)$ guaranteed reactance values		
125	Effective winding capacitance to earth		
	a) Per Phase Micro farad		
	b) All phases connected together Micro farad		
126	Effective surge impedance to neutral per phase	Ohms	
127	Synchronous impedance	Ohms	
	a) Harmonics voltage generated by the generator at 100%, 75%, 50%, 25% and no load		
	b) X/R ratio from fundamental to 20th harmonic		
	c) Harmonic impedance at each harmonic upto 20 th harmonic		
	d) Permissible current at each harmonic other than fundamental.		
128	Armature resistance per phase at:		
	a) 25 deg. C	Ohms	
	b) 75 deg. C	Ohms	
129	Field resistance per phase at :		
	a) 25 deg. C	Ohms	
	b) 75 deg. C	Ohms	
130	Effective negative sequence resistance		
131	Time constants		
132	Direct axis open circuit TIME CONSTANT T'_{do}	Sec.	
133	Direct axis 3 phase transient short circuit time constant T'_{d3}	Sec.	

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SL No.	DESCRIPTION	UNIT	DATA
134	Direct axis 2 phase transient short circuit time constant $T'd_2$	Sec.	
135	Direct axis 1 phase transient short circuit time constant $T'd_1$	Sec.	
136	Direct axis sub-transient short circuit time constant d''	Sec.	
137	A-periodic 3 phase short circuit time constant Ta_3	Sec.	
138	A-periodic 2 phase short circuit time constant Ta_2	Sec.	
139	A-periodic 1 phase short circuit time constant Ta_1	Sec.	
140	Armature winding short circuit time constant Ta	Sec.	
141	Quadrature axis transient open circuit time constant $T'q_0$	Sec.	
142	Direct axis transient short circuit time constant $T'd$	Sec.	
143	Direct axis sub-transient open circuit time constant $T''d_0$	Sec.	
144	Quadrature axis sub-transient open circuit time constant $T''q_0$	Sec.	
145	Quadrature axis sub-transient short circuit time constant $T''q$	Sec.	
146	Direct axis open circuit excitation winding time constant T_{fdo}	Sec.	
147	Direct axis open circuit equivalent damper circuit time constant T_{kdo}	Sec.	
148	Direct axis short circuit excitation winding time constant T_{fd}	Sec.	
149	Direct axis short circuit equivalent damper winding time constant T_{kd}	Sec.	
150	Acceleration time T_j	Sec.	
151	Stored energy constant H	KW sec/KVA	
152	Maximum temperature with the secondary cooling water inlet temperature as 34 deg C		
153	Maximum absolute temperatures when generator delivers 660 MW at 0.85 p.f. at its terminals.		
	a) Stator windings	Deg. C	
	b) Stator core		
	i) In contact with insulated winding	Deg. C	
	ii) Not in contact with insulated winding	Deg. C	
154	Stator teeth temperature	Deg. C	
155	Rotor windings	Deg. C	

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SL No.	DESCRIPTION	UNIT	DATA
156	Mechanical parts in contact with or adjacent to insulation	Deg. C	
157	Damper winding	Deg. C	
158	Rotor surface	Deg. C	
159	Other miscellaneous parts	Deg. C	
160	Cooled gas	Deg. C	
161	Hot gas in the stator and rotor	Deg. C	
162	Water to inlet of gas/air cooler	Deg. C	
163	Water at outlet of gas/air cooler	Deg. C	
164	Maximum absolute temperatures when generator delivers maximum capability of the turbine (with VWO, HP heaters out, over-pressure conditions etc.) at 0.85 p.f. at its terminals		
165	Generator losses, also indicate where one loss components is included in the another one. Give curves for various losses Vs. load as above at different hydrogen pressure.		
166	No load loss		
	a) Iron loss	KW	
	b) Rotor copper loss	KW	
167	Full load loss		
	a) Iron loss	KW	
	b) Stator copper loss	KW	
	c) Stray load loss	KW	
	d) Rotor copper loss	KW	
	e) Friction and windage loss	KW	
	f) Mechanical losses including bearing losses	KW	
	g) Exciter and exciter rheostat losses	KW	
	h) Collector brush contact losses	KW	
	i) Rotary rectifier losses	KW	
	j) Fan loss	KW	
	k) Shaft seal loss	KW	
	l) Eddy current loss	KW	
	m) Total loss at full load	KW	
	n) Any other loss (indicate)	KW	

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SL No.	DESCRIPTION	UNIT	DATA
	Dissipation losses in		
	a) Hydrogen/Air cooler		
	b) Seal oil cooler		
	c) Exciter air cooler		
	d) Excitation system panels		
168	ADDITIONAL DATA:		
	Permissible overload and duration		
	"Rapid defluxing" time and the technique used.		
	Surge capacitor requirement for the generator must be stated with reasons.		
	What provisions are made for automatic generator runback (turbine control point set back) and loss of cooling?		
	To what power level is runback required and what time is allowed for runback		
	Furnish permissible volts/HZ vs time characteristic of the generator		
	Describe your standard practice in coordinating connection of isolated phase bus duct to generator main leads		
	Have you furnished any generator of this rating with Brushless excitation system		
	Furnish the no-load saturation and zero Power-factor saturation curve for AC exciter used for brushless excitation system, if proposed. Details of Generator rotor winding temperature monitoring system and rotor winding earth fault detection system		
	Furnish detailed literature for the excitation system proposed for the generator including		
	a) Performance (transient and steady state) characteristics		
	b) Initial high response characteristics		
	c) Initial high response characteristics		
	d) Exciter ratings (where applicable)		
	e) Performance record as per relevant clause of specs.		
	f) List of instruments provided		
	Describe the performance characteristics of voltage regulator, proposed for this generator.		

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SL No.	DESCRIPTION	UNIT	DATA
	Provide dimensioned general arrangement drawings for the following equipment:		
	a) Seal oil tank		
	b) Hydrogen Coolers		
	Details of generator neutral grounding system		
	Furnish the schematic diagram of excitation system, giving its controls & interface with automatic voltage regulation.		
	Type of Cooling		
	a) Stator winding		
	b) Stator Core		
	c) Rotor		
	Rated Output	MW	
	Transient rise of voltage on sudden rejection of full load at rated power factor		
	a) With AVR	P.U.	
	b) Without AVR	P.U.	
	Zero sequence Resistance		
	Inertia constant H	KW-Sec/KVA	
	a) Generator & Exciter		
	b) Complete turbine generator unit		
	Short circuit current	P.U.	
	Sub transient current		
	a) On 3 phase short circuit		
	b) on 2 phase short circuit		
	c) on 1 phase short circuit		
	Transient current		
	a) On 3 phase short circuit		
	b) on 2 phase short circuit		
	c) On 1 phase short circuit		
	Steady state current		
	a) On 3 phase short circuit		
	b) on 2 phase short circuit		

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SL No.	DESCRIPTION	UNIT	DATA
	c) On 1 phase short circuit		
	Whether specified earth fault current and duration as per specification (Yes/No)		
	Indicate values of earth current and duration		
	Voltage regulation under conditions of rated speed voltage & output (%)		
	a) at 0.8 power factor lag		
	b) at unity power factor		
	c) at 0.90 power factor load		
	Maximum continuous kva capacity of generator		
	- With one cooler out of operation		
	Maximum inductive capacity	KVAR	
	Excitation requirements at		
	a) Rated load		
	b) No load		
	c) At maximum capacitive load (at Zero active power		
	d) Under field forcing condition		
	Short circuit torque as a ratio of full load torque		
	Fly wheel moment (GD ²) of generator + exciter	Kg m2	
	Capacity of space heaters at 415 V where applicable	KW	
	Number, type and rating of CT's and PT's used exclusively for EHG and generator excitation system		
	Design and construction features		
	Stator Core		
	a) Type of spring mounting		
	b) Grade of sheet steel (Thickness & loss figure)		
	Stator Windings		
	a) Type and Class of insulation		
	b) Resistance per phase at 20 deg. C	Ohm	
	c) Capacitance per phase (i)		
	d) Dielectric Test Voltage Value	KV	
	e) Impulse voltage strength peak	KV	

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SL No.	DESCRIPTION	UNIT	DATA
	f) Is the winding transposed in the ends?		
	Terminals		
	a) No. of terminals brought out		
	b) Type of cooling of terminals and connectors		
	c) Type of terminal bushings		
	d) Number of distributed multi ratio bushing CT's & relaying accuracy class that is accommodated in the bushing furnished		
	e) Dielectric Test Voltage-KV		
	f) Impulse Voltage strength-KV		
	Rotor		
	a) Material of rotor forging		
	b) Material of retaining ring forging		
	c)Material of rotor wedge		
	d) Type of retaining ring mounting		
	e) material of Damper winding		
	f) Over speed Test Value and duration		
	Rotor Winding		
	a) Class & Type of insulation		
	b) Turns per pole		
	c) Resistance at 20 °C (ohms)		
	d) Dielectric Test Voltage value	KV	
	Bearing		
	a) Type of bearing (Pedestal/End Shield)		
	b) Oil quantity per bearing (m3/hr)		
	c) Oil pressure	(kg/cm2)	
	d) Grade of Oil		
	Shaft Seal		
	a) Type of seal		
	b) Pressure of Seal oil	(kg/cm2)	
	c) Grade of oil		
	d) Quantity of oil per seal	(m3/hr)	

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SL No.	DESCRIPTION	UNIT	DATA
	Gas/Air Coolers		
	a) Number of Coolers		
	b) Material of:		
	i) Tubes		
	ii) Fins		
	c) Material of tube plate		
	d) Quantity of cooling water required/ cooler	m3/hr	
	e) material of water boxes		
	f) Pressure drop across cooler on water side (m.w.c)		
	AUTOMATIC VOLTAGE REGULATORS		
	a) Manufacturer		
	b) Type		
	c) Power supply to the regulator (Volts)		
	d) Range of generator voltage adjustment(%)		
	i) in auto position		
	ii) in manual position		
	e) Frequency range of operation	Hz	
	f) temperature range of operation	Deg.C	
	g) Accuracy (%)		
	h) Dead band		
	i) Excitation system response time with AVR (The time for the generator field voltage to attain 95% of the difference between field forcing voltage and rated field voltage with 5% drop in generator terminal voltage and generator at rated MVA)		
	j) Time required for generator terminal voltage to get restored to within 2% of the nominal preset value when subject to sudden loss of rated output.		
	BRUSHLESS EXCITATION SYSTEM		
	Pilot exciter		
	a) Manufacturer		
	b) Type		
	c) Type of drive		

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SL No.	DESCRIPTION	UNIT	DATA
	d) Normal Speed	Rpm	
	e) Rated Voltage	Volts	
	f) Rate frequency	Amp	
	g) Rated current	Amp	
	h) Type of insulation		
	Rectifier for pilot exciter		
	a) Manufacturer		
	b) Type		
	c) Rated rectifier voltage	Volts	
	d) Rated rectifier current	Amp	
	e) Ceiling rectifier current	Amp	
	f) Ceiling rectified current	Amp	
	g) Total number of rectifier cells per parallel path of a bridge		
	h) Number of parallel paths per bridge arm		
	i) No. of bridge arms		
	j) Maximum peak inverse voltage rating of a cell	Volts	
	k) Method of over voltage protection		
	l) Maximum number of bridges/rectifier cells without which the rectifier can give output corresponding to generator MCR		
	Main Exciter		
	a) Manufacturer		
	b) Type		
	c) Type of drive		
	d) Normal Speed	rpm	
	e) Rated rectifier voltage	Volts	
	f) Rated rectified current	Amp	
	g) Ceiling rectified voltage	Volts	
	h) Ceiling rectified current	Amp	
	i) Exciter field voltage with manual control (rectified)		
	i) Maximum	Volts	
	ii) Minimum	Volts	

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SL No.	DESCRIPTION	UNIT	DATA
	j) Field current at generator MCR and rated power factor lagging	Amp	
	k) nominal exciter response ratio		
	l) Class of insulation		
	m) Insulation material on rotor winding		
	n) insulation material on field winding		
	o) Type of end winding support		
	p) Maximum temperature with secondary cooling water temperature of 31 deg. C		
	i) Exciter stator winding in contact with insulation		
	ii) Exciter stator winding not in contact with insulation		
	iii) Rotor winding		
	Exciter rectifier assembly		
	a) Manufacturer		
	b) Type of rectifier		
	c) Total number of rectifier cells per ring		
	d) Number of parallel paths per bridge arm		
	e) Number of bridge arms		
	f) Maximum number of rectifier cells/bridge without which the rectifier can give output corresponding to generator MCR		
	g) Maximum peak inverse voltage rating of cell	Volts	
	h) Number of rectifier cells in series in each bridge arms		
	i) Method of overvoltage protection		
	j) Overload rating of the rectifier cell		
	k) Ceiling output voltage of rectifier assembly	Volts	
	l) Ceiling output current of rectifier assembly	amp	
	m) Maximum junction temperature of rectifier cells		
	n) Method of mounting cells to cooling fins		
	o) Make and type of cooling fins		
	p) Type of visual indication provided for faulty rectifier cells		
	Air/Water Coolers (For Exciter)		
	a) Number of Coolers		

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SL No.	DESCRIPTION	UNIT	DATA
	b) Material of		
	i) Tubes		
	ii) Fins		
	c) Material of tube plates		
	d) Material of water boxes		
	e) Quantity of circulating water required per cooler	m ³ /hr	
	f) Maximum allowable water temperature	deg.C	
	g) Pressure drop across the cooler on water side	mwc	
	GAS SYSTEM		
	a) Volume of Hydrogen space in generator	m ³	
	b) Cooling gas flow	m ³ /min	
	c) Volume of CO ₂ at NTP required for displacing air	m ³	
	d) Volume of CO ₂ at NTP required for displacing hydrogen	m ³	
	e) Volume of H ₂ at NTP required for displacing carbon-di-oxide and to bring the casing to the rated pressure	m ³	
	f) Purity of H ₂ required	%	
	i) Normal		
	ii) Minimum allowable		
	g) Leakage of H ₂ by volume at NTP per day at rated H ₂ pressure in the generator		
	h) Is Nitrogen required to displace CO ₂ in the generator		
	i) Volume of air at NTP required to displace CO ₂	m ³	
	j) Requirement of compressed air for gas tightness test		
	k) No. of cylinders proposed to be furnished		
	i) Hydrogen		
	ii) Carbon dioxide		
	iii) Nitrogen (if required)		
	l) Standards to which the cylinders conform		
	i) Hydrogen		
	ii) Carbon dioxide		
	iii) Nitrogen (if required)		
	m) Internal volume of the cylinder		

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SL No.	DESCRIPTION	UNIT	DATA
	i) Hydrogen		
	ii) Carbon dioxide		
	iii) Nitrogen (if system require)		
	SEAL OIL SYSTEM		
	Seal Oil Pump Motor Set		
	a) Type		
	b) Numbers		
	c) Capacity	m3/hr	
	d) Discharge pressure (gauge)	kg/cm2	
	e) Shut-off Head	mwc	
	f) Size of motor	KW	
	Vapour extraction unit		
	(in seal oil drain) on air side stream		
	a) Type		
	b) Capacity	m3/hr	
	c) Size of motor	KW	
	Vapour extractor motor set		
	a) Type		
	b) Numbers		
	c) Capacity		
	d) Discharge pressure		
	e) Shut-off head		
	f) Seal oil flow and pressure required for normal operation		
	MAIN WEIGHTS :		
	a) Heaviest lift of generator stator with trunnions etc.		
	b) Weight of complete generator stator	Tonnes	
	c) Weight of complete rotor	Tonnes	
	d) Weight of complete generator	Tonnes	
	e) Weight of lifting beam assembly	Tonnes	
	Critical speeds for Generator + exciter (if any)	rpm	
	a) First		

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SL No.	DESCRIPTION	UNIT	DATA
	b) Second		
	c) Third		
	Motors (rated above 50 kW) (attach separate data sheet for separate motors)		
	Equipment driven by motor		
	Rated output for 50 °C ambient air/31 °C cooling water temperature	kw	
	Temperature rise at rated output conditions as in item 2.40.02 above	deg.C	
	Class and type of insulation		
	Rated voltage	Volts	
	Efficiency at rated output	%	
	Power factor at rated output		
	Rated current	amp.	
	Locked Rotor kVA (Indicate the Rated output kW upper limit)		
	Upper limit of locked rotor current	amp.	
	Whether motor is capable of two successive hot starts with the driven equipment coupled	Yes/No	
	Rated speed	rpm	
	Rated torque		
	Starting torque		
	Pull out torque		
	Applicable standard to which motor generally conforms		
	Manufacturer		
	Type of enclosure, degree of protection and method of cooling		
	Type of terminal box for stator leads		
	Bearing type		
	Rotor Earth fault protection		
	Whether for single earth fault or for both single and double earth fault		
	Make		
	Type		

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SL No.	DESCRIPTION	UNIT	DATA
	Range		
	Requirement of auxiliary supply		
	a. Voltage		
	b. AC/DC		
	c. Frequency		
	d. VA		
	Shaft current relay with CT		
	CT Dia		
	CT Ratio		
	CT VA and Accuracy		
	Core weight		
	Core dimension		
	Core material		
	Relay make and type		
	Relay range		
	Exciter Field Breaker		
	a) Manufacturer		
	b) Type		
	c) Rated DC voltage		
	d) Rated continuous current at 50 °C design ambient		
	e) Short time rating		
	f) No. of main poles		
	g) Material of main poles		
	h) No. of arcing contacts		
	i) Material of arcing contacts		
	j) Type & material of arcing chutes		
	k) Closing coil voltage with operating voltage range		
	l) Tripping coil voltage with operating voltage range		
	Exciter Field discharge resistance		
	a) Manufacture		
	b) Type		

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SL No.	DESCRIPTION	UNIT	DATA
	c) Material		
	d) Current rating		
	e) Power rating		
	Enclosure		
	a) Type of enclosure		
	b) Degree of protection		
	c) Type & thickness of sheet steel		
	d) Overall dimensions		
	e) Weight		
	CONTROL PANEL		
	CONTROL PANEL/DESK (furnish data separately for each control panel/desk)		
	Control panel/Desk (Service)		
	Tentative dimensions control panel/desk	mm	
	Detail of components	Make & Type	
	Contactors (Furnish details for AC & DC separately)		
	Timers (Furnish details for AC & DC separately)		
	Relay (Furnish details for AC & DC Relays separately)		
	Control switch		
	Push button		
	Ammeter/voltmeter selector switches		
	Indicating lamps		
	Space heater		
	Terminal blocks		
	Indicating Instruments		
	Wires		
	Panel		
	Annunciator		
	Whether detail write-up of the scheme furnished	Yes/No	
	Details of mimic diagram		

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2.0 GENERATOR PROTECTION PANEL & METERING PANEL

S. No.	Technical Particulars	Unit	Data
1.0	General		
1.1	Type (simplex / duplex / panel cum desk)		
1.2	Make		
1.3	Maximum dimensions width x depth x height	mm	
1.4	Weight of each panel		
1.5	Degree of protection		
1.6	Colour shade		
1.7	Cold rolled sheet steel thickness		
	(a) Load bearing members	mm	
	(b) Non-loading members	mm	
1.8	Cable entry top / bottom		
1.9	Control cable glands to be supplied		
1.10	Purchaser's external cable sizes		
1.11	Any special interconnecting cable between panels to be provided by vendor.		
1.12	Special requirements:		
a)	Matching with existing / new panels of others	Yes/No	
b)	Coordination with other suppliers		
c)	Hardware and accessories for protocol converter and connection to DCS		
1.13	Earth bus material & size inside the panel		
1.14	Equipment list for each panel		
1.15	Auxiliary voltages		
a)	A.C.	V	
b)	DC	V	
2.0	Particulars of Protective relays		
2.1	Relay type required		

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S. No.	Technical Particulars	Unit	Data
2.2	Mounting		
2.3	Communication protocol		
2.4	Wiring arrangement		
2.5	Testing facility		
2.6	Minimum rating of contacts for auxiliary and output relays :		
	(a)Voltage	V, DC	
	(b) Continuous current	A, DC	
	(c)Make & carry for 1 sec.	A, DC	
	(d)Breaking capacity		
	(i) Resistive	Watts	
	(ii) Inductive	Watts	
2.7	Relay type and protection [For Generator] (List out all protection and relay type used)		
2.8	Relay type and protection [For Generator Transformer] (List out all protection and relay type used)		
2.9	Relay type and protection [For Unit Transformer] (List out all protection and relay type used)		
2.10	Tripping Relays		
	(a)Make / designation		
	(b)Static / Electromagnetic		
	(c) Rated voltage	V, DC	
2.11	Trip circuit Super Vision Relays		
	(a)Make / designation		
	(b)Static / Electromagnetic		

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S. No.	Technical Particulars	Unit	Data
	(c) Rated voltage	V, DC	
2.12	Indicating Lamps		
a	Type		
b	Ratings		
c	Voltage	V	
d	Wattage	W	
3.0	Meters		
3.1	Make		
3.2	Type of measurement		
3.3	Measuring range in primary watts.		
3.4	CT ratio		
3.5	VT ratio		
3.6	Accuracy class		
3.7	Burden		
	(a)Current coil	VA	
	(b)Voltage coil	VA	
3.8	Transducers		
a	Output	4-20mA	
b	Accuracy		
c	Burden	VA	
4.0	Timers		

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S. No.	Technical Particulars	Unit	Data
4.1	Make		
4.2	Type designation		
4.3	Range of time delay		
4.4	(a)On energization	m sec.	
	(b)On de-energization	m sec.	

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3.0 ISOLATED PHASE BUS DUCT

S. No.	Technical Particulars	Unit	Bidder Data	Remarks
1.0	General			
1.1	System nominal voltage	kV		
1.2	System maximum voltage	kV		
1.3	Number of phases			
1.4	Rated Frequency	Hz		
1.5	Neutral Grounding			
1.6	Insulation level			
a	1 min power frequency withstand voltage	kV		
b	Impulse withstand voltage	kVp		
1.7	Short Circuit Level			
a	Symmetrical short circuit capacity	kA		
b	Dynamic capacity	kAp		
1.8	Auxiliary Voltage			
a	Air Pressurization/Hot Air blowing	V		
b	Space heating voltage	V		
1.9	Reference standard			
2.0	Busduct			
2.1	Make			
2.2	Type of bus duct			
2.3	Service			
2.4	Type of cooling			
2.5	Nominal service voltage/rated frequency			
2.6	Busduct length			
2.7	Rated voltage class			

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
2.8	Continuous current rating of bus duct under site conditions between			
	a) Main run between Generator and GT	Amps		
	b) Tap off to UT and SET	Amps		
2.9	Basic impulse withstand level (1.2 x 50 micro sec wave)	kVp		
2.10	One minute power frequency dry withstand voltage	kV		
2.11	Short time current for one second /Dynamic withstand current a) Main run b) Tap off	KA /KAp		
2.12	Maximum temperature rise of conductor over 50°C ambient	°C		
2.13	Maximum temperature rise of enclosure over 50°C ambient	°C		
2.14	Maximum temperature rise of conductor over 50° C ambient when carrying short circuit current for 1 sec	°C		
3.0	Bus conductor			
3.1	Bus conductor Material			
3.2	Bus conductor size for			
	a) Main run between Generator and GT	mmxmm		
	b) Tap off run for UT and SET	mmxmm		
3.3	Bus conductor shape			
3.4	Busbar Dimension			
3.5	Method of joining adjacent sections			
3.6	Parameters	ohms		

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
a	Resistance/meter/Phase at 20°C			
b	Inductive reactance per phase at 20 deg.C at 50 Hz (main/tap-offs)			
c	Capacitive reactance per phase at 20deg.C at 50 Hz (main/tap-offs)			
4.0	Bus enclosure			
4.1	Bus Enclosure Material			
4.2	Shape of Enclosure			
4.3	Inner diameter and thickness	mm		
4.3	Cross section of enclosure	mmxmm		
4.4	Method of joining adjacent sections			
4.5	Parameters			
a	Resistance/meter/Phase at 20°C			
b	Inductive reactance per phase at 20 deg.C at 50 Hz (main/tap-offs)			
c	Capacitive reactance per phase at 20deg.C at 50 Hz (main/tap-offs)			
4.6	Power loss			
a	Power loss in the isolated phase bus duct at full load			
b	Middle phase	kW/m		
c	Each outer phase	kW/m		
d	Total	kW/m		
e	Power loss in bus conductor when carrying rated current	kW/3 ph. Metre run		
f	Power loss in bus enclosure when carrying rated current	kW/3 ph.		

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
		Metre run		
g	Total power loss(Conductor and enclosure)	KW		
5.0	Bellows			
5.1	Manufacturer			
5.2	Material and grade			
5.3	Maximum permissible expansion			
6.0	Phase to phase spacing			
a	Main run	mm		
b	Tap off	mm		
c	Minimum phase to earth clearance	mm		
7.0	Material of gasket for inspection window			
8.0	Disconnecting links			
a	Quantity/Location			
b	Rated current under site conditions			
9.0	Insulators and seal off bushings			
9.1	Make			
9.2	Rated Voltage	kV		
9.3	One minute Power Frequency Withstand Voltage	kVrms		
9.4	Impulse Withstand Voltage (1.2 x 50 micro-second Wave)	kVp		
9.5	Minimum Creepage Distance	mm/kV		

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
9.6	Insulators			
	a) Material of Insulators			
	b) Cantilever strength			
	c) Weight of insulator	kg		
	d) No of supports and insulator span			
10.0	Seal-off bushings			
10.1	Make			
10.2	Current rating of Seal of Bushings	Amps		
10.3	Material of Seal Off Bushings			
10.4	Type			
10.5	Mechanical Strength			
10.6	Weight of each bushing	kg		
11.0	Pressurization equipment			
11.1	Pressure of supply air	Kg/cm ²		
11.2	Pressure to be maintained inside bus ducts			
11.3	Scavenging rate	l/hr		
11.4	Guaranteed leakage rate (through bus ducts)	l/hr		
11.5	Quantity of air required			
12.0	Hot air blowing system	Yes/No		
13.0	Current transformer			

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
13.1	Type			
13.2	Rated voltage class	kV		
13.3	One second thermal rating	kA		
13.4	Dynamic rating	kA		
13.5	Insulation class			
13.6	Accuracy class			
14.0	Voltage Transformer			
14.1	Type			
14.2	Service			
14.3	Rated Voltage			
a	Primary	V		
b	Secondary Voltage	V		
14.4	Winding connection			
a	Primary			
b	Secondary			
c	Insulation class			
14.5	Over voltage factor			
a	Continuous			
b	30 second			
14.6	Accuracy class			

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
15.0	Surge protection			
15.1	Type			
15.2	Service			
15.3	Rated voltage class	kV		
15.4	Nominal Discharge current			
15.5	Power frequency withstand voltage	kV		
15.6	Lightning impulse withstand voltage	kVp		
16	Earthing Material			
117	Finish of Bus Enclosure			
18	Rain hood required Yes/No			
19	Degree of protection for enclosure			

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4.0 MOTOR

SL. NO.	DESCRIPTION	UNIT	DATA
1.	Manufacturer		
2.	Type and frame size		
3.	Nos. required		
4.	Application		
5.	Specification & Codes		
6.	Capacity for specified climatic conditions [50°C]		
7.	Location for installation		
8.	Type of enclosure & ventilation		
9.	Degree of protection		
10.	Type of duty		
11.	No. of phases, frequency & voltage		
12.	Permissible variations in		
a)	Voltage		
b)	Frequency		
c)	Combined		
13.	At rated voltage & frequency		
a)	Full load current		
b)	Full load speed		
c)	No load current		
14.	Minimum permissible voltage during starting :		
15.	Maximum permissible time at minimum permissible voltage during running at full load.		
16.	Maximum permissible time at 75% of rated voltage during running at full load.		
17.	Whether motor stalls at 70% of rated voltage Efficiency & power factor.		
18.	Stator winding		
	Type & nos. of terminals Brought out		
	Resistance between terminals at 20°C		
	Resistance per phase at 20°C		

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SL. NO.	DESCRIPTION	UNIT	DATA
	Inductance per phase		
	Capacitance per phase		
	Starting current as % of full load current		
19.	Torque at full load in Kgm.		
a)	Break away torque in % of full load torque		
b)	Pull up torque in % of full load torque		
c)	Pull out torque in % of full load torque		
20.	Starting time in sec.		
a)	Without mechanism coupled		
b)	Mechanism coupled through hydraulic coupling when it may be presumed that load is transferred to motor shaft only after attaining almost full speed.		
	i. with rated voltage		
	ii. with 80% of rated voltage		
	iii. with 110% of rated voltage		
21.	Starting time in sec. With mechanism coupled through flexible coupling		
a)	with rated voltage		
b)	with 80% of rated voltage		
c)	with 110% of rated voltage		
22.	Safe stall time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
23.	Safe stall time (Cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
24.	Limiting motor temperature to determine safe stall time		
25.	Permissible maximum accelerating time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
26.	Permissible maximum accelerating time (cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
27.	Class of Insulation And Material		
28.	Whether insulation is suitable for 415 V, 6.6kV system		
29.	Temperature rise under normal conditions over 50°C ambient temperature		
30.	By resistance method --- °C over cooling water temp. for CACW motors.		
31.	Degree centigrade over cooling air temp. for CACA motor.		
32.	By Thermometer method ---- Degree centigrade over cooling water temp. for CACW motor.		
33.	Degree centigrade over cooling air temp. for CACA motor.		
34.	Method of starting :		
35.	Permissible starting duty cycles :		
36.	Stator thermal time constant :		
37.	Method of cooling (If applicable)		
	Details of water cooling system		
a)	No. of cooler		
b)	Water requirement per cooler		
c)	Losses removed by cooler		
d)	Max. permissible temperature of cooling water at inlet		
e)	Max. permissible temperature of cooling water at outlet		
f)	Maximum permissible pressure at water outlet		
g)	Water pressure drop through the cooler		
h)	Temp. of cold air coming out & entering the machine For permissible cooling water temperature of [31°C]		
i)	Temp. rise of air passing through machine at full load.		
j)	Air pressure drop through The cooler		
k)	Temp. rise of water through cooler		
l)	Protection against leakage of water :		

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SL. NO.	DESCRIPTION	UNIT	DATA
m)	Arrangement to ensure the water flow		
38.	Bearings		
a)	Number :		
b)	Type :		
c)	Lubrication system :		
d)	Quantity of lubricant reqd. For both the bearings. Life in hours at rated speed :		
e)	Recommended lubricant :		
f)	Bearing end play :		
g)	Inlet oil pressure :		
h)	Temp. rise of oil :		
i)	Max. permissible temp. of bearing :		
j)	Max. Permissible temp. of Oil		
k)	Permissible running time without forced oil at full load & full speed :		
39.	Whether bearings are provided with 4 wire, platinum RTD having 100-ohm resistance at 0°C for remote temp. Indication.		
a)	Whether bearings are provided with local temperature indicator having two adjustable contacts rated for 5A at 240V AC or 0.5A at 220V DC. : Yes/No		
b)	If forced lube oil system provided : Yes / No		
c)	Qty of lubricant required for initial filling.		
d)	Recommended period after which lubricant should be replaced		
e)	Bearing cooling water requirement		
f)	Max. Permissible bearing cooling water inlet temp. (permissible)		
g)	Max. Permissible bearing cooling water outlet temp.		
h)	Terminal designation corresponds to direction of rotation (Facing driving end).		
i)	Terminal boxes with accessories separate terminal boxes provided.		
40.	Winding temp. detectors		
41.	Bearing temp. detectors		

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SL. NO.	DESCRIPTION	UNIT	DATA
42.	Moisture detectors		
43.	Neutral terminals		
44.	Main terminal box details		
a)	Type & Nos.		
b)	Fault level permissible for 0.25 sec.		
c)	Location		
d)	Cable gland size & no.		
e)	Direction of cable entry.		
45.	Space Heater		
a)	Number		
b)	Location		
c)	Capacity of each		
d)	Total power requirement		
e)	Voltage.		
46.	Details of 4 wire platinum RTD having 100 ohm resistance at 0°C for winding temp. detector.		
a)	Nos. provided		
b)	Location		
47.	Whether CTs for differential protection are provided : Yes / No		
a)	If Yes, no. of CTs supplied along with motors C.T. details		
	i. C.T. ratio		
	ii. Knee point voltage		
b)	S.C. withstand capacity		
c)	Type of mounting		
48.	Shaft orientation		
49.	Shaft extension		
50.	Grounding pads size nos. & location		
51.	Method of coupling to driven mechanism		
52.	Motor GD ² :		
53.	Lifting device		
54.	Weight		

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SL. NO.	DESCRIPTION	UNIT	DATA
a)	Weight of stator (wound)		
b)	Weight of rotor (wound)		
c)	Weight of base plate		
d)	Weight of cooler		
e)	Net weight of motor		
f)	Shipping dimensions & weight		
55.	Thermometer provided		
a)	In cold air path		
b)	In hot air path		
c)	For measurement of oil temp.		
56.	Characteristic curves furnished		
a)	Speed vs. current at rated voltage	Yes / No	
b)	Speed vs. torque at 110%, 100%, 90% and 80% of rated voltage:	Yes / No	
c)	Thermal withstand curve for hot & cold conditions.	Yes / No	
d)	Efficiency vs. load:	Yes / No	
e)	P.F. Vs. load:	Yes / No	
f)	Current vs. time:	Yes / No	
g)	Negative phase sequence curve:	Yes / No	
57.	Drawings furnished		
a)	General arrangement of motor	Yes / No	
b)	Main terminal box showing the method of terminating the incoming cables Yes/No	Yes / No	
c)	Instruction manuals	Yes / No	
	MOTOR (DC)		
1.	GENERAL		
a)	Manufacturer :		
b)	Equipment driven by Motor :		
c)	Motor type :		
d)	Country of origin :		
2.	DESIGN & PERFORMANCE		
a)	Frame Size :		

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SL. NO.	DESCRIPTION	UNIT	DATA
b)	Type of duty :		
c)	Type of enclosure & type of cooling :		
d)	Applicable standard to which motor generally confirms:		
e)	Type of mounting :		
f)	Direction of rotation :		
g)	KW rating at amb. Temp. 50 °C :		
h)	Rated power supply voltage		
	i. Armature circuit (V) :	V	
	ii. Field circuit (V) :	V	
i)	Permissible voltage variation :		
j)	Minimum permissible starting voltage :		
k)	Rated speed at rated voltage (RPM) :	RPM	
l)	At rated voltage		
	i. Full load current (A) :	A	
	ii. NO load current (A) :	A	
m)	Starting current (A) :		
	i. 100% voltage :		
	ii. 85 % voltage :		
n)	Starting time (with pump coupled) :		
	i. 100% voltage (Sec) :		
	ii. 85 % voltage :		
	iii. 80 % voltage :		
o)	Efficiency at rated voltage at :		
	i. 100% load :		
	ii. 75% load:		
	iii. 50% load:		
p)	Safe stall time (sec) at 110% :		
	i. Hot condition :		
	ii. Cold condition :		
q)	Torque (Kg-m) :		
	i. Starting at min. permissible voltage:		
	ii. Rated:		

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SL. NO.	DESCRIPTION	UNIT	DATA
r)	Fly wheel moment (GD2) motor (Kg-m)		
3.	CONSTRUCTIONAL FEATURES		
a)	Winding insulation :		
	i. Class & type :		
	ii. Tropicalised (Yes/No) :		
	iii. Temp. rise over specified ambient of 50 °C. :		
	iv. Method of temp. measurement :		
b)	Degree of protection of terminal box for :		
	i. Main terminal box :		
	ii. Space heaters (AUX. TB) :		
c)	For main terminal box :		
	i. No. and type of cable gland :		
	ii. Recommended cable size (Armature/field) :		
d)	Fault level (KA, sec) :		
e)	Bearings :		
	i. Type (at DE/NDE):		
	ii. Make :		
	iii. Recommended lubricant :		
	iv. Life :		
f)	Weight of motor (Kg.) :		
g)	Field current at rated speed (A)		
h)	Field resistance (Ohm) at rated speed at 30 °C		
i)	Field trimmer rating (Ohm) for getting basic speed at 30 °C.		
j)	Resistance (Ohm) between terminals at 30°C.		
	i. Armature :		
	ii. Series winding :		
	iii. Inter pole winding :		
	iv. Shunt winding resistance:		
k)	1 st and 2 nd critical speed :		
l)	Overload that can be carried by motor without changing overall performance and period for which it is applicable		

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SL. NO.	DESCRIPTION	UNIT	DATA
m)	Grounding device :		
n)	Space heater :		
	i. No. & location :		
	ii. Volt & KW rating :		
4.	RESISTORS		
a)	Starting (external) resistance :		
	i. Type of resistor :		
	ii. Ohmic, current & power rating of resistor elements		
	iii. Max. permissible temp. of resistor elements :		
	iv. Connection diag. Of resistor elements		
	v. No. of startup stages/steps :		
	vi. Resistance values of stages :		
	-at 30 deg. C (Ohm) :		
	-at running condition (Ohm) :		
	vii. Expected temp of resistor at running condition		
	viii. Expected temp of box at running condition		
	ix. Mounting/stacking of resistor elements and G.A. of resistor box		
b)	Schematic connection diag. Of motor with starting resistor and field trimmer resistor.		
5.	CHARACTERISTIC CURVES		
a)	Starting current/times :		
b)	Thermal withstand curve for hot and cold condition		
c)	Torque/speed		
d)	Load/Efficiency		
e)	Speed/Time		

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5.0 MOTOR ACTUATORS

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		
2.	Application		
3.	Motor type		
	Supply voltage	V	
4.	Phase, frequency	Hz	
5.	Motor rated voltage	V	
6.	Control Voltage	V	
7.	Voltage and its variation	V	
8.	Frequency and its variation	Hz	
9.	Combined V & f variation	%	
10.	Degree of Protection		
11.	Winding Insulation		
12.	Temperature Rise (over ambient temperature)	°C	
13.	Painting		
14.	Motor Starting		
a)	Method		
b)	Starting Current		

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6.0 LT TRANSFORMER (OIL TYPE/DRY TYPE)

6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Make		
2.	Application		
3.	Location		
4.	Type		
5.	Reference standard		
6.	Rated power (indicative)		
7.	Rated winding voltage ratio (line to line)		
8.	Number of phases		
9.	Winding		
10.	Rated frequency		
11.	Type of cooling		
12.	Insulation Class		
13.	Temperature rise Over ambient temperature of 50°C		
a	For Winding by resistance method		
b	For Oil by Thermometer method		
14.	Insulation level (LI/AC)		
a	HV- (LI/AC)		
b	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
15.	Vector group		

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6.6/0.433 kV LV AUXILIARY TRANSFORMER					
		Dry Type			Oil Type
16.	Short-circuit impedance on principal tap				
17.	Parallel operation of transformer				
18.	Type of taps provided				
19.	Taps provided on				
20.	Range of taps				
21.	Method of Tap charge control-				
a	Manual local				
b	Electrical local				
c	Electrical remote				
d	Automatic				
22.	System earthing				
a	H.V.				
b	L.V.				
23.	Terminal arrangement				
a	H.V.				
b	L.V.				
24.	Neutral for earthing				
25.	Transformer bushing	HV	LV	LV - N	
26.	Voltage class KV(r.m.s.)				
27.	Creepage distance mm				
28.	Min. Ph-Ph/ Ph-E clearance mm				
29.	System fault Level				

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6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
a	HV Side		
b	LV Side		
30.	Max. Noise level		
31.	Auxiliary supply		
32.	LV neutral side current transformer for standby earth fault protection		
33.	Guaranteed no load loss (kW)		
34.	Guaranteed load loss (kW)		
35.	Efficiency		
a	At full load		
b	At 75% load		
c	At 50% load		
36.	Accessories		
	Each transformer furnished With fittings and accessories as per specification.		
37.	Approximate overall dimensions		
a	Length		
b	Breadth		
c	Height		
38.	Crane lift for un taking core and coil assembly Approximate Weights		
a	Core and coil		
b	Enclosure and fittings		
c	Oil		
d	Total weight		

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6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
39.	Shipping Details:		
a	Weight of the heaviest package		
b	Dimension of the largest package :(LxBxH)		
40.	Tests		
	Routine test as per IS and other tests as per specification		

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7.0 LT PCC/MCC/DISTRIBUTION BOARD

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material	Cu/Al	
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Colour finish shade	Interior exterior	

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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Starters		
3.1	Type	DOL Rev / Star-Delta	
3.2	Contactor rated duty		
3.3	Single phasing preventer required.	Yes / no	
3.4	Thermal overload relay reset	Manual / Auto	
4.0	Circuit breakers		
4.1	Maker's name		
4.2	Voltage, frequency & no.of phases , poles		
4.3	Rated operating duty		
4.4	Circuit breakers type		
4.5	Short circuit withstand current for 1 sec. Duration	kA	
4.6	Rated making current	kAp	
4.7	Rated current at site reference ambient temp	A °C	
4.8	Type of operating mechanism		
4.9	Minimum no. of auxiliary Contacts for purchaser's use		
4.10	Control voltage		
a	For Spring charging motor	V AC/DC	
b	For closing/tripping	V AC/DC	
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	
b	Closing at normal voltage	%	
c	Trip coil	%	
4.12	Power required for closing at normal voltage	W	
4.13	Power required for tripping at normal voltage	W	

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S. No.	DESCRIPTION	UNIT	DATA
4.14	Spring charging motor details:		
a	Rating	kW	
b	Rated voltage	V, AC/DC	
c	Spring charging	Sec.	
	Electrical and mechanical anti-pumping features been provided	Yes/No	
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		
5.2	Rated operating duty		
5.3	Rated breaking capacity	kA (rms)	
5.4	Rated making current	kA (Peak)	
5.5	On/Off operation		
5.6	Manual	Yes/No	
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	
5.8	Auxiliary contacts required	Yes/No	
6.0	Contactors		
6.1	Make		
6.2	Rated duty	AC3/AC4	
6.3	No of poles		
6.4	Utilization category		
6.5	Rated voltage of auxiliary contacts	V	
6.6	Rated voltage of coil	V	
6.7	Rated breaking capacity	Factor of rated current	
6.8	Rated making capacity	Factor of rated current	
6.9	Limits of operation		
a	Supply voltage variation		

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S. No.	DESCRIPTION	UNIT	DATA
b	Supply frequency variation for closing		
c	Drop out voltage		
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		
7.1	Voltage Ratio		
7.2	CT Ratio		
7.3	Measuring CTs		
7.4	Protection CTs		
7.5	Measuring VTs		
7.6	Protection VTs		
8.0	Control transformers		
8.1	Make		
8.2	Type		
8.3	Applicable standards		
8.4	Ratio		
8.5	Class of insulation		
8.6	Rated output	VA	
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		
10.2	Make		
10.3	Type designation		
10.4	Setting range		
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		
11.2	Make		
11.3	Type		
11.4	Current setting range		

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	
12.0	Under voltage relay		
12.1	Make		
12.2	Type		
12.3	Voltage rating	V	
12.4	Setting range	V	
13.0	Auxiliary relays and timers		
13.1	Make		
13.2	Type		
13.3	Coil voltage	V	
14.0	Control/selector switch		
14.1	Make		
14.2	Type designation		
15.0	Meters		
15.1	Applicable Standards		
15.3	Accuracy Class		
15.4	Make		
15.5	Type		
16.0	<u>Voltmeter</u>		
16.1	Make		
16.2	Type		
16.3	Applicable standards		
16.4	Accuracy class		
17.0	<u>Ammeter</u>		
17.1	Make		
17.2	Type		
17.3	Applicable standards		
17.4	Accuracy class		

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S. No.	DESCRIPTION	UNIT	DATA
18.0	<u>Indicating lamps</u>		
18.1	Make		
18.2	Type		
18.3	Voltage	V	
18.4	Wattage of lamp	W	
19.0	<u>Push buttons</u>		
19.1	Make		
19.2	Type designation		
19.3	Contact rating	A	
20.0	<u>Space heater</u>		
20.1	Make		
20.2	Type		
20.3	Rated voltage	V	
21.0	<u>Wiring and terminal blocks</u>		
21.1	Voltage grade		
21.2	Insulation		
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	
b	Control wiring	Sq.mm	
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		
	II) For Fixed Type		
21.5	Minimum current rating of terminal blocks	A	

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8.0 415V NON SEGREGATED PHASE BUS DUCT

S. No.	DESCRIPTION	UNIT	DATA
1.	Make/ Name of Manufacturer		
2.	Type of Busduct	Segregated /non segregated	
3.	Type of cooling	Natural/Forced	
4.	Reference Standard		
5.	Rated Voltage	V	
6.	No of phase and Frequency	Hz	
7.	Insulation level a) Min Power frequency Voltage b) Impulse withstand voltage	kVrms kVp	
8.	Rated Continuous current	Amp	
9.	Short time withstand capability a) Symmetrical for 1 sec b) Momentary	kA kAp	
10.	Maximum temperature rise over 50 degree design ambient temperature a) Bus bar b) Enclosure	Degree	
11.	Degree of protection of enclosure		
12.	Bus bar a) Material & Grade b) Conductivity c) Size		
13.	Enclosure a) Material & Grade b) Thickness c) Ph- ph spacing d) Over all dimension		
14.	Dc resistance in micro ohm/metre/phase a) At 20 degree		

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S. No.	DESCRIPTION	UNIT	DATA
	b) At 85 degree		
15.	Reactance in ohm/meter/phase		
16.	Capacitance to ground		
17.	Losses in watt/meter/phase		
18.	Insulators		
	a) Make		
	b) Material		
	c) No per support		
	d) Voltage Glass		
	e) Compression strength		
	f) Cantilever strength		
19.	Size and material of ground bus		
20.	Support steel structure		
21.	Whether the following has been provided		
	a) Thermostat controlled space heater		
	b) Silica gel breather		
	c) Drain plug		
	d) Neoprene rubber gaskets at joints		
	e) Disconnecting links		
22.	Painting shade		
	a) Interior		
	b) Exterior		

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9.0 220V DC SYSTEM

SL. NO.	DESCRIPTION	UNIT	DATA
A.	DC SYSTEM		
	BATTERY		
	General		
	• Make		
	• Catalogue No.		
	• Type		
	• Reference Standard		
	Rating		
	• Rated Voltage	Volt	
	• 10-hour rating at 27 Deg.C to end cell voltage	AH	
	• 2-hour discharge rate to end cell voltage	Amp	
	• 1 –hour discharge rate to end cell voltage	Amp	
	• 1 -minute discharge rate to end cell voltage	Amp	
	Performance		
	• Battery duty cycle curve furnished	Yes/No	
	• Cell voltage characteristics during duty cycle furnished	Yes/No	
	• Minimum cell voltage during duty cycle	Volt	
	• AH efficiency at 10-hour discharge rate	%	
	• Expected life of Battery	Yr	
	Battery Characteristics		
	• Recommended charging rate for		
	i) Float charging	Amp	
	ii) Equalising Charge	Amp	
	iii) Boost charging in 10 hrs.		
	• Start	Amp	
	• Finish	Amp	
	• Recommend specific gravity at 27 Deg.C		
	i) For first filling		
	ii) At full charge		

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SL. NO.	DESCRIPTION	UNIT	DATA
	iii) At end of 10-hour discharge		
	• Short-circuit current for a dead-short across battery terminals, when		
	i) Float charge at 2.15 V/Cell	kA	
	ii) Boost charge at 2.75 V/Cell	kA	
	• Battery internal resistance	Ohm	
1	Cells		
	• Number of cells per battery	Nos.	
	• Nominal Cell voltage	V	
	• Cell voltage at the end of duty cycle	V	
	• Cell voltage at the end of full discharge at 10-hour rate	V	
	• Type of the cell		
	• Cell designation as per relevant Standard		
	• Material of the container		
	• Overall dimension of each cell (LxDxH)	mm	
	• Weight of complete cell		
	i) Without electrolyte	kg	
	ii) With electrolyte	Kg	
	• Internal resistance of cell	Ohm	
2	Intercell Connector		
	• Intercell connector furnished	Yes/No	
	• Type of intercell connector	bolted/burned	
	• Material of intercell connector		
3	Plates		
	• Number of positive plates per cell	Nos.	
	• Type of positive plate		
	• Type of negative plate		
4	Separator		
	• Type		
	• Material		
	• Thickness	mm	

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SL. NO.	DESCRIPTION	UNIT	DATA
5	Electrolyte		
	• Amount of electrolyte for first filling		
	i) Per cell	litre	
	ii) Per set	litre	
	• First filling with 10% extra furnished	Yes/No	
	• Electrolyte conforms to		
6	Racks		
	• Number of racks per battery	Nos.	
	• Number of cells per rack	Nos.	
	• Type of racks	Rows/Tiers	
	• Material of rack		
	• Racks provided with		
	i) Numbering tags for cells	Yes/No	
	ii) Clamps for cables	Yes/No	
	• Insulator furnished for		
	i) Cell	Yes/No	
	ii) Stand	Yes/No	
	• Inter-row, Miter-tier connectors and end take-off furnished	Yes/No	
	• Connector hardwares furnished	Yes/No	
7	Dimension & Weight		
	• Overall dimension (LxDxH)	mm	
	• Approx. Weight	Kg	
	• Battery layout drawing furnished	Yes/No	
8	Ventilation requirement furnished	Yes/No	
9	List of accessories furnished	Yes/No	
10	Technical leaflets furnished	Yes/No	
	BATTERY CHARGER		
i)	GENERAL		
	a. Make		
	b. Catalogue No.		

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SL. NO.	DESCRIPTION	UNIT	DATA
	c. Type		
	d. Reference Standard		
ii)	A.C. Input		
	a. Voltage \pm % variation	Volt, %	
	b. Phase	No.	
	c. Frequency \pm % variation	Hz., %	
	d. Input current	Amp	
iii)	D.C. Output		
	a. Voltage	Volt/Cell	
	b. Current	Amp.	
	Type of Cooling		
iv)	Max. Temp rise within cubicle above site ambient		
	a. Rectifier transformer	°C	
	b. SCR	°C	
v)	Performance		
	a. Regulation for 0-100% rated load with \pm 10% Input voltage and \pm 5% input frequency variation	%	
	b. Ripple content in O.C. output		
	i) With battery	%	
	ii) Without battery	%	
	c. Guaranteed efficiency at rated load	%	
	d. Power factor at rated load	%	
vi)	Miscellaneous		
	a. Charger provided with following features		
	i) Automatic voltage regulation	Yes/No	
	ii) Current limiting circuitry	Yes/No	
	iii) Smoothing filter circuit	Yes/No	
	iv) Soft-start feature	Yes/No	
	v) Automatic load sharing during parallel operation	Yes/No	
	b. SCR elements provided with		
	i) Surge protection	Yes/No	

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SL. NO.	DESCRIPTION	UNIT	DATA
	ii) Fast acting HRC fuse	Yes/No	
vii)	A. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
viii)	A. C. Fuse / MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
ix)	A.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rated Current	Amp	
	e. Utilization category		
	f. Thermal overload with In-built single-phase preventer provided	Yes/No	
x)	Rectifier Transformer		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating		
	i) KVA	KVA	
	ii) Voltage	V	
	iii) % reactance	%	

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SL. NO.	DESCRIPTION	UNIT	DATA
	e. Class of insulation		
	f. Method of cooling		
xi)	Controlled Rectifier (SCR)		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. RMS Current rating	Amp	
	e. Surge Current		
	i) One-cycle	Amp	
	ii) Repetitive Cycle	Amp	
	f. Peak inverse voltage		
	i) Continuous	Volt	
	ii) Surge	Volt	
xii)	D.C. Fuse/MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating		
	i) Continuous	Amp	
	ii) Interrupting	KA	
xiii)	D.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating	Amp	
	e. Utilization category		
xiv)	Blocking Diodes		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating		

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SL. NO.	DESCRIPTION	UNIT	DATA
	i) One – minute	Amp	
	ii) One-hour	Amp	
	e. Peak inverse voltage	Volt	
xv)	Indication Lamps		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Wattage	Watt	
	e. Series resistor	Ohm	
xvi)	Meters		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Size	mm	
	e. Accuracy		
xvii)	Alarm Facia		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. No. of window per facia	Nos.	
xviii)	D. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating	Amp	
	e. No. of poles	Nos.	
xix)	Charger Panel		
	a. Make		
	b. Type		
	c. Reference Standard		
	d. Enclosure		

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SL. NO.	DESCRIPTION	UNIT	DATA
	i) Degree of protection		
	ii) Sheet steel thickness	mm	
	e. Panel provided with		
	i) Internal lamp with door-switch	Yes/No	
	ii) Space heater with thermostat	Yes/No	
	iii) 5A, 3-pin receptacle with plug	Yes/No	
	f. Internal Wiring		
	i) Insulation		
	ii) Voltage grade	V	
	iii) Minimum conductor size	mm ²	
	g. Power Terminals		
	i) Make		
	ii) Size/Cat. No.		
	h. Control Terminals		
	i) Make		
	ii) Size/Cat. No.		
	iii) 20% spare terminal furnished	Yes/No	
	i. Ground Terminal furnished	Yes/No	
	j. Overall dimension (LxDxH)	mm	
	k. Weight	Kg	
	l. General Arrangement drawings furnished	Yes/No	

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10.0 HV CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.1.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
a)	In air	A	
b)	In ground	A	
c)	In duct	A	
d)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
a)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
b)	Grad and Shape of conductor		
c)	Nominal cross section area	mm ²	
d)	Number of wires		
e)	Diameter of wire	mm	
f)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	i. Between cores	mm	
	ii. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.20	Inner sheath		
a)	Material, confirming standard / type		
b)	Extruded	Yes/No	
c)	Calculated diameter over laid up cores		
d)	Thickness (min)	mm	
e)	Diameter of cable over inner sheath	mm	
f)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
g)	Filler Material details		
1.21	Armouring		
a)	Material		
b)	Type of armouring		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S. No.	DESCRIPTION	UNIT	DATA
c)	No. and size of strip/wire		
d)	Whether galvanized	Yes/No	
e)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
a)	Material confirming standard/ type		
b)	Extruded	Yes/No	
c)	Minimum Thickness of sheath	mm	
d)	Tolerance on thickness of sheath	mm	
e)	Min. tensile strength	N/sq mm	
f)	Min. elongation percentage at rupture		
g)	Colour of Outer sheath		
h)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification and standards	Yes/No	
1.23	Overall diameter of cable and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous current		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/km	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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11.0 LT POWER & CONTROL CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.2.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
e)	In air	A	
f)	In ground	A	
g)	In duct	A	
h)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
g)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
h)	Grad and Shape of conductor		
i)	Nominal cross section area	mm ²	
j)	Number of wires		
k)	Diameter of wire	mm	
l)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	iii. Between cores	mm	
	iv. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.20	Inner sheath		
h)	Material, confirming standard / type		
i)	Extruded	Yes/No	
j)	Calculated diameter over laid up cores		
k)	Thickness (min)	mm	
l)	Diameter of cable over inner sheath	mm	
m)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
n)	Filler Material details		
1.21	Armouring		
f)	Material		
g)	Type of armouring		

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S. No.	DESCRIPTION	UNIT	DATA
h)	No. and size of strip/wire		
i)	Whether galvanized	Yes/No	
j)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
i)	Material confirming standard/ type		
j)	Extruded	Yes/No	
k)	Minimum Thickness of sheath	mm	
l)	Tolerance on thickness of sheath	mm	
m)	Min. tensile strength	N/sq mm	
n)	Min. elongation percentage at rupture		
o)	Colour of Outer sheath		
p)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification	Yes/No	
1.23	Overall diameter of cable and and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous currents		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/k m	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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12.0 ILLUMINATION SYSTEM

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC	
1.2	Variation in Supply		
	a) Voltage	%	
	b) Frequency	%	
	c) Combined voltage & frequency	%	
1.3	Design Ambient Air Temperature	°C	
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	
	b) At 220V DC (For DC LP)	kA(DC)	
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		
b	Conductor size	SWG	
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		
2.2	Rated Voltage, phase and Frequency	AC	
2.3	One Minute Withstand Voltage	V	
2.4	Mounting Type		
	a) LDBs		
	b) Single Phase LP		
2.5	Type and no of circuits & feeder rating		
2.6	Colour shade		
2.7	Lighting Transformer		
	a) Type		
	b) Voltage Ratio	V	
	c) Taps	%	
	d) Vector Group		
	e) Impedance	%	
	f) Rating	KVA	
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		
3.2	Luminaries		
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		

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	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		
	a) Luminaires		
	b) Accessories		
4.0	Schedule of fitting and Accessories		
5.0	Technical details of luminaries		
5.1	Lamps		
	a Maximum permissible supply voltage variation	± %	
	b Luminous output		
	i) After 100 burning hours	Lumens	
	ii) After 1000 burning hours	Lumens	
	c Average burning hour life	Hours	
5.2	Ballasts & Starters		
	a Maximum permissible supply voltage variation	± %	
	b Power loss at nominal working voltage		
	c Maximum hot spot temperature of ballast		
	d Conductor material of ballast		
	e Insulation class of ballast winding		
	f Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		
	a Power factor		
5.4	Luminaires		
	a Weight of luminaries	Kgs	
	b Earthing terminal		
	i) Material		
	ii) Suitable upto conductor size	SWG	
	c Internal wiring size	Sq.mm	
	d Terminal block suitable for conductor size	Sq.mm	
	e Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
	f Wire guard thickness	mm	
	g Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		

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6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		
8.1	Make		
8.2	Type		
8.3	Output	VA	
8.4	Accuracy Class		
8.5	Literature enclosed	Yes/No	
9.0	Meters		
9.1	Make		
9.2	Type		
9.3	Accuracy Class		
9.4	Literature enclosed	Yes/No	
10.0	Relays (if any provided)		
10.1	Make		
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a) Normally open		
	b) Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		
11.2	Suitable for use in hazardous area		
	a) Area classification		
	b) Gases/Vapor group		
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	
12.0	Lighting Control Switches		
12.1	Make		
12.2	Decorative		

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12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	
14.0	Lighting wires		
14.1	Make		
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	CONDUITS		
15.1	Make		
15.2	Rigid Steel		
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		
17.1	Make		
17.2	Type of Poles/Towers		
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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13.0 CABLE CARRIER SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		
2.	Size of Tray	mm	
3.	Material		
4.	Application		
5.	Type of Tray		
6.	Thickness of Tray	mm	
7.	Thickness of Galvanization	mm	
8.	Tray Cover Size	mm	
9.	Cable Tray Accessories		
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	

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14.0 EARTHING & LIGHTNING PROTECTION SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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15.0 6.6KV SWITCHGEAR

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material		
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Color finish shade	Interior Exterior	

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		
3.3	Rated operating duty		
3.4	Circuit breakers type		
3.5	Short circuit withstand current for 1 sec. Duration	kA	
3.6	Rated making current	kAp	
3.7	Rated current at site reference ambient temp	A	
3.8	Type of operating mechanism		
3.9	Minimum no. of auxiliary Contacts for purchaser's use		
3.10	Control voltage		
	Spring charging motor	V AC/DC	
3.11	Closing Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.12	Opening Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.13	Operating time		
	Opening time	ms	
	Breaking time	ms	
	Total tripping time	ms	
	Total Closing time	ms	
3.14	Number of breaks per pole		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S. No.	DESCRIPTION	UNIT	DATA
4.0	Contactor		
	Voltage class	kV	
	Short time Rating		
	Duty		
5.0	Fuse		
	Voltage class	kV	
	Rupturing capacity	kAp	
6.0	Current Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Basic Insulation level	kV	
6.1	CT for differential protection		
	Class		
	Secondary resistance at 75 ° C		
	Knee Point Voltage		
	Excitation Current		
6.2	CT for Metering		
	Class		
	Secondary resistance at 75 ° C		
6.3	CT for Protection		
	Class		
7.0	Voltage Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Voltage ration		
8.0	Meters		
a	Make		
b	Type		

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S. No.	DESCRIPTION	UNIT	DATA
8.1	Voltmeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
8.2	Ammeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
9.0	Indicating lamps		
a	Make		
b	Type		
c	Voltage	V	
d	Wattage of lamp	W	
10.0	Push buttons		
a	Make		
b	Type		
c	Contact rating	A	
11.0	Space heater		
a	Make		
b	Type		
c	Rated voltage	V	
d	Power rating	W	
12.0	Wiring and terminal blocks		
a	Voltage grade		
b	Insulation		
c	Minimum size of conductor for:		
d	Power wiring	Sq.mm	
e	Control wiring	Sq.mm	
f	Type of terminal blocks:		

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S. No.	DESCRIPTION	UNIT	DATA
g	I) For Withdraw able Type		
h	II) For Fixed Type		
i	Minimum current rating of terminal blocks	A	
13.0	ABT Panel		
a	Make		
b	Type		
c	Panel thickness	mm	
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		

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16.0 VARIABLE FREQUENCY DRIVE

S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
1	Manufacturer Name		
2	Model No.		
3	Application		
4	Quantity		
5	Enclosure Protection Rating		
6	Output Current Rating at ambient temperature		
7	% derating considered for specific ambient		
8	Rated Voltage (volts) Input		
9	Output Frequency Range (Hz)		
10	Number of Phases and Frequency (Hz)		
a.	Short time current rating		
b.	Dynamic rating		
11	Rectifier type & Design		
12	Inverter type & Design		
13	Min/Recommended / Max switching frequencies (kHz)		
14	Filters		
a.	Line Side		
b.	Load Side		
15	Drive Input		
16	Output Modulation Method		
17	Speed Accuracy (+/- %)		
18	Response time (speed)		
19	Response time (Torque)		
20	Type of cooling		
21	Whether VVFD is suitable for outdoor installation		
22	Drive Control Capabilities		
a.	Start/Stop Push button		
b.	Modbus control		
23	Permissible % variation		
a.	Voltage		
b.	Frequency		

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S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
24	Load parameters at rated voltage & frequency		
a.	Output Frequency (Hz)		
b.	Full Load current (Amp)		
c.	VVF Heat dissipation (w)		
25	VVF Efficiency		
a.	At Full rated Torque		
b.	At 75% of full load torque		
c.	At 50% of full load torque		
26	Drive Power factor range		
	At rated speed, Torque		
27	DC Voltage		
28	Fundamental power factor		
29	Switching Frequency		
a.	Drive Dimensions		
b.	Length		
c.	Height		
d.	Depth		
e.	Weight		
30	Metering		
a.	Applicable Standards		
b.	Accuracy Class		
c.	Make		
d.	Type		

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17.0 6.6KV SEGREGATED PHASE BUSDUCT

S. No.	Technical Particulars	Unit	Bidder Data	Remarks
1.0	General			
1.1	System nominal voltage	kV		
1.2	System maximum voltage	kV		
1.3	Number of phases			
1.4	Rated Frequency	Hz		
1.5	Neutral Grounding			
1.6	Insulation level			
a	1 min power frequency withstand voltage	kV		
b	Impulse withstand voltage	kVp		
1.7	Short Circuit Level			
a	Symmetrical short circuit capacity	kA		
b	Dynamic capacity	kAp		
1.8	Space heating voltage	V		
1.9	Reference standard			
2.0	Busduct			
2.1	Make			
2.2	Type of bus duct			
2.3	Service			
2.4	Type of cooling			
2.5	Nominal service voltage/rated frequency			
2.6	Busduct length			
2.7	Rated voltage class			
2.8	Continuous current rating of bus duct under site conditions between			
	a) UT and associated 6.6kV unit switchgear	Amps		
	b) ST and associated 6.6kV station switchgear	Amps		

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
	c) Tie between Station and Unit switchgear	Amps		
2.9	Basic impulse withstand level (1.2 x 50 micro sec wave)	kVp		
2.10	One minute power frequency dry withstand voltage	kV		
2.11	Short time current for one second /Dynamic withstand current	KA /KA _p		
2.12	Maximum temperature rise of conductor over 50°C ambient	°C		
2.13	Maximum temperature rise of enclosure over 50°C ambient	°C		
2.14	Maximum temperature rise of conductor over 50° C ambient when carrying short circuit current for 1 sec	°C		
3.0	Bus conductor			
3.1	Bus conductor Material			
3.2	Bus conductor size for			
	a) Between UT and 6.6kV Unit Switchgear	mmx mm		
	b) Between ST and 6.6 kV Station switchgear	mmx mm		
3.3	Bus conductor shape			
3.4	Busbar Section			
4.0	Bus enclosure			
4.1	Bus Enclosure Material			
4.2	Shape of Enclosure			
4.3	Cross section of enclosure	mmx mm		

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
4.4	Phase barriers			
a	Material of Phase Barriers			
b	Phase Clearance (Minimum) Phase to Phase Phase to Earth	mm x mm		
5.0	Parameters of busduct			
5.1	Resistance/meter/Phase at 20°C of conductor for			
5.2	Inductive reactance/meter/phase at 20°C for			
5.3	Capacitive reactance/metre/phase at 20°C			
5.4	Heat loss in the bus duct at full rated current			
5.5	Weight of 3-phase duct	kg		
5.6	Standard section length	m		
5.7	Minimum required clearances from the periphery of the bus duct			
	i) To structural steel work parallel to the duct	mm		
	ii) To structural steel work perpendicular to the duct	mm		
5.8	Type of Joints between Adjacent Sections of Bus Conductor Welded/Bolted			
9.0	Insulators and seal off bushings			
9.1	Make			
9.2	Rated Voltage	kV		
9.3	One minute Power Frequency Withstand Voltage	kVrms		
9.4	Impulse Withstand Voltage (1.2 x 50 micro-second Wave)	kVp		
9.5	Minimum Creepage Distance	mm/kV		

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
9.6	Insulators			
	a) Material of Insulators			
	b) Cantilever strength			
	c) Weight of insulator	kg		
	d) No of supports and insulator span			
10.0	Seal-off bushings			
a	Current rating of Seal of Bushings	Amps		
b	Material of Seal Off Bushings			
c	Type			
d	Mechanical Strength			
e	e) Weight of each bushing	kg		
11	Earthing Material			
12	Finish of Bus Enclosure			
13	Rain hood required Yes/No			
14	Degree of protection for enclosure			

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**TURBO GENERATOR & AUXILIARIES
(PACKAGE NUMBER: R&M-SP-02)
VOLUME-III
PART-C
TECHNICAL SCHEDULES-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
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6. Forms and Schedules

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VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
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SECTION-II:DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

TURBO GENERATOR & AUXILIARIES (PACKAGE NUMBER: R&M-SP-02)

VOLUME-III, PART-C TECHNICAL SCHEDULES-I&C (TO BE FILLED BY BIDDER)

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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{Only the Applicable portion of the Data Sheet based on the scope of work as firmed up in Section-I, Volume-II should be retained and the remaining portion should be deleted. The scope of work in Section-I, Volume-II is based on Residual Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA) Report. The bidder is to provide datasheet for each type and make of the instrument/equipment offered by them.}

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1 DISTRIBUTED CONTROL SYSTEM

Table 1.1
Data Sheet for DCS

S.N	Feature	To be Filled by Bidder
1	Type of the system offered and Model No.	
2	Make	
3	Year of launching of the system	
4	Is the system offered, the latest system available/ being marketed in the international market by the vendor	
5	Place of Manufacturing	
6	Is the offered system confirms to the Specification provided in the tender document with regard to Spare Capacity, Expandability, Redundancy,	
6	Is the System offered is with open system architecture to enable integration of third party hardware/ software applications	
7	Support direct connectivity to Ethernet based LAN	
8	Deterministic and secure architecture	
9	On-line removal/replacement of I/O modules/ drive control modules possible without switching off power supply to the corresponding rack & without affecting controller operation	
10	Total I/O handling capacity of Controller	
11	No. of Tags handling capacity of Controller	
12	Total Power requirement for the offered system	
13	Total Heat Load of all cabinets	
14	Scanning rate for:	
a	Analog Signal	
b	T/C Signal	
c	RTD Signal	
d	Binary Signal	

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S.N	Feature	To be Filled by Bidder
15	Loop Execution Time for:	
a	Interlocks	
b	Close loops	
16	Auto switchover to backup redundancy Level:	
a	Controller Level	
b	Power supply Level	
c	Communication Level	
17	Output Status on Controller Failure	
18	Battery back-up duration for control processor	
19	Non-volatile memory capacity to store programs, standard software to perform control, DAS & Diagnostic functions	
20	Maximum no. of Channels for:	
a	Analog Input module	
b	T/C Input module	
c	RTD Input module	
d	Analog Output module	
e	Binary Input Module	
f	Binary Output module	
21	Optical Isolation for Binary Input/Output provided.	
22	Galvanic isolation for Analog Input/Output provided	
23	Can the analog and binary controls be implemented at different execution speeds, in the multi-function controllers.	
24	Simulation of Analog/Digital Input/Output possible.	
25	Data Transmission speed for:	
a	Ethernet LAN	
b	Data Highway	
c	I/O Bus	

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Table 1.2
Data Sheet for High Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	No. of Inputs/Module	
2	Types of Input (Linear)	
3	Accuracy	
4	A/D Converter	
5	Temperature Effect	
6	CMRR	
7	NMRR	
8	MTBF	
9	Stability	
10	Diagnostic	
11	Isolation	

Table 1.3
Data Sheet for Low Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input (Grounded/ Ungrounded)	
4	Cold junction compensation	
5	Accuracy	
6	A/D Converter	
7	Temperature Effect	
8	CMRR	
9	NMRR	
10	MTBF	
11	Stability	
13	Diagnostic	
14	Isolation	

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Table 1.4
Data Sheet for Binary Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Contact Bounce Filtering Provided	

Table 1.5
Data Sheet for SOE Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Time stamping provided	
14	Time Resolution	
15	Filter Delay Time	

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Table 1.6
Data Sheet for Smart Transmitter Interface Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Protocol	
6	Accuracy	
7	Function	
8	Diagnostic	
9	Isolation	

Table 1.7
Data Sheet for Pulse Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Minimum Pulse Width	

Table 1.8
Data Sheet for Analog Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	

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S.N	Feature	To be Filled by Bidder
3	Types of Output	
4	MTBF & MTTR	
5	Isolation	
6	Accuracy	
7	Load	
8	Diagnostic	
9	Isolation	
10	Power supply	
11	Short circuit Protection	

Table 1.9
Data Sheet for Binary Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Contact rating	
6	Contact Voltage	
7	Switching Frequency	
8	Contact Life	
9	Power supply	
10	Isolation	

Table 1.10
Data Sheet for Controller

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	Processor make	
3	Type of Processor/minimum word length	
4	Memory Size	
5	No. of Loops	

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S.N	Feature	To be Filled by Bidder
6	No. of I/O	
7	Configuration	
8	Battery Backup Available	
9	Duration of Battery backup	
10	Redundancy	
11	Change Over Time	
12	Failure of any one of the processor not to affect system operation	
13	What could be the maximum loading of the Controller CPU with the configuration offered	
14	Cycle Time	
15	Expansion facility available	
16	Data Transfer mode	
17	MTBF & MTTR	

Table 1.11
Data Sheet for Engineering Station

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Processor	
3	Cache Memory	
4	RAM	
5	Hard disk Drive	
6	CD Drive	
7	Video card	
8	Operating System	
9	Interfacing Ports	
10	Monitor	
a	Type	
b	Size	
c	Resolution	

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S.N	Feature	To be Filled by Bidder
d	Colours	
e	Sync	
f	Dot per inch	
g	Glare Filter	
h	Make & Model no.	
11	keyboard	
a	Type	
b	Make & Model No.	
c	Key lock control	
12	Mouse	
a	Type	
b	Make & Model no.	
13	Is on line program modification (Control algorithms, logic, sequence programs etc.) and loading possible from Engineering console through data highway without taking the controller in 'standby' mode? Specify limitation, if any	
14	Is it possible to access the control configurations (both regulatory and discrete) along with dynamic updating of process variables (analog values and binary status) from the Engineering station.	
15	Can the system configuration modified and loaded into controller from engineering station	
16	Programming language used for implementing logics / control schemes	

Table 1.12
Data Sheet for Dot Matrix Printer

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Printer Speed	

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S.N	Feature	To be Filled by Bidder
3	Print Density	
4	Buffer capacity	
5	Interface	
6	Character sets	
7	Paper size	
8	Power Supply	
9	Cartridge Life	
10	Diagnostic	

Table 1.13
Data Sheet for Laser Printer

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Printer memory	
4	Speed	
5	Resolution	
6	Colors	
7	Duty Cycle	
8	Power Supply	
9	Paper Size	
10	Cartridge Life	
11	Diagnostic	
12	Interfaces	

Table 1.14
Data Sheet for Interposing Relays

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Coil Voltage	
4	Contact	
5	Contact Rating	

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S.N	Feature	To be Filled by Bidder
6	Coil Insulation Class	
7	Mechanical Life	
8	Coil Protection	
9	Connection	
10	Mounting	

Table 1.15
Data Sheet for Operator Work Stations

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	Monitor Support	
5	CD Drive	
6	Power Supply	
7	Keyboard	
8	Pointing Device	
9	Monitor	

Table 1.16
Data Sheet for Servers

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	RAID	
5	Monitor Support	
6	CD Drive	
7	Power Supply	
8	Keyboard	
9	Pointing Device	
10	Monitor	

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Table 1.17
Data Sheet for LCD

S.N	Features	Minimum Requirements
1	Viewable Picture Area	
2	Resolution	
3	Aspect Ratio	
4	Display Colors	
5	LCD Panel	
6	Contrast Ratio	
7	Brightness	
8	Viewing Angle	
9	Computer Interface	
10	Cabinet Material	
11	Finish	
12	Mounting	
13	Power supply	
14	Accessories	

Table 1.18
Data Sheet for Engineering Laptop

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	CD Drive	
5	Power Supply	
6	Communication Ports	
7	Screen size	
8	Battery	

Table 1.19
Data Sheet for SOE Station

S.N	Features	To be filled by bidder
1	Processor	

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S.N	Features	To be filled by bidder
2	Configuration	
3	Internal Clock	
4	Memory	
5	Hard disk	
6	CD Drive	
7	Communication Port	
8	Monitor support	
9	Keyboard	
10	Pointing Device	
11	Monitor	

Table 1.20
Data Sheet for SOE Log Printer

S.N	Features	To be filled by bidder
1	Type	
2	No. of Needles	
3	Printing Speed	
4	Character dimension	
5	Buffer	
6	Local Memory	
7	Communication Port	
8	Power supply	
9	Paper size	
10	Paper input capacity	
11	Character sets	
12	Transfer distance	
13	Print features	
14	Reliability	
15	Noise Level	
16	Ribbon Life	
17	Diagnostics	
18	No. of Copies	

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S.N	Features	To be filled by bidder
19	Accessories	

Table 1.21
Data Sheet for HSRS Station

S.N	Features	To be filled by bidder
1	Processor	
2	Configuration	
3	Internal Clock	
4	Memory	
5	Hard disk	
6	CD Drive	
7	Communication Port	
8	Monitor support	
9	Keyboard	
10	Pointing Device	
11	Monitor	

Table 1.22
Data Sheet for PADO Server

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	RAID	
5	Monitor Support	
6	CD Drive	
7	Power Supply	
8	Keyboard	
9	Pointing Device	
10	Monitor	

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Table 1.23
Data Sheet for MIS LCD Screens

S.N	Features	To be filled by bidder
1	Viewable Picture Area	
2	Resolution	
3	Aspect Ratio	
4	Display Colors	
5	LCD Panel	
6	Contrast Ratio	
7	Brightness	
8	Viewing Angle	
9	Computer Interface	
10	Power supply	
11	Accessories	

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2 COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM (CMMS)

Table 2.1
Data Sheet for CMMS Server

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	RAID	
5	Monitor Support	
6	CD Drive	
7	Power Supply	
8	Keyboard	
9	Pointing Device	
10	Monitor	

Table 2.2
Data Sheet for Laser Printer for CMMS

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Printer memory	
4	Speed	
5	Resolution	
6	Colors	
7	Power Supply	
8	Paper Size	
9	Cartridge Life	
10	Diagnostic	
11	Interfaces	

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3 SMART TRANSMITTER MAINTENANCE STATION (STMS)

Table 3.1
Data Sheet for STMS Station

S.N	Features	To be filled by bidder
1	Processor	
2	Configuration	
3	Memory	
4	Hard disk	
5	CD Drive	
6	Communication Port	
7	Monitor support	
8	Keyboard	
9	Pointing Device	
10	Monitor	

Table 3.2
Data Sheet for Laser Printer for STMS

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Printer memory	
4	Speed	
5	Resolution	
6	Colors	
7	Power Supply	
8	Paper Size	
9	Cartridge Life	
10	Interfaces	

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4 STATION LAN

Table 4.1
Data Sheet for Station LAN Server

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	RAID	
5	Monitor Support	
6	CD Drive	
7	Power Supply	
8	Removable Bulk storage Drive	
9	Keyboard	
10	Pointing Device	
11	Monitor	

Table 4.2
Data Sheet for Station LAN Switch

S.N	Features	To be filled by bidder
1	Type	
2	Ports	
3	Cabling Type	
4	Switching Capacity	
5	Management interface	
6	Management Methods	
7	Optical Transceiver	
8	Power supply	
9	Standards compliance	
10	Enclosure protection class	
11	Mounting	

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5 TIME SYNCHRONIZATION SYSTEM

Table 5.1
Data Sheet for Master Clock System

S.N	Features	To be filled by bidder
1	GPS Antenna type	
2	Noise	
3	GPS Receiver	
4	Tracking method	
5	Output data format	
6	Communication speed	
7	Output rate	
8	Signal Processing unit	
9	Reference	
10	Time accuracy	

Table 5.2
Data Sheet for Slave Clocks

S.N	Features	To be filled by bidder
1	Type	
2	Time Reference	
3	Time Accuracy	
4	Connection	
5	Input	
6	Outputs	
7	Display	
8	Display Size	
9	Viewing Distance	
10	Protection degree	
11	Supply Voltage	
12	Signal Updating	
13	Environment	
14	Indication	
15	Mounting	

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6 STEAM & WATER ANALYSIS SYSTEM

Table 6.1
Data Sheet for Conductivity Analyzer

S.N	Features	To be filled by bidder
A	Sensor	
1	Type of Cell	
2	Conductivity Range	
3	Cell Constant	
4	Temperature Compensation	
5	Process Connection	
6	Wetted Parts	
7	Pressure rating	
B	Transmitter	
1	Type	
2	Mounting	
3	Protection Class	
4	Output	
5	Display	
6	Zero/span Adjustment	
7	Temperature Compensation	
8	Diagnostics	
9	Alarm	
10	Enclosure	
11	Accuracy	
12	Response Time	
13	Measuring Cycle	
14	Repeatability	
15	Stability	
16	Power Supply	

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Table 6.2
Data Sheet for pH Analyzer

S.N	Features	To be filled by bidder
A	Sensor	
1	Type of Cell	
2	Temperature Compensation	
3	Process Connection	
4	Pressure rating	
5	Range	
6	Measuring	
7	Liquid Junction	
B	Transmitter	
1	Type	
2	Mounting	
3	Protection class	
4	Output	
5	Display	
6	Calibration	
7	Temp. Compensation	
8	Diagnostic	
9	Alarm	
10	Enclosure	
11	Accuracy	
12	Repeatability	
13	Response Time	
14	Stability	
15	Power Supply	

Table 6.3
Data Sheet for Silica Analyzer

S.N	Features	To be filled by bidder
1	Type	
2	Operating range	

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S.N	Features	To be filled by bidder
3	Output	
4	Accuracy	
5	Calibration	
6	Response time	
7	Life of light source	
8	Power supply	
9	Alarm Facility	

Table 6.4

Data Sheet for Sodium Analyzer

S.N	Features	Minimum Requirements
1	Type of cell	
2	Flow Chamber	
3	Operating Range	
4	Measuring Electrode	
5	Output	
6	Accuracy	
7	Response Time	
8	Mounting	
9	Calibration	
10	Power Supply	
11	Serial Interface	

Table 6.5

Data Sheet for Hydrazine Analyzer

S.N	Features	To be filled by bidder
1	Type	
2	Operating Range	
3	Output	
4	Accuracy	
5	Reproducibility	
6	Temperature Compensation	

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S.N	Features	To be filled by bidder
7	Response Time	
8	Mounting	
9	Power Supply	

Table 6.6
Data Sheet for Dissolved Oxygen Analyzer

S.N	Features	To be filled by bidder
1	Type	
2	Range	
3	Enclosure	
4	Output	
5	Temperature Compensation	
6	Accuracy	
7	Sensor Response Time	
8	Mounting	
9	Power Supply	

Table 6.7
Data Sheet for Phosphate Analyzer

S.N	Features	To be filled by bidder
1	Type of Cell	
2	Flow Chamber	
3	Operating Range	
4	Output	
5	Temperature Compensation	
6	Accuracy	
7	Response Time	
8	Mounting	
9	Calibration	
10	Power Supply	

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Table 6.8
Data Sheet for Chloride Analyzer

S.N	Features	Minimum Requirements
1	Type of Cell	
2	Flow Chamber	
3	Operating Range	
4	Output	
5	Temperature Compensation	
6	Accuracy	
7	Sensitivity	
8	Response Time	
9	Mounting	
10	Calibration	
11	Power Supply	

Table 6.9
Data Sheet for SWAS WorkStation

S.N	Features	To be filled by bidder
1	Processor	
2	Configuration	
3	Memory	
4	Hard disk	
5	CD Drive	
6	Communication Port	
7	Monitor support	
8	Keyboard	
9	Pointing Device	
10	Monitor	

Table 6.10
Data Sheet for Laser Printer for SWAS

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Printer memory	

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S.N	Feature	To be Filled by Bidder
3	Speed	
4	Resolution	
5	Colors	
6	Duty Cycle	
7	Power Supply	
8	Paper Size	
9	Cartridge Life	
10	Diagnostic	
11	Interfaces	

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7 CONTINUOUS STACK EMISSION MONITORING SYSTEM

Table 7.1
Data Sheet for Carbon Monoxide (CO) Analyzer

S.N	Features	To be filled by bidder
1	Principle of Measurement	
2	Measurement Range	
3	Accuracy	
4	Linearity	
5	Repeatability	
6	Response Time	
7	Zero Drift	
8	Span Drift	
9	Purging System	
10	Diagnostic	

Table 7.2
Data Sheet for Carbon Dioxide (CO2) Analyzer

S.N	Features	Minimum Requirements
1	Principle of Measurement	
2	Measurement Range	
3	Accuracy	
4	Linearity	
5	Repeatability	
6	Response Time	
7	Temperature Drift	
8	Zero Drift	
9	Span Drift	
10	Temperature Compensation	
11	Filter	
12	Purging System	
13	Diagnostic	

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Table 7.3
Data Sheet for SO_x - NO_x (Combined) Analyzer

S.N	Features	To be filled by bidder
1	Principle of Measurement	
2	Measurement Range	
3	Accuracy	
4	Linearity	
5	Repeatability	
6	Response Time	
7	Temperature Drift	
8	Zero Drift	
9	Span Drift	
10	Filter	
11	Temperature Compensation	
12	Purging System	
13	Diagnostic	

Table 7.4
Data Sheet for Dust Density/Opacity Analyzer

S.N	Features	To be filled by bidder
1	Principle of Measurement	
2	Measurement Range	
3	Accuracy	
4	Linearity	
5	Repeatability	
6	Response Time	
7	Temperature Drift	
8	Zero Drift	
9	Span Drift	
10	Filter	
11	Temperature Compensation	
12	Purging System	
13	Diagnostic	

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8 VIBRATION MONITORING SYSTEM

Table 8.1

Data Sheet for Vibration Sensor

S.N	Features	To be filled by bidder
1	Sensitivity	
2	Measurement range	
3	Frequency Range (+/- 10%)	
4	Resolution	
5	Linearity	
6	Sensing Element	
7	Housing material	
8	Sealing	
9	Electrical connection type/position	
10	Excitation Voltage	
11	Cable type/length	

Table 8.2

Data Sheet for Keyphasor Sensor

S.N	Features	To be filled by bidder
1	Type	
2	Sensitivity	
3	Measurement range	
4	Frequency Range	
6	Linearity	
7	Probe body material	
8	Electrical connection type/position	
9	Excitation Voltage	
10	Cable type	

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Table 8.3
Data Sheet for Vibration Monitors

S.N	Features	To be filled by bidder
1	Sensitivity	
2	Accuracy	
3	Frequency Range	
4	Transducer Supply	
5	Alarm Adjustment	

Table 8.4
Data Sheet for Thrust Position Monitor

S.N	Features	To be filled by bidder
1	Sensitivity	
2	Accuracy	
3	Frequency Range	
4	Transducer Supply	
5	Alarm Adjustment	
6	Repeatability	

Table 8.5
Data Sheet for Case Expansion Monitor

S.N	Features	To be filled by bidder
1	Sensitivity	
2	Accuracy	
3	Frequency Range	
4	Transducer Supply	
5	Alarm Adjustment	
6	Repeatability	

Table 8.6
Data Sheet for Tachometer/RPM Monitor

S.N	Features	To be filled by bidder
1	Sensitivity	
2	Accuracy	

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S.N	Features	To be filled by bidder
3	Frequency Range	
4	Transducer Supply	
5	Alarm set points	
6	Alarm Adjustment	
7	RPM Range	
8	Resolution	

Table 8.7

Data Sheet for Eccentricity/Keyphasor Monitor

S.N	Features	To be filled by bidder
1	Input signal	
2	Accuracy	
3	Frequency Response	

Table 8.8

Data Sheet for Temperature Monitor

S.N	Features	To be filled by bidder
1	Input signal	
2	Accuracy	
3	Alarm Adjustment	

Table 8.9

Data Sheet for Server

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	RAID	
5	Monitor Support	
6	DVD Drive	
7	Power Supply	
8	Network Adapter	
9	Sound Card	

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S.N	Features	To be filled by bidder
10	Graphic Card	
11	Recording Speed	
12	Keyboard	
13	Pointing Device	
14	Monitor	

Table 8.10
Data Sheet for Workstation

S.N	Features	To be filled by bidder
1	Processor	
2	Configuration	
3	Internal Clock	
4	Memory	
5	Hard disk	
6	CD Drive	
7	Communication Port	
8	Monitor support	
9	Keyboard	
10	Pointing Device	
11	Monitor	

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9 PROGRAMMABLE LOGIC CONTROLLER (PLC)

Table 9.1

Data Sheet for PLC

S.N	Feature	To be Filled by Bidder
1	Type of the system offered and Model No.	
2	Make	
3	Year of launching of the system	
4	Is the system offered, the latest system available/ being marketed in the international market by the vendor	
5	Place of Manufacturing	
6	Is the offered system confirms to the Specification provided in the tender document with regard to Spare Capacity, Expandability, Redundancy,	
7	Is the System offered is with open system architecture to enable integration of third party hardware/ software applications	
8	Support direct connectivity to Ethernet based LAN	
9	Deterministic and secure architecture	
10	On-line removal/replacement of I/O modules/ drive control modules possible without switching off power supply to the corresponding rack & without affecting controller operation	
11	Total I/O handling capacity of Controller	
12	No. of Tags handling capacity of Controller	
13	Total Power requirement for the offered system	
14	Total Heat Load of all cabinets	
15	Scanning rate for	
a	Analog Signal	
b	T/C Signal	
c	RTD Signal	
d	Binary Signal	
16	Loop Execution Time for	
a	Interlocks	

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S.N	Feature	To be Filled by Bidder
b	Close loops	
17	Auto switchover to backup redundancy Level	
a	Controller Level	
b	Power supply Level	
c	Communication Level	
18	Output Status on Controller Failure	
19	Battery back-up duration for control processor	
20	Non-volatile memory capacity to store programs, standard software to perform control, DAS & Diagnostic functions	
21	Maximum no. of Channels for	
a	Analog Input module	
b	T/C Input module	
c	RTD Input module	
d	Analog Output module	
e	Binary Input Module	
f	Binary Output module	
22	Optical Isolation for Binary Input/Output provided.	
23	Galvanic isolation for Analog Input/Output provided	
24	Can the analog and binary controls be implemented at different execution speeds, in the multi-function controllers.	
25	Simulation of Analog/Digital Input/Output possible.	
26	Data Transmission speed for	
a	Ethernet LAN	
b	Data Highway	
c	I/O Bus	

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Table 9.2
Data Sheet for High Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	No. of Inputs/Module	
2	Types of Input (Linear)	
3	Accuracy	
4	A/D Converter	
5	Temperature Effect	
6	CMRR	
7	NMRR	
8	MTBF	
9	Stability	
10	Diagnostic	
11	Isolation	

Table 9.3
Data Sheet for Low Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input (Grounded/ Ungrounded)	
4	Cold junction compensation	
5	Accuracy	
6	A/D Converter	
7	Temperature Effect	
8	CMRR	
9	NMRR	
10	MTBF	
11	Stability	
13	Diagnostic	
14	Isolation	

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Table 9.4
Data Sheet for Binary Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Contact Bounce Filtering Provided	

Table 9.5
Data Sheet for SOE Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Time stamping provided	
14	Time Resolution	
15	Filter Delay Time	

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Table 9.6

Data Sheet for Smart Transmitter Interface Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Protocol	
6	Accuracy	
7	Function	
8	Diagnostic	
9	Isolation	

Table 9.7

Data Sheet for Pulse Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Minimum Pulse Width	

Table 9.8

Data Sheet for Analog Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	

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S.N	Feature	To be Filled by Bidder
3	Types of Output	
4	MTBF & MTTR	
5	Isolation	
6	Accuracy	
7	Load	
8	Diagnostic	
9	Isolation	
10	Power supply	
11	Short circuit Protection	

Table 9.9
Data Sheet for Binary Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Contact rating	
6	Contact Voltage	
7	Switching Frequency	
8	Contact Life	
9	Power supply	
10	Isolation	

Table 9.10
Data Sheet for Controller

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	Processor make	
3	Type of Processor/minimum word length	
4	Memory Size	
5	No. of Loops	

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S.N	Feature	To be Filled by Bidder
6	No. of I/O	
7	Configuration	
8	Battery Backup Available	
9	Duration of Battery backup	
10	Redundancy	
11	Change Over Time	
12	Failure of any one of the processor not to affect system operation	
13	What could be the maximum loading of the Controller CPU with the configuration offered	
14	Cycle Time	
15	Expansion facility available	
16	Data Transfer mode	
17	MTBF & MTTR	

Table 9.11
Data Sheet for Engineering Station

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Processor	
3	Cache Memory	
4	RAM	
5	Hard disk Drive	
6	CD Drive	
7	Video card	
8	Operating System	
9	Interfacing Ports	
10	Monitor	
a	Type	
b	Size	
c	Resolution	
d	Colors	
e	Sync	
f	Dot per inch	

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S.N	Feature	To be Filled by Bidder
g	Glare Filter	
h	Make & Model no.	
11	keyboard	
a	Type	
b	Make & Model No.	
c	Key lock control	
12	Mouse	
a	Type	
b	Make & Model no.	
13	Is on line program modification (Control algorithms, logic, sequence programs etc.) and loading possible from Engineering console through data highway without taking the controller in 'standby' mode? Specify limitation, if any	
14	Is it possible to access the control configurations (both regulatory and discrete) along with dynamic updating of process variables (analog values and binary status) from the Engineering station.	
15	Can the system configuration modified and loaded into controller from engineering station	
16	Programming language used for implementing logics / control schemes	

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10 SYSTEM CABINETS & JUNCTION BOX

Table 10.1
Data Sheet for Cabinets

S.N	Feature	To be Filled by Bidder
1	Make	
2	Cabinet Dimension	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Anti vibration pad	
8	Painting	
9	Gland Plate thickness	
10	Grounding	
11	Ventilation	
12	Lighting	
13	Lifting arrangement	
14	Tag Plates	

Table 10.2
Data Sheet for Junction Box

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Dimension	
3	Mounting	
4	Protection class	
5	Material & Thickness	
6	Doors	
7	Cable entry	
8	Gasket	
9	Painting	
10	Gland Plate thickness	
11	Grounding	
12	Tag Plates	

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Table 10.3
Data Sheet for LIE/LIR

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Mounting	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Gland Plate thickness	
8	Air Connection	
9	Sample line Entry	
10	Drain Pipe	
11	Painting	
12	Anti Vibration Pad	
13	Grounding	
14	Tag Plates	
15	Dimension	

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11 FIELD INSTRUMENTS

Table 11.1
Data Sheet for Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	Turn Down ratio	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Operating Voltage	
13	Output Signal	

Table 11.2
Data Sheet for Thermocouple

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Wire Gauge	
4	Protection tube OD/ Material/ Filling	
5	Response time	
6	Accuracy	
7	Characteristics	
8	MOC Head/ Protection Class	
9	Cable connection	

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Table 11.3
Data Sheet for RTD

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	No. of Elements	
4	Wire Gauge	
5	Protection tube OD/ Material/ Filling	
6	Response time	
7	Accuracy	
8	Characteristics	
9	MOC Head/ protection class	
10	Cable connection	

Table 11.4
Data Sheet for Pressure Gauge/DP Gauge/ Draught Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Sensing Element Material	
4	Movement Material	
3	Case Material / Protection Class	
5	Dial Size	
6	Scale	
7	Over range Protection	
8	Adjustment	
9	Element Connection	
10	Process Connection	
11	Accuracy	
12	Repeatability	
13	Response time	
14	Chemical Seal Unit	

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Table 11.5
Data Sheet for Temperature Gauge

S.N	Feature	To be Filled by Bidder
1	Make/Model No.	
2	Type	
3	Stem	
4	Movement Materials	
5	Case Material/Protection class	
6	Dial Size	
7	Scale	
8	Adjustment	
9	Range Selection	
10	Over range Protection	
11	Instrument Connection	
12	Process Connection	
13	Accuracy	
14	Repeatability	
15	Response Time	

Table 11.6
Data Sheet for Level Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing Element & material	
4	Body Material	
5	End Connection	
6	Accuracy	
7	Housing	
8	Zero / Span adjustment	
9	Packing material	

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Table 11.7
Data Sheet for Pressure/DP Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing Element material	
4	Wetted Parts material	
5	Case Material	
6	Over range for Pressure / Vacuum Switch	
7	Process Connection	
8	Switch Configuration	
9	Switch Rating	
10	Cable Connection	
11	Enclosure Class	
12	Accuracy	
13	Repeatability	

Table 11.8
Data Sheet for Conductivity Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Sensing elements	
3	Probe Material	
4	Repeatability	
5	Accuracy	
6	Probe length	
7	End connection	
8	Rating of contacts	
9	Enclosure class	
10	Housing material	
11	Electrical Connection	

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Table 11.9
Data Sheet for Capacitance Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Sensing elements	
3	Probe Material	
4	Repeatability	
5	Accuracy	
6	Probe length	
7	End connection	
8	Rating of contacts	
9	Enclosure class	
10	Housing material	
11	Electrical Connection	

Table 11.10
Data Sheet for Displacer Type Level Switch

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	MOC of Float/Stem	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Electrical Connection	
13	Output Signal	

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Table 11.11
Data Sheet for Displacer Type Level Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	MOC of Float/Stem	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Electrical Connection	
13	Output Signal	

Table 11.12
Specification for Ultrasonic Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	

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S.N	Feature	To be Filled by Bidder
10	Mounting	
11	Transmitter housing material/enclosure	

Table 11.13

Data Sheet for Radar Type Level Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	
10	Mounting	
11	Transmitter housing material/enclosure	

Table 11.14

Data Sheet for RF Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Particle size	
3	Insertion length	
4	Mounting	
5	Process connection	
6	Protection Class	
7	Cable connection	

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Table 11.15
Data Sheet for Flow Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Insertion length	
3	Mounting	
4	Process connection	
5	Protection Class	
6	Cable connection	

Table 11.16
Data Sheet for Rotameters

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Fluid media	
4	Float Material	
5	Accuracy	
6	Process connection	
7	Enclosure material & protection class	

Table 11.17
Data Sheet for Flow Glass

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Size	
4	Body Material	
5	Glass material	
6	Pressure Rating	
7	Temperature Rating	
8	Protection class	
9	Connection	

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Table 11.18
Data Sheet for Hydrogen Analyzer

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Type	
5	Measurement Range	
6	Accuracy	
7	Linearity	
8	Response time	
9	Temperature compensation	
10	Sample filter	
11	Zero & Span Adjustment	
12	Indication	
13	Enclosure Type/Material	
14	Type of Electronics	
15	Calibration	
16	Output signals	

Table 11.19
Data Sheet for Pneumatic Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Diaphragm Material	
4	Spring Material	
5	Body Material	
6	Stem material	
7	Coupling type & material	
8	Pneumatic Connection	
9	Action on Air Failure	
10	Angle of operation	

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S.N	Feature	To be Filled by Bidder
11	Signal Range	
12	Manual Operation	

Table 11.20
Data Sheet for Electrical Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Motor rating	
4	Power supply	
5	Control Supply	
6	Electrical Connection	
7	Body Material & Protection Class	
8	Gear Train Material	
9	Input Signal	
10	Output Signal	
11	Manual Operation	

Table 11.21
Data Sheet for I-to-P Converter

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Air Supply	
3	Input Signal	
4	Output Signal	
5	Linearity	
6	Hysteresis	
7	Mounting	
8	Protection class	
9	Enclosure	
10	Drift	
11	Direct/Reverse action Facility	

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Table 11.22
Data Sheet for Smart Positioner

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Input	
3	Power Supply	
4	Type of Electronics	
5	Valve position sensing	
6	Enclosure Type/Material	
7	Operating Range	
8	Modes of operation	
9	Flow characteristics	
10	Fail safe/Freeze feature	
11	Air supply pressure	
12	Process Connection	

Table 11.23
Data Sheet for Air Filter Regulator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Inlet Pressure	
4	Output	
5	Filter Element size	
6	Filter Element Material	
7	Drain	
8	Bowl Material	
9	Enclosure Protection class/ Material	
10	Process connection	

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Table 11.24

Data Sheet for Position Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Power Supply	
3	Type	
4	Output	
5	Accuracy	
6	Enclosure Protection class/ Material	
7	Cable Entry	

Table 11.25

Data Sheet for Limit Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Sensing Element	
3	Material	
4	Repeatability	
5	No. of Contacts	
6	Contact Ratings	
7	Enclosure type/material	
8	Electrical Connection	
9	Set point	
10	Mounting	

Table 11.26

Data Sheet for Solenoid Valve

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Operating Principle	
3	Coil Voltage Rating	
4	Body	
5	Trim	
6	Manual Operation	

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S.N	Feature	To be Filled by Bidder
7	Duty	
8	Sealing	
9	Coil enclosure	
10	Coil Insulation Class	
11	Cable Connection	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-C	[53]	25.09.2014

12 PROCESS CONNECTION PIPING & ACCESSORIES

Table 12.1
Data Sheet for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	

Table 12.2
Data Sheet for Impulse Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	

Table 12.3
Data Sheet for Copper Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	
6	PVC Coating thickness	

Table 12.4
Data Sheet for Fittings for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Fitting	

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S.N	Feature	To be Filled by Bidder
3	Material	
4	Size	
5	Pressure Rating	
6	Temperature Rating	

Table 12.5

Data Sheet for Compression Fittings for Impulse Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Fitting	
3	Material	
4	Size	
5	Ferrule	
6	Pressure Rating	
7	Temperature Rating	

Table 12.6

Data Sheet for CS Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	
6	Type of threading	
7	Thickness of galvanization	

Table 12.7

Data Sheet for Ball Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	

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S.N	Feature	To be Filled by Bidder
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	
9	Ball Material	
10	Seat Material	
11	Stem material	

Table 12.8
Data Sheet for Globe Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	
9	Ball Material	
10	Seat Material	
11	Stem material	

Table 12.9
Data Sheet for Air Header

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Thickness	
5	Test Pressure	

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S.N	Feature	To be Filled by Bidder
6	Inlet Connection	
7	Outlet Connection	
8	Drain Connection	
9	Inlet Valve type/size	
10	Drain Valve type/size	
11	Distribution Valve type/size	

Table 12.10
Data Sheet for Instrument Manifolds

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Type	
5	Ports	
6	Rating	
7	Connection	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-C	[57]	25.09.2014

13 INSTRUMENTATION CABLES & ACCESSORIES

Table 13.1
Data Sheet for Thermocouple Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of pairs	
4	Conductor material/Size	
5	No. of Strands/Area of cross section	
6	Conductor Insulation	
7	Lay	
8	Shielding	
9	Drain Wire	
10	No. of twist per metre	
11	Pair Identification	
12	Inner Sheath	
13	Armour	
14	Outer Sheath	
15	Color Coding	
16	Voltage Grade	
17	Code/Standard	

Table 13.2
Data Sheet for RTD Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Triads	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	

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LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-C	[58]	25.09.2014

S.N	Feature	To be Filled by Bidder
9	Lay	
10	Shielding	
11	Drain Wire	
12	Triad Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 13.3

Data Sheet for Instrumentation Signal Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Pairs	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Pair Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	

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LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-C	[59]	25.09.2014

S.N	Feature	To be Filled by Bidder
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 13.4
Data Sheet for Fibre Optic Cable (Single Mode)

S.N	Feature		To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@1310 nm	
		@1550 nm	
2	Mode field Diameter	@1310 nm	
		@1550 nm	
3	Maximum Cable Cut-off Wavelength		
4	Maximum Zero Dispersion Wavelength		
5	Minimum Zero Dispersion Wavelength		
6	Maximum Zero Dispersion Slope		
7	Maximum Polarization Mode Dispersion		
8	Gigabit Ethernet Length 1000BASE-LX		
9	Ten Gigabit Ethernet Length	10GBASE-LX	
		10GBASE-LX4	
10	Maximum Core/cladding Concentricity Error		
11	Cladding Diameter		
12	Cladding Non-circularity		
13	Coating Diameter		
14	Maximum Coating Concentricity Error		
15	Temperature Dependence (-60 to +85C)		
16	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		
17	Minimum Proof Test		
18	Bending Induced Attenuation (100 turns, 75mm diameter)		

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Table 13.5
Data Sheet for Fibre Optic Cable (Multi Mode)

S.N	Feature		To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@850 nm	
		@1300 nm	
2	Overfilled Launch Bandwidth	@850 nm	
		@1300 nm	
3	Gigabit Ethernet Length	1000BASE-SX	
		1000BASE-LX	
4	Ten Gigabit Ethernet Length	10GBASE-SR	
		10GBASE-LX4	
5	Numerical Aperture		
6	Core Diameter		
7	Maximum Core Non-circularity		
8	Maximum Core/cladding Concentricity Error		
9	Cladding Diameter		
10	Cladding Non-circularity		
11	Coating Diameter		
12	Maximum Coating Concentricity Error		
13	Temperature Dependence (-60 to +85C)		
14	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		
15	Minimum Proof Test		
16	Bending Induced Attenuation (100 turns, 75mm diameter)		

Table 13.6
Data Sheet for Cable Tray

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size (Width/Height)	
4	Perforation	
5	Length	

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S.N	Feature	To be Filled by Bidder
6	Thickness	
7	Coating of Hot dip Galvanizing	
8	Accessories	
9	Code/Standard	

Table 13.7
Data Sheet for Cable Glands

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Protection	
3	Compression	
4	Threading Type	
5	Material	
6	Check Nut	

Seal of Company

Signature : _____
 Name : _____
 Designation : _____
 Date : _____

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-002	01	Tender Document for Selection of R&M Contractors – Turbo Generator & Auxiliaries Volume-III, Part-C	[62]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-I
COMMERCIAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

MASTER INDEX (ALL VOLUMES)

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		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
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	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

BALANCE OF PLANT (PACKAGE NUMBER: R&M-SP-03)

VOLUME-I COMMERCIAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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List of Acronym

CIF	: Cost Insurance Freight
CIP	: Carriage insurance paid
CPBG	: Contract Performance Bank Guarantee
CST	: Central Sales Tax
DCB	: Domestic Competitive bidding
FOB	: Free on Board
GCC	: General Condition of Contract
GOI	: Government of India
GST	: Goods & Service tax
INR	: Indian Rupee
I&C	: Instrumentation & Control
ITB	: Instruction to Bidder
LOA	: Letter of Award
LOI	: Letter of Intent
MoEF	: Ministry of Environment and Forests
MSL	: Main Sea Level
PERT	: Program evaluation and review technique
R & M	: Renovation and Modernization
SCC	: Special Condition of Contract
VAT	: Value added Tax

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors– Balance of Plant Volume-I	[ix]	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

1.0 INVITATION FOR BID

Tender No : [-----]

1.1 Introduction

[Give brief introduction about the name, ownership, business & Power Projects of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of Balance of Plant of package of XXX MW Unit no.-XX ----- of the Power Plant]

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, invites sealed Tenders in English language from Prequalified Bidders for the Renovation & Modernization of Balance of Plant package of Unit No. [XXX] of the [XXX] Power Plant on Domestic Competitive Bidding (DCB) basis as per the scope of work given Technical Specification Volume-II.

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly of existing equipment / systems, replacement of specified equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing and forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, all associated civil works including supply of cement, steel etc., testing & commissioning, successful completion of trial operation and guarantee tests for [Balance of Plant] package of Unit no. [XXX] of [XXX] Power Plant. The detailed scope of work is given in Technical Specification Vol. II.

The brief scope of work is given below: -

[-----]
[-----]
[-----]
]

For detailed Scope of Work & Services, refer Section-I of Volume-II of this Specification.

1.4 Tender Details

(a)	Cost of Tender Documents	:	INR [---]
(b)	Bid Guarantee Amount	:	INR [-----]
(c)	Date of issuance of Tender Document	:	[-----]
(d)	Date & Time of pre-Bid Conference	:	[-----]

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors–Balance of Plant Volume-I	-1-	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

(e)	Last Date & Time of Receipt of Bid (Both Part I & Part II)	:	[-----]
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of facilities and performance guarantee test shall be as per SCC.

1.6 Bid Submission

- (a) The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.
- (b) The Bid proposals are to be submitted in two parts in separate sealed covers as follows:
 - Part I** : Bid Guarantee and Technical & Commercial Proposal without prices
 - Part II** : Price Schedule and Schedule of Functional Guarantee parameters with values.
- (c) All other terms and conditions along with the Technical Specifications, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- (d) Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:
[Designation, Address and Contact details.....]
.....]
- (e) Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- (f) The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the respective quoted Foreign Currencies.
- (g) Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- (h) The Tender Documents are meant for the exclusive purpose of bidding against the subject package and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Owner, intends to carry out the Renovation & Modernization of Balance of Plant Package of [Unit no.-XX ----- of the XXXX Power Plant].

Under the subject Tender, [Utility] invites bid for Renovation & Modernization of Balance of Plant package of the said Renovation & Modernization work to be carried out as per the accompanying Technical Specifications. The Bidder shall submit the offer for complete scope of work indicated in the Technical Specification.

2.2 Address and Contact Details of Owner

[Designation, Address and Contact details

-----]

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Owner's Consultant

[-----], hereinafter referred to as "Consultant" is the Consulting Engineer for the project, appointed by the Owner, [-----], to provide project consultancy services.

2.5 Sources of Fund

[Utility] intends to finance the subject Package of the said renovation & modernization work, through Internal and other sources & External/ Domestic Commercial/ Borrowing from international development funding agencies. [Utility] has tied up the required fund for this package.

2.6 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Owner will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.7 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.8 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents. It shall include the following:

- Disassembly of existing equipment/ systems as required.
- Detailed design of the systems/equipment covering all Mechanical, Electrical, Control & Instrumentation, Civil and Structural works.
- Complete manufacture, including shop inspection and testing.
- Providing engineering drawings, data, operational & maintenance manuals, etc., for the Owner's review/ approval.

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- (e) Packing, forwarding and transportation including insurance from the manufacturer's works to plant site and transportation from storage yard to erection site.
- (f) Receipt, storage, preservation and conservation of system/equipment at site including construction of storage facility viz. covered, semi-covered, air-conditioned, open yard at the space allocated at site by Owner including storage-cum-erection and all other specified & statutorily required insurance.
- (g) Pre-assembly, if any, erection, testing, commissioning, completion of plant and equipment/ system, conducting trial operation, performance guarantee test and handing over of all the plant and equipment/ system covered under this specification.
- (h) Carrying out all related civil and structural works at site including construction of foundations, buildings, structures etc. Including supply of cement and steel and all other required materials.
- (i) Supply of mandatory spares and tools & tackles.
- (j) Training of Owner's personnel.

Detailed scope is provided in Volume-II of the Technical Specifications.

Bids not covering the entire scope mentioned hereinabove may be treated as incomplete and hence are liable for rejection.

2.9 Time Schedule

The completion Time Schedule for Completion of R&M work and Performance Guarantee Tests shall be as given in the SCC.

2.10 Tender Documents

The scope of contract, technical specification, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following volumes:

Volume – I	:	Commercial
Volume – I Chapter-1	:	Invitation for Bid
Volume – I Chapter-2	:	Instructions To Bidders
Volume – I Chapter-3	:	General Project Information
Volume – I Chapter-4	:	General Condition of Contract (GCC)
Volume – I Chapter-5	:	Special Condition of Contract (SCC)
Volume – I Chapter-6	:	Forms & Schedules
Volume – II	:	Technical Specifications
Volume – II Section-I	:	Project Technical Specification
Volume – II	:	Detailed Technical Specification-Mechanical

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Section-II, Part-A		
Volume – II Section-II, Part-B	:	Detailed Technical Specification-Electrical
Volume – II Section-II, Part-C	:	Detailed Technical Specification-I&C
Volume – II Section-II, Part-D	:	Detailed Technical Specification-Civil
Volume – III	:	Technical Schedules
Volume – III, Part-A	:	Technical Schedule-Mechanical
Volume – III, Part-B	:	Technical Schedule-Electrical
Volume – III, Part-C	:	Technical Schedule-I&C

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Owner.

The Bidder is expected to examine all instructions, forms, terms, conditions, specifications and other information in the bidding documents. Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Owner in writing by post or by e-mail followed by postal confirmation at the Owner's address indicated in ITB. The Owner will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than twenty-one (21) days prior to the deadline for submission of bids prescribed by the Owner. Owner's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Owner will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operation and does not in any way adversely impact the interest of the Owner. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Owner may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the bidding documents.

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The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.11 Preparation of Bids

2.11.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.11.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

The bidders are required to submit, the bids for the Renovation and Modernization work in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical Data Sheets, List of Tools & Tackles, Deviations to Technical and Commercial Specifications/Conditions, Overall Completion Time Period & L-1 Network Schedule, Resource Deployment Schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part-II Bid will comprise Quoted Price and Quoted Performance Guarantee Parameters. Initially, only the Part-I Bid will be opened and Part-II Bid is kept in safe custody.

After evaluation of the Techno-Commercial (Part-I) Bids, each Bidder who has submitted a broadly responsive Part-I Bid, will be invited for Techno-Commercial Discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a memorandum. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions. The date & time for opening of Price Bid will be intimated separately.

Techno-Commercial Bid should not contain any price data.

Price Bid should not contain any matter in respect of Technical and / or Commercial aspects other than the details specifically sought by the Owner.

2.11.3 Bid Submission

- (1). Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2). All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered. All bids shall be prepared in the English language only, by typing or printing.

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- (3). [One original and 9 (nine) identical] copies of the original with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., "Original", "Copy No. 1", "Copy No. 2" etc.).
- (4). All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (5). The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (6). The Bidder's Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (7). In the event of discrepancy between "Original" and any copy of the bids, the hard copy of Original shall prevail.
- (8). The Bid shall be submitted to [-----]. Bid submitted to any other office of Owner is liable for rejection. Bids submitted by Telefax or e-mail will be rejected
- (9). Owner will receive Bids in respect of all the equipment/systems and scope of work as set forth in the accompanying Technical Specifications. All bids shall be prepared and submitted in accordance with the Tender Documents.
- (10). Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Technical Specifications in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11). A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Owner's rights or the successful Bidder's obligations under the contract.
- (12). Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13). Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Contractor under the Contract.
- (14). Either the agent or the Principal manufacturer directly could bid in a tender, but not both. In case both submit the tenders, the tender of the manufacture will alone be considered.
- (15). An agent representing one manufacturer in a tender will not be allowed to quote on behalf of another manufacturer along with previous manufacturer in a subsequent / parallel tender for the same item.

2.11.4 Bid Guarantee

- (1). The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of "[-----]" payable at "[-----]".

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- (2). The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank.
- (3). Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Owner at ([-----]). In the event of any deviation in this regard, the decision of Owner as to whether the same could be accepted or not, will be final and binding on the Bidder.
- (4). The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Owner.
- (5). No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified herein above or from banks not specified hereinabove will be liable for rejection.
- (6). Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7). The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Owner or fails to submit Contract Performance Guarantee.
- (8). The Bid Guarantee of all unsuccessful Bidders shall be returned after price cover opening and price evaluation. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Owner and acceptance thereof.

2.11.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part– I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part–I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Owner, at its discretion, may consider appropriate, shall be read out. The Part – II (Price Bid) will be lodged and opening date of the same will be intimated separately to those Bidders whose Part-I Bid will be determined to be substantially responsive to Tender Conditions and Technical specifications in all respects.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.
3. Owner takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

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2.12 Composition of Techno Commercial Bid (Part-1 Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 9 (nine) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B of this Volume).
- (ii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iii). Letter of consent: To be furnished by the Bidder and Consortium Partners- as per Annexure—D of this Volume
- (iv). Bid Guarantee- as per Annexure A.
- (v). Schedule of Prices as per Schedule – F1 (Table 1 to Table-7) with the word "Quoted" in lieu of Price data and all other details except price data.
- (vi). Mandatory spares as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (vii). Recommended spares (with the word "Quoted" in lieu of Price data)
- (viii). Tools & Tackles as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (ix). Schedule of Performance Guarantees- as per Schedule – F1 (Table-8) with the word "Quoted" in lieu of Performance Guarantee parameters
- (x). Signed copy of all the corrigendum's/amendments/clarifications, if any issued for the tender
- (xi). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (xii). Deviations to the Commercial specification, if any, as per Schedule – F3.
- (xiii). Deviations to Technical Specifications, if any, as per Schedule – F4.
- (xiv). Requirements of the Contractor at site, as per Schedule – F5.
- (xv). Resource deployment schedule as per Schedule – F6
- (xvi). Details of the present commitments of the Bidder, details of contracts in hand
- (xvii). Details of Sub-Contractors/Sub-Suppliers/Sub-Vendors, if any
- (xviii). Quality Assurance Programme
- (xix). Technical Details to be furnished with the Bid as called for in the Technical Specification Vol-II and Technical Bid Data Sheet Vol-III.
- (xx). Schedule of weights and dimensions
- (xxi). Coefficients and indices for price variation formula

The Part-I Bid shall not contain any Price data.

2.13 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices and the Performance Guarantee parameters only in the specified format. Price given in Part-II should cover the entire scope of work as given in Part-I of the offer including list of mandatory spares and Tools & tackles with itemized price and should be as per Schedule of Price enclosed. **[One original and 9 (Nine) identical]** copies shall be submitted.

1. The Price Bid shall contain the following :

- (i). Duly filled in Form of bid as per Annexure-C
- (ii). Completely filled in Schedule of Prices Schedule – F1 (Table 1 to Table-7)

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- (iii). Completely filled in Schedule of Performance Guarantees Schedule – F1 (Table-8).
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed formats. The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
 3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Owner shall be final. All entries shall be in English language only.
 4. The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the quoted Foreign Currencies.
 5. Prices in Indian supply shall be quoted on Ex-works supply of plant & equipment basis including Packing & forwarding. Inland transportation, Insurance charges, etc. shall be indicated separately.
 6. Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation.

2.14 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the Contractor's obligations mentioned in tender document specification or to be reasonably inferred from the tender documents/ specification in respect of the disassembly/ dismantling of existing equipment facility as specified, design, manufacture, including procurement and subcontracting (if any), delivery, construction, installation, commissioning, completion of the facilities and conductance of Performance Guarantee tests for the facilities including supply of mandatory spares, recommended spare & tools/ tackles (if any). This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the facilities, conducting Guarantee tests and, where so required by the tender documents, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the tender documents, all in accordance with the requirements of the Conditions of Contract and Technical Specifications.

Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the tender documents.

Prices quoted by the Bidder shall be subject to adjustment during performance of the Contract to reflect changes in the cost of labour, material, etc. A bid submitted with a fixed price quotation will not be rejected, but the price adjustment will be treated as zero. The price adjustment provision will not be taken into consideration in bid evaluation.

2.15 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if any shall be signed by the person signing the Bid. Printed literature, it enclosed need

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not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.16 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Owner may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Specifications by amendment.
2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Specifications, which will be notified. Amendments will be hosted in Owner's website. Bidders are requested to visit Owner's website and note amendments, if any, before submission of bid. Owner shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.17 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

2.18 Information to be Furnished with the Bid

1. The Bid (Part-I) must clearly indicate the name of the manufacturer, the type or model of each principal item of equipment proposed to be supplied and erected. The Bid should also contain drawings and descriptive materials indicating general dimensions, material from which the parts are manufactured, principles of operation and the extent of pre-assembly involved, major erection equipment required to be deployed, method of erection and the proposed erection Organization structure.
2. The above information shall be provided by the Bidder in the form of separate sheets, drawings, catalogues, etc.
3. Any Bid not containing sufficient descriptive material to describe accurately the system / equipment proposed may be treated as incomplete and hence rejected. Such descriptive materials and drawings submitted by the Bidder will be retained by the Owner. Any major departure from these 'drawings and descriptive material submitted will not be permitted during the execution of the Contract' without specific written permission of the Owner.
4. Oral statements made by the Bidder at any time regarding quality, quantity or arrangement of the equipment or any other matter will not be considered.
5. Standard catalogue pages and other documents of the Bidder may be used in the Bid to provide additional information and data as deemed necessary by the Bidder.
6. In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy of all data sheets, Schedule, List of Mandatory spares, tools & tackles and Bar Chart/PERT as well as deviation tables in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation. Bidder shall submit all the filled in datasheet also in soft copy. Bidder shall also furnish soft copies and hard copies of Data Sheet with filled in details wherever details are required to be indicated by the Bidder.

2.19 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other

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interested parties are advised to refrain from contacting by any means, the Owner and/or his employees/ representatives on matters related to the Bids under consideration. The Owner, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

2.20 Validity of Bid

1. The Bid shall be kept valid for acceptance for **[180 days]** from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Owner from participating in any of the Owner's tenders.

2.21 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully informs himself as to all the conditions and matters which may in any way affect the 'Renovation and Modernization work to be carried out or the cost thereof. Bidders are required to visit the plant to get familiarized with local conditions. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Owner.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Owner at least **[7 (seven) days]** before the date stipulated for pre-bid meeting. The Owner then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till **[21 days]** prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Owner. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.
3. Pre-Bid Conference will be organized and outcome of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Owner to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.
5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

2.22 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Owner not later than **[-----]** Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

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2.23 Single Bidder Responsibility

1. The scope of supply and services shall be under single Bidder responsibility.
2. The successful Bidder should not sub contract the entire work on back to back basis or otherwise.

2.24 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Owner for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Owner, even though the Owner may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

2.25 Deputation of Representatives for Discussion

After opening of the Bid, if the Owner desires to have techno-commercial discussion on the Bid, the Bidder shall be in a position to depute his competent representatives of various disciplines at short notice with full authority for finalising technical parameters as well as Commercial Terms and Conditions of the Tender.

2.26 Evaluation of Bid

1. For evaluation and comparison of price bid, the prices indicated at [-----] summary of Prices as per Schedule [-----] will be considered. The Bids received will be evaluated by the Owner to ascertain the lowest evaluated substantially responsive Bid vis-à-vis the Tender Specifications. The Bidder has to satisfy himself that full information is furnished as required in the specifications. Lack of particulars or incomplete information furnished will run the risk of rejection of the bid. The following major procedures would be followed for evaluation of bids.
2. All the Bidders would be brought on par with reference to Technical Specification, Commercial Condition, Instructions to Bidders and subsequent techno-commercial discussions/ clarifications.
3. After the evaluation of Part-I bids (techno-commercial bids) and before opening of Part-II bids (Price Bids), in case the bidders are asked to make changes to their techno commercial offer that may have price implications, Owner may give the bidders opportunity to submit addendum to price bid covering the price implication only against such changes before the opening of Part-II bids (Price Bids). All the bidders will be notified, at least 15 days before the Price Bid opening date, about such changes against which they can submit addendum to Price Bid.
4. Commercial loading would be done for non-compliance of commercial terms and conditions of the Tender Specifications other than the vital clauses, as the case may be.
5. To facilitate evaluation and comparison, the Owner will convert all bid prices expressed in foreign currencies into Indian Rupee at State Bank of India Bills Selling exchange rates prevailing on the date of opening of the price bid.
6. The Bidder is eligible for a price variation as per Tender Condition. However Price variation shall not be considered for Bid evaluation.

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7. Technical loading will be done for omission of price data in respect of equipment/facilities, spares, tools & tackles, etc. The highest quoted corresponding price will be loaded against such omission. If no quoted price is available, the loading will be done as per the corresponding price as estimated by the Owner.
8. The Bidder has to meet the minimum functional performance levels indicated in Volume-II Technical Specification for all categories of Guarantees. If one or more of Functional Performance Parameters offered by the Bidder is inferior to the minimum functional performance level (i.e. higher or lower than maximum or minimum value specified in Technical Specification), then such bid will be considered non-responsive and rejected.
9. The quoted values for Performance Guaranteed Parameters given in Table below would be evaluated using evaluation factors specified. The evaluation factors shall be applicable to the differential values calculated from among the Bidders of corresponding item with appropriate highest or lowest value (i.e., the best quoted value) as the base. The evaluation will be based on the guarantee parameters inclusive of all tolerance furnished at the Guaranteed Condition. Bidders to note that the values indicated in the Schedule of Performance Guarantees shall be inclusive of all tolerances including measurement uncertainty.

Table-Bid Evaluation Factors

Sl. No.	Functional Performance Parameter	Evaluation Factor Rate
1.	Auxiliary Power	[-----]INR per kW
2.	HCl Consumption in DM Plant	[-----]INR per kg
3.	NaOH Consumption in DM Plant	[-----]INR per kg
4.	[Pre-treatment Plant Chemical Consumption]	[-----]INR per kg
5.	[NaCl Consumption in Softening Plant]	[-----]INR per kg
6.	{Any Other Chemical, as applicable}	[-----]

The evaluation factors rate shall be prorated for any fractions of the specified value.

The basis on which Bidders to quote Functional Performance Parameters shall be as per Volume-II Technical specification.

- (1). Arithmetical errors will be rectified on the following basis:
 - If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.
 - If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
 - If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.
- (2). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder

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shall not charge any amount separately for that item from the Owner. If the terms, such as 'not applicable' "-----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.27 Local Conditions

1. The Bidder shall inspect the site and shall satisfy himself of the site conditions and shall apprise himself of the procedure for engagement of agencies/labour and shall collect any other information, which may be required before submitting the Bid.
2. Wages not less than Minimum wages for Contract labour shall be paid as applicable in this region from time to time. Claims and objections due to ignorance of site conditions will not be considered after submission of Bid.
 - (i). The Bidder is required to carefully examine the Technical & General Specification, commercial Terms and Conditions, drawings and other details relating to work given in the Tender Specification and get fully acquainted as to all conditions and matters which may in any way affect the work or the cost thereof.
 - (ii). The Bidder shall be deemed to have exhaustively examined the Tender Specifications including the Form of Contract, to have obtained all information and clarifications on all matters whatsoever that might affect the carrying out of the work and to have satisfied himself as to the adequacy of his Bid. He is deemed to have known the scope, nature and magnitude of the work and the requirements of materials and labour involved etc. and as to all work he has to complete in accordance with the Contract for the adequacy of his Bid.
 - (iii). The Bidder shall be deemed to have visited and carefully examined the plant/ site and surroundings, to have satisfied himself about the nature and details of all existing structures, if any, and also as to the nature and conditions of the railways, roads, bridges and culverts, means of transport and communications, whether by land, water or air and as to possible interruptions thereto and the access to and from the site, to have made independent enquiries, examined and satisfied himself as to the sources for obtaining earth, gravel, sand, stones, bricks and all other construction materials, the site for disposal of surplus earth and debris, the available accommodation, underground existing services, sub-soil water conditions, storms, prevailing winds, climatic conditions and all other similar matters which may affect the work.
 - (iv). The Bidder shall be deemed to have acquainted himself with the Indian Income tax Act, 1961, Indian Companies Act, 1956, Indian Customs Act, 1962, Indian Central Excise Act, Value Added Tax, Indian Sales Tax Act, Indian Electricity Act, Central Electricity Authority Regulations, Indian Boiler Regulations, Factories Act, Pollution Control Regulations and other related Acts & Laws prevalent in the State of [-----] and in India and as amended from time to time. The Owner shall not entertain any request for clarifications from the Bidders regarding such local conditions.
 - (v). Any neglect or omission or failure on the part of the bidder in obtaining necessary and reliable information as stated above or on any other matter affecting the Bidder shall not relieve him from any risk or liabilities or the entire responsibility for completion of the work in accordance with the

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Tender Specifications.

2.28 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and technical specification. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with “Original” of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily rejected and ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.
2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Owner at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Owner towards Owner's cost, loss and damage to Owner.

2.29 Blacklisting/Debarring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Owner.

2.30 Award of Contract

1. Award Criteria
 - The Owner will award the contract to the successful Bidder whose Techno-commercial bid has been determined to be substantially responsive and Price Bid to be the lowest evaluated bid, provided that the Bidder is determined to be qualified to perform the contract satisfactorily.
 - The Owner reserves the right to vary the quantity of any of the Items / Spares and / or delete any Item / Spares altogether at the time of Award of Contract.
2. Owner's Right to Accept Any Bid and to Reject Any or All Bids

The Owner reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Owner's action.
3. Notification of Award

Prior to the expiration of the period of bid validity, the Owner will notify the successful Bidder in writing by registered letter (Letter of Award or LOA) or by

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email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Owner will promptly notify each unsuccessful Bidder and will discharge its bid security.

4. Signing the Contract Agreement

At the same time as the Owner notifies the successful Bidder that its bid has been accepted, the Owner will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

Within *[twenty-eight (28)]* days of receipt of the Contract Agreement, the successful Bidder shall sign and date the Contract Agreement and return it to the Owner.

5. Corrupt or Fraudulent Practices

The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, [Name of Utility] requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. The Owner may reject a Bid Proposal of a successful Bidder if it emerges that the Bidder recommended for award has engaged in Corrupt or Fraudulent practices in competing for the subject contract. The Owner may declare a Bidding firm ineligible for participation in future tenders of the Owner, either indefinitely or for a stated period of time, if it at any time it emerges that the firm has engaged in Corrupt or Fraudulent practices in competing for or in executing a contract of the Owner. Corrupt Practice means the offering, giving, receiving or soliciting of anything of value to influence the procurement process or contract execution. Fraudulent practice means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

2.31 Agency Commission

No Agency commission shall be payable under the Contract.

2.32 Contract Performance Bank Guarantee (CPBG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period. If the contract price is in more than one currency, CPG shall be 10% of respective currency.

If the bidder is a Consortium of two or more firms, in addition to the Contract Performance Bank Guarantee (CPG) of 10% of Contract Price furnished by the Consortium Leader, each of the other consortium member will furnish Additional Contract Performance Bank Guarantee equal to 1% of Contract Price

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2.33 Contract Quality Assurance

1. The Bidder shall include in his Bid a detailed Quality Assurance Programme containing the overall quality, management and procedures which he proposes to follow in the performance of the 'Works' during various phases.
2. After Letter of Award (LOA) the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall form a part of the 'Contract'.

2.34 Codes & Standards

Specifications give reference to Indian or internationally accepted Standards. However, equipment or materials meeting other recognized National or International Standards, which ensure an equal or superior quality than Standards specified, will also be accepted. For details of codes and standards refer Technical specification, Volume-II.

2.35 Vital Clauses

The following clauses in the Tender Specification & Draft Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Warranty
- Liquidated Damages
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Owner / Purchaser : [-----]
- Consultant : [-----]
- Project Title : [-----]
- Location : [-----]
- Latitude : [-----]
- Longitude : [-----]
- Elevation above MSL : [-----]
- Nearest Railway Station : [-----]
- Nearest Sea Port : [-----]
- Nearest Airport : [-----]
- Road Access/Approach to Site : [-----]

For Project & Site related detailed information, refer Clause No. 2 of Section-I of Volume-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Works, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract.
- iv. **"Contract"** means the Agreement entered into between Owner and Contractor as per the 'Contract Agreement' signed by the parties, including contract documents, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Contractor's Equipment"** means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities.
- vii. **"Contractor"** means the person(s), Firm or a Company whose bid to perform the Contract has been accepted by the Owner and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Contractor.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Owner for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.
- ix. **"Contractor's Representative"** means any person nominated by the Contractor & approved by the Owner hereof to perform the duties delegated by the Contractor.
- x. **"Consulting Engineer"** means Owner's Engineer appointed by the Owner. Also refers to any other firm(s) or person(s) as may be appointed by the Owner from time to time.

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- xi. **“Commissioning”** means the construction of plant and equipment for operation of the Facility at rated capacity are complete and the plant and equipment achieves the designated full load/full capacity, at designated fuel/input.
- xii. **“Completion”** means that the Facilities (or a specific part thereof where specific parts are agreed) have been completed operationally and structurally and put in a tight and clean condition, and that all work in respect of pre-commissioning of the Facilities or such specific part thereof has been completed and commissioning has been attained as per Technical Specifications.
- xiii. **“Competent Authority”** means any agency, authority, department, inspectorate, ministry or statutory person (whether autonomous or not) of GOI, [Name of the State], Ministry of Environment and Forests (MoEF) any other State of the Republic of India or any local authority.
- xiv. **“Day”** means calendar day of the Gregorian calendar.
- xv. **“Defect Liability Period”** means the period of validity of the warranties given by the Contractor, commencing at completion of the Facilities or a part thereof, during which the Contractor is responsible for defects with respect to the Facilities.
- xvi. **“Effective Date”** means the date from which the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor shall be determined.
- xvii. **“Erection Services”** means those entire services ancillary to the supply of the plant and equipment for the Facilities, to be provided by the Contractor under the Contract. e.g. transportation and provision of marine or other similar insurance, inspection, expediting, site preparation works (including the provision and use of Contractor’s Equipment and the supply of all construction materials required), installation, testing, Pre-commissioning, commissioning, operations, maintenance, the provision of operations and maintenance manuals, training of Owner’s Personnel etc.
- xviii. **“Facilities”** means the plant and equipment to be supplied and installed, as well as all the Erection Services to be carried out by the Contractor under the Contract.
- xix. **“Force Majeure”** means mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- xx. **“GCC”** means the General Conditions of Contract hereof.
- xxi. **“Good Industry Practice”** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Contractor, equipment manufacturer or operator applying the standards generally adopted by global Contractors, global equipment manufacturers and operators in the construction or operation of power generation facilities or the manufacture of equipment therefore, except in so far as inconsistent with any applicable Indian law or directive.
- xxii. **“Guarantee Test(s)”** means the test(s) specified in the Technical Specifications to be carried out to ascertain whether the Facilities or a

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- specified part thereof is able to attain the Functional/Performance Guarantees specified in the Technical.
- xxiii. **"Incoterms"** means International rules for interpreting trade terms published by the International Chamber of Commerce (latest edition), Paris (France). Unless inconsistent with any provisions of the contract, the meaning of any trade term and the rights and obligations of the parties there under shall be as prescribed by Incoterms.
 - xxiv. **"Inspector/Inspecting Engineer"** means the Owner or any person nominated by the Owner from time to time, to inspect the equipment of works under the contract and/or the duly authorized representative of the Owner.
 - xxv. **"Latent Defect"** means the defects inherent in the material or arising out of design deficiency which does not manifest itself during the Warranty Period/Defect Liability Period, as described in this GCC.
 - xxvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Owner notifying the Contractor that its Bid Proposal has been accepted.
 - xxvii. **"Month"** means calendar month of the Gregorian calendar.
 - xxviii. **"Manufacturer's Works" or "Contractor's Works"** means the place used by the Contractor, its manufacturer, supplier, collaborators or sub-contractors/vendors/sub-vendors for the performance of the works.
 - xxix. **"Operational Acceptance"** means the acceptance by the Owner of the Facilities (or any part of the Facilities where the Contract provides for acceptance of the Facilities in parts), which certifies the Contractor's fulfillment of the Contract in respect of performance guarantees of the Facilities.
 - xxx. **"Owner" or "Purchaser"** shall mean the [Name of the Utility], and includes its legal successors or permitted assignees.
 - xxxi. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
 - xxxii. **"Pre-commissioning"** means the testing, checking and other requirements specified in the Technical specifications that are to be carried out by the Contractor in preparation for commissioning.
 - xxxiii. **"Project"** means the Owner's [-----] in respect of which the Contract has been signed.
 - xxxiv. **"Project Consultant" or "Owner's Consultant"** means the engineering firm or person(s) appointed by the Owner to render engineering project consultancy services for the project.
 - xxxv. **"Project Manager"** means the person appointed by the Owner thereof and named as such, to perform the duties delegated by the Owner.
 - xxxvi. **"Plant and Equipment"** means permanent plant, equipment, systems, machinery, apparatus, articles and things of all kinds to be provided and incorporated in the Facilities by the Contractor under the Contract (including the spare parts to be supplied by the Contractor under the Contract Agreement), but does not include Contractor's Equipment.
 - xxxvii. **"SCC"** means the Special Conditions of Contract hereof.

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- xxxviii. **“Site”** means the land and other places upon which the Facilities are to be installed, and such other lands or places as may be specified in the Contract as forming part of the Site.
- xxxix. **“Sub Contractor”, including “Vendors/Sub-Vendors”**, means any firm or person to whom execution of any part of the Facilities, including preparation of any design or supply of any plant and equipment is subcontracted directly or indirectly by the Contractor, and includes its legal successors or permitted assignees.
- xl. **“Technical Specification / “Tender Documents”** means the document, setting out a description and specification of the Works and statement of the technical and other standards to which the Works are to be performed including any modifications thereto made in accordance with the Conditions. This includes the technical & commercial specifications and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xli. **“Tenderer”/“Bidder”** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Owner, for the Project.
- xl.ii. **“Time for Completion”** means the time within which completion of the Facilities as a whole (or of a part of the Facilities where a separate time for completion of such part has been specified) is to be attained in accordance with the stipulations and provisions of the Contract.
- xl.iii. **“Warranty Period” or “Defect Liability Period”** means the period during which the Contractor shall remain liable for repair or replacement of any defective part of the works performed under the contract, free of cost.
- xl.iv. **“Work(s)”** means and includes the tasks of furnishing of equipment, labour & services, transport, handling, unloading and storage at site, civil construction and complete erection, testing, commissioning putting into satisfactory operation and completion of successful performance tests, reliability tests and any other guaranteed parameters as defined in the Contract, replacement, modification, repair of defective parts or equipment during warranty period and rectification of latent defects during latent defect period.
- xl.v. **“Writing” or “Written”** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Owner. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

Terms and expressions not herein defined shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

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4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Owner.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing.
- vi. The bid & schedules/ attachment submitted by the contractor

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Construction of the Contract

The Contracts to be entered between the Owner and the Contractor shall be as under:

First Contract: For Ex-Works Supply of all Plant & Equipment including Mandatory Spares and technological and miscellaneous structures with all accessories.

Second Contract: For providing all services i.e. Inland Transportation for Delivery at Site, Inland Transit Insurance, Unloading, Storage, Handling at Site, Erection, Insurance Covers other than inland transit insurance, Testing, Commissioning and Conducting Guarantee Tests in respect of all the Equipment supplied under the First Contract, Civil works including supplies such as cement & reinforcement steel and all other services as specified in the Contract Documents.

The above two Contracts will contain a cross-fall breach clause specifying that breach of one Contract will constitute breach of the other Contracts which will confer a right on the Owner to terminate the other Contract also at the risk and the cost of the Contractor.

The award of the separate Contracts shall not in any way dilute the responsibility of the Contractor for the successful completion of the Facilities as per Contract Documents and a breach in one Contract shall automatically be construed as a breach of the other Contract which will confer a right on the Owner to terminate the other Contract also at the risk and the cost of the Contractor.

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4.6 Independent Contractor

The Contractor shall be an independent contractor performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Contractor shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or Subcontractors engaged by the Contractor in connection with the performance of the Contract shall be under the complete control of the Contractor and shall not be deemed to be employees of the Owner, and nothing contained in the Contract or in any subcontract awarded by the Contractor shall be construed to create any contractual relationship between any such employees, representatives or Subcontractors and the Owner.

4.7 Consortium

If the Bidder/Contractor is a joint venture or consortium of two or more firms, all such firms shall be jointly and severally bound to the Owner for the fulfillment of the provisions of the Contract and the Bidder shall submit a letter of consent to this effect (with Part-I Bid) signed by all consortium members. For Consortiums, the consortium partners shall designate one of such firms to act as a leader with authority to bind the consortium. The composition or the constitution of the joint venture or consortium shall not be altered without the prior consent of the Owner.

4.8 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.9 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.10 Origin

"Origin" means the place where the materials, equipments and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.11 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or E-mail to the address of the relevant party indicated in the Contract.

Either party may change its postal address, telefax number, or E-mail ID or addressee for receipt of such notices by ten (10) days' notice to the other party in writing

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

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4.12 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [.....] shall have exclusive jurisdiction in all matters arising under the Contract.

4.13 Settlement of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Owner and the Contractor in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Owner & Contractor shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

Either Owner or the Contractor may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities

Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Owner and the Contractor shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within *[twenty eight (28)]* days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by the Appointing Authority for arbitrator is given below.

Appointing Authority for Arbitrator:

- President, Institution of Engineers in case of an Indian Contractor.

If one party fails to appoint its arbitrator within *[forty-two (42)]* days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Arbitration proceedings as follows:-

- In case of an Indian Contractor Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996.

The Place for Arbitration shall be: *[New Delhi]*, India.

The language of arbitration shall be English.

The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The

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parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- the parties shall continue to perform their respective obligations under the Contract unless they otherwise agree
- The Owner shall pay the Contractor consideration due to the Contractor.

4.14 Scope of Facilities

- Unless otherwise expressly limited in the Technical Specifications, Facilities the Contractor's obligations cover the provision of all Plant and Equipments including spares and the performance of all Services required for design, manufacture (including procurement, quality assurance, construction, installation, associated civil works, Structural and others construction works, precommissioning and delivery) of the Plant and Equipment and the installation, commissioning, completion of facilities and performance testing of the Facilities in accordance with the plans, procedures, specifications, drawings, codes and any other documents as specified in the Technical Specifications. Such specifications include, but are not limited to, the provision of supervision and engineering services; the supply of labour, materials, equipment, spare parts and accessories; Contractor's Equipments; construction utilities and supplies; temporary materials, structures and facilities; transportation loading & unloading.
- The Contractor shall, unless specifically excluded in the Contract, perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for attaining Completion of the Facilities.

4.15 Time for Commencement and Completion

- The Contractor shall commence work on the scope of work under this Tender from the date of Letter of Award. Contractor shall thereafter proceed with the Facilities in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- The Contractor shall attain Completion of the Facilities (or of a part where a separate time for Completion of such part is specified in the Contract) within the time stated in the SCC subject to time extensions, the contractor is entitled under the contract conditions or time extension expressly grouted by the Owner.

4.16 Spare Parts

In addition to the supply of Mandatory Spare Parts included in the Contract, the Contractor agrees to supply other spare parts (recommended spares) required for the operation and maintenance of the Facilities for 3 years. However, the identity, specifications and quantities of such spare parts and the terms and conditions relating to the supply thereof are to be agreed between the Owner and the Contractor, and the price of such spare parts shall be that given in Price Schedule for recommended spares. The price of such spare parts shall include the purchase price thereof and other costs and expenses (including the Contractor's fees) relating to the supply of spare parts. The prices of recommended spares covered in price schedule shall be valid for a period of six months after the date of Notification of Award of Main Equipment and Mandatory Spares.

- The Contractor shall supply the recommended spares at the same terms and conditions as are otherwise applicable to this Contract.

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- All the spares for the equipment under the Contract will strictly conform to the Specification and other relevant documents and will be identical to the corresponding main equipment/components supplied under the Contract and shall be fully interchangeable.
- All the Mandatory Spares covered under the Contract shall be manufactured along with the main equipments as a continuous operation and the delivery of the spares will be affected along with the main equipments in a phased manner and the delivery would be completed by the respective dates for the various categories of equipment as per the agreed schedule. If order for the Recommended Spares has been placed with the Contractor prior to commencement of manufacture of the main equipment this shall be applicable for manufacturer of recommended spares as well.
- The Contractor will provide the Owner with the manufacturing drawings, catalogues, assembly drawings and any other document required by the for the recommended spares. Such details will be furnished to the Owner as soon as they are prepared but in any case not later than six months prior to commencement of manufacture of the corresponding main equipment.
- In addition to the spares recommended by the Contractor, if the Owner further identifies certain particular items of spares, the Contractor will submit the prices and delivery quotation for such spares within [30] days of receipt of such request with a validity period of 6 months for consideration by the Owner and placement of order for additional spares, if the Owner so desires.
- The quality plan and the inspection requirement finalised for the main equipment will also be applicable to the corresponding spares.
- The Contractor will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/components/ equipment covered under the Contract and will further ensure with his vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.
- The Contractor shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered under the Contract. The same provision will also be applicable to spares supplied by Sub-contractors.
- For the first 6 years from the schedule date of completion of facilities the prices will be derived from the corresponding Ex-Works Price at which the order for such spares have been placed by Owner as a part of Mandatory Spares or Recommended Spares, or from the rates of Mandatory Spares or Recommended Spares as quoted by/negotiated with the Contractor. Ex-Works order price of future spares shall be computed in accordance with the price adjustment provisions covered under the main Contract excepting that the base indices will be counted from the scheduled date of Commissioning of the last equipment under the main project. The Contractor will indicate in advance the delivery period of the items of spares, which the Owner may procure in accordance with this clause. In case of emergent requirements of spares, the Contractor would make every effort to expedite the manufacture and delivery of such spares on the basis of mutually agreed time schedule.
- In case the Contractor fails to supply the mandatory or recommended spares in the terms stipulated above, the Owner shall be entitled to purchase the same from the alternate sources at the risk and the cost of the Contractor and recover from the Contractor, the excess amount paid by the Owner over the

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rates worked on the above basis. In the event of such risk purchase by the Owner, the purchases will be as per the Works and Procurement Policy of the Owner prevalent at the time of such purchases and the Owner at his option may include a representative from the Contractor in finalising the purchases.

- It is expressly understood that the final settlement between the parties in terms of relevant clauses of the Contract Documents shall not relieve the Contractor of any of his obligations under the provision of long term availability of spares and such provisions shall continue to be enforced till the expiry of 6 years period reckoned from the scheduled date of Commissioning of the Plant and Equipment unless otherwise discharged expressly in writing by the Owner.
- The Contractor shall warrant that all spares supplied will be new and in accordance with the Contract Documents and will be free from defects in design, material and workmanship. The defects liability period for spares shall be 12 months from the date it is put to use. In case of failure of any spare part due to fault in design material or workmanship the same part will be replaced by the contractor without any extra cost of the Owner.

In case of any failure in the original component/equipments due to faulty designs, materials and workmanship, the corresponding spare parts, if any, supplied will be replaced without any extra cost to the Owner unless a joint examination and analysis by the Owner and the Contractor of such spare parts prove that the defect found in the original part that failed, can safely be assumed not to be present in spare parts. Any replaced spare parts will have the Defects Liability period of 12 months from the date it is put in use. The discarded spare parts will become the property of the Contractor as soon as they have been replaced by the Contractor. In any case the defect liability of spares will expire at the end of 48 months from the date of their receipt at site

The Defects Liability of spares that are not used within 18 months from the respective date of the delivery at Site will, be subject to condition that all such spares are stored in accordance with Contractor's standard recommended practice, if any, and the same has been furnished to the Owner.

4.17 Contractor's Responsibilities

- a) The Contractor shall design, manufacture (including associated purchases and/or subcontracting), disassemble/dismantle wherever required, install, commission and complete the Facilities and carryout the Guarantee tests with due care and diligence in accordance with the Contract.
- b) Before entering into this contract the Contractor is responsible to have examined the data relating to the Facilities provided by the Owner, and on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve contractor of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.
- c) The Contractor shall acquire in its name all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Contractor's and Subcontractor's personnel and entry permits for all imported Contractor's Equipment.

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- d) The Contractor shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any and all liabilities, damages, claims, fines, penalties and expenses of whatever nature arising or resulting from the violation of such laws by the Contractor.

4.18 Owner's Responsibilities

- a) The Owner shall be responsible for acquiring and providing legal and physical possession of the Site and access thereto, and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract, including all requisite rights of way.
- b) The Owner shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Owner to obtain them in the Owner's name, are necessary for the execution of the Contract.
- c) If requested by the Contractor, the Owner shall use its best endeavours to assist the Contractor in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Contractor or Subcontractors or the personnel of the Contractor or Subcontractors, as the case may be, to obtain.
- d) The Owner shall be responsible for the continued operation of the Facilities after Completion.

4.19 Taxes & Duties

- a) Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation. The reimbursement of these taxes shall be on actual subject to the quoted value of these taxes as ceiling corresponding to the base price. Additional liability of taxes and duties arising out of price variation shall be reimbursed against documentary evidence over and above the ceiling (quoted value). Statutory variation in Indian taxes and duties will be dealt with as per the relevant stipulations of the specification.
- b) Except as otherwise specifically provided in the Contract, the Contractor shall bear and pay all Taxes, Duties, Levies and Charges including Entry Tax, Service Tax, if applicable in connection with the Facilities in India and outside India. All taxes, duties & levies on works contract, if any, shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- c) All taxes, duties and levies including entry tax/octroi (if any) in respect of all components, equipments and material to be dispatched directly from the sub-vendor's works to site shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- d) In case there is introduction of GST or any other tax in lieu of existing Excise Duty/Service Tax and VAT/ Sales Tax, the contract price will be adjusted for the impact of any differential tax liability subject to documentary evidence. This will be restricted to direct transaction between the owner and contractor, and bought out items directly dispatched from sub-vendor's works to project site.

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- e) Further all taxes, duties and levies including sales tax on works contract, Entry Tax, if any, in respect of civil construction works, erection & commissioning if any and custom duty/sales tax as applicable on the materials used for such construction works shall be to the contractor's account and no separate claim in this regard will be entertained by the Owner. Incidence of Service Tax & cess on any component of the Bid Price shall be to the Contractor's account and bidders shall include Service Tax as applicable at the date seven (7) days prior to the date of bid submission in the bid price. The Contract Price will be adjusted for impact of any change in the rate of service tax or cess on service tax subsequent to this date for direct transactions between the Owner and the Contractor.
- f) If any tax exemptions, reductions, allowances or privileges may be available to the Contractor, the Owner shall use its best endeavours to enable the Contractor to benefit from any such tax savings to the maximum allowable extent.

4.20 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Owner by the Contractor herein shall remain vested in the Contractor or, if they are furnished to the Owner directly or through the Contractor by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Owner shall however be free to reproduce all drawings, documents and other material furnished to the Owner for the purpose of the contract including, if required, for operation and maintenance.

4.21 Confidential Information

- a) The Owner and the Contractor shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Contractor may furnish to its Subcontractor(s) such documents, data and other information it receives from the Owner to the extent required for the Subcontractor(s) to perform its work under the Contract, in which event the Contractor shall obtain from such Subcontractor(s) an undertaking of confidentiality similar to that imposed on the Contractor.
- b) The Owner shall not use such documents, data and other information received from the Contractor for any purpose other than the operation and maintenance of the Facilities. Similarly, the Contractor shall not use such documents, data and other information received from the Owner for any purpose other than the design, procurement of Plant and Equipments, construction or such other work and services as are required for the performance of the Contract.
- c) The obligation of a party, shall not apply to that information which
 - now or hereafter enters the public domain through no fault of that party
 - can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto
 - Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

4.22 Representatives

- a) Project Manager

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If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Owner shall appoint and notify the Contractor in writing of the name of the Project Manager. The Owner may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Contractor without delay. The Owner shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Owner at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

All notices, instructions, information and other communications given by the Contractor to the Owner under the Contract shall be given to the Project Manager, except as herein otherwise provided.

b) Contractor's Representative & Construction Manager

- If the Contractor's Representative is not named in the Contract, then within *[fourteen (14) days]* of the Effective Date, the Contractor shall appoint the Contractor's Representative and shall request the Owner in writing to approve the person so appointed. If the Owner makes no objection to the appointment within *[fourteen (14)]* days, the Contractor's Representative shall be deemed to have been approved. If the Owner objects to the appointment within *[fourteen (14)]* days giving the reason there for, then the Contractor shall appoint a replacement within *[fourteen (14) days]* of such objection.
- The Contractor's Representative shall represent and act for the Contractor at all times during the currency of the Contract and shall give to the Project Manager all the Contractor's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Owner or the Project Manager to the Contractor under the Contract shall be given to the Contractor's Representative or, in its absence, its deputy, except as herein otherwise provided. The Contractor shall not revoke the appointment of the Contractor's Representative without the Owner's prior written consent, which shall not be unreasonably withheld. If the Owner consents thereto, the Contractor shall appoint some other person as the Contractor's Representative.
- The Contractor's Representative may, subject to the approval of the Owner (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Contractor's Representative, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Owner and the Project Manager.
- From the commencement of installation of the Facilities at the Site until Operational Acceptance, the Contractor's Representative shall appoint a suitable person as the construction manager (hereinafter referred to as "the Construction Manager"). The Construction Manager shall supervise all work done at the Site by the Contractor and shall be present at the Site throughout normal working hours except when on leave, sick or absent for reasons connected with the proper performance of the Contract. Whenever the

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Construction Manager is absent from the Site, a suitable person shall be appointed to act as his or her deputy.

- The Owner may by notice to the Contractor object to any representative or person employed by the Contractor in the execution of the Contract who, in the reasonable opinion of the Owner, may behave inappropriately, may be incompetent or negligent, or may commit a serious breach of the Site regulations.
- If any representative or person employed by the Contractor is removed.

4.23 Work Program

a) Contractor's Organization

The Contractor shall supply to the Owner and the Project Manager a chart showing the proposed organization to be established by the Contractor for carrying out work on the Facilities. The chart shall include the identities of the key personnel together with the curricula vitae of such key personnel to be employed within *[twenty one (21)]* days of the Effective Date. The Contractor shall promptly inform the Owner and the Project Manager in writing of any revision or alteration of such an organization chart.

b) Program of Performance

Within *[twenty-eight (28)]* days after the date of Notification of Award of Contract, the Contractor shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply, transport, assemble, install and precommissioning the Facilities, as well as the date by which the Contractor reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Contractor to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Contractor shall accord with the Time Schedule included in Contract Schedule 3 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Contractor shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Contractor's actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Contractor shall, at the request of the Owner or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

e) Work Procedures

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

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If agreed between the Owner and the Contractor, the Contractor may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

4.24 Subcontractors and Subvendors

- a) The Contract Agreement specifies major items of supply or services and a list of approved Subcontractors against each item, including vendors. Insofar as no Subcontractors are listed against any such item, the Contractor shall prepare a list of Subcontractors for such item for inclusion in such list. The Contractor may from time to time propose any addition to or deletion from any such list. The Contractor shall submit any such list or any modification thereto to the Owner for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Owner for any of the Subcontractors shall not relieve the Contractor from any of its obligations, duties or responsibilities under the Contract.
- b) The Contractor shall select and employ its Subcontractors/Subvendors for such major items from those listed.

4.25 Design and Engineering

- a) Specifications and Drawings

The Contractor shall execute the basic and detailed design and the engineering work in compliance with the provisions of the Contract, or where not so specified, in accordance with good engineering practice. The Contractor shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents that it has prepared, whether such specifications, drawings and other documents have been approved by the Project Manager or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Contractor by or on behalf of the Owner.

- b) Codes and Standards

Wherever references are made in the Contract to codes and standards in accordance with which the Contract shall be executed, the edition or the revised version of such codes and standards current at the date *[twenty eight (28)]* days prior to date of bid submission shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

- c) Approval/Review of Technical Documents by Project Manager

The Contractor shall prepare (or cause its Subcontractors to prepare) and furnish to the Project Manager the documents for its approval Any part of the Facilities covered by or related to the documents to be approved by the Project Manager shall be executed only after the Project Manager's approval thereof.

Project Manager shall either return one copy thereof to the Contractor with its approval endorsed thereon or shall notify the Contractor in writing of its disapproval thereof and the reasons there for and the modifications that the Project Manager proposes. The Project Manager shall not disapprove any document, except on the grounds that the document does not comply with some specified provision of the Contract or that it is contrary to good engineering practice. The procedure for submission of the documents by the Contractor and their approval by the Project Manager shall be discussed and finalised with the Contractor.

If any dispute or difference occurs between the Owner and the Contractor in connection with or arising out of the disapproval by the Project Manager of any document and/or any modification(s) thereto that cannot be settled between the

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parties within a reasonable period, then such dispute or difference may be referred to an Adjudicator. If such dispute or difference is referred to an Adjudicator, the Project Manager shall give instructions as to whether and if so, how, performance of the Contract is to proceed. The Contractor shall proceed with the Contract in accordance with the Project Manager's instructions, provided that if the Adjudicator upholds the Contractor's view on the dispute, then the Contractor shall be reimbursed by the Owner for any additional costs incurred by reason of such instructions and shall be relieved of such responsibility or liability in connection with the dispute and the execution of the instructions as the Adjudicator shall decide, and the Time for Completion shall be extended accordingly.

The Project Manager's approval, with or without modification of the document furnished by the Contractor, shall not relieve the Contractor of any responsibility or liability imposed upon it by any provisions of the Contract except to the extent that any subsequent failure results from modifications required by the Project Manager.

4.26 Procurement

a) Plant and Equipment

The Contractor shall manufacture or procure and transport all the Plant and Equipments in an expeditious and orderly manner to the Site.

b) Transportation

The Contractor shall at its own risk and expense transport all the Plant and Equipments and the Contractor's Equipments to the Site by the mode of transport that the Contractor judges most suitable under all the circumstances. Unless otherwise provided in the Contract, the Contractor shall be entitled to select any safe mode of transport operated by any person to carry the Plant and Equipments and the Contractor's Equipment. Upon dispatch of each shipment of the Plant and Equipments and the Contractor's Equipments, the Contractor shall notify the Owner by telex, cable, telefax, facsimile or Electronic Data Interchange (EDI) of the description of the Plant and Equipments and of the Contractor's Equipments, the point and means of dispatch, and the estimated time and point of arrival in the country where the Site is located, if applicable, and at the Site. The Contractor shall furnish the Owner with relevant shipping documents to be agreed upon between the parties.

The Contractor shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Plant and Equipments and the Contractor's Equipments to the Site. The Owner shall use its best endeavours in a timely and expeditious manner to assist the Contractor in obtaining such approvals, if requested by the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any claim for damage to roads, bridges or any other traffic facilities that may be caused by the transport of the Plant and Equipments and the Contractor's Equipments to the Site.

4.27 Installation

a) Setting Out/Supervision/Labour

Bench Mark: The Contractor shall be responsible for the true and proper setting-out of the Facilities in relation to bench marks, reference marks and lines provided to it in writing by or on behalf of the Owner.

If, at any time during the progress of installation of the Facilities, any error shall appear in the position, level or alignment of the Facilities, the Contractor shall forthwith notify the Project Manager of such error and, at its own expense,

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immediately rectify such error to the reasonable satisfaction of the Project Manager. If such error is based on incorrect data provided in writing by or on behalf of the Owner, the expense of rectifying the same shall be borne by the Owner.

Contractor's Supervision: The Contractor shall give or provide all necessary superintendence during the installation of the Facilities, and the Construction Manager or its deputy shall be constantly on the Site to provide full time superintendence of the installation. The Contractor shall provide and employ only technical personnel who are skilled and experienced in their respective callings and supervisory staff who are competent to adequately supervise the work at hand.

The Contractor shall provide and employ on the Site in the installation of the Facilities such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the Contract. The Contractor is encouraged to use local labour that has the necessary skills. Unless otherwise provided in the Contract, the Contractor shall be responsible for the recruitment, transportation, accommodation and catering of all labour, local or expatriate, required for the execution of the Contract and for all payments in connection therewith.

The Contractor shall at its own expense provide the means of repatriation to all of its and its Subcontractor's personnel employed on the Contract at the Site to their various home countries. It shall also provide suitable temporary maintenance of all such persons from the cessation of their employment on the Contract to the date programmed for their departure. In the event that the Contractor defaults in providing such means of transportation and temporary maintenance, the Owner may provide the same to such personnel and recover the cost of doing so from the Contractor.

The Contractor shall, in all dealings with its labour and the labour of its Subcontractors currently employed on or connected with the Contract, pay due regard to all recognized festivals, official holidays, religious or other customs and all local laws and regulations pertaining to the employment of labour.

b) Contractor's Equipments

All Contractors' Equipments brought by the Contractor onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Contractor shall not remove the same from the Site without the Project Manager's consent that such Contractor's Equipments are no longer required for the execution of the Contract. Unless otherwise specified in the Contract, upon completion of the Facilities, the Contractor shall remove from the Site all Equipments brought by the Contractor onto the Site and any surplus materials remaining thereon.

The Owner will, if requested, use its best endeavours to assist the Contractor in obtaining any local, state or national government permission required by the Contractor for the export of the Contractor's Equipments imported by the Contractor for use in the execution of the Contract that is no longer required for the execution of the Contract.

c) Site Regulations and Safety

The Owner and the Contractor shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. The Contractor shall prepare and submit to the Owner, with a copy to the Project Manager, proposed Site regulations for the Owner's approval, which approval shall not be unreasonably withheld.

Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Facilities, gate control, sanitation, medical care, and fire prevention.

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d) Opportunities for Other Contractors

The Contractor shall, upon written request from the Owner or the Project Manager, give all reasonable opportunities for carrying out the work to any other contractors employed by the Owner on or near the Site. If the Contractor, upon written request from the Owner or the Project Manager, makes available to other contractors any roads or ways the maintenance for which the Contractor is responsible, permits the use by such other contractors of the Contractor's Equipments, or provides any other service of whatsoever nature for such other contractors, the Owner shall fully compensate the Contractor for any loss or damage caused or occasioned by such other contractors in respect of any such use or service, and shall pay to the Contractor reasonable remuneration for the use of such equipments or the provision of such services.

The Contractor shall also so arrange to perform its work as to minimize, to the extent possible, interference with the work of other contractors. The Project Manager shall determine the resolution of any difference or conflict that may arise between the Contractor and other contractors and the workers of the Owner in regard to their work.

The Contractor shall notify the Project Manager promptly of any defects in the other Contractors' work that come to its notice, and that could affect the Contractor's work. The Project Manager shall determine the corrective measures, if any, required to rectify the situation after inspection of the Facilities. Decisions made by the Project Manager shall be binding on the Contractor.

e) Emergency Work

If, by reason of an emergency arising in connection with and during the execution of the Contract, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Facilities, the Contractor shall immediately carry out such work.

If the Contractor is unable or unwilling to do such work immediately, the Owner may do or cause such work to be done as the Owner may determine is necessary in order to prevent damage to the Facilities. In such event the Owner shall, as soon as practicable after the occurrence of any such emergency, notify the Contractor in writing of such emergency, the work done and the reasons there for. If the work done or caused to be done by the Owner is work that the Contractor was liable to do at its own expense under the Contract, the reasonable costs incurred by the Owner in connection therewith shall be paid by the Contractor to the Owner. Otherwise, the cost of such remedial work shall be borne by the Owner.

f) Site Clearance

Site Clearance in Course of Performance: In the course of carrying out the Contract, the Contractor shall keep the Site reasonably free from all unnecessary obstruction, store or remove any surplus materials, clear away any wreckage, rubbish or temporary works from the Site, and remove any Contractor's Equipments no longer required for execution of the Contract. **Clearance of Site after Completion:** After Completion of all parts of the Facilities, the Contractor shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site and Facilities clean and safe.

g) Watching and Lighting

The Contractor shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper execution and the protection

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of the Facilities, or for the safety of the owners and occupiers of adjacent property and for the safety of the public as per specification.

4.28 Testing & Inspections

- a) The Contractor shall at its own expense carry out at the place of manufacture and/or on the Site all such tests and/or inspections of the Plant and Equipments and any part of the Facilities as are specified in the Contract.
- b) The Owner and the Project Manager or their designated representatives shall be entitled to attend the aforesaid test and/ or inspection, provided that the Owner shall bear all costs and expenses incurred in connection with such attendance including, but not limited to, all travelling and board and lodging expenses.
- c) Whenever the Contractor is ready to carry out any such test and/or inspection, the Contractor shall give a reasonable advance notice of such test and/or inspection and of the place and time thereof to the Project Manager. The Contractor shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Owner and the Project Manager (or their designated representatives) to attend the test and/or inspection.
- d) The Contractor shall provide the Project Manager with a certified report of the results of any such test and/or inspection. If the Owner or Project Manager (or their designated representatives) fails to attend the test and/or inspection, or if it is agreed between the parties that such persons shall not do so, then the Contractor may proceed with the test and/or inspection in the absence of such persons, and may provide the Project Manager with a certified report of the results thereof.
- e) The Project Manager may require the Contractor to carry out any test and/or inspection not required by the Contract, provided that the Contractor's reasonable costs and expenses incurred in the carrying out of such test and/or inspection shall be added to the Contract Price. Further, if such test and/or inspection impede the progress of work on the Facilities and/or the Contractor's performance of its other obligations under the Contract, due allowance will be made in respect of the Time for Completion and the other obligations so affected.
- f) If any Plant and Equipment or any part of the Facilities fails to pass any test and/or inspection, the Contractor shall either rectify or replace such Plant and Equipment or part of the Facilities and shall repeat the test and/or inspection upon giving a notice.
- g) If any dispute or difference of opinion shall arise between the parties in connection with or arising out of the test and/or inspection of the Plant and Equipments or part of the Facilities that cannot be settled between the parties within a reasonable period of time, it may be referred to the Adjudicator.
- h) The Contractor shall afford the Owner and the Project Manager, at the Owner's expense, access at any reasonable time to any place where the Plant and Equipments are being manufactured or the Facilities are being installed, in order to inspect the progress and the manner of manufacture or installation, provided that the Project Manager shall give the Contractor a reasonable prior notice.
- i) The Contractor agrees that neither the execution of a test and/ or inspection of Plant and Equipments or any part of the Facilities, nor the witnessing of any test by the Owner, nor the issuance of any test certificate shall relieve the Contractor of any obligation under this Contract.
- j) No part of the Facilities or foundations shall be covered up on the Site without the Contractor carrying out any test and/or inspection required under the Contract. The Contractor shall give a reasonable notice to the Project Manager whenever any such part of the Facilities or foundations is ready or about to be ready for test and/or

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inspection; such test and/or inspection and notice thereof shall be subject to the requirements of the Contract.

- k) The Contractor shall uncover any part of the Facilities or foundations, or shall make openings in or through the same as the Project Manager may from time to time require at the Site, and shall reinstate and make good such part or parts.

4.29 Completion of the Facilities

- a) As soon as the Facilities or any part thereof has, in the opinion of the Contractor, been completed operationally and structurally and put in a tight and clean condition as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Contractor shall so notify the Owner in writing.
- b) The Owner shall supply the operating and maintenance personnel as specified in the Form of Contract Agreement for Pre-commissioning of the Facilities or any part thereof.
- c) As soon as all works in respect of Pre-commissioning are completed and, in the opinion of the Contractor, the Facilities or any part thereof is ready for Commissioning, the Contractor shall commence Commissioning as per procedures stipulated in Technical Specifications, and as soon as Commissioning is satisfactorily completed, the Contractor shall so notify the Project Manager in writing.
- d) If the Project Manager notifies the Contractor of any defects and/ or deficiencies, the Contractor shall then correct such defects and/or deficiencies.

If the Project Manager is satisfied that the Facilities or that part thereof have reached Completion, the Project Manager shall, within **[seven (7)]** days after receipt of the Contractor's notice, issue a Completion Certificate stating that the Facilities or that part thereof have reached Completion as at the date of the Contractor's notice.

If the Project Manager is not so satisfied, then it shall notify the Contractor in writing of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's repeated notice, and the above procedure shall be repeated.

- e) If the Project Manager fails to issue the Completion Certificate and fails to inform the Contractor of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's notice, or if the Owner makes use of the Facilities or part thereof, then the Facilities or that part thereof shall be deemed to have reached Completion as of the date of the Contractor's notice, or as of the Owner's use of the Facilities, as the case may be.
- f) As soon as possible after Completion, the Contractor shall complete all outstanding minor items so that the Facilities are fully in accordance with the requirements of the Contract, failing which the Owner will undertake such completion and deduct the costs thereof from any monies owing to the Contractor.
- g) Upon Completion, the Owner shall be responsible for the care and custody of the Facilities or the relevant part thereof, together with the risk of loss or damage thereto, and shall thereafter take over the Facilities or the relevant part thereof.

4.30 Commissioning & Operation Acceptance

- a) Commissioning

Commissioning of the Facilities or any part thereof Acceptance shall be completed by the Contractor as per procedures detailed in the Technical Specifications. The Contractor shall, unless otherwise specified in Contract/ Tender Specifications, supply utilities, lubricants, chemicals, catalysts, facilities, services and other matters required for Commissioning.

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b) Guarantee Test

The Guarantee Tests (and repeats thereof) shall be conducted by the Contractor after Commissioning of the Facilities or the relevant part thereof to ascertain whether the Facilities or the relevant part can attain the Functional Guarantees specified in the Contract Documents. The Contractor's and Project Manager's advisory personnel shall attend the Guarantee Test. The Owner shall promptly provide the Contractor with such information as the Contractor may reasonably require in relation to the conduct and results of the Guarantee Tests (and any repeats thereof). If for reasons not attributable to the Contractor, the Guarantee Tests of the Facilities or the relevant part thereof cannot be successfully completed within the period from the date of Completion, specified in the SCC or any other period agreed upon by the Owner and the Contractor, the Contractor shall be deemed to have fulfilled its obligations with respect to the Functional Guarantees.

c) Operational Acceptance

Operational Acceptance shall occur in respect of the Facilities or any part thereof when

- the Guarantee Tests have been successfully completed and the Functional Guarantees are met; or
- The Guarantee Tests have not been successfully completed or has not been carried out for reasons not attributable to the Contractor within the period from the date of Completion specified in the SCC or any other agreed upon period as specified in GCC.
- The Contractor may give a notice to the Project Manager requesting the issue of an Operational Acceptance Certificate in respect of the Facilities or the part thereof specified in such notice as at the date of such notice.
- The Project Manager shall, after consultation with the Owner, and within forty five (45) days after receipt of the Contractor's notice, issue an Operational Acceptance Certificate. If within *[forty five (45)]* days after receipt of the Contractor's notice, the Project Manager fails to issue the Operational Acceptance Certificate or fails to inform the Contractor in writing of the justifiable reasons why the Project Manager has not issued the Operational Acceptance Certificate, the Facilities or the relevant part thereof shall be deemed to have been accepted as at the date of the Contractor's said notice.

d) Partial Acceptance

If the Contract specifies that Completion, Commissioning and Guarantee Tests shall be carried out in respect of parts of the Facilities, the provisions relating to Completion and Commissioning including the Guarantee Tests shall apply to each such part of the Facilities individually, and the Operational Acceptance Certificate shall be issued accordingly for each such part of the Facilities. If a part of the Facilities comprises facilities such as buildings, for which no Commissioning or Guarantee Tests are required, then the Project Manager shall issue the Operational Acceptance Certificate for such facility when it attains Completion, provided that the Contractor shall thereafter complete any outstanding minor items that are listed in the Operational Acceptance Certificate.

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4.31 Completion Time and Liquidated Damage

- a) Completion Time Period
The Contractor guarantees that it shall attain Completion of the Facilities (or a part for which a separate time for completion is specified in the SCC) within the Time for Completion specified in the SCC.
- b) If the Contractor fails to attain Completion of the Facilities or any part thereof within the Time for Completion, the Contractor shall pay to the Owner liquidated damages in the amount computed at the rates specified in the SCC. The aggregate amount of such liquidated damages shall in no event exceed the amount specified as "Maximum" in the SCC.
However, the payment of liquidated damages shall not in any way relieve the Contractor from any of its obligations to complete the Facilities or from any other obligations and liabilities of the Contractor under the Contract.
- c) No bonus will be given for earlier completion of the facilities or part thereof.

4.32 Defects Liability

- a) The Contractor warrants that the Facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the Plant and Equipments supplied and of the work executed.
- b) The Defects Liability Period shall be *[eighteen (18)]* months from the date of Completion of the Facilities (or any part thereof) or *[twelve (12)]* months from the date of Operational Acceptance of the Facilities (or any part thereof).
If during the Defects Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipments supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect. The Contractor shall not be responsible for the repair, replacement or making good of any defect or of any damage to the Facilities arising out of or resulting from any of the following causes:
 - improper operation or maintenance of the Facilities by the Owner
 - operation of the Facilities outside specifications provided in the Contract
 - Normal wear and tear.
- c) The Owner shall give the Contractor a notice stating the nature of any such defect together with all available evidence thereof, promptly following the discovery thereof. The Owner shall afford all reasonable opportunity for the Contractor to inspect any such defect.
- d) The Owner shall afford the Contractor all necessary access to the Facilities and the Site to enable the Contractor to perform its obligations.
- e) If the repair, replacement or making good is of such a character that it may affect the efficiency of the Facilities or any part thereof, the Owner may give to the Contractor a notice requiring that tests of the defective part of the Facilities shall be made by the Contractor immediately upon completion of such remedial work, whereupon the Contractor shall carry out such tests.
- f) If the Contractor fails to commence the work necessary to remedy such defect or any damage to the Facilities caused by such defect within a reasonable time (which shall in no event be considered to be less than fifteen (15) days), the Owner may,

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following notice to the Contractor, proceed to do such work, and the reasonable costs incurred by the Owner in connection therewith shall be paid to the Owner by the Contractor or may be deducted by the Owner from any monies due to the Contractor or claimed under the Performance Security.

- g) If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defects Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the Defects Liability Period extended by a period of *[twelve (12) month]* from the time such replacement/repair of the Facilities or any part thereof.

4.33 Functional Guarantees

The Contractor guarantees that during the Guarantee Tests, the Facilities and all parts thereof shall attain the Functional Guarantees as per the Contract. If, for reasons attributable to the Contractor, Functional Guarantees are not met either in whole or in part, the Contractor shall, within a mutually agreed time, at its cost and expense make such changes, modifications and/or additions to the Plant or any part thereof as may be necessary to meet such Guarantees. The Contractor shall notify the Owner upon completion of the necessary changes, modifications and/or additions, and shall seek the Owner's consent to repeat the Guarantee Test. If the specified Functional Guarantees are not established even during the repeat of the Guarantee Tests, the Owner may at its option, either reject the plant and equipment and recover from the Contractor payments already made or Accept the equipment/system/plant after levying Liquidated Damages as specified.

4.34 Patents Indemnity

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Owner may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Contractor or the use of the such Facilities.

4.35 Limitation of liability

Except in cases of criminal negligence or wilful misconduct by the Contractor, the aggregate liability of the Contractor to the Owner, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Contractor to indemnify the Owner with respect to patent infringement.

Except in cases of criminal negligence or wilful misconduct by the Contractor, the Contractor shall not be liable to the Owner, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs, provided that this exclusion shall not apply to any obligation of the Contractor to pay liquidated damages to the Owner.

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4.36 Transfer of Ownership

Ownership of the Plant and Equipments (including spare parts) to be imported into India shall be transferred to the Owner upon loading on to the mode of transport to be used to convey the Plant and Equipments from the country of origin to that country.

Ownership of the Plant and Equipments (including spare parts) procured from within India shall be transferred to the Owner when the Plant and Equipments including spares are loaded on to the mode of transport to be used to convey the Plant and Equipments including spares from the works to the site and upon endorsement of the despatch documents in favour of the Owner. Ownership of the Contractor's Equipments used by the Contractor and its Subcontractors in connection with the Contract shall remain with the Contractor or its Subcontractors. Ownership of any Plant and Equipments in excess of the requirements for the Facilities shall revert to the Contractor upon Completion of the Facilities or at such earlier time when the Owner and the Contractor agree that the Plant and Equipments in question are no longer required for the Facilities, provided quantity of any Plant and Equipments specifically stipulated in the Contract shall be the property of the Owner whether or not incorporated in the Facilities. Notwithstanding the transfer of ownership of the Plant and Equipments, the responsibility for care and custody thereof together with the risk of loss or damage shall remain with the Contractor until Completion of the Facilities.

4.37 Care of Facilities

The Contractor shall be responsible for the care and custody of the Facilities or any part thereof until the date of Completion of the Facilities, where the Contract provides for Completion of the Facilities in parts, until the date of Completion of the relevant part, and shall make good at its own cost any loss or damage that may occur to the Facilities or the relevant part thereof from any cause whatsoever during such period. The Contractor shall also be responsible for any loss or damage to the Facilities caused by the Contractor or its Subcontractors in the course of any work carried out.

4.38 Loss of or Damage to Property; Accident or Injury; Indemnification

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with the supply and installation of the Facilities and by reason of the negligence of the Contractor or its Subcontractors, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Owner, its contractors, employees, officers or agents.

4.39 Insurance

- a) The Contractor shall at its expense take out and maintain in effect, or cause to be taken out and maintained in effect, during the performance of the Contract, the insurances set forth below in the sums and with the deductibles and other conditions as specified. The identity of the insurers and the form of the policies shall be subject to the approval of the Owner, who should not unreasonably withhold such approval.
 - Cargo Insurance during Transport:-Covering loss or damage occurring while in transit from the Contractor's or Subcontractor's works or stores until arrival at the Site, to the Plant and Equipments (including spare parts thereof) and to the Contractor's Equipments.

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- Installation All Risks Insurance:-Covering physical loss or damage to the Facilities at the Site, occurring prior to Completion of the Facilities, with an extended maintenance coverage for the Contractor's liability in respect of any loss or damage occurring during the Defects Liability Period while the Contractor is on the Site for the purpose of performing its obligations during the Defects Liability Period.
 - Third Party Liability Insurance: - Covering bodily injury or death suffered by third parties (including the Owner's personnel) and loss of or damage to property occurring in connection with the supply and installation of the Facilities.
 - Automobile Liability Insurance:-Covering use of all vehicles used by the Contractor or its Subcontractors (whether or not owned by them) in connection with the execution of the Contract.
 - Workers' Compensation:-In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Other Insurances Such other insurances as may be specifically agreed upon by the parties.
- b) The Owner shall be named as co-insured under all insurance policies taken out by the Contractor pursuant except for the Third Party Liability, Workers' Compensation and Owner's Liability Insurances, and the Contractor's Subcontractors shall be named as co-insured's under all insurance policies taken out by the Contractor except for the Cargo Insurance During Transport, Workers' Compensation and Owner's Liability Insurances. All insurers' rights of subrogation against such co-insured's for losses or claims arising out of the performance of the Contract shall be waived under such policies.
- c) The Form of Contract Agreement, deliver to the Owner certificates of insurance (or copies of the insurance policies) as evidence that the required policies are in full force and effect. The certificates shall provide that no less than twenty one (21) days' notice shall be given to the Owner by insurers prior to cancellation or material modification of a policy.
- d) The Contractor shall ensure that, where applicable, its Subcontractor(s) shall take out and maintain in effect adequate insurance policies for their personnel and vehicles and for work executed by them under the Contract, unless such Subcontractors are covered by the policies taken out by the Contractor.
- e) The Owner shall at its expense take out and maintain in effect during the performance of the Contract those insurances specified.
- f) the Owner may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Contractor under the Contract any premium that the Owner shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Contractor. If the Owner fails to take out and/or maintain in effect the insurances the Contractor may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Owner under the Contract any premium that the Contractor shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Owner. If the Contractor fails to or is unable to take out and maintain in effect any such insurances, the Contractor shall nevertheless have no liability or responsibility towards the Owner, and the Contractor shall have full recourse against the Owner for any and all liabilities of the Owner herein.
- g) The Owner shall give to the Contractor all such reasonable assistance as may be required by the Contractor. With respect to insurance claims in which the Owner's interest is involved, the Contractor shall not give any release or make any

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compromise with the insurer without the prior written consent of the Owner. With respect to insurance claims in which the Contractor's interest is involved, the Owner shall not give any release or make any compromise with the insurer without the prior written consent of the Contractor.

- h) Wherever total damages/loss of equipments/materials, would occur, the Contractor will be entitled to payment of all payments received from the underwriters except the following amounts:
- The amount paid to the Contractor under the Contract in respect of equipments/materials damaged/lost (excluding the pro-rata initial advance) but including the entire amount of escalation, if any, already paid to the Contractor.
 - Custom Duties and taxes which have already been paid by the Owner.
 - In case of damage to any equipments/materials during any stage, the Contractor upon rectification of the damaged equipment to the satisfaction of the Owner shall be paid to the extent of full claims settled by the underwriters.
- i) All the Plants & Equipment being supplied by the Owner free of cost for installation of the equipment, cabling, earthing and lightning protection etc. by the Contractor, covered by this specification shall be kept insured by the Contractor against loss, damage, theft, pilferage, fire etc. from the point of unloading at Site up to the time of taking over by the Owner including handling, in plant transportation, storage, installation, testing and commissioning, etc. and the Contractor shall be fully responsible for making good of any loss or damage at his own cost within a reasonable time as mutually agreed upon by the Owner and the Contractor. Any loss/damage shall be brought to the Owner's notice immediately. The premium paid by the Contractor to the Insurance Company for such insurance shall be reimbursed by the Owner to the Contractor at actual against documentary proof to be furnished by the Contractor. The Contractor shall obtain competitive quotation for such insurance and shall take prior approval from the Owner before taking the insurance. The insurable value of the equipment being procured by the Owner will be intimated to the Contractor for the purpose of insurance.
- It will be the responsibility of the Contractor to lodge, pursue and settle all claims with the Insurance Company in case of any damage, loss, theft, pilferage, fire, etc. and the Owner shall be kept informed about it. The losses, if any, will have to be borne by the Contractor, if the claims are not lodged and pursued properly or in the time or if the same are not settled by the Insurance Company.

4.40 Change in Laws & Regulation

- a) If, after the date **[seven (7)]** days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Contractor and/or the Time for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Contractor has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Owner and the Contractor and not on procurement of raw materials, intermediary components etc. by the Contractor. Notwithstanding the foregoing, such additional or reduced costs shall

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not be separately paid or credited if the same has already been accounted for in the price adjustment provisions wherever applicable.

4.41 Force Majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected. Force Majeure events include Acts of God, Acts of Government, war, sabotage, riots, civil commotion, revolution, flood, earthquake, cyclone, fire, epidemic etc.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within *[fourteen (14)]* days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfil its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
 - constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby
 if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.
- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than *[sixty (60)]* days or an aggregate period of more than one hundred and *[twenty (120)]* days on account of one or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.
- (g) Force Majeure shall not apply to any obligation of the Owner to make payments to the Contractor herein.

4.42 Change in the Facilities

(a) Introducing a Change

- The Owner shall have the right to propose, and subsequently require, the Contractor during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Facilities (hereinafter called "Change"), provided that such Change falls within the general scope of the Facilities and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the Facilities and the technical compatibility of the Change envisaged with the nature of the Facilities as specified in the Contract.
- The Contractor may from time to time during its performance of the Contract propose to the Owner (with a copy to the Project Manager) any Change that the Contractor considers necessary or desirable to improve the quality, efficiency or safety of the Facilities. This includes any additional scope of

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work that the contractor thinks is essential for achieving the minimum performance level specified in the SCC or the Contract. The Owner may at its discretion approve or reject any Change proposed by the Contractor.

- No change made necessary because of any default of the Contractor in the performance of its obligations under the Contract shall be deemed to be a Change, and such change shall not result in any adjustment of the Contract Price or the Time for Completion.

(b) Changes Originating from Owner

- If the Owner proposes a Change, it shall send to the Contractor a “Request for Change Proposal,” requiring the Contractor to prepare and furnish to the Project Manager as soon as reasonably practicable a “Change Proposal,” which shall include the following:
 - ✓ brief description of the Change
 - ✓ effect on the Time for Completion
 - ✓ estimated Cost of the Change
 - ✓ effect on Functional Guarantees (if any)
 - ✓ effect on any other provisions of the Contract.
- The pricing of any Change shall, as far as practicable, be calculated in accordance with the rates and prices included in the Contract. If the rates and prices of any change are not available in the Contract, the parties thereto shall agree on specific rates for the valuation of the Change.
- If before or during the preparation of the Change Proposal it becomes apparent that the aggregate effect of compliance therewith and with all other Change Orders that have already become binding upon the Contractor to increase or decrease the Contract Price as originally set forth in the Contract Agreement by more than fifteen (15) percent, the Contractor may give a written notice of objection thereto prior to furnishing the Change Proposal as aforesaid. If the Owner accepts the Contractor’s objection, the Owner and the Contractor shall agree on specific rates for valuation of the change.
- Upon receipt of the Change Proposal, the Owner and the Contractor shall mutually agree upon all matters therein contained including agreement on rates if such rates are not available in the Contract or if the limit of 15% set forth has been exceeded. Within *fourteen (14)* days after such agreement, the Owner shall, if it intends to proceed with the Change, issue the Contractor with a Change Order.
- If the Owner is unable to reach a decision within *fourteen (14)* days, it shall notify the Contractor with details of when the Contractor can expect a decision.
- If the Owner decides not to proceed with the Change for whatever reason, it shall, within the said period of *fourteen (14)* days, notify the Contractor accordingly.
- If the Owner and the Contractor cannot reach agreement on the price for the Change, an equitable adjustment to the Time for Completion, or any other matters identified in the Change Proposal, the Owner may nevertheless instruct the Contractor to proceed with the Change by issue of a “Pending Agreement Change Order.”

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Upon receipt of a Pending Agreement Change Order, the Contractor shall immediately proceed with effecting the Changes covered by such Order. The parties shall thereafter attempt to reach agreement on the outstanding issues under the Change Proposal.

(c) Changes Originating from Contractor

- The Contractor shall submit to the Project Manager a written "Application for Change Proposal," giving reasons for the proposed Change and including the information. Upon receipt of the Application for Change Proposal, the parties shall follow the procedures indicated above for "Request for Change Proposal."

4.43 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Contractor is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:
- Any Change in the Facilities or
 - any occurrence of Force Majeure or
 - any suspension order given by the Owner or reduction in the rate of progress or
 - any changes in laws and regulations or
 - any default or breach of the Contract by the Owner, or any activity, act or omission of any other contractors employed by the Owner or
 - any other matter specifically mentioned in the Contract;
- By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Contractor.
- (b) Except where otherwise specifically provided in the Contract, the Contractor shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Owner and the Contractor shall agree upon the period of such extension.
- (c) The Contractor shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.44 Suspension

- (a) The Owner/ Project Manager may, by notice to the Contractor, order the Contractor to suspend performance of any or all of its obligations under the Contract. Such notice shall specify the obligation of which performance is to be suspended, the effective date of the suspension and the reasons thereof. The Contractor shall thereupon suspend performance of such obligation (except those obligations necessary for the care or preservation of the Facilities) until ordered in writing to resume such performance by the Project Manager/ Owner.

If, by virtue of a suspension order given by the Project Manager/ Owner, other than by reason of the Contractor's default or breach of the Contract, the Contractor's performance of any of its obligations is suspended for an aggregate period of more than *[ninety (90)]* days, then at any time thereafter and provided that at that time such performance is still suspended, the Contractor may give a

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notice to the Project Manager requiring that the Owner shall, within *[twenty eight (28)]* days of receipt of the notice, order the resumption of such performance or request and subsequently order a change, excluding the performance of the suspended obligations from the Contract.

- (b) If the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas;

Then the Contractor may by *[fourteen (14)]* days' notice to the Owner suspend performance of all or any of its obligations under the Contract, or reduce the rate of progress. If the Contractor's performance of its obligations is suspended or the rate of progress is reduced, then the Time for Completion shall be extended, and any and all additional costs or expenses incurred by the Contractor as a result of such suspension or reduction shall be paid by the Owner to the Contractor in addition to the Contract Price, except in the case of suspension order or reduction in the rate of progress by reason of the Contractor's default or breach of the Contract.

- (c) During the period of suspension, the Contractor shall not remove from the Site any Plant and Equipment, any part of the Facilities or any Contractor's Equipment, without the prior written consent of the Owner.

4.45 Termination

(a) Termination for Owner's Convenience

The Owner may at any time terminate the Contract for any reason by giving the Contractor a notice of termination. Upon receipt of the notice of termination, the Contractor shall either immediately or upon the date specified in the notice of termination

- (i) cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition.
- (ii) terminate all subcontracts, except those to be assigned
- (iii) remove all Contractor's Equipments from the Site, repatriate the Contractor's and its Subcontractors' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Contractor, subject to the payment, shall

- ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- ✓ Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

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In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Contractor the following amounts

- ✓ the Contract Price, attributable to the parts of the Facilities executed by the Contractor as on the date of termination
- ✓ the costs reasonably incurred by the Contractor in the removal of the Contractor's Equipment from the Site and in the repatriation of the Contractor's and its Subcontractors' personnel
- ✓ any amounts to be paid by the Contractor to its Subcontractors in connection with the termination of any subcontracts, including any cancellation charges
- ✓ costs incurred by the Contractor in protecting the Facilities and leaving the Site in a clean and safe condition
- ✓ the additional cost of satisfying other obligations, commitments and claims that the Contractor may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Contractor's Default

- (i) The Owner, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons thereof to the Contractor:

If the Contractor becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Contractor is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Contractor takes or suffers any other analogous action in consequence of debt

If the Contractor assigns or transfers the Contract or any right or interest therein in violation of the provision.

If the Contractor, in the judgement of the Owner has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

- (ii) If the Contractor
- has abandoned or repudiated the Contract
 - has without valid reason failed to commence work on the Facilities promptly the progress of Contract performance for more than *twenty*

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eight (28)] days after receiving a written instruction from the Owner to proceed

- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient materials, services or labor to execute and complete the Facilities in the manner specified in the program at rates of progress that give reasonable assurance to the Owner that the Contractor can attain Completion of the Facilities by the Time for Completion as extended

then the Owner may, without prejudice to any other rights it may possess under the Contract, give a notice to the Contractor stating the nature of the default and requiring the Contractor to remedy the same. If the Contractor fails to remedy or to take steps to remedy the same within *fourteen (14)]* days of its receipt of such notice, then the Owner may terminate the Contract forthwith by giving a notice of termination to the Contractor.

(iii) The Contractor shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d) below
- deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Works and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

(iv) The Owner may enter upon the Site, expel the Contractor, and complete the Facilities itself or by employing any third party. The Owner may, to the exclusion of any right of the Contractor over the same, take over and use with the payment of a fair rental rate to the Contractor, with all the maintenance costs to the account of the Owner and with an indemnification by the Owner for all liability including damage or injury to persons arising out of the Owner's use of such equipment, any Contractor's Equipments owned by the Contractor and on the Site in connection with the Facilities for such reasonable period as the Owner considers expedient for the supply and installation of the Facilities.

Upon completion of the Facilities or at such earlier date as the Owner thinks appropriate, the Owner shall give notice to the Contractor that such Contractor's Equipment will be returned to the Contractor at or near the Site and shall return such Contractor's Equipments to the Contractor in

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accordance with such notice. The Contractor shall thereafter without delay and at its cost remove or arrange removal of the same from the Site.

- (v) The Contractor shall be entitled to be paid the Contract Price attributable to the Facilities executed as at the date of termination, the value of any unused or partially used Plant and Equipments on the Site, and the costs, if any, incurred in protecting the Facilities and in leaving the Site in a clean and safe condition. Any sums due to the Owner from the Contractor accruing prior to the date of termination shall be deducted from the amount to be paid to the Contractor under this Contract.
- (vi) If the Owner completes the Facilities, the cost of completing the Facilities by the Owner shall be determined.

If the sum that the Contractor is entitled to be paid, plus the reasonable costs incurred by the Owner in completing the Facilities, exceeds the Contract Price, the Contractor shall be liable for such excess.

The Owner and the Contractor shall agree, in writing, on the computation described above and the manner in which any sums shall be paid.

(c) Termination by Contractor

- i. If
 - the Owner has failed to pay the Contractor any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Contractor may give a notice to the Owner that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Owner to remedy the same, as the case may be. If the Owner fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within *[fourteen (14) days]* after receipt of the Contractor's notice, or
 - the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas or failure to obtain any governmental permit necessary for the execution and/or completion of the Facilities which the Owner is required to obtain as per provision of the Contract or as per relevant applicable laws of the country,

then the Contractor may give a notice to the Owner thereof, and if the Owner has failed to pay the outstanding sum, to approve the invoice or supporting documents, to give its reasons for withholding such approval, or to remedy the breach within *[twenty eight (28) days]* of such notice, or if the Contractor is still unable to carry out any of its obligations under the Contract for any reason attributable to the Owner within twenty eight (28) days of the said notice, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.

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- ii. If the Owner becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Owner takes or suffers any other analogous action in consequence of debt, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.
- iii. If the Contract is terminated, then the Contractor shall immediately
 - cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
 - terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d)(ii)
 - remove all Contractor's Equipment from the Site and repatriate the Contractor's and its Subcontractor's personnel from the Site
 - In addition, the Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as of the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
 - ✓ Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as of the date of termination in connection with the Facilities.
- iv. If the Contract is terminated, the Owner shall pay to the Contractor all payments, and reasonable compensation for all loss or damage sustained by the Contractor arising out of, in connection with or in consequence of such termination.
- (d) The expression "Facilities executed" shall include all work executed, Erection Services provided, any all Plant and Equipments acquired (or subject to a legally binding obligation to purchase) by the Contractor and used or intended to be used for the purpose of the Facilities, up to and including the date of termination.
- (e) In calculating any payment due from the Owner to the Contractor, account shall be taken of any sum previously paid by the Owner to the Contractor under the Contract, including any advance payment paid.

4.46 Assignment

The Contractor shall not, without the express prior written consent of the Owner, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Contractor shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Renovation & Modernization of Balance of Plant BOP) Package for [-----]
- **Bid Document No. :** [-----]
- **The Owner is:**
 - Name of Owner: [-----]
 - Address of Owner: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]
- **The Project Manager is:**
 - Name of Project Manager: [-----]
 - Address of Project Manager: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]

5.2 Effective Date

The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor.

The following three activities will be completed within [two (2)] months from the date of Letter of Acceptance:

- (a) The contract agreement will be executed by the Owner and the Contractor. (b) The Contractor will submit to the Owner the Contract Performance Bank Guarantee, any Additional Contract Performance Bank Guarantee by Consortium Partners if applicable, and the Advance Payment Bank Guarantee.
- (c) The Owner will pay the Contractor the Advance Payment as per the Terms of Payment.

The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Owner shall be as follows:

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Owner) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Owner may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

5.4 Liquidated Damage for Delay

5.5 Rate of Liquidated Damage for Delay

If the Contractor fails to successfully achieve completion of R&M activities and commissioning of the retrofitted facilities as per the scope of work within the time period specified in SCC, the Contractor shall pay to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

1.	Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	Liquidated Damage payable at the rate Rs.[.....] for each week of delay
2.	Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	Liquidated Damage payable at the rate Rs [.....] for each day of delay

The Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender are independent and shall be applied separately.

5.6 Liquidated Damage for Non-fulfilment of Functional Guarantees

If the Contractor fails to successfully achieve the Functional Guarantees during Performance Guarantee Test as per the Tender Specification, the Contractor shall pay

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

Sl. No.	Functional Guarantee Parameter	Rate of Liquidated Damage
1	Auxiliary Power	[-----]INR per kW increase
2	Cooling Tower Cold water Temp	[-----]INR per 0.25 ^o C increase
3	HCl Consumption in DM Plant	[-----]INR per kg increase
4	NaOH Consumption in DM Plant	[-----]INR per kg increase
5	[Pre-treatment Plant Chemical Consumption]	[-----]INR per kg increase
6	[NaCl Consumption in Softening Plant]	[-----]INR per kg increase
7	{Any Other Chemical, as applicable}	[.....]

The reference condition for Performance Guarantee Parameters shall be as per Volume-II Technical Specification.

The Liquidated Damage for non-fulfillment of the different Functional Guarantee Parameters are independent of one another and shall be applied separately.

{Note: The rate of LD for any functional guarantee parameter shall be at least 1.5 times the corresponding Bid Evaluation Factor, if applicable}

5.7 Maximum Leivable Liquidated Damages

The amount of Liquidated Damage for delay shall be limited to a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd)contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares. This limit is applicable for the Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender taken together.

The aggregate amount **of Liquidated Damage for non-fulfilment of functional guarantee shall be limited to** a maximum of 10 % of the total contracts price (i.e. sum of Ist and IInd component contract prices) including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The limit on maximum leivable Liquidated Damage for Delay and maximum leivable Liquidated Damage for non-fulfillment of functional guarantee are independent of each other and shall apply separately.

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5.8 Payment of Liquidated Damages

Contractor shall pay to the owner any Liquidated Damages that are payable as per the provisions of the Contract within thirty (30) days of receipt of Owner's invoice setting forth amount of Liquidated Damages that are then due and payable. If Contractor delays payment of Liquidated Damages that are payable under the provisions of the Contract beyond thirty (30) days, Owner, at its discretion, shall be entitled to recover such amounts by either setting off the relevant unpaid amount against any payment(s) due to the Contractor or by making a demand under Contract Performance Bank Guarantee.

5.9 Contract Price

- a) The Contract Price shall be as (Contract Price and Terms of Payment) of the Form of Contract Agreement.
- b) The Contractor shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

5.10 Terms of Payment

- a) The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement. The procedures to be followed in making application.
- b) No payment made by the Owner herein shall be deemed to constitute acceptance by the Owner of the Facilities or any part(s) thereof.
- c) The currency or currencies in which payments are made to the Contractor under this Contract to the Form of Contract Agreement, subject to the general principle that payments will be made in the currency or currencies in which the Contract Price has been stated in the Contractor's bid.

5.11 Contract Securities (Bank Guarantees)

- a) The Contractor shall provide the securities (Bank Guarantees) specified below in favour of the Owner at the times, and in the amount, manner and form specified below.
- b) Advance Payment Bank Guarantee
 - The Contractor shall, within *[thirty (30)]* days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to *[ninety (90)]* days beyond the date of Completion of Facilities.
 - The security shall be in the form of an Unconditional Bank Guarantee. The Advance Payment Bank Guarantee shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of equipment/facilities received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Facilities supplied and received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of those Facilities. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Contractor's responsibility and liabilities under the Contract including in respect of the Facilities for which the reduction in the value of security is allowed.
- c) Performance Security (Performance Bank Guarantee)

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- The Contractor shall, within [thirty (30)] days of the notification of award, provide a Bank Guarantee for the due performance of the Contract for ten percent (10%) of the Contract Price with an initial validity upto [ninety (90)] days beyond the Defects Liability Period. If the bidder is a Consortium of two or more firms, in addition to the Contract Performance Bank Guarantee (CPBG) of 10% of Contract price furnished by the Consortium Leader, each of the other consortium member will furnish Additional Contract Performance Bank Guarantee equal to 1% of Contract Price within [thirty (30)] days of the Notification of Award.
- The Bank Guarantee shall be denominated in the currency or currencies of the Contract, or in a freely convertible currency acceptable to the Owner.

5.12 Sequential Supply

The Contractor is required to supply the material and equipment under the Contract in a sequential manner as per the requirement at site for erection. If Contractor supplies any material/equipment ahead of the requirement as per the agreed Detailed Time Schedule, the Owner, at its discretion, may withhold progressive payment for such material/equipment till the time it is due for supply as per the agreed Detailed Time Schedule.

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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	Sample Format for Letter of Consent to be furnished by the Bidder and Consortium Partners
Annexure-E	NOT USED
Schedule F1 Table-1	Summary of Price Schedule
Schedule F1 Table-2	Price Schedule for Supply of Plant and Equipment Including Packing and Forwarding Charges
Schedule F1 Table-3A	Price Schedule for Mandatory Spares
Schedule F1 Table-3B	Price Schedule for Recommended Spares
Schedule F1 Table-4	Price Schedule for Tools & Tackles
Schedule F1 Table-5	Price Schedule for Erection Services Including Dismantling / Disassembly, Unloading, Handling, Storage, Preservation at Site, Erection, Testing, Commissioning and Performance Guarantee Tests of Plant and Equipment
Schedule F1 Table-6	Price Schedule for Civil works
Schedule F1 Table-7	Price Schedule for Training Charges
Schedule F1 Table-8	Schedule of Performance Guarantee Parameters
Schedule F2	Overall Time Schedule
Schedule F3	Deviation Schedule to Tender Document Vol-I Commercial
Schedule F4	Deviation Schedule to Technical Specification
Schedule F5	Requirements of the Contractor at Site
Schedule F6	Contractor's Resource Deployment Schedule

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Schedule F7	Coefficients and Indices for Price Variation Formula
II	Forms and Appendices to form part of Contract
Annexure-F	Form of Contract Agreement
Contract Schedule-1	Terms of Payment
Contract Schedule-2	Price Adjustment
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Approved Subcontractors
Contract Schedule-5	Scope of Works and Supply by the Owner
Contract Schedule-6	Functional Guarantees
Contract Schedule-7	Quality Assurance
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Bank Guarantee

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.: Bank Guarantee No:
Date :

To:
 [Details of Designated Official]
 [-Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [.....] dated [.....] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [.....] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [Name of package and R&M project], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [.....] (in words and figures) valid for 300 days from [.....] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [.....] Bank at (local address) [.....] having our Head Office at [.....] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of [.....] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

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This Guarantee shall be irrevocable and shall remain valid upto [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorised officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
 Name :
 Designation :
 Staff Code No. :

Banker's Seal :
 Date :

Witness:

1. Signature :
 Full name in block letters :
 Designation :
 Address :

2. Signature :
 Full name in block letters :
 Designation :
 Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[-Name of Utility] [.....]

Sub : ____ (Name of Package) [.....]

Tender

No.

[.....]

Having carefully examined the Tender Specifications issued to us for your Tender No. [.....] dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the 'works' in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification. The plant, equipment and systems offered are of the best and latest technology and of international standards.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR _____ (Indian Rupees [.....] only)/ _____ in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of 180 (One Hundred Eighty) days from the date of opening of bids by Owner and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to [Name of Utility], assignees or authorized nominees such sums of money as are stipulated in conditions contained in Tender Specification and agree to furnish Bank Guarantee for Contract Performance as per the proforma prescribed by Owner and for

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the sum equal to 10% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Owner is not bound to accept the lowest or any Bids received and Owner has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Owner and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From:

Dated:

[-----]
[-----]
[-----]

To :

[-----]
[-----]
[-----]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire works as described in the specifications in conformity with the specifications and Tender Specifications, as per prices quoted by us in the Schedule of Prices and Schedule of Performance Guarantees [Schedule] enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Ownerr [Name of Utility] and for the sum equal to 10% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Owner is received and accepted by the Owner.

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

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1. Signature
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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ANNEXURE – D
(SAMPLE FORMAT)

LETTER OF CONSENT

TO BE FURNISHED BY THE BIDDER and CONSORTIUM PARTNERS

We hereby declare that the undersigned firm [-----] (Name and Complete address of the Associate(s) / Consortium Partners / Individual Companies of the Group) hereby agrees to associate with [-----] (Name and Complete address of the Bidder) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Bidder and Associate / Consortium Partner / Individual Companies of the Group) [-----] Package for the [-----] Project at [-----] in the state of [-----], India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of [-----] package, fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Owner's Project site.

On award of LOA, we the Consortium Partners agree to furnish an on demand back up bank guarantee for 5 % for our portion of work.

1. Witness

For Consortium Partner

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address

Seal of the Company

2. Witness

For Bidder

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address:

Seal of the Company:

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ATTACHMENT TO THE LETTER OF CONSENT
Scope of Work of the Each Consortium Partner:

For Bidder

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

For Each Consortium Partner

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

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**ANNEXURE – E
NOT USED**

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

SCHEDULE – F1: TABLE - 1

SUMMARY OF PRICE SCHEDULE

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.1	NOT USED		
1.2	NOT USED		
1.3	NOT USED		
1.4	NOT USED		
2.	NOT USED		
3.	Supply of Plant & Equipment including Technological and misc. structures with all accessories (Ex-Works) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum price basis.		
4.	Sales Tax Payable on Indigenous equipment - on Ceiling basis. (a) VAT (b) Central Sales Tax (CST)		
5.	(a) Inland transport of imported plant & equipment on lumpsum and firm price basis.		
	(b) Inland transport of Indigenous plant & equipment on lumpsum and firm price basis		
6.	Lumpsum price for Civil Works including, supplies such as cement, reinforcement steel etc.at site cost, including Design & Engineering and Construction of entire Civil works.		
7.	Erection services including dismantling/disassembly, unloading, handling, storage and preservation at site, Erection, testing, commissioning and PG tests of plant & equipment on lumpsum price basis		
8.	Marine cum erection insurance on lumpsum and firm price basis		
9.	NOT USED		
10.	Training charges on firm price basis with ceiling.		
11.	VAT on Works Contract on ceiling basis		
12.	Service Tax including Education Cess on Ceiling basis		

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(In Figures and Words)

S.No.	Description	Foreign Currency	INR
13.	Others, if any (Please specify),		
14.	Total price of package (excluding mandatory spares and Tools & Tackles. (Total of Sl.Nos.1.4 + 2 to 13).		
15.	Mandatory Spares on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-3)		
16.	Tools & Tackles on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-4)		
17.	Grand total price of package including Mandatory Spares and Tools & Tackles. (Total of SI Nos 14+15+16).		

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

Document Number	Rev No	Description	Page No.	Date of Issue
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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SCHEDULE – F1: TABLE - 2

**PRICE SCHEDULE FOR SUPPLY OF PLANT AND EQUIPMENT INCLUDING
PACKING AND FORWARDING CHARGES**

S.No.	Description	
		Supply Ex-works price including packing and forwarding
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		

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S.No.	Description	Supply Ex-works price including packing and forwarding

	Sub Total (3)	
4	Total (1 + 2 + 3)	

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3A
PRICE SCHEDULE FOR MANDATORY SPARES

S. No.	Description	Price
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2	NOT USED	
3	Supply (Ex-works) of Mandatory Spares including Packing and Forwarding on lumpsum and Firm Price	
4.	a) NOT USED.	
	b) Inland transport on lumpsum and firm price basis.	
5	Insurance (Lumpsum and firm price basis)	
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7	Total price of Mandatory Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3B
PRICE SCHEDULE FOR RECOMMENDED SPARES

S. No.	Description	Price
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2	NOT USED	
3	Supply (Ex-works) of Recommended Spares including Packing and Forwarding on lumpsum and Firm Price	
4.	a) NOT USED.	
	b) Inland transport on lumpsum and firm price basis.	
5	Insurance (Lumpsum and firm price basis)	
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7	Total price of Recommended Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-4
PRICE SCHEDULE FOR TOOLS & TACKLES

S. No	Description	Indigenous Price in INR
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2.	NOT USED	
3.	Supply (Ex-works) of Tools and Tackles including Packing and Forwarding on Lumpsum and firm Price	
4.	a) NOT USED.	
	b) Inland transport for indigenous items on lumpsum and firm price basis.	
5.	Insurance (lumpsum and firm price basis)	
6.	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7.	Total price of Tools and Tackles (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-5

**PRICE SCHEDULE FOR ERECTION SERVICES INCLUDING
DISMANTLING/DIASSEMBLY, UNLOADING, HANDLING, STORAGE,
PRESERVATION AT SITE, ERECTION, TESTING, COMMISSIONING AND
PERFORMANCE GUARANTEE TESTS OF PLANT AND EQUIPMENT**

(In Figures and Words)

S.No.	Description	Total Price for complete work at Site
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		
	Sub Total (3)	
4	Total (1 + 2 + 3)	

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Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 6

PRICE SCHEDULE FOR CIVIL WORKS

S.No.	Description	PRICE
1.		
2		
3		
4		
5		
.....		
.....		
	Total	

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 7

PRICE SCHEDULE FOR TRAINING CHARGES

S.No.	Description	PRICE
1.		
2		
3		
4		
5		
.....		
.....		
	Total	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 8

SCHEDULE OF PERFORMANCE GUARANTEE PARAMETERS

The Bidder shall furnish performance guarantee of the Package in respect of all items listed below.

Category – I: Performance Guarantees under Liquidated Damages [L.D]

S. No	Particulars	Unit	Value inclusive of design, manufacture and all other Tolerances including measurement uncertainty
1			
2			
3			
.....			
.....			

Category – II: Mandatory Performance Guarantees

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			

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S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
3			
.....			
.....			

Category -III: Requirement under Demonstration Category

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			
3			
....			
.....			
.....			

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F2
OVER ALL TIME SCHEDULE
(Bidder to fill-in and submit with its Bid)

S.No	Work Description	Days from Effective Date	
		Start	Finish
1	Design & Engineering		
2	Manufacture of Plant/Equipment		
	(a)		
	(b)		
	(c)		
		
		
3	Delivery of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
4	Dismantling/Disassembly of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
5	Civil work at Site		
6	Erection of of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
7	Trial Operation & Provisional Take Over		
8	Performance Guarantee tests Completion and Final Take Over		

Signature :

Name :

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---	-------------------

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I) . The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I) , then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SCHEDULE – F4

DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Owner's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Owner's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F5
REQUIREMENTS OF THE CONTRACTOR AT SITE
(Bidder to fill-in and return with its Bid)

The Bidder shall state his requirements against each of the following including the basis of requirements:

A.	Requirements Description	Quantity

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE - F6
CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE

A) Construction Equipment

The Bidder shall indicate the schedule of construction equipment, proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
1									
2									
3									
...									
...									

B) Resource Deployment Schedule

The Bidder shall indicate the schedule of manpower resources proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
2.	Human Resources								
2.1	Engineering Category								
2.1.1	Project Engineers								
2.1.2	Mechanical Engineers								
2.1.3	Electrical Engineers								
2.1.4	Civil Engineers								
2.1.5	C&I Engineers								
2.1.6	Commissioning Engineers								
2.1.7	Structural Engineers								
2.1.8	Others (bidder shall indicate) as applicable for the work								
2.2	Supervisory Category								
2.2.1	Const. Manager								
2.2.2	Electrical Supervisors								
2.2.3	Mechanical Supervisors								
2.2.4	C&I Supervisors								
2.2.5	Civil Supervisors								
2.2.6	Purchase Officer (s)								
2.2.7	Finance/Site Office								
2.2.8	Inspection/Quality Control								
2.2.9	Others (Bidder shall indicate) as applicable for the work								

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S. No.	Type of Resource	Months						
2.3	Labour Category							
2.3.1	Welder							
2.3.2	Fitter							
2.3.3	Rigger							
2.3.4	Un-skilled labour							
2.3.5	Others (Bidder shall indicate) as applicable for the work							

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F7
COEFFICIENTS AND INDICES FOR PRICE ADJUSTMENT FORMULA

Ex-Works price component of Plant and Equipment excluding mandatory spares				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Erection Services Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Civil Works Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Note: Bidder to fill up value of all Coefficients, names of indices and value of indices on the base date for Price Adjustment as per Contract Schedule-2. This schedule must be submitted along with Part-I Bid (Techno Commercial Bid) Bidders to use continuation sheets if required.

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Form of Contract Agreement

Form of Contract Agreement

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THIS CONTRACT AGREEMENT is made the _____day of _____, 20_____.
 BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of [country of Employer] and having its principal place of business at [address of Employer] (hereinafter called “the Employer”), and (2) [name of Contractor], a corporation incorporated under the laws of [country of Contractor] and having its principal place of business at [address of Contractor] (hereinafter called “the Contractor”)

WHEREAS the Employer desires to engage the Contractor to dismantle/disassemble, design, manufacture, test, deliver, install, complete and commission certain Facilities, viz.

[.....]
 [.....]
 [.....]

(“the Facilities”) and the Contractor have agreed to such engagement upon and subject to the terms and conditions hereinafter appearing.

NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

a) Contract Documents means this signed Contract agreement and its annexure/appendices, and the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. The following will constitute the Contract Documents:

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing.
- vi. The bid & its schedules/ attachment submitted by the contractor.

a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.

b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender.
- vi. The bid & schedules/ attachment Drawing submitted by the contractor.

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1.3 Definitions

The Definitions of terms and expressions shall be as per GCC clause 4.1. Terms and expressions not defined in GCC shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder:
The Contract Price shall be the aggregate of: [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Employer shall be as follows:

1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Employer) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Employer may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

The detailed Time Schedule shall be as per Contract Schedule 2.

Contract Schedules

The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

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Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]

-----[Title]

In the presence of -----

Signed by for and on behalf of the Contractor

-----[Signature]

-----[Title]

In the presence of -----

CONTRACT AGREEMENT

dated the -----day of-----, 20_-----

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

- Contract Schedule 1 : Terms of Payment
- Contract Schedule 2 : Price Adjustment
- Contract Schedule 3 : Time Schedule
- Contract Schedule 4 : List of Approved Subcontractors
- Contract Schedule 5 : Scope of Works and Supply by the Employer
- Contract Schedule 6 : Functional Guarantees
- Contract Schedule 7: Quality Assurance

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Contract Schedule-1

Terms of Payment

The Employer shall pay the Contractor in the following manner and at the following times, on the basis of the Price Break down given in the Section on Price Schedules. Payments will be made in the currencies quoted by the Bidder unless otherwise agreed between the parties. Application for payment in respect of part deliveries may be made by the Contractor as work proceeds.

I. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares):

1	10% of the total Ex-Works price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	50% of Ex-Works price for each identified equipment as progressive payment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of Ex-Works price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer
4	20% of the total Ex-Works price	On Completion of Facilities
5	5% of the total Ex-Works price	Successful completion of Performance Guarantee Test

II. Terms of Payment for Supply of Mandatory Spares and Recommended Spares

1	70% of the Ex-Works Price of each Spare	Upon dispatch of the identified Spare after dispatch clearance by employer on raising of invoice by the Contractor and submission of evidence of shipment
2	30% of the Ex-Works Price of each Spare from within India	On receipt of Spare at site and physical verification and certification by the Employer

III. Terms of Payment for Local Transportation, Inland Transit Insurance

For Plant & Equipment except Spares		
1	100% of Local Transportation, Inland Transit Insurance pro-rata to value of the equipment	On receipt of Equipment at site and upon raising of Invoice by the Contractor
For Spares		
2	100% of Local Transportation, Inland	On receipt of Spare at site and upon

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	Transit Insurance pro-rata to value of Spare	raising of Invoice by the Contractor
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IV. Terms of Payment for Erection of Plant & Equipment

1	10% of Total Price for Erection of Plant & Equipment	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Erection of Plant & Equipment as progressive payment pro-rata to value of plant & equipment erected	On certification by Employer of successful erection of plant & equipment and successfully passing of quality checks
3	10% of Total Price for Erection of Plant & Equipment	On Completion of Facilities
4	5% of Total Price for Erection of Plant & Equipment	Successful completion of Performance Guarantee Test

V. Terms of Payment for Civil Works

1	10% of Total Price for Civil Works	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Civil Works as progressive payment	On certification by Employer regarding value of work completed & successfully passing of quality checks
3	10% of Total Price for Civil Works	On Completion of Facilities
4	5% of Total Price for Civil Works	Successful completion of Performance Guarantee Test

VI. Terms of Payment for Price Adjustment Amount

Any increase in the Price of any component Contract shall be paid as per the Terms of Payment for base price. The initial 10% advance payment pertaining to increase in price shall be paid along with progressive payment of that equipment. Reduction to the Contract Price, if any, due to price adjustment provisions, shall be effected by recovering 100% of the reduction amount (including advance) from any of the Contractor's bills falling immediately due for payment.

VII. Terms of Payment for Taxes & Duties

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Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other Tax or Duty payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon receipt of corresponding Plant & Equipment or Spare at site and submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such Taxes & Duties.

VIII.

Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such variation.

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Contract Schedule-2

PRICE ADJUSTMENT

- (i) The Contract Price shall be subject to price adjustment during performance of the Contract to reflect changes in the cost of labour and material in accordance with the provisions described below.
- (ii) Only following components of the Contract Price will be subject to Price adjustment :
 - (a) Ex-Works (India) price of plant and equipment excluding Mandatory Spares. The price adjustment amounts towards these price components shall be without any ceiling.
 - (b) Erection Services component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
 - (c) Civil Works component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
- (iii) Price adjustment amounts towards aforesaid components of Contract Price shall be paid in the respective currencies of Contract.
- (iv) The indices for price adjustment shall necessarily be of India and shall be well established and nationally recognized in India. Preferably Government indices shall be used.
- (v) The price adjustment formula for the components of the Contract Price above shall be as stipulated hereinafter.
- (vi) **Ex-Works price component of Plant and Equipment excluding mandatory spares**

The price component of the equipment for any shipment/ dispatch comprises of a fixed portion (designated as 'F' and the value of which is specified hereunder) and a variable portion linked with the indices for various materials and labour.

The amount of price adjustment towards variable portion payable/recoverable on each shipment/dispatch shall be computed as under :

$$ES = ES_1 - ES_0$$

ES₁ will be computed as follows:

$$ES_1 = ES_0 \left\{ F + a \times \frac{A_1}{A_0} + b \times \frac{B_1}{B_0} + c \times \frac{C_1}{C_0} + Lb \times \frac{L_1}{L_0} \right\}$$

Where

ES = Adjustment to Ex-Works component expressed in the currency of the Contract payable to the contractor for each shipment/dispatch

ES₁ = Adjusted amount of Ex-works price component expressed in the currency of the Contract payable to the Contractor for each shipment/dispatch

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- ES₀ = Ex-works for the plant and equipment in the currency of the Contract, shipment/dispatch wise.
- The fixed portion of the ex-works component of the Contract Price (F) shall be 0.15.
 - a, b,c etc. shall be co-efficient of major materials/items involved in the ex-works component of the Contract Price. The sum of these co-efficient shall be between 0.50 to 0.60.
 - A, B, C etc. shall be published price indices of corresponding major materials/items. Such indices shall necessarily be of India.
 - 'Lb" shall be co-efficient for labour component in the ex-works of the Contract Price which shall be between 0.25 to 0.35.
 - 'L' shall be labour index.
 - Sum of all the material co-efficient and the labour co-efficient shall be 0.85.

For the indices(A, B, C etc.), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid.

Subscript '1' refers to indices/exchange rates as of:

(a) three months prior to the date of shipment/dispatch for labour, and

(b) six months prior to the date of shipment/dispatch for material.

In case of shipments/dispatches which are delayed beyond the schedule date of shipment/dispatch for reasons attributable to the Contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of shipment/dispatch and the actual date of shipment/dispatch.

(vii) Erection Services Component

The price component for erection services comprises of a fixed portion and a variable portion linked with the index of labour.

$$ER = ER_1 - ER_0$$

ER₁ will be computed as follows:

$$ER_1 = ER_0 (0.15 + 0.85 \frac{FL_1}{FL_0})$$

Where:

ER	=	Adjustment to erection services component of contract price payable to the contractor for each billing.
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ER ₁	=	Adjusted amount of erection services component of Contract Price payable to the Contractor.
ER ₀	=	Value of the Erection work done in the billing period (month)
FL	=	Indian field labour index namely, All India Consumer Price Index for Industrial Workers (All India Monthly Average) as published by Labour Bureau, Simla, Government of India.

For the indices, subscript 'o' refers to indices as on 30 days prior to date set for opening of Part-I bids. .

For the indices, subscript '1' refers to the indices as applicable for the month of execution of the erection work. For the exchange rates, subscript '1' refers to the exchange rates as applicable on the last day of the month of execution of the erection work.

In case of erection activities which are delayed beyond the schedule date for reasons attributable to the contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of completion and actual date of completion of the respective erection activity.

(viii) The following components of the contract price shall not be subject to price adjustment and shall remain firm during the execution of the contract :

- (1) Ocean Freight and Marine Insurance for Plant and Equipment, mandatory spares and recommended spares.
- (2) Price for Mandatory spares & Recommended Spares.
- (3) Inland Transportation charges (including Inland Transit Insurance, port clearance, port handling & port charges) for plant & equipment and Spare Parts.

(ix) Civil Works Component

The Price of Civil Works for any month comprises a fixed part designated as 'F' and variable parts linked to indices for labour, steel, cement, other commodities and Fuel & Power. The monthly price adjustment amount for the civil works component of the Contract Price will be computed as per the formula given below:

$$EC = EC_1 - EC_0$$

EC₁ will be computed as follows:

$$EC_1 = EC_0 \left\{ F + a \times \frac{MI_1}{MI_0} + b \times \frac{LI_1}{LI_0} + c \times \frac{FI_1}{FI_0} + d \times \frac{SI_1}{SI_0} + e \times \frac{CI_1}{CI_0} \right\}$$

Where

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- EC = Adjustment to Civil Works price component expressed in the currency of the Contract payable to the contractor for each month
- EC₁ = Adjusted amount of Civil Works price component expressed in the currency of the Contract payable to the Contractor for each month
- EC₀ = Value of Civil Works done expressed in the currency of the Contract for the billing period (month).
- The fixed portion (F) of the Civil Works component of the Contract Price shall be 0.15.
 - 'a' is the coefficient for material cost other than cement and steel involved in the Civil Works component of the Contract Price and it shall be 0.15.
'b' is the coefficient for labour cost involved in the Civil Works component of the Contract Price and it shall be 0.3.
'c' is the coefficient for Fuel & Power cost involved in the Civil Works component of the Contract Price and it shall be 0.05.
'd' is the coefficient for steel cost involved in the Civil Works component of the Contract Price and it shall be 0.25.
'e' is the coefficient for cement cost involved in the Civil Works component of the Contract Price and it shall be 0.10.
 - MI shall be All India Whole Sale Price Index for all commodities as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry.
LI shall be All India Consumer Price Index for industrial labour as published by Labour Bureau, Government of India
FI shall Index Number of Wholesale Price for group Fuel & Power as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry
SI shall Index Number of Wholesale Price for Steel as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry
CI shall Index Number of Wholesale Price for Cement as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

For the indices(MI, LI,FI, SI and CI), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid. Subscript '1' refers to indices as of one prior to the month for which Civil Works is being billed.

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Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

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Contract Schedule-4
LIST OF SUB-CONTRACTORS
[List of approved subcontractors shall be placed]

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Contract Schedule-5

SCOPE OF WORKS AND SUPPLY BY THE EMPLOYER

[Scope of Works and Supply by the Employer shall be placed]

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Contract Schedule-6
FUNCTIONAL GUARANTEES
[Functional Guarantees shall be placed]

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Contract Schedule-7
QUALITY ASSURANCE

[After Letter of Award (LOA), the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall]

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Contractor]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:	Bank Guarantee No:	Date:
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To:

[Name & Address of Owner (Utility)]

.....
]

Dear Sirs,

1 In consideration of the [.....] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Contractor's Name] having its registered office at.....hereinafter referred to as the 'CONTRACTOR', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures] and the same having been unequivocally accepted by the CONTRACTOR and the CONTRACTOR having agreed to provide a **Contract Performance Bank Guarantee** for the faithful performance of the entire CONTRACT including the Warranty Obligations /Liabilities under the CONTRACT equivalent to 10% (ten percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONTRACTOR by reason of any breach of the said CONTRACTOR of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to Rs.....(Rupees.....only). Any

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such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONTRACTOR or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The Bank further irrevocably guarantees and undertakes to pay any amount due and payable by the CONTRACTOR by reasons of non-fulfilment of any of the following obligations of the Contractor:
 - (a) Successful and satisfactory operation of the plant & equipment supplied and erected under the said Contract as per the Technical Specifications and other Tender/Contract documents.
 - (b) That the equipment installed under the said Contract shall be new and in accordance with Contract Documents and be free from all defects in design, engineering, material workmanship and performance for a period of 12 calendar months after final takeover of the equipment by the OWNER and that upon written notice from the OWNER, the CONTRACTOR shall remedy free of any expense to the OWNER, such defects as noticed and developed under the normal use of the said plant & equipment, within the said guarantee period.
- 4 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONTRACTOR. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 5 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONTRACTOR and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONTRACTOR or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 6 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONTRACTOR to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 7 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Contractor or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 8 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONTRACTOR's liabilities.

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- 9 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONTRACTOR(S).
- 10 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended from time to time for such period as may be desired by [Name of Contractor.....] on whose behalf this guarantee has been given.
- 11 Signed at.....this.....day of.....20.....

Signature :
Name :
Designation :
Staff Code No :

Bank Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**PREPARED BY
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MASTER INDEX (ALL VOLUMES)

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

BALANCE OF PLANT (PACKAGE NUMBER: R&M-SP-03)

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RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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ABBREVIATIONS TO BE USED

{The utilities are advised to use the following standard abbreviations while preparing Model Tender Document for their power plant.}

AAQ	Ambient Air Quality
ACB	Air Circuit Breaker
ACF	Activated Carbon Filter
ACG	Automatic Control Gear
AHP	Ash Handling Plant
AHU	Air Handling Unit
ASME	American Society of Mechanical Engineers
AVR	Automatic Voltage Regulator
BOP	Balance of Plant
CAVT	Cold Air Velocity Air Flow Test
CBD	Continuous Blow Down
CCTV	Closed Circuit Television
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CHP	Coal Handling Plant
CLCS	Closed Loop Control System
COC	Cycle of Concentration
CT	Cooling Tower
CV	Control Valve
CW	Cooling Water

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DBT	Dry Bulb Temperature
DCDB	Direct Current Distribution Board
DDCMIS	Digital Distributed Control Monitoring Information System
DGA	Dissolved Gas Analyser
DM	Demineralization
DMCW	Demineralized Cooling Water
DP	Differential Pressure
ELCID	Electromagnetic Core Imperfection Detection
EOT	Electrically Operated Traveling Crane
ETP	Effluent Treatment Plant
EWS	Engineer's Work Station
FO	Fuel Oil
GCV	Gross Calorific Value
HP	High Pressure
HT	High Tension
HVAC	Heating, Ventilation and Air Conditioning
HVWS	High Velocity Water Spray System
IBD	Intermittent Blow Down
I/O	Input / Output
IPR	Inter Posing Relay
ISMB	Indian Standard Medium Beam
LDO	Light Diesel Oil
LE	Life Extension

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LP	Low Pressure
LT	Low Tension
LTSH	Low Temperature Super Heater
LVS	Large Video Screen
MB	Mixed Bed
MCCB	Module Case Circuit Breaker
MOCB	Minimum Oil Circuit Breaker
MoEF	Ministry of Environment & Forest
OPC	Object linked embedded Process Control
OWS	Operator Working Station
PHE	Plate Type Heat Exchanger
PLF	Plant Load Factor
PLC	Programmable Logic Controller
PRDS	Pressure Reducing De-superheating Station
PSF	Pressure Sand Filters
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RLA	Residual Life Assessment
RO	Reverse Osmosis
RTD	Resistance Temperature Detector
SAC	Strong Acid Cation
SBC	Strong Base Anion

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TFT	Thin Film Transistor (Monitor)
TMCR	Turbine Maximum Continuous Rating
TPS	Thermal Power Station
TR	Tons of Refrigeration
TC	Thermocouple
UCR	Unit Control Room
UPS	Uninterruptible Power Supply
VVVFD	Variable Voltage and Variable Frequency Drive
WBT	Wet Bulb Temperature

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1 INTENT OF SPECIFICATION

- 1.1 The intent of this specification is to Renovate and Modernize various equipment & systems of Mechanical Balance of Plant (BOP) including but not limited to *[Plant Water System consisting of Raw Water Intake System, Raw Water Pump House, Pre-Treatment Plant, DM Plant, CW system including Cooling Towers, ACW System, CW Treatment System, Service Water System, Chlorination Plant, Chemical Laboratory, Effluent Treatment Plant and other BOP Systems like Compressed Air System, Fuel Oil Systems, Fire Fighting System, HVAC System, Continuous Stack Emission Monitoring System, Miscellaneous mechanical System, all associated Electrical system, Control & Instrumentation systems and Civil & Structural work]*. The renovated Mechanical Balance of Plant shall be capable of operating with the parameters as detailed in various clauses of this specification and will be compatible with the Main Plant System of the Plant consisting of *[2 (Two) Units]*, each is intended to give the output of *[210/215/220/250] MW*.
- 1.2 The Bidder shall carry out the required replacement / refurbishment / retrofitting of the various equipment/systems of BOP package as per the requirements of his design so as to make the same capable of operating for an extended life of *[20/25]* years and producing the specified output parameters mentioned in the subsequent clauses at this specification in order to be compatible with the requirement of Main Plant package. The scope of replacement / refurbishment / retrofitting shall include but shall not be limited to the scope of work mentioned in clause 4.6 which is based on the recommendation of RLA/CA and EA studies conducted during *[.....]*. However, any other items/systems which have not been specifically mentioned but are considered necessary by the Bidder for giving the intended performance of various equipment/systems of BOP package, shall also be included in the scope of Bidder and shall be separately highlighted by the Bidder in his proposal.
- 1.3 Bidders are required to quote the performance guarantee values for Auxiliary power consumption, Chemical Consumption and Cooling Tower Cold Water Temperature in response to the minimum/maximum performance parameters specified in the Table 1.1 below.

Table: 1.1

S. No.	Parameter	Performance Guarantee Values
1	Maximum Auxiliary Power Consumption (kW)	<i>[.....]</i>
2	Maximum HCL Consumption	<i>[.....]</i>
3	Maximum NaOH Consumption	<i>[.....]</i>

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

4	Maximum NaCl Consumption, if applicable	[....]
5	Maximum Cooling Tower Cold Water Temperature (deg C)	[....]

- 1.4 Bidders to note that in case performance guarantee values quoted for Cooling Water Temperature is inferior to the specified values, the bids will be considered as non responsive. In case of Auxiliary power consumption, Chemical Consumption, NaCl Consumption, the best quoted value shall be considered as base parameter and other bids shall be cost loaded as per difference between base parameter and respective quoted guaranteed parameter multiplied by evaluation factors specified in the Commercial Volume (Volume-I). The modified/replaced/retrofitted equipment will conform to the requirement of the specification provided in Section-II of Volume-II. The relevant technical details like OEM's Specifications and Drawings for the existing equipment required to be modified / replaced / retrofitted have also been provided in Volume-II, Section-II for the reference of the Bidders.
- 1.5 Bidders are required to carry out necessary modifications / replacement in the existing mechanical / electrical equipment or systems including related civil/structural works as per specification requirement and also based on their own assessment.
- 1.6 The scope of work for R&M shall include designing / re-designing, basic and detailed engineering, re-engineering, refurbishing / retrofitting, supply, inspection and testing at supplier's works, packing, forwarding to site, forwarding from site to Bidder's facilities, unloading and storage at site, pre-assembly, machining if required, site fabrication, erection, replacing of various equipment and systems, application of paints and thermal insulation, carrying out all pre-commissioning checks/ tests and any other work required to complete the system, commissioning and trial operation, performance tests of various equipment and systems covered under this Specification. Bidder's scope shall also include dismantling of the existing equipment/ facilities, including unloading & transportation to designated storage / disposal yard, wherever required as a result of augmentation of existing mechanical, electrical, I&C and civil/structural/ architectural works. The Bidder shall restore the equipment/ facilities, whenever applicable, after carrying out necessary renovations/modifications under the scope of R&M works.
- All the tools & tackles, labour and other facilities required for dismantling and restoration shall also be in the scope of the Bidder.
- Bidder shall also put back into service all the systems/equipment of the units after completion of R&M works, whether any modification is carried out on the same or not. All necessary tools, tackles, labour, instruments, spares, consumables etc. required for putting back into operation shall also be provided by the Bidder.

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- 1.7 It is not the intent to specify completely herein all aspects of services and equipment to be provided by the Bidder who in any case shall be responsible for fulfillment of the intent of Specification. Irrespective of whether specifically mentioned or not, the services, equipment and systems to be provided in accordance with this Specification shall also form a part of the scope of work and shall conform in all respects to the highest standard of engineering, design, quality and workmanship so that after completion of R&M work by the Bidder, the plant shall be capable of performing completely in a safe, reliable and sustained manner as acceptable to the Owner.
- 1.8 Unless otherwise specifically clarified by the Owner, interpretation by the Owner in respect of scope of supplies & services and the meaning of the Specifications, drawings, requirements of operation, maintenance, redundancy etc., shall be final and binding on the Bidder. Owner shall have the right to reject or accept any work or material which in his assessment is not technically complete and proven to meet the requirements of this Specifications and/or applicable National and International Codes & Standards mentioned elsewhere in this Specification.
- 1.9 The requirements, conditions, appendices etc, given in various parts/ sections of technical Specifications shall form integral part of this Specification. Bidder is required to carefully examine and understand the Specifications and seek clarifications, if required, to ensure that he has understood the Specifications as intended by the Owner. In the absence of any specific clarifications made to the Owner during Bidding stage, the interpretation of Owner shall be final. The Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. All such points are required to be clarified & resolved during Bidding stage.
- 1.10 Any deviation or variation from the scope of supply and services or the intent of the Specification shall be clearly brought out under the schedule of Technical / Commercial deviations, irrespective of the fact that such deviation / variation may be standard practice or possible interpretation of the Specifications by the Bidder. In case, no clear and specific deviation is taken by the Bidder in the relevant schedule of Bid Proposal Sheet while making his Bid proposal, it will be construed that the Bidder shall comply with the stipulations of the Specification fully with regard to scope of services and supplies to be provided by him to achieve the objective of R&M. Further, unless otherwise specifically clarified by the Owner, the interpretation by the Owner in respect of scope of supplies and services to be performed by the Bidder shall be final and binding.
- 1.11 If the Bidder feels that, in his opinion certain features brought out in his offer are superior to what has been specified, these may be highlighted separately in the Bid. The Bidder at his own discretion may also make Alternate offers, which in his opinion

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are of superior technology, material etc. to the specified requirements leading to better performance like efficiency / output etc. of the units after renovation. In such case, the Bidder shall carry out a comprehensive study and clearly identify the scope of offer in his alternate proposal. The Bidder shall furnish that detailed study to Owner along with the Bid where the Bidder shall bring out in detail the scope of modifications required to be carried out by him in the various systems and equipment including but not limited to *[Plant Water System consisting of Raw Water Intake System, Pre-Treatment Plant, DM Plant, CW system including Cooling Towers, ACW System, Effluent Treatment Plant and other BOP Systems like Compressed Air System, Fuel Oil Systems, Fire Fighting System, HVAC System, Continuous Stack emission Monitoring System, Miscellaneous mechanical System, all associated Electrical system, Control & Instrumentation systems and Civil & Structural work]*.

Such Alternate proposals shall be supplemented with sufficient amount of information like specified design standards and performance requirements, Bidder's experience, operating feedback, provenness, etc. for justifying such proposals. Implications of such Alternate offers on the performance, output, efficiency, auxiliary power consumption, etc. shall be clearly brought out in the Bid to enable the Owner to determine the advantages, superiority and acceptability of the proposals.

However the Bidder's Base offer shall necessarily be in line with the Specification requirements. Under no circumstances the equipment and services as specified shall be brought out as an Alternate offer.

The Base offers will be evaluated as per procedure outlined in the Bid documents and the Alternate Offers of the lowest evaluated Bidder will only be considered for acceptance or otherwise. Owner may reject alternative proposals submitted by the Bidder at his sole discretion, without assigning any reason what so ever.

- 1.12 In the event of conflict between requirements of any two clauses of the Specification documents or requirements of different Codes/ Standards specified, the more stringent requirement as per the interpretation of the Owner shall apply, unless confirmed otherwise by the Owner in writing.
- 1.13 The General technical conditions pursuant to the Contract, placed separately in this Specification, shall form an integral part of the Specification. These conditions shall supplement all the detailed technical Specification and requirement identified in this Specification.
- 1.14 Out of complete unit comprising of mechanical, electrical, C&I systems and equipment, some components/systems are envisaged to be replaced with new ones having better design features while some of the other components are to be refurbished / upgraded by the Bidder under present R&M Work. It shall be the responsibility of the Bidder to ensure that components/ equipment/ systems being supplied new OR components/

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equipment/ systems being refurbished / upgraded by him are fully compatible and integrated with the existing equipment / systems so as to give safe, reliable and sustained operation of the complete unit. Modifications needed on the assembled equipment to ensure complete integration are to be brought out by the Bidder in the Bid and such modifications, if any, after Owner's approval shall be carried out by the Bidder to the satisfaction of the Owner.

- 1.15 The systems shall operate without any restriction over the entire range of operating conditions as envisaged in the subsequent section of the Specification. The Bidder shall ensure that after R&M there are no restrictions/ alterations in modes of operations of the system, as per the original/existing operation philosophy.
- 1.16 As the various equipment/ systems/ components are to be fitted in the existing plant, Bidder is advised to visit the plant site to get fully conversant with the job, site conditions, and constraints, and collect all the information as required and as available before quoting against this Specification.
- 1.17 A brief extract of the existing plant, the original design details/ performance parameters along with plant details, operating history and known problem areas; wherever possible are brought out in the successive section of this Specification. Relevant plant layout drawings and certain key schematic drawings, as available, have also been provided in Annexure-I of this section of the specification for the purpose of familiarization & guidance only. The successful Bidder shall prepare and provide the additional drawings and documents describing the design and engineering details and the manuals for carrying out erection, commissioning and operation of the renovated unit.

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2 SITE & PROJECT SPECIFIC INFORMATION

2.1 Project Name

Project Title: [...]

Existing Capacity: [X xMW]

2.2 Project Location

The proposed project site is located at [...], in District [...] in the state of [...]. The location details of the project site are as indicated below:

Table: 2.1

Particulars	
Latitude	[... ° ... ' ..."] N
Longitude	[... ° ... ' ..."] E
Height above mean sea level	[...] m
Seismic Zone	Zone - [...]
Distance from [...] town	[...] km
Distance from national highway No. [...]	[...] km
Distance from state highway No. [...]	[...] km
Distance of nearest airport [...]	[...] km
Distance of nearest seaport [...]	[...] km

2.3 Climatological Data

Table: 2.2

Particulars	
Highest monthly mean of daily maximum temperature	[...] deg C
Lowest monthly mean of daily maximum temperature	[...] deg C
Highest monthly mean of daily minimum	[...] deg C

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Particulars	
temperature	
Lowest monthly mean of daily minimum temperature	[...] deg C
Annual mean of daily maximum temperature	[...] deg C
Annual mean of daily minimum temperature	[...] deg C
Extreme highest temperature	[...] deg C
Extreme lowest temperature	[...] deg C
Design ambient temperature (unless specified otherwise)	{50} deg C
Relative Humidity: Maximum Minimum	[...] % [...]
Average annual rainfall	[...] cm
Heaviest rainfall in 24 hours so far	[...] cm
Number of rainy days in a year	[...]
Highest monthly mean of wind speed	[...] km/h
Lowest monthly mean of wind speed	[...] km/h
Maximum wind speed	[...] km/h

Table: 2.3

Season	Dry bulb temperature	Wet bulb temperature
Summer	[...] deg C	[...] deg C
Monsoon	[...] deg C	[...] deg C
Winter	[...] deg C	[...] deg C

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2.4 Fuel

At present the power station is sourcing coal from [.....] coal mines. The coal is being transported to the project site by [Indian Railways/ MGR system/ cross country conveyor]. Proximity of Railway line to site from [.....] Railway Station is about [.....] km. The railway link shall also be used for transportation of heavy equipment to site during construction phase and to bring main and secondary fuel to the power plant during operation of plant. Fuel Oil is being transported to the project site by [Indian Railways/ Road Tankers].

2.4.1 Secondary Liquid Fuels

[Analysis of Heavy Fuel Oil (HFO/HPS/LSHS as applicable) & Light Diesel Oil (LDO)]:

{Analysis of Heavy fuel oil (HFO/HPS/LSHS as applicable) and Light diesel oil (LDO) which is being used in the existing Boiler for start-up, coal flame stabilization and low load operation shall be specified in the table given below:}

Table: 2.4

SL. No.	Particulars	Range/ value
(A)	Analysis of heavy furnace oil (HFO)	
i)	Specification	[Furnace oil conforming to IS:1593, heavy grade]
ii)	Average gross calorific value	[.... /] kCa1/kg
iii)	Flash point	[.... /] deg C
iv)	Pour point	[.... /] deg C
v)	Kinematic viscosity at 50 deg C	[.... /] centistokes
vi)	Specific heat	[.... /] kcal/kg/deg C
vii)	Ash	[.... /] % by weight
viii)	Sediment	[.... /] % by weight
ix)	Sulphur	[.... /] % by weight
x)	Water content	[.... /] % by volume
xi)	Acidity	[.... /]

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SL. No.	Particulars	Range/ value
xii)	Specific gravity	[.... /]
(B)	Analysis of heavy petroleum stock (HPS)	
i)	Calorific value	[.... /] kCa1/kg
ii)	Acidity inorganic	[.... /]
iii)	Flash point	[.... /] deg C
iv)	Pour point	[.... /] deg C
v)	Kinematic viscosity in cst at 50deg C	[.... /] cst
vi)	Kinematic viscosity in cst at 100 deg C	[.... /] cst
vii)	Sediment	[.... /] % by weight
viii)	Ash	[.... /] % by weight
ix)	Sulphur	[.... /] % by weight
x)	water content	[.... /] % by Volume
(C)	Analysis for low sulphur heavy stock (LSHS) fuel oil	
i)	Gross calorific value	[.... /] kCa1/kg
ii)	Flash point	[.... /] deg C
iii)	Pour point	[.... /] deg C
iv)	Ash content	[.... /] % by weight
v)	Total sulphur	[.... /] % by weight
vi)	Sediment	[.... /] % by weight

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SL. No.	Particulars	Range/ value
vii)	Water content	[... / ...] % by Volume
viii)	Viscosity (maximum)	At 38 deg C - [...] cst At 50 deg C - [...] cst At 60 deg C - [...] cst At 70 deg C - [...] cst At 80 deg C - [...] cst At 90 deg C - [...] cst At 99 deg C - [...] cst At 100deg C - [...] cst At 110deg C - [...] cst
ix)	Specific gravity	[... / ...]
x)	Specific heat	[... / ...] kcal/kg/deg C
(D)	Light Diesel Oil (LDO)	[As per IS:1460 (latest)]

2.5

Water Analysis

[Describe the source of consumptive and / or cooling water (name of river or sea or bore well) and the type of condenser cooling system being adopted for the unit.]

Chemical analysis of water which is used for this project is indicated as below:

Table: 2.5

Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
A	Raw Water Analysis		
1	Calcium	mg/l	[...]
2	Magnesium	mg/l	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
3	Sodium	mg/l	[...]
4	Potassium	mg/l	[...]
5	Total Cations	meq/l	[...]
6	Bicarbonates	mg/l	[...]
7	Carbonates	mg/l	[...]
8	Nitrate	mg/l	[...]
9	Chloride	mg/l	[...]
10	Sulphate	mg/l	[...]
11	Total Anions	meq/l	[...]
12	Colloidal Silica	mg/l	[...]
13	Reactive Silica	mg/l	[...]
14	Iron Fe	mg/l	[...]
15	pH value	.....	[...]
16	Turbidity	NTU	[...]
17	Total Dissolved Solids	mg/l	[...]
18	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[...]
19	BOD	mg/l	[...]
20	COD	mg/l	[...]
B	Clarified Water Analysis		
1	Calcium	mg/l	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
2	Magnesium	mg/l	[....]
3	Sodium	mg/l	[....]
4	Potassium	mg/l	[....]
5	Total Cations	meq/l	[....]
6	Bicarbonates	mg/l	[....]
7	Carbonates	mg/l	[....]
8	Nitrate	mg/l	[....]
9	Chloride	mg/l	[....]
10	Sulphate	mg/l	[....]
11	Total Anions	meq/l	[....]
12	Silica	mg/l	[....]
13	Iron Fe	mg/l	[....]
14	pH value	.....	[....]
15	Turbidity	NTU	[....]
16	Total Dissolved Solids	mg/l	[....]
17	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[....]
C	Demineralised Water for Power Cycle Make up		
The quality parameters of demineralised water is in use for make up to the condenser hotwell and make up to the closed cycle equipment cooling water (ECW) system is as below:			
1	pH	{6.8 – 7.2}

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
2	Silica, as SiO ₂	ppm	≤{0.01}
3	Conductivity	micro mho/cm	≤{0.1}

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3 EXISTING PLANT DETAILS

The Power Plant, is of the configuration of [...x...MW]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The boiler for the unit is of [PF/CFBC] design. The boiler is provided with [front & rear/ corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. The Original Equipment supplier of respective Balance of Plant equipment are provided in the respective equipment's section at Clause No. 3.2 of this section of the specification. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [...] Substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...]& [...] coal mines. The consumptive water for the power plant is being sourced from [...river /...sea].

3.1 Operational Background

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. Various Equipments of Balance of Plant system has under gone degradation in its original design parameters with respect to its name plate design parameters and also in terms of parameters like Capacity, efficiency and number of outages etc. over the years of its life. The deterioration experienced over the years in Plant's Equipment performance parameters and its current operating parameters are given below.

3.1.1 BOP Equipment's Average Performance Parameters over the Life

Table: 3.1
Equipment's Average Performance Parameters over the Life

Equipment Name	Years after Installation	Availability (%)	Output (Capacity)	Efficiency (%)	Aux. Power Consumption (%)	Forced Outages (Nos.)
[...]	5	[...]	[...]		[...]	[...]
	10	[...]	[...]		[...]	[...]
	15	[...]	[...]		[...]	[...]
	20	[...]	[...]		[...]	[...]

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Equipment Name	Years after Installation	Availability (%)	Output (Capacity)	Efficiency (%)	Aux. Power Consumption (%)	Forced Outages (Nos.)
	25	...	...		...	...
[.....]	5	...	...		...	...
	10	...	...		...	...
	15	...	...		...	...
	20	...	...		...	...
	25	...	...		...	...

3.1.2

BOP Equipment's Average Performance Parameters during the last five years

Table 3.2 indicated below, illustrates variations over the last five years in the performance parameters.

{Furnish in the Table 3.2 below, the Average Values for the last five years. However, for the Parameters in respect of 'One Year back' and 'Current Year', furnish the Maximum, the Minimum and the Average Values.}

Table: 3.2

Equipment's Average Performance Parameters during the Last Five Years

Equipment Name	Period	Availability (%)	Output (Capacity)	Efficiency (%)	Aux. Power Consumption (%)	Forced Outages (Nos.)
[.....]	Four Years back
	Three Years back
	Two Years back
	One Year back
	Current year
[.....]	Four Years

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Equipment Name	Period	Availability (%)	Output (Capacity)	Efficiency (%)	Aux. Power Consumption (%)	Forced Outages (Nos.)
	back					
	Three Years back	...	...		...	...
	Two Years back	...	...		...	...
	One Year back	...	...		...	...
	Current year	...	...		...	...

3.1.3

Auxiliary Power Consumption of Equipment of BOP Systems

Table-3.3

Sl. No.	Equipment/System	Units	Power Consumption
1	[Raw Water Intake Pump]	kW	...
2	[CW Pump]	kW	...
3	[ACW Pump]	kW	...
4	[Equipment under Water Pretreatment Plant]	kW	...
5	[Equipment under Effluent Treatment plant]	kW	...
6	[Softening Plant Supply pumps, if applicable]	kW	...
7	[DM Plant supply pumps]	kW	...
8	[Electro chlorination plant supply pumps, if applicable]	kW	...
9	[Electro Chlorination units, if applicable]	kW	...
10	[Service Air Compressor]	kW	...
11	[Instrument Air Compressor]		...

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Sl. No.	Equipment/System	Units	Power Consumption
12	[Fuel Oil Unloading Pump]	kW	[...]
13	[Fuel Oil Forwarding / Pressuring Pump]	kW	[...]
14	[Air Conditioning System]	kW	[...]
15	[Ventilation System]	kW	[...]
16	[DM Plant]	kW	[...]
17	[IDCT]	kW	[...]
18	[Induced Draft Cooling Tower]	kW	[...]
19	[Any other continuously running equipment under BOP Package]	kW	[...]
20	Total Auxiliary Power Consumption of BOP	kW	[...]

3.1.4

Stack Emissions, Ambient Air Quality and Process Effluents

The Project has been regularly monitoring the environmental parameters such as stack emission, ambient air quality (AAQ), noise pollution and liquid waste pollution in accordance with applicable norms by employing [M/s....., which is an agency approved by State Pollution Control Board].

The existing environmental data and the limits specified for different pollutants, the locations of their measurements and the frequency of monitoring are given in the table below.

Table 3.4
Status of Stack Emissions, Ambient Air Quality and Process Effluents

Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
Stack Emissions	SPM (mg/Nm ³)	Not to exceed [...]	[...]		[...]	[...]
Ambient Air Quality		On 24 Hrs	On Annual Basis	On 24 Hrs	On Annual Basis	

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)			Parameters Achieved		No. of locations for measurement	Frequency of Sampling.
		Basis		Basis			
	SPM (µg/m ³)	[...]	[...]	[...]	[...]	[...]	[...]
	RPM (µg/m ³)	[...]	[...]	[...]	[...]		
	SO ₂ (µg/m ³)	[...]	[...]	[...]	[...]		
	NO _x (µg/m ³)	[...]	[...]	[...]	[...]		
Process Effluent Leaving the Plant Boundary	ETP Treated Water Quality						
	pH	[...]		[...]			
	Colour	[...]		[...]			
	Odour	[...]		[...]			
	Temperature	[...]		[...]			
	TSS (mg/l)	[...]		[...]			
	Oil & grease (mg/l)	[...]		[...]		[...]	[...]
	COD (mg/l) (mg/l)	[...]		[...]			
	BOD (mg/l)	[...]		[...]			

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Environmental Aspects	Parameters Specified by State Pollution and Control Board (SPCB)		Parameters Achieved	No. of locations for measurement	Frequency of Sampling.
	Chloride (mg/l)		
	Sulphate (mg/l)	...	...
	TDS (mg/l)	...	...
	Zinc (mg/l)	...	...
	Fluoride (mg/l)	...	...
	Mercury (mg/l)	...	...

3.1.5 Feedback from the Plant Operators

Detailed discussions were held with the Plant operators who provided the feedback about the design and operation related problems of various systems. These are listed in the Table 3.5 below.

Table 3.5
Feedback from the Plant Operators

S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
1
2
3
4
5
6

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S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
7	[.....]	[.....]	[.....]
8	[.....]	[.....]	[.....]
9	[.....]	[.....]	[.....]
...	[.....]	[.....]	[.....]

3.1.6 Tripping and Maintenance Record

{Indicate in the table below the tripping and maintenance record for the past three years.}

Table: 3.6

Year	Total Trippings	No. of Trippings due to BOP Auxiliaries	Other Major Causes of Trippings	Maintenance carried out
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current Year	[.....]	[.....]	[.....]	[.....]

3.1.7 Maximum Achievable Load due to performance constraint

[Due to performance constraint of various equipment of BOP systems including ESP, the maximum generation from the unit is restricted to [...] MW. The operational data at the above maximum load is indicated in the table below.]

Table: 3.7

Nature of constraint	Output (MW)	Unit's Gross Efficiency (%)	BOP Equipment Capacity	BOP Aux. Power Consumption (%)
[...]	[...]	[...]	[...]	[...]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

Nature of constraint	Output (MW)	Unit's Gross Efficiency (%)	BOP Equipment Capacity	BOP Aux. Power Consumption (%)
[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]

3.1.8 Record of Reportable Accidents

[The record of reportable accidents for the past three years, is mentioned in the Table below]

Table: 3.8

Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current Year	[.....]	[.....]	[.....]	[.....]

3.1.9 Operation & Maintenance Difficulties due to Plant Limitations

[Difficulties are being experienced in day to day maintenance of the plant due to design deficiency, layout of the plant, obsolescence of equipment and non availability of spare parts etc. These are mentioned in the Table below]

Table: 3.9

S.No.	Nature of Difficulty	Specific Reason (Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)
1	[.....]	[.....]
2	[.....]	[.....]

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S.No.	Nature of Difficulty	Specific Reason (Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

3.2 Salient Technical Feature of Power Plant

{Describe in this sub-section, the Design Parameters and Salient Features of all the important Equipment and Systems of BOP Systems as mentioned below}

3.2.1 Raw Water System

[The consumptive water for the plant is sourced from [...] river/sea located at a distance of [...] km from the plant boundary. Traveling water screens have been installed at the entry of intake water pump house to remove the floating debris and other foreign materials. The intake water pump house is installed with [...] intake pumps of capacity [...] m³/hr, out of which [...] pumps are normally working and the remaining [...] pumps are standby. The raw water is pumped from the intake water pump house to the in-plant raw water reservoir, which has a storage capacity of [...] days. From in-plant raw water reservoir, raw water is pumped to the Pretreatment Plant by means of Raw Water Pumps located in raw water Pump House. The details of the system are mentioned in the table below:]

Table: 3.10

Description	Units	Design Parameters
Traveling Water Screens		
Number of Screens	.....	[....]
Type of Screens (Single Flow / Dual Flow)		[....]
Flow Capacity per screen	m ³ /hr	[....]
Width of Screen	m	[....]

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Description	Units	Design Parameters
Depth of Screen from operating floor to sump floor	m	[...]
Depth of water from the sump floor		
a) At lowest water level	m	[...]
b) At highest water level	m	[...]
Maximum velocity through the screens at the lowest water level	m/s	[...]
Speed of Traveling Water Screen	m/s	[...]
Mesh Opening size of the screen	mm	[...]
Material and size of the wire mesh	....	[...]
Height of the screen baskets	m	[...]
Normal head loss through the screen	mm	[...]
Maximum head loss through the screen	mm	[...]
Number of wash water pumps (Working+ Standby)	....	[...]
Intake Pumps		
Number of Intake pumps	.....	[...]
Number of operating pumps	.....	[...]
Type of Pump	.....	[...]
Make and Model	.....	[...]
Impeller type and design	[...]
Intake well diameter	m	[...]
Intake well finished bed level	m	[...]

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Description	Units	Design Parameters
Intake well plinth level	m	[...]
Pump house top level	m	[...]
Pump house inside clear plan dimension	m x m	[...]
Rated Flow	m ³ /hr	[...]
Rated Speed	rpm	[...]
Head at the discharge flange for the Rated Flow	mwc	[...]
Total Developed Head	mwc	[...]
Shut off head of the Pump	mwc	[...]
Range of operation	%	[...]
Maximum capacity upto which pump can be operated satisfactorily.	m ³ /hr	[...]
Run-away speed (reverse)	rpm	[...]
Minimum Submergence required (minimum distance required from the minimum water level to the centre line of bowl) at a)Minimum Capacity b)Design Capacity c)Maximum Capacity (run out)	mm	a) [...] b) [...] c) [...]
NPSH required at a)Minimum Capacity b)Design Capacity c)Maximum Capacity (run out)	mwc	a) [...] b) [...] c) [...]
NPSH available at minimum water	mwc	[...]

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Description	Units	Design Parameters
level		
Pump Specific Speed	[....]
System Suction Speed at design condition (based on NPSH available at minimum water level in sump)	[....]
Pump Suction Speed (based on NPSH required) at design condition	.....	[....]
Pump & drive combined critical Speed 1st 2nd	rpm	1 st [....] 2 nd [....]
Maximum efficiency of the pump at design point to be considered for arriving at the guaranteed power consumption at motor terminals	%	[....]
Maximum efficiency of the pump motor at design point to be considered for arriving at the guaranteed power consumption at motor terminals	%	[....]
Location of the thrust bearing	.....	[....]
Type of thrust bearing cooling	.....	[....]
Qty of water required for thrust bearing cooling	m ³ /h	[....]
Type of shaft sealing	.....	[....]
Qty of water required for shaft sealing	m ³ /h	[....]
Qty of water required for lubrication of line shaft bearing	m ³ /h	[....]
Rotor over speed	rpm	[....]
Motor Rating	kW	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[25]	25.09.2015

Description	Units	Design Parameters
Material of construction of Impeller	[....]
Material of construction of Suction bell	[....]
Material of construction of Casing	[....]
Material of construction of Wearing rings	[....]
Material of construction of Pump shaft	[....]
Material of construction of Line shaft	[....]
Material of construction of Shaft coupling	[....]
Material of construction of Shaft sleeve	[....]
Material of construction of Line shaft bearing	[....]
Material of construction of Column pipe	[....]
Material of construction of Shaft enclosing tube	[....]
Material of construction of Discharge elbow	[....]
Material of construction of Distance piece	[....]
Material of construction of Matching flanges	[....]
Butterfly Valve		
Name of manufacturer	[....]
Model No	[....]
Type	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[26]	25.09.2015

Description	Units	Design Parameters
Valve Design Code & Design Rating	[....]
End Flange details (Refer standard also)	[....]
Type of actuator	[....]
Flow a) Operating b) Maximum	m ³ /h	a) [....] b) [....]
Sealing direction	[....]
Pressure a) Operating b) Design	kg/cm ²	a) [....] b) [....]
Disc differential pressure	kg/cm ²	[....]
Material of construction of Body	[....]
Material of construction of Body linings	[....]
Material of construction of Shaft sealing	[....]
Material of construction of Shaft bearing	[....]
Material of construction of Stem material	[....]
Material of construction of Disc material	[....]
Material of construction of Seat on body/disc	[....]
Material of construction of Internal hardware	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[27]	25.09.2015

Description	Units	Design Parameters
Material of construction of Hand wheel/lever	.....	[...]
Raw Water Intake Pipe line		
Pipe		
Manufacturer	.....	[...]
Type of construction	.....	[ERW/ SAW]
Material of construction	.....	[...]
Type of joints	.....	[Screwed joint / Welded Joint / Flanged Joint]
Size	mm	[...]
Wall thickness	mm	[...]
Pipe Route Length of Underground Portion	m	[...]
Pipe Route Length of Over ground Portion	m	[...]
Provision of Air Release Valves	.....	[...]
Fittings		
Manufacturer	.....	[...]
Type of joints	.....	[Screwed joint / Welded Joint / Flanged Joint]
Flanges		
Manufacturer	[...]
Material standard	[...]
Type	[...]
Raw Water Reservoir & Pump House		
Raw Water Pumps		

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Description	Units	Design Parameters
Number of Raw Water pumps	[....]
Number of operating pumps	[....]
Type of Pump	.....	[....]
Make and Model	.....	[....]
Impeller type and design	.....	[....]
Pump house top level	m	[....]
Pump house inside clear plan dimension	m x m	[....]
Rated Flow	m ³ /hr	[....]
Rated Speed	rpm	[....]
Head at the discharge flange for the Rated Flow	mwc	[....]
Total Developed Head	mwc	[....]
Shut off head of the Pump	mwc	[....]
Range of operation	%	[....]
Maximum capacity upto which pump can be operated satisfactorily.	m ³ /hr	[....]
Run-away speed (reverse)	rpm	[....]
Minimum Submergence required (minimum distance required from the minimum water level to the centre line of bowl) at a)Minimum Capacity b)Design Capacity c)Maximum Capacity (run out)	mm	a) [....] b) [....] c) [....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[29]	25.09.2015

Description	Units	Design Parameters
NPSH required at a) Minimum Capacity b) Design Capacity c) Maximum Capacity (run out)	mwc	a) [....] b) [....] c) [....]
NPSH available at minimum water level	mwc	[....]
Pump Specific Speed	.....	[....]
System Suction Speed at design condition (based on NPSH available at minimum water level in sump)	.....	[....]
Pump Suction Speed (based on NPSH required) at design condition	.....	[....]
Pump & drive combined critical Speed 1st 2nd	rpm	1 st [....] 2 nd [....]
Maximum efficiency of the pump at design point to be considered for arriving at the guaranteed power consumption at motor terminals	%	[....]
Maximum efficiency of the pump motor at design point to be considered for arriving at the guaranteed power consumption at motor terminals	%	[....]
Location of the thrust bearing	.....	[....]
Type of thrust bearing cooling	[....]
Qty of water, if required, for thrust bearing cooling	m ³ /h	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[30]	25.09.2015

Description	Units	Design Parameters
Type of shaft sealing	.....	[....]
Qty of water required for shaft sealing	m ³ /h	[....]
Qty of water required for lubrication of line shaft bearing	m ³ /h	[....]
Rotor over speed	rpm	[....]
Motor Rating	kW	[....]
Material of construction of Impeller	.....	[....]
Material of construction of Suction bell	.....	[....]
Material of construction of Casing	.....	[....]
Material of construction of Wearing rings	.....	[....]
Material of construction of Pump shaft	.....	[....]
Material of construction of Line shaft	.....	[....]
Material of construction of Shaft coupling	.....	[....]
Material of construction of Shaft sleeve	.....	[....]
Material of construction of Line shaft bearing	.....	[....]
Material of construction of Column pipe	.....	[....]
Material of construction of Shaft enclosing tube	.....	[....]
Material of construction of Discharge elbow	[....]
Material of construction of Distance piece	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[31]	25.09.2015

Description	Units	Design Parameters
Material of construction of Matching flanges	.....	[...]
Butterfly Valve		
Name of manufacturer	.....	[...]
Model No	.....	[...]
Type	.....	[...]
Valve Design Code & Design Rating	.....	[...]
End Flange details (Refer standard also)	.....	[...]
Type of actuator	.....	[...]
Flow c) Operating Maximum	m ³ /h	[...] [...]
Sealing direction	.....	[...]
Pressure a) Operating b) Design	kg/cm ²	[...] [...]
Disc differential pressure	kg/cm ²	[...]
Material of construction of Body	.....	[...]
Material of construction of Body linings	.....	[...]
Material of construction of Shaft sealing	[...]
Material of construction of Shaft bearing	[...]

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Description	Units	Design Parameters
Material of construction of Stem material	[...]
Material of construction of Disc material	[...]
Material of construction of Seat on body/disc	[...]
Material of construction of Internal hardware	[...]
Material of construction of Hand wheel/lever	[...]

3.2.2

Water Pre-Treatment Plant

[Water Pre-Treatment Plant is a common facility for all the units of the power plant. Pre-treatment plant supplies clarified water to DM plant, Cooling Tower Make-up, cooling water to the auxiliaries of BOP system, coal handling plant dust suppression, Service Water and to the Drinking Water System. There are two numbers of clarifiers of [...].m³/hr capacity to meet all the clarified water requirements of the whole plant, except DM plant. The clarified water requirement for DM plant is met by a separate clarifier of capacity [...] m³/hr. The details of the plant are mentioned in the table below:]

Table: 3.11

Description	Units	Design Parameters
Aerator		
Number	.....	[...]
Type	.....	[...]
Material	[...]
Design Flow	m ³ /h	[...]
% of Sludge	%	[...]
Stilling Chamber for Main Clarifier		

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Description	Units	Design Parameters
Number	[....]
Purpose	[To dampen out any turbulence of the incoming water and for pre-chlorination]
Material	.....	[....]
Capacity (Retention Time)	min	[....]
Specialties	.....	[Suitable draining arrangement has been provided for the stilling chamber and drain lines is extended upto the sludge pocket for final disposal to the common sludge sump. Pre chlorination of raw water is carried out at stilling chamber]
Chlorination System		
Type of System	....	[....]
Number of Ton Containers	Nos.	[....]
Number of Streams	Nos.	[....]
Number of Chlorinators	Nos.	[....]
Continuous dosing rate	ppm	[....]
Chlorine solution pipe size and material.	.....	[....]
Provision of Booster Pumps (Working and Standby)	Nos.	[....]
Safety skid	[....]
Flash Mixer		
Number	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[34]	25.09.2015

Description	Units	Design Parameters
Type	.....	[...]
Material of Construction	.....	[...]
Agitator Type	.....	[...]
Agitator Number	.....	[...]
Isolation gates along with hand wheels for Agitator	.....	[...]
Capacity of each Agitator (Retention Time)	min	[...]
Details of Draining arrangement	.....	[...]
Flocculator		
Material of inlet from flash mixer to Flocculation tank	.....	[...]
Number	.....	[...]
Type	.....	[...]
Material of Construction	.....	[...]
Rated net output capacity	m ³ /h	[...]
Retention time (minimum)	min	[...]
Sludge Transfer Pumps		
Number of Pump	[...]
Type	[...]
Location	[...]
Rated Capacity	m ³ /h	[...]
Duty	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[35]	25.09.2015

Description	Units	Design Parameters
Range of operation	%	[...]
Design standard	.....	[...]
Material of Construction of Casing	.....	[...]
Material of Construction of Impeller	.....	[...]
Material of Construction of Shaft sleeve	.....	[...]
Material of Construction of Shaft bearing	.....	[...]
Material of Construction of Base plate	.....	[...]
Material of Construction of Stuffing box	.....	[...]
Material of Construction of Impeller shaft	.....	[...]
Pump Motor Rating	kW	[...]
Pressure Gauge details	.....	[...]
Requirement of Interlock	.....	[...]
Clarified Water Tank		
Capacity of Clarified Water Tank	m ³	[...]
Length x Width of Clarified Water Tank	mxm	[...]
Depth of Clarified Water Tank (both over ground & underground)	m	[...]
Dead Storage for Fire Fighting	m ³	[...]
DM Plant supply pumps		
Type	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[36]	25.09.2015

Description	Units	Design Parameters
Duty	.....	[....]
Location	.....	[....]
No. of Pumps required	.....	[....]
No. of Pumps working	.....	[....]
Liquid handled	.....	[....]
Normal water level	m	[....]
Minimum water level	m	[....]
Maximum water level	m	[....]
Performance Standard	.....	[....]
Minimum Flow capacity	m ³ /h	[....]
Speed	rpm	[....]
Total dynamic head	mlc	[....]
Range of operation	%	[....]
Type of gland lubrication and sealing	.....	[....]
Type of coupling	.....	[....]
Material of construction for Casing	.....	[....]
Material of construction for Impeller	.....	[....]
Material of construction for Shaft sleeve	.....	[....]
Material of construction for Shaft bearing	[....]
Material of construction for Base plate	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[37]	25.09.2015

Description	Units	Design Parameters
Material of construction for Stuffing box	.....	[....]
Material of construction for Impeller shaft	.....	[....]
Pump Motor Rating	kW	[....]
Filtration Plant for DM Water Supply		
Type of Filtration Plant (Gravity/ Pressure Filter)	.....	[....]
Dimension of Filtration Plant	.....	[....]
Number of Filters for DM Water Supply (Working & Standby)	.....	[....]
Type of Filtering Media	.....	[....]
Filtration Area per filter	m ²	[....]
Rated Service Flow Rate	m ³ /h	[....]
Design Surface Flow Rate	m ³ /m ² /h	[....]
Suspended Particles in inlet water	mg/l	[....]
Suspended Particles in outlet water	mg/l	[....]
Back wash flow rate	m ³ /h	[....]
Back washing medium	.....	[....]
Time period of back washing	.....	[....]
Details of Air Blowers	.....	[....]
Filtration Plant for Potable Water Supply		
Type of Filtration Plant (Gravity/ Pressure Filter)	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[38]	25.09.2015

Description	Units	Design Parameters
Dimensions of Filtration Plant	.....	[....]
Number of Filters for Potable Water Supply (Working & Standby)	.....	[....]
Type of Filtering Media	.....	[....]
Filtration Area per filter	m ²	[....]
Rated Service Flow Rate	m ³ /h	[....]
Design Surface Flow Rate	m ³ /m ² /h	[....]
Suspended Particles in inlet water	mg/l	[....]
Suspended Particles in outlet water	mg/l	[....]
Back wash flow rate	m ³ /h	[....]
Back washing medium	.....	[....]
Time period of back washing	.....	[....]
Details of Air Blowers	.....	[....]
Filtered /Potable Water tank		
Number	.....	[....]
Effective capacity	m ³	[....]
Type	[....]
Design Code	[....]
Location	[....]
Free board,	mm	[....]
Bottom shape	[....]
Dimension	m	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[39]	25.09.2015

Description	Units	Design Parameters
Material of construction	.....	[...]
Inside protection	.....	[...]
Overflow, drain and sample connection	.....	[...]
Level indicator	.....	[...]
Level switch	.....	[...]
Level integrator transmitter	.....	[...]
Potable Water Chlorination		
Number of cylinders	Nos.	[...]
Type of Cylinders	.....	[...]
Number of Chlorinators	Nos.	[...]
Capacity of Chlorinators	gms/h	[...]
Dosing Rate	ppm	[...]
Provision of Booster Pumps (Working and Standby)	Nos.	[...]
Potable Water Supply Pumps		
Location	.....	[...]
No. of Pumps	.....	[...]
No. of Pumps normally working	.....	[...]
Performance Standard	[...]
Rated. Flow capacity	m ³ /h	[...]
Min. Flow capacity	m ³ /h	[...]
Speed.	rpm	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[40]	25.09.2015

Description	Units	Design Parameters
Static head of pumping system	mlc	[...]
Total developed head	mlc	[...]
Pump shut off head	mlc	[...]
Range of operation	%	[...]
Motor rating	kW	[...]
Design standard	.....	[...]
Material of construction of Casing	.....	[...]
Material of construction of Impeller	.....	[...]
Material of construction of Shaft sleeve	.....	[...]
Material of construction of Thrust bearing	.....	[...]
Material of construction of Base plate	.....	[...]
Material of construction of Stuffing box, glands, and lantern ring	.....	[...]
Material of construction of Pump Shaft	.....	[...]
Motor Driven Pumps for Fire Fighting		
Number of motor driven pumps	.....	[...]
No. of pumps normally working	.....	[...]
Performance Standard	[...]
Rated. Flow capacity	m ³ /h	[...]
Speed.	rpm	[...]
Static head of pumping system	mlc	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[41]	25.09.2015

Description	Units	Design Parameters
Total developed head	mlc	[...]
Pump shut off head	mlc	[...]
Range of operation	%	[...]
Motor rating	kW	[...]
Design standard	.....	[...]
Material of construction of Casing	.....	[...]
Material of construction of Impeller	.....	[...]
Material of construction of Shaft sleeve	.....	[...]
Material of construction of Thrust bearing	.....	[...]
Material of construction of Base plate	.....	[...]
Material of construction of Stuffing box, glands, and lantern ring	.....	[...]
Material of construction of Pump Shaft	.....	[...]
Diesel Engine Driven Pumps for Fire Fighting		
Number of diesel engine driven pumps	.....	[...]
No. of pumps normally working	.....	[...]
Performance Standard	.....	[...]
Rated. Flow capacity	m ³ /h	[...]
Speed.	rpm	[...]
Static head of pumping system	mlc	[...]
Total developed head	mlc	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[42]	25.09.2015

Description	Units	Design Parameters
Pump shut off head	mlc	[...]
Range of operation	%	[...]
Diesel engine rating	kW	[...]
Design standard	.....	[...]
Material of construction of Casing	.....	[...]
Material of construction of Impeller	.....	[...]
Material of construction of Shaft sleeve	.....	[...]
Material of construction of Thrust bearing	.....	[...]
Material of construction of Base plate	.....	[...]
Material of construction of Stuffing box, glands, and lantern ring	.....	[...]
Material of construction of Pump Shaft	.....	[...]
Jockey Pumps for Fire Fighting System		
Number of Jockey pumps	.....	[...]
No. of pumps normally working	.....	[...]
Performance Standard	.....	[...]
Rated. Flow capacity	m ³ /h	[...]
Speed.	rpm	[...]
Total developed head	mlc	[...]
Service Water tank		
Number	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[43]	25.09.2015

Description	Units	Design Parameters
Effective capacity	m ³	[...]
Type	.....	[...]
Design Code	.....	[...]
Location	.....	[...]
Free board,	mm	[...]
Bottom shape	.....	[...]
Dimension	m	[...]
Material of construction	.....	[...]
Inside protection	.....	[...]
Overflow, drain and sample connection	.....	[...]
Level indicator	.....	[...]
Level switch	.....	[...]
Level integrator transmitter	.....	[...]
Service Water Supply Pumps		
Location	.....	[...]
No. of Pumps required	.....	[...]
No. of Pumps working	.....	[...]
Performance Standard	[...]
Rated. Flow capacity	m ³ /h	[...]
Min. Flow capacity	m ³ /h	[...]
Speed.	Rpm	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[44]	25.09.2015

Description	Units	Design Parameters
Static head of pumping system	mlc	[...]
Total developed head	mlc	[...]
Pump shut off head	mlc	[...]
Range of operation	%	[...]
Motor rating	kW	[...]
Design standard	.....	[...]
Material of construction of Casing	.....	[...]
Material of construction of Impeller	.....	[...]
Material of construction of Shaft sleeve	.....	[...]
Material of construction of Thrust bearing	.....	[...]
Material of construction of Base plate	.....	[...]
Material of construction of Stuffing box, glands, and lantern ring	.....	[...]
Material of construction of Pump Shaft	.....	[...]
Chlorination Power Water Pumps		
Location	.....	[...]
No. of Pumps	.....	[...]
No. of Pumps working	[...]
Performance Standard	[...]
Rated. Flow capacity	m ³ /h	[...]
Min. Flow capacity	m ³ /h	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[45]	25.09.2015

Description	Units	Design Parameters
Speed.	Rpm	[...]
Total developed head	mlc	[...]
Pump shut off head	mlc	[...]
Range of operation	%	[...]
Motor rating	kW	[...]
Design standard	.....	[...]
Material of construction of Casing	.....	[...]
Material of construction of Impeller	.....	[...]
Material of construction of Shaft sleeve	.....	[...]
Material of construction of Thrust bearing	.....	[...]
Material of construction of Base plate	.....	[...]
Material of construction of Stuffing box, glands, and lantern ring	.....	[...]
Material of construction of Pump Shaft	.....	[...]

3.2.3

CW / ACW System and Cooling Towers

[CW system for the power plant is working on once through principle. The water is being sourced from [name of the river/canal]. The cooling water from the above source is being drawn through a channel which is connected to the forebay of the CW pump house. From CW pump house the water is being pumped by CW pumps to the Condenser. From the Condenser outlet, hot water discharges through the seal pit from where the hot water is carried through the discharge duct/channel, which terminates at the downstream of the intake point of the [river/canal].

OR

CW system for the power plant works on once through type cooling system/ re-circulating system with natural draft / induced draft cooling towers. The CW system uses raw/clarified quality of water and is working on [...] cycles of concentration. CW pump house is a common facility for all the units of the power plant. There are two CW pumps of capacity [...] m3/hr provided for each unit. In addition, there are two standby

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CW pumps common to all the units. Dedicated ACW pump which is located at CW pump house supplies the required ACW to PHE / The requirement of ACW system is being tapped from the cold CW header feeding the condenser. The hot return ACW water after cooling the auxiliaries of boiler and turbine joins the hot CW header and is sent to the cooling towers for cooling. The cold water from the cooling water flows to the fore bay of CW Pump House for recirculation into the system. One natural draft (NDCT) / induced draft cooling tower (IDCT) has been provided for each unit. The cooling tower cools the water from [...] deg C to [...] deg C. The cooling tower has been designed for an inlet wet bulb temperature of [...] deg C.

CW chemical dosing system consists of acid dosing system, dosing of anti-sealant/ dispersant/ anti-corrosive/ equivalent chemicals, including addition of these chemicals to make up for the losses from the system and maintain the required concentration of chemicals in the cooling water to prevent scale deposition/ corrosion of equipment / coolers' internal surfaces. CW side stream filtration system is provided to remove suspended solid, precipitated TDS resulting due to increase in concentration of dissolved solids from the circulating system due to evaporation losses in cooling tower. The details of the system are mentioned in the table below:].

Table: 3.12

Description	Units	Design Parameters
CW PUMP		
Name of manufacturer	.....	[...]
Model Number	.....	[...]
Total No. of CW pumps	.....	[...]
Type	.....	[...]
Fluid	.....	[...]
Location	.....	[...]
Number of operating pumps	.....	[...]
No. of standby pumps	.....	[...]
Shut off head of the Pump	mwc	[...]
Rated Speed	rpm	[...]
Maximum efficiency of the CW pump at design point	%	[...]

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Description	Units	Design Parameters
Maximum efficiency of the CW pump motor	%	[...]
Rated Capacity	m ³ /h	[...]
Total head at Rated Flow	mwc	[...]
Range of operation	%	[...]
Lowest low water level at fore bay	mm	[...]
Highest high water level at forebay	mm	[...]
Forebay equipment head loss	mwc	[...]
Power Loss in Bearings Line shaft Bearings: Thrust Bearing (if provided in pump):	kW	[...] [...]
Maximum capacity up to which pump is operated satisfactorily	%	[...]
Minimum Capacity up to which pump is operated satisfactorily	%	[...]
Maximum power consumption at motor terminals in the pump operating range	kW	[...]
Minimum Power Consumption at motor terminals in the operating range	kW	[...]
Power consumption at motor terminals at shut off head	kW	[...]
Pump input power at run-out flow	kW	[...]
Motor Rating of the Pump	kW	[...]
Run-away speed (reverse)	rpm	[...]
Minimum Submergence (minimum distance from the minimum water level to the centre line of Draft Tube (Formed suction) inlet.	mm	a) Minimum Capacity-[...] b) Design Capacity-[...]

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Description	Units	Design Parameters
		<i>c) Maximum Capacity-[....]</i>
Height from sump invert level to center line of Draft Tube (Formed suction) inlet	mm	<i>[....]</i>
Height from centre line of Draft Tube inlet(Formed suction) to Impeller eye	mm	<i>[....]</i>
NPSH required at a) Minimum Capacity b) Design Capacity c) Maximum Capacity (run out)	mwc	<i>a) Minimum Capacity-[....] b) Design Capacity-[....] c) Maximum Capacity-[....]</i>
NPSH available at minimum water level	mwc	<i>[....]</i>
Pump Specific Speed	.....	<i>[....]</i>
System Suction Speed at design condition (based on NPSH available at minimum water level in sump)	.....	<i>[....]</i>
Pump Suction Speed (based on NPSH required) at design condition	.....	<i>[....]</i>
Pump & drive combined critical Speed a) 1st b) 2nd	rpm	<i>a) [....] b) [....]</i>
Rotor over speed	rpm	<i>[....]</i>
Motor Rating (at 50 deg C)	kW	<i>[....]</i>
Impeller type and design	.....	<i>[....]</i>
Type of Thrust Bearings	.....	Mitchel or Kingsbury
Number of Bearings of the following type & its location a) Cutless rubber type b) "Thorden" Type	<i>a) [....] b) [....] c) [....]</i>

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[49]	25.09.2015

Description	Units	Design Parameters
c) Thrust Bearings (in pump) d) Thrust Bearings (in motor) e) Other types (Specify the type)		d) [....] e) [....]
Spacing between line shaft bearing	mm	[....]
Impeller shaft diameter,	mm	[....]
Line Shaft diameter,	mm	[....]
Diameter of Formed Suction (inlet to the impeller)	mm	[....]
Suction draft tube (Formed intake) dimensions (width x height)	mm	[....]
Impeller diameter at inlet	mm	[....]
Impeller diameter at outlet	mm	[....]
Size of pump discharge flange	mm	[....]
Distance from Pump house floor to the Minimum water level	mm	[....]
Diametrical clearance between wearing rings	mm	[....]
ACW Pump		
Name of manufacturer	....	[....]
Model Number	[....]
Total No. of ACW pumps	[....]
Type	[....]
Fluid	[....]
Location	[....]
Number of operating pumps	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[50]	25.09.2015

Description	Units	Design Parameters
No. of standby pumps	.....	[....]
Shut off head of the Pump	mwc	[....]
Rated Speed	rpm	[....]
Maximum efficiency of the pump at design point	%	[....]
Maximum efficiency of the pump motor at design point	%	[....]
Rated Capacity	m ³ /h	[....]
Total head at Rated Flow	mwc	[....]
Range of operation	%	[....]
Lowest low water level at fore bay	mm	[....]
Highest high water level at forebay	mm	[....]
Maximum power consumption at motor terminals in the pump operating range	kW	[....]
Minimum Power Consumption at motor terminals in the operating range	kW	[....]
Minimum Submergence (minimum distance from the minimum water level to the centre line of Draft Tube (Formed suction) inlet.	mm	a) Minimum Capacity-[....] b) Design Capacity-[....] c) Maximum Capacity-[....]
Height from sump invert level to center line of Draft Tube (Formed suction) inlet	mm	[....]
Height from centre line of Draft Tube inlet(Formed suction) to Impeller eye	mm	[....]
NPSH required at a)Minimum Capacity b) Design Capacity	mwc	a) Minimum Capacity-[....] b) Design Capacity-[....] c) Maximum Capacity-[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[51]	25.09.2015

Description	Units	Design Parameters
c) Maximum Capacity (run out)		
NPSH available at minimum water level	mwc	[...]
Pump Specific Speed	.....	[...]
Pump & drive combined critical Speed		
a) 1st	rpm	a) [...]
b) 2nd		b) [...]
Motor Rating (at 50 deg C)	kW	[...]
Capacity of EOT Crane provided for CW pump house	Tons	[...]
Stop log gates		
No. of Stop log gates	.....	[...]
Service	.....	[...]
Type of gate	.....	[...]
Location	.....	[...]
Design standard	.....	[...]
Gate sections	.....	[...]
Channel width	.....	[...]
No. of sections per set	.....	[...]
Dimensions (LXWXH)	mm	[...]
Weight of Stop log gate		[...]
Each segment weight	kg	
Total weight		
Coarse Screen		
No. of racks	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[52]	25.09.2015

Description	Units	Design Parameters
Service	.....	[...]
Location	.....	[...]
Design standard	.....	[...]
Type of rack	.....	[...]
Size of rack	mm	[...]
Capacity	m ³ /h	[...]
Dimension of rack	mm	[...]
wire size	gauge	[...]
Spacing between wires	mm	[...]
Design differential head	mm	[...]
Trash Rack		
No. of racks	.....	[...]
Service	.....	[...]
Location	.....	[...]
Design standard	.....	[...]
Type of rack	.....	[...]
Dimension of rack	mm	[...]
Bar thickness	mm	[...]
Spacing between bars	mm	[...]
Design differential head	mwc	[...]
CW Pipe, Recirculation pipe line and make water pipe line		
Pipe		

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[53]	25.09.2015

Description	Units	Design Parameters
Route Length of Underground Portion	mm	[...]
Route Length of Over ground Portion	mm	[...]
Manufacturer	.....	[...]
Type of construction	.....	[ERW/ SAW]
Material of construction	.....	[...]
Type of joints	.....	[Screwed joint / Welded Joint / Flanged Joint]
Size	mm	[...]
Wall thickness	mm	[...]
Provision of ARV	.....	[...]
Fittings		
Manufacturer	.....	[...]
Type of joints	.....	[Screwed joint / Welded Joint / Flanged Joint]
Flanges		
Manufacturer	.....	[...]
Material standard	.....	[...]
Type	.....	[...]
Rubber Expansion Joints		
Manufacturer	[...]
Service	[...]
Design Standard	[...]
Number of Expansion Joints	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[54]	25.09.2015

Description	Units	Design Parameters
Size (Diameter)	.....	[...]
Type	.....	[...]
Operating Temperature	.....	[...]
Design temperature	.....	[...]
Design Pressure	.....	[...]
Flow	m ³ /h	[...]
Pressure drop across expansion joint	kg/cm ²	[...]
End connection	.....	[...]
Butterfly Valves		
Name of manufacturer	.....	[...]
Model No	.....	[...]
Fluid	.....	[...]
Type	.....	[...]
Size	mm	[...]
Type of operation	.....	[Manual/ electrical actuated/ electro hydraulic actuated]
Number of valves	.....	[...]
Valve Design Code & Design Rating	[...]
End Flange details	[...]
Type of actuator	[...]
Flow	m ³ /h	[...]
Normal		
Maximum		

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[55]	25.09.2015

Description	Units	Design Parameters
Sealing direction	.....	[....]
Pressure a) Design b) Operating	kg/cm ²	a) Design-[....] b) Operating-[....]
Disc differential pressure	kg/cm ²	[....]
Natural Draft Cooling Tower, as applicable		
Type of Tower	.....	[Counter Flow/Cross Flow]
Number of Tower per unit	.....	[....]
Rated water flow per tower	m ³ /h	[....]
Design wet bulb temperature	deg C	[....]
Approach	deg C	[....]
Cooling range at rated flow	deg C	[....]
Design ambient relative humidity (average)	%	[....]
Height of top of tower above sill	m	[....]
Height of throat above sill	m	[....]
Height of top of air inlet above sill	m	[....]
Depth of fill at periphery/centre	m	[....]
Internal diameter of tower	m	Diameter at Sill Level-[....] Diameter at Throat-[....] Diameter at Top-[....]
Evaporation Loss at Rated Condition,	m ³ /h	[....]
Temperature of leaving air	deg C	Dry Bulb-[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[56]	25.09.2015

Description	Units	Design Parameters
		<i>Wet Bulb-[....]</i>
Total air area/tower (Fill area)	m ²	[....]
Total louvered area/tower (Inlet area)	m ²	[....]
Water flow area	m ²	[....]
Water flow rate per m ³ of effective fill volume	m ³	[....]
Plan area of fill	m ²	[....]
Cooling water flow per unit fill area L	kg	[....]
Dry air flow per unit fill area G	kg	[....]
Ratio of water to air weight L/G	.....	[....]
Temperature of air at fill outlet wet bulb/dry bulb	deg C	[....]
Total dry air flow per tower	kg	[....]
Inlet air enthalpy	kJ/kg	[....]
Exit air enthalpy	kJ/kg	[....]
Total heat exchange per hour	kJ	[....]
Evaporation loss (maximum)	m ³ /h	[....]
Drift loss (maximum)	m ³ /h	[....]
Draft loss	kg/cm ²	[....]
Performance Co-efficient	.....	[....]
Duty Co-efficient	[....]
Frictional losses in inlet pipe upto distribution trough	mwc	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[57]	25.09.2015

Description	Units	Design Parameters
Static head from ground level to centre line of hot water header to Cooling Tower.	mwc	[...]
Tower fill		
Make	.....	[...]
Model	.....	[...]
Flute size	.....	[...]
Material of fill	.....	[...]
Mattress size of the fill	mm	[...]
Material of fill support	.....	[...]
Total wetted surface area m ² of fill per tower	m ²	[...]
Thickness of fill member	mm	[...]
Total fill volume per tower	m ³	[...]
Number of fill decks	.....	[...]
Equivalent fill height	m	[...]
Hot water distribution system		
Main inlet pipe:		
Nos.	.....	[...]
Diameter	mm	[...]
Thickness	mm	[...]
Material of construction	[...]
Pressure class	kg/cm ²	[...]

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Description	Units	Design Parameters
Distribution pipes		
Type	[...]
Material of construction	[...]
Diameter	mm	[...]
Pressure class of Distribution Pipe	kg/cm ²	[...]
Nozzles		
Make of nozzle	.....	[...]
Type of nozzle	.....	[...]
Material of construction of Nozzle	.....	[...]
Nozzle spacing	mm	[...]
No. of nozzles per tower	.....	[...]
Elevation, inlet above curb	m	[...]
Water pressure at centerline of CT inlet pipe	kg/cm ²	[...]
Arrangement for flow measurement	.....	[...]
Arrangement for temperature measurement	.....	[...]
Arrangement for pressure measurement	.....	[...]
Cold water basin		
Basin dimensions	m	[...]
Effective capacity	m ³	[...]
[Induced Draft Cooling Tower (IDCT), as applicable]		

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[59]	25.09.2015

Description	Units	Design Parameters
Type of Tower	.....	[Counter Flow/Cross Flow]
Number of Tower per unit	.....	[...]
Overall Dimension of the Cooling Tower	mxmxm	[LxBxW]
Rated water flow per tower	m ³ /h	[...]
Design wet bulb temperature	deg C	[...]
Approach	deg C	[...]
Cooling range at rated flow	deg C	[...]
No. of working cells	.....	[...]
No. of spare cell	.....	[...]
No. of fans per cell	.....	[...]
Length of each cell	m	[...]
Width of each cell	m	[...]
Whether fan blades to have adjustable pitch	.....	[...]
Type of fill	.....	[...]
Whether fills are removable type	.....	[...]
Gear box service factor	.....	[...]
Details of Space heater	.....	[...]
Stack Height	m	[...]
Design pressure for hot water Distribution basin	kg/cm ²	[...]
Basin Type	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[60]	25.09.2015

Description	Units	Design Parameters
Storage capacity between normal to minimum water level	m ³	[...]
Minimum water level (Difference between lowest water level and level at top of mud sill at the basin cold water outlet)	mm	[...]
Free board in the basin	mm	[...]
Slope of basin floor towards sludge pit	.....	[...]
Number of sludge pits	.....	[...]
Number of cold water outlet channels	.....	[...]
Number of Sluice Gates per cold water outlet channel	.....	[...]
Number of screens per cold water outlet channel	.....	[...]
Maximum velocity through screens under minimum water level condition	m/s	[...]
Minimum clear space between any two fan stacks on adjacent cells	mm	[...]
Fans		
Name of Manufacturer	.....	[...]
Capacity	Kg/h	Dry Air - [...] Moisture – [...] Total - [...]
Design exit air temperature	deg C	[...]
Density of exit air	Kg/m ³	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[61]	25.09.2015

Description	Units	Design Parameters
Speed/No. of blades	rpm	[...]
Diameter at tip	mm	[...]
Tip velocity range	m/s	[...]
Clearance between tip and diffuser	mm	[...]
Fan air flow rate per cell	m ³ /h	[...]
Static pressure at fan	mmwg	[...]
Total pressure at fan	mmwg	[...]
Fan HP @ fan shaft/motor shaft	.....	[...]
Fan total efficiency	%	[...]
Fan Motor		
Name of Manufacturer	.....	[...]
Type	.....	[...]
Speed	rpm	[...]
Efficiency at full load	%	[...]
Motor rating	kW	[...]
Time for acceleration of fan	min	[...]
Starting torque	kgm	[...]
Fan Gear Box		
Name of Manufacturer	[...]
Type	[...]
Service Factor	[...]
Gear Ratio	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[62]	25.09.2015

Description	Units	Design Parameters
Gear Material	.....	[...]
Type of Coupling to Drive Shaft	.....	[...]
Type of Cooling	.....	[...]
Efficiency of reduction gear	%	[...]
Shaft	.....	Material - [...] Diameter – [...] Length - [...]
Side Stream Filtration System		
Type	.....	[...]
Quantity	.....	[...]
Shell material	.....	[...]
Normal Capacity	.....	[...]
Filtrating medium	.....	[...]
Water intake pressure	kg/cm ²	[...]
Suspending particles in intake water	(mg/l)	[...]
Suspending particles in outlet water	(mg/l)	[...]
Operation mode	.....	[...]
Design surface flow rate	m ³ /h	[...]
Design flow rate	m ³ /h	[...]
Water head loss at terminal	mWC	[...]
Backwash flow rate	m ³ /h	[...]
Backing washing medium	[...]
Time period of backwashing	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[63]	25.09.2015

Description	Units	Design Parameters
Filtration area/filter	mm2	[...]
Diameter	mm	[...]
Cylindrical Length	mm	[...]
Details of Blowers	.....	[...]
CW Chlorination System		
Type of System	....	[...]
Number of Ton Containers	Nos.	[...]
Number of streams	Nos.	[...]
Number of Evaporators	Nos.	[...]
Number of Chlorinators	Nos.	[...]
Continuous dosing rate	ppm	[...]
Shock dosing rate	ppm	[...]
Shock dosing duration	min	[...]
Shock dosing frequency	Number of times in 24 hrs.	[...]
Chlorine solution pipe size and material.	.....	[...]
Number of dispersers for continuous dosing	.....	[...]
Number of dispersers for shock dosing	Nos.	[...]
Isolation valves for dispersers with auto operation	Nos.	[...]
Provision of Booster Pumps (Working and Standby)	Nos.	[...]
Safety skid	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[64]	25.09.2015

Description	Units	Design Parameters
Provision of Chlorine leak detection system and Absorption Tower etc.	[....]

3.2.4

DM Plant

[DM plant consists of three streams, each of [...] m³/hr capacity. There are two DM water tanks of [...].m³ capacity. A common regeneration system has been provided for all the three streams. DM plant operates on semi-automatic system with PLC controls. The details of the plant are mentioned in the table below:]

Table: 3.13

Description	Units	Design Parameters
Demineralization Plant		
No. of DM Streams	[....]
No. of working streams	[....]
No. of standby streams	[....]
Water source	[....]
Installation	[Indoor/Outdoor]
Normal operation	[Automatic/Semi Automatic]
Net permeate water output	m ³ /h	[....]
Period between successive regenerations	h/day	Anion & Cation Resins: [....] hrs Mixed Bed resins: [....] day
Pressure Vessels Type	[Vertical, welded, cylindrical shell type, dished ends]
Number of Pressure Vessels (For Each type i.e. Strongly acidic cation exchanger (SAC), Weak Acid Cation exchanger (WAC), Strongly basic anion exchanger (SBA), Weak Base Anion exchanger (WBA), Mixed bed exchanger (MB))	SAC-[....], WAC - [....] SBA-[....] WBA-[....] MB-[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[65]	25.09.2015

Description	Units	Design Parameters
Size of Pressure Vessels (For Each type i.e. Strongly acidic cation exchanger (SAC), Weak Acid Cation exchanger (WAC), Strongly basic anion exchanger (SBA), Weak Base Anion exchanger (WBA), Mixed bed exchanger (MB))		<i>SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]</i>
Type of Resin		<i>SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]</i>
Volume of Resin		<i>SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]</i>
Net outflow/unit	m ³ /h	<i>SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]</i>
Design surface flow rate	m ³ /m ² /h	<i>SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]</i>
Design Pressure	kg/cm ²	<i>SAC-[...], WAC - [...]</i>

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[66]	25.09.2015

Description	Units	Design Parameters
		SBA-[...] WBA-[...] MB-[...]
Design Temperature	deg C	[...]
Material of Construction of Shell	.....	SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]
Material of Construction of Dished End	.....	SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]
Effective Bed Depth	mm	SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]
Buffer Bed Depth	mm	SAC-[...], WAC - [...] SBA-[...] WBA-[...] MB-[...]
Inert bed	mm	SAC-[...], WAC - [...] SBA-[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[67]	25.09.2015

Description	Units	Design Parameters
		WBA-[...] MB-[...]
Air Blowers for MB exchanger and Neutralization Pit		
Numbers	.....	[...]
Type	.....	[...]
Duty	.....	[...]
Capacity of each blower for Mixed Bed	.....	[...]
Developed Head	mwc	[...]
MOC of Casing	.....	[...]
MOC of Lobes / impeller	.....	[...]
MOC of Shaft	.....	[...]
MOC of Safety valve	.....	[...]
Degasser Tower (DGT)		
Number	.....	[...]
Type	.....	[...]
Maximum & minimum capacity	%	[...]
Fill material	.....	[...]
CO ₂ content	ppm	[...]
Design Code	.....	[...]
Size (Diameter x Height)	mm	[...]
Material of Construction (Shell, Distributers, collectors, Nozzles etc.)	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[68]	25.09.2015

Description	Units	Design Parameters
Degassed Water Storage Tank (DGWT)		
Number	.....	[...]
Design Code	.....	[...]
Location	.....	[...]
Type	.....	[...]
Useful capacity	hrs	[...]
Free Board	mm	[...]
Material of construction	.....	[...]
Degassed Water Pumps (DGP)		
Number	.....	[...]
Type	.....	[...]
Duty	.....	[...]
Capacity	m ³ /h	[...]
TDH	mwc	[...]
Speed	rpm	[...]
Pump Efficiency	%	[...]
Motor Rating	kW	[...]
Material of Construction	[...]
Air Blowers for Degassser		
Numbers	[...]
Type	[...]
Duty	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[69]	25.09.2015

Description	Units	Design Parameters
Capacity of each blower for Mixed Bed	.....	[...]
Developed Head	mwc	[...]
MOC of Casing	.....	[...]
MOC of Lobes / impeller	.....	[...]
MOC of Shaft	.....	[...]
MOC of Safety valve	.....	[...]
Ultra Filtration Unit, as applicable		
Number of trains	.....	[...]
Feed Temperature	deg C	[...]
Recovery from UF	%	[...]
UF Treated (Filtrate) Flow <i>[capacity of MB + Water required for backwashing of UF membrane + chemical preparation requirements 5% margin above total requirements]</i>	.....	[...]
Mode of Operation	.....	[...]
Type of Operation	.....	[...]
Type of Membrane	.....	[...]
Type of Membrane mounting	.....	[Horizontal/ Vertical]
Regeneration Equipment		
Number of Acid Bulk Storage Tanks	....	[...]
Capacity of Acid Bulk Storage Tanks	kl	[...]
Number of Alkali Bulk Storage Tanks	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[70]	25.09.2015

Description	Units	Design Parameters
Capacity of Alkali Bulk Storage Tanks	kl	[...]
Number of Acid Dosing Tanks	....	[...]
Capacity of Acid Dosing Tanks	kl	[...]
Material of Acid Dosing Tanks	....	[...]
No. of Alkali Dosing Tanks	....	[...]
Capacity of Alkali Dosing Tanks	kl	[...]
Material of Alkali Dosing Tanks	....	[...]
Number of Regeneration Pumps	....	[...]
Capacity of Regeneration Pumps	lpm	[...]
No. of Acid unloading pumps	...	[...]
Capacity of Acid unloading pumps	m ³ /hr	[...]
Number of Alkali unloading pumps	....	[...]
Capacity of Alkali unloading pumps	m ³ /hr	[...]
Number of Heaters for Anion regeneration Water	.....	[...]
Capacity of Heater for Anion regeneration water	kW	[...]
Number of Compartments for Neutralizing Pit	....	[...]
Capacity of Neutralizing Pit	m ³	[...]
No. of Effluent Disposal Pumps	....	[...]
Capacity of Effluent Disposal Pumps	m ³ /hr	[...]
Type of Effluent Disposal Pumps	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[71]	25.09.2015

Description	Units	Design Parameters
Type of Lining of Pit	....	[...]
DM Water Transfer Pumps		
No. of Pumps	.....	[...]
No. of Pumps Working	.....	[...]
No. of Pumps Stand-by	.....	[...]
Suction Lift/Head Available	mlc	[...]
Flow	m ³ /h	[...]
Total Dynamic Head	mlc	[...]
Rated Speed	rpm	[...]
Range of Operation	%	[...]
Suction specific speed	US unit	[...]
Pump Efficiency	%	[...]
Motor Rating	kW	[...]
Material of Construction	.....	[...]
DM Water Storage Tank		
Number	.....	[...]
Design code	.....	[...]
Capacity of each tank	m ³	[...]
Overall Dimension of the Tank	[...]
Free Board	mm	[...]
Type and pressure class	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[72]	25.09.2015

Description	Units	Design Parameters
Material of construction and Thickness	.....	[....]
Other Major Accessories		
Boiler Fill Pumps		
No. of Pumps	.....	[....]
No. of Pumps Working	.....	[....]
No. of Pumps Stand-by	.....	[....]
Suction Lift/Head Available	mlc	[....]
Flow	m ³ /h	[....]
Total Dynamic Head	mlc	[....]
Rated Speed	rpm	[....]
Range of Operation	%	[....]
Suction specific speed	US unit	[....]
Pump Efficiency	%	[....]
Motor Rating	kW	[....]
Material of Construction	.....	[....]

3.2.5 Air-Conditioning and Ventilation System

[The central control room, switchyard control room, ESP controls room and selected areas of service building have been provided with centralized air-conditioning system. The central air-conditioning system of chilled water type has been provided for various control rooms and DX type of plant has been provided for ESP control room, switchyard control room and other areas in the service building. Packaged type of air-conditioners has been provided for water treatment plant control room. Evaporative ventilation system has been provided for TG building along with roof extractors. Other areas are ventilated by a combination of exhaust and supply air fan. The details of the system are mentioned in the table below:].

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Table: 3.14

Description	Units	Design Parameters
Split Air Conditioner (Ductable / Non-Ductable)		
Location	.....	[...]
Quantity.	.....	[...]
Type	.....	[...]
Make	.....	[...]
Model No.	.....	[...]
Capacity	TR	[...]
Power Consumption	kW	[...]
Overall Dimension (L x B x D)	mm	[...]
Gross Weight	kg	[...]
Refrigerant Compressor		
Manufacturer	.....	[...]
No. of Units	.....	[...]
Type	.....	[...]
Refrigerant	.....	[...]
Condensing Temperature	deg C	[...]
Evaporating Temperature	deg C	[...]
Capacity	kCal/h	[...]
Speed	rpm	[...]
BHP	[...]
Lubrication type		[...]
Coil (Condenser and Evaporator)		

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[74]	25.09.2015

Description	Units	Design Parameters
Manufacturer	.....	[...]
Type	.....	[...]
Quantity		[...]
Centrifugal Fan		
Quantity	.....	[...]
Manufacturer	.....	[...]
Model No.	.....	[...]
Type	.....	[...]
Capacity	m ³ /h	[...]
Specific weight of air at temperature considered	kg/m ³	[...]
Rated speed	rpm	[...]
Total head at above speed	mmwg	[...]
Static head at rated speed	mmwg	[...]
Critical speed of fan and shaft	rpm	[...]
Fan power at rated speed	kW	[...]
Fan total efficiency at rated speed	%	[...]
Wheel diameter	mm	[...]
Overall Wheel width	mm	[...]
Outlet velocity	m/s	[...]
Material used in wheel and its thickness	mm	[...]
Material used in shaft	[...]
Type of bearing	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[75]	25.09.2015

Description	Units	Design Parameters
Type of fan drive	[...]
Drive manufacturer	[...]
Number of belts	[...]
Size of belts	[...]
Vibration Isolator Manufacture	[...]
Vibration Isolator size and No.	[...]
Outlet damper type & size	[...]
Material and thickness of louver and casing	[...]
Inlet damper type & size	[...]
Material and thickness of plate used in the casing and flap on the damper	[...]
Rated volt of motor	[...]
Motor rating	kW	[...]
Type of insulation	[...]
Type of enclosure	[...]
Overall dimension including fan & motor	[...]
Axial Flow Fan		
Loation	[...]
Quantity	[...]
Manufacturer	[...]
Model No.	[...]
Type	[...]
Specific weight of air	kg/m ³	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[76]	25.09.2015

Description	Units	Design Parameters
Capacity	m ³ /h	[...]
Static head at rated speed	mmwg	[...]
Total head at rated speed	mmwg	[...]
Rated speed	rpm	[...]
Critical speed of fan	rpm	[...]
Fan power at rated speed	kW	[...]
Fan efficiency at rated speed	%	[...]
Wheel diameter	mm	[...]
No. of blades in wheel	.....	[...]
Outlet velocity in	m/s	[...]
Material used in fan wheel	.....	[...]
Material in other parts	.....	[...]
Type of fan bearing	.....	[...]
Type of drive	.....	[...]
Rated volt of motor	.....	[...]
Motor Rating	kW	[...]
Type of insulation	.....	[...]
Type of enclosure	.....	[...]
Cooling Towers for Chilling Plant		
Type	[...]
Capacity		
Material of construction of Casing & Sump	[...]
Details of Fan	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[77]	25.09.2015

Description	Units	Design Parameters
Type of Fill	[....]
Type of Louvers	[....]
Nozzles Material	[....]
Details of Drift Eliminators	[....]
Details of Supporting structure	[....]
Details of Strainer at water outlet	[....]
Material of Distribution Pipe	[....]
Air Handling Unit (AHU)		
Type	[....]
Make	[....]
Quantity	[....]
Supply air fan parameter	Capacity - [....] Static Pressure - [....]
Supply air motor rating	kW	[....]
Cooling coil details:	Air Quantity - [....] Face Area - [....] Number of tubes - [....] Material of construction for coil - [....] Material of construction for fin - [....]
Dampers (face & bypass):	Type - [....] Material - [....]
Details of Filter	Type, number - [....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[78]	25.09.2015

Description	Units	Design Parameters
		Capacity - [....] Media, efficiency and face velocity of filter - [....]
Heaters	.....	Type - [....] Make - [....] Quantity - [....] Capacity - [....]
Humidifier	.....	Type - [....] Make - [....] Quantity - [....] Capacity - [....]
Air Washer		
Type	.....	[....]
Make	.....	[....]
Quantity	.....	[....]
Number & material of spray/ flooding nozzles	.....	[....]
Air Washer Fan Capacity	m ³ /h	[....]
Fans Static Pressure	Pa	[....]
Fan Power Consumption	kW	[....]
Air washer sump capacity	m ³	[....]
Speed	rpm	[....]
Water makeup rate	m ³ /h	[....]
Number, size, of spray header pipes	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[79]	25.09.2015

Description	Units	Design Parameters
Material of Construction	[....]

3.2.6

Fire Fighting System

[Fire fighting system is a common facility provided for all the units. This consists of pressured hydrant system for all the auxiliary buildings, pump houses and administrative building. Automatic high velocity sprinklers system has been provided for power transformers, turbine oil tanks and lube oil system equipments. Medium velocity sprinkler system has been provided for cable galleries and coal conveyor galleries. Portable types of fire extinguishers have been provided throughout the plant for fighting small and localized fires. The details of the system are mentioned in the table below:]

Table: 3.15

Description	Units	Design Parameters
Hydrant System		
Number of Internal Hydrant	[....]
No. of internal hydrant valves	[....]
Number of External Hydrant valves	[....]
No. of Water monitors	[....]
Type of Hydrant valves	[....]
Make of Hydrant valves	[....]
Material of body of Hydrant valves	[....]
Material of trim of Hydrant valves	[....]
Type of Hoses	[....]
Make of Hoses	[....]
Material of Hoses	[....]
Type of isolation Valves	[....]
Make of isolation valves	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[80]	25.09.2015

Description	Units	Design Parameters
Material of body of isolation valves	[...]
Material of trim of isolation valves	[...]
HVW & MVW Spray System		
Areas Protected Under HVW Spray System	[...]
Areas Protected Under MVW Spray	[...]
Type of detection system(s) at various areas	[...]
Fire Extinguishers & Fire Station Equipments		
Manufacturer	[...]
Model	[...]
Quantity	[...]
Fire Detection and Control System		
Make, type & model no. of Fire detection and alarm system	[...]
Addressable multisensor type smoke detector	[...]
Addressable photo electric type smoke detector	[...]
Linear heat sensing cable detector	[...]
QB detector	[...]
Fire Water Pumps and Pump House		
Hydrant System Pumps & Drive		
Number & type of drive	[...]
Type of pumps	[...]
Make and model no.	[...]

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Description	Units	Design Parameters
Capacity	m ³ /h	[...]
Head	mwc	[...]
Speed	rpm	[...]
Power Consumption	kW	[...]
Motor Rating	kW	[...]
Material of Construction	.....	[...]
Spray System Pumps & Drive		
Number & type of drive	.....	[...]
Type of pumps	.....	[...]
Make and model no.	.....	[...]
Capacity	m ³ /h	[...]
Head	mwc	[...]
Speed	rpm	[...]
Power Consumption	kW	[...]
Motor Rating	kW	[...]
Material of Construction	.....	[...]
Jockey Pumps & Drive		
Number & type of drive	[...]
Type of pumps	[...]
Make and model no.	[...]
Capacity	m ³ /h	[...]
Head	mwc	[...]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[82]	25.09.2015

Description	Units	Design Parameters
Speed	rpm	[...]
Power Consumption	kW	[...]
Motor Rating	kW	[...]
Material of Construction	.....	[...]
Diesel Engines & Engine Driven Pumps		
Number of type for each pump	.....	[...]
Type of engine	.....	[...]
Make & model no.	.....	[...]
Capacity	m ³ /h	[...]
Head	mwc	[...]
Material of construction - Casing & Impeller of hydrant System pumps	.....	[...]
Material of construction - Casing & Impeller of Spray system pumps	.....	[...]
Material of construction - Casing & Impeller of jockey pumps	.....	[...]
Inert Gas Extinguisher		
Type of agent gas employed for the inert gas extinguishing system	.....	[...]
Capacity of each gas cylinders	liter	[...]
Total quantity of Gas	kg	[...]
Total Number of Cylinders	.....	[...]

3.2.7

Plant and Instrument Air System

[Plant and instrument air system is a common facility for all the units of the plant. For meeting the instrument air requirement, [...] number of oil free screw compressors [...] working and [...] standby, each of [...] m³/hr capacity and discharge pressure of [...] kg/cm² (g) have been provided along with dryers. Equal number of air compressors of

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similar rating has been provided to meet the requirement of plant air system. The air drying plant for the instrument air has been provided to achieve a dew point of (-) 40 deg C at atmospheric pressure. The details of the system are mentioned in the table below:]

Table: 3.16

Description	Units	Design Parameters
Location	.....	[....]
No. of instrument air (IA) compressors	.....	Working-[....] Standby-[....]
No. of service air (SA) compressors	.....	Working-[....] Standby-[....]
Type	.....	[....]
Duty	.....	[....]
Free Air Delivery of IA compressor	m ³ /h	[....]
Discharge Pressure of IA compressor	kg/cm ²	[....]
Power Consumption of IA compressor	kW	[....]
Motor Rating	kW	[....]
Free Air Delivery of SA compressor	m ³ /h	[....]
Discharge Pressure of IA compressor	kg/cm ²	[....]
Power Consumption of IA compressor	kW	[....]
Motor Rating of IA compressor	kW	[....]
Noise level near compressors	dBA	[....]
Vibration (measured at top and bottom of main bearing)	[....]
Type of Drive	[....]
Number of starts per hour	[....]

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Description	Units	Design Parameters
Type of transmission	[...]
Anti vibration arrangement	[...]
Type of control	[...]
Type of Annunciation	[...]
Flange standard	[...]
MOC of Compressor chamber	[...]
MOC of Rotors	[...]
MOC of Bearing	[...]
MOC of Timing Gear	[...]
MOC of Base Plate	[...]
MOC of Inlet throttle valve & housing	[...]
MOC of Shaft seals	[...]
Auxiliary Cooling Water Requirement		
Quality	[...]
Inlet temperature	[...]
Design pressure	[...]
Normal inlet pressure	[...]
pH value	[...]
Maximum pressure drop allowable between inlet and outlet points	[...]
Intake Air Filter		
Numbers	[...]

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Description	Units	Design Parameters
Location	[....]
Type	[....]
Silencer	[....]
Air flow rate	[....]
Particle removing efficiency	%	[....]
Maximum pressure drop at stated air flow rate	kg/cm ²	[....]
Air Receiver		
Quantity	[....]
Type	[....]
Design pressure	[....]
Design code	[....]
Capacity of each air receiver	[....]
Material of construction of shell	[....]
Material of construction of dished ends	[....]
Material of construction of flanges	[....]
Intercooler, Aftercooler, Moisture Separator		
Aftercooler		
Installation	[....]
Type	[....]
Relief Valve	[....]
Moisture Separator	[....]
Trap Station	[....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[86]	25.09.2015

Description	Units	Design Parameters
Temperature Indicator	[....]
Temperature Switch	[....]
Level Gauge	[....]
Intercooler		
Type	[....]
Relief Valve	[....]
Trap Station	[....]
Pressure Gauge	[....]
Temperature Indicator	[....]
Temperature Switch	[....]
Piping, Valves and Fittings for Compressed Air System		
Details of Pipes for cooling water line	[....]
Details of Pipes for compressed air line & interconnecting air line	[....]
Details of Fittings for cooling water line	[....]
Details of Fittings for compressed air piping & interconnecting air piping	[....]
Details of Valves for air line	[....]
Details of Valves for cooling water line	[....]
Air Drying Plants		
Quantity of Drier	[....]
Type	[....]
Design airflow, at plant inlet	Nm ³ /m	[....]

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Description	Units	Design Parameters
Dew point of outlet air at atmospheric pressure	[...]

3.2.8

Fuel Oil System

[The fuel oil system has been designed for the use of Light Diesel Oil (LDO) for start-up and Heavy Fuel Oil (HFO) for load carrying and flame stabilization purposes. Two tanks of [...] kl each have been provided for the storage of HFO and two tanks of [...] kl each have been provided for the storage of LDO. The system has been provided with unloading, transferring and pressurization pumps along with necessary filters and heating arrangement. The details of the system are mentioned in the table below:]

Table: 3.17

Description	Units	Design Parameters	
Storage Tank (HFO/LDO)		HFO	LDO
Capacity of each tank	m ³	[...]	[...]
Quantity	.....	[...]	[...]
Applicable code for design	.....	[...]	[...]
MOC	.....	[...]	[...]
Dimension, dia and height	mm	[...]	[...]
Shell plate thickness,	mm	[...]	[...]
Roof plate thickness	mm	[...]	[...]
Unloading Pump (HFO/LDO)		HFO	LDO
Manufacturer	[...]	[...]
Type	[...]	[...]
Number of pumps	[...]	[...]
Number of pumps in standby/ service	[...]	[...]

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Description	Units	Design Parameters	
Rated capacity per pump	m ³ /hr	[...]	[...]
Discharge pressure at rated capacity	kg/cm ²	[...]	[...]
Total developed head	mlc	[...]	[...]
Rated speed of the pump	rpm	[...]	[...]
Efficiency at rated capacity	%	[...]	[...]
Pump kW at rated capacity and total head	kW	[...]	[...]
Power Consumption	kW	[...]	[...]
Pump heating arrangement	.....	[...]	[...]
Material of Construction	.....	[...]	[...]
Pressurizing Pump (HFO/LDO)		HFO	LDO
Manufacturer	.....	[...]	[...]
Type	.....	[...]	[...]
Number of pumps	.....	[...]	[...]
Number of pumps in standby/ service	.....	[...]	[...]
Rated capacity per pump	m ³ /hr	[...]	[...]
Discharge pressure at rated capacity	kg/cm ²	[...]	[...]
Total developed head	mlc	[...]	[...]
Rated speed of the pump	rpm	[...]	[...]
Efficiency at rated capacity	%	[...]	[...]
Pump KW at rated capacity and total head	kW	[...]	[...]
Power Consumption	kW	[...]	[...]
Type of coupling	[...]	[...]

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Description	Units	Design Parameters	
Pump heating arrangement	[...]	[...]
Material of Construction	[...]	[...]
Heavy Fuel Oil Heaters			
Manufacturer	.....	[....]
Type	.....	[....]
Total number	.....	[....]
Numbers standby	.....	[....]
Fluid on	.....	[....]
Tube side		[....]	
Shell side	.....	[....]
Capacity of each heater	T/h	[....]	
Normal steam consumption per heater	T/h	[....]	
Inlet temperature	deg C	[....]	
Outlet temperature	deg C	[....]	
Operating pressure	kg/cm ²	[....]	
Heat transfer surface area	m ²	[....]	
Number of tubes	[....]	
Number of passes per heater	[....]	
Tube outside diameter	mm	[....]	
Tube thickness	mm	[....]	

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Description	Units	Design Parameters
Tube length	mm	[....]
Tube pitch	mm	[....]
Inner diameter of shell	mm	[....]
Outer diameter of shell	mm	[....]
Oil Strainers for Unloading Pump		
Manufacturer	.....	[....]
Type	.....	[....]
Number provided	.....	[....]
Number in standby service	.....	[....]
Mesh size	.....	[....]
Ratio of straining area to inlet area	.....	[....]
Maximum pressure drop at rated flow	kg/cm ²	
100% cleanliness		[....]
75% cleanliness		[....]
Oil Strainers for Forwarding Pump		
Manufacturer	.....	[....]
Type	.....	[....]
Number provided	.....	[....]
Number in standby service	[....]
Mesh size	[....]
Ratio of straining area to inlet area	[....]

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Description	Units	Design Parameters
Maximum pressure drop at rated flow in Kg/Cm2 with a. 100% cleanliness b. 75% cleanliness	kg/cm ²	[....]

3.2.9

Mill Reject Handling System

Description	Units	Design Parameters
Quantity of rejects	T/unit	[....]
Temperature Rejects	deg C	[....]
Make	....	[....]
Capacity	TPH	[....]
Conveying speed of rejects	m/s	[....]
Particle size considered for conveying	mm	[....]
Pipe size	mm	[....]
Motor rating	kW	[....]
Capacity of mill rejects storage hopper	T	[....]
Material of construction of parent material of rejects storage hopper	....	[....]
Thickness of liner of rejects storage hopper	mm	[....]
Minimum valve angle of hopper	Degree	[....]
Clear head room available below hopper for truck movement	m	[....]
Type, number and capacity of hoist envisaged	T	[....]
Total weight of the system	T	[....]
Air Compressor		

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Description	Units	Design Parameters
No. of air compressors	Working-[....] Standby-[....]
Type	.....	[....]
Duty	.....	[....]
Free Air Delivery	m ³ /h	[....]
Discharge Pressure	kg/cm ²	[....]
Power Consumption	kW	[....]
Motor Rating	kW	[....]
Noise level near compressors	dBA	[....]
Vibration (measured at top and bottom of main bearing)	.....	[....]
Type of Drive	.....	[....]
Type of transmission	.....	[....]
Anti vibration arrangement	.....	[....]
Type of control	.....	[....]
Type of Annunciation	.....	[....]
Flange standard	.....	[....]
MOC of Compressor chamber	.....	[....]
MOC of Rotors	.....	[....]
MOC of Base Plate	.....	[....]

3.2.10

Cranes/Hoists

[For the maintenance of various equipments, manually /electrically operated cranes and hoists have been provided. The details of various Cranes & Hoists are mentioned in the table below:]

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Description	Units	Design Parameters
EOT Cranes		
Quantity	[....]
Location/Name of the Building	[....]
Span	m	[....]
Crane capacity	T	[....]
Main hook		[....]
Auxiliary hook		[....]
Manufacturer	.....	[....]
Type	.....	[....]
Indoor/ Outdoor	.....	[....]
Height of lift	m	[....]
a. Main hook		[....]
Above floor		[....]
Below floor Aux hook		[....]
b. Auxiliary hook		[....]
Above floor		[....]
Below floor		[....]
Duty Class	.....
Speeds (normal & Creep - 10% of main speed)	m/ min	[....]
a. Main hoist & creep		[....]
b. Aux. Hoist & creep		[....]
c. Cross travel		[....]
d. Long travel		[....]
Sheave material, type of guard	.....	[....]
a. Main hoist		[....]
b. Aux hoist		[....]
Rope Drum Quantity, Material	[....]
a. Main hoist		[....]
b. Aux hoist		[....]

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Description	Units	Design Parameters
Gantry rail size / Hardness	[....]
Crab rail size/Hardness	[....]
Wheel Material	.....	[....]
Hardness	.....	[....]
Wheel diameter / Nos provided for LT wheel CT wheel	mm	[....] [....]
Motor Rating: Hoist (Main) Micro Hoist (Main) Long Travel/Cross Travel	kW	[....] [....] [....]
Speeds Main Hoist Cross Travel " Long Travel "	m/min	[....] [....] [....]
U/S Crane		
Hoist type	.....	[....]
Capacity	T	[....]
Quantity	[....]
Duty Class	[....]
Span	m	[....]
Material Specification Frame Hook Load Chain	[....] [....] [....]

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Description	Units	Design Parameters
Hand Chain		[...]
Hand Chain Wheel		[...]
Load chain wheel		[...]
Gears.		[...]
Electric Hoist		
Quantity	.....	[...]
Location	.....	[...]
Capacity	T	[...]
Duty classification	.....	[...]
Wire ropes		[...]
a. Type of construction		[...]
b. Size	.....	[...]
c. Number of falls		[...]
d. Factor of safety		[...]
Rope drum		[...]
a. Materials	.....	[...]
b. Diameter		[...]
Drives		[...]
a. Type & material of gear box	.....	[...]
b. Gear & pinion		[...]
Motors		[...]
a. Type & number		[...]
b. kW rating		[...]
c. Synchronous speed	.....	[...]
d. Class of insulation		[...]
e. Pull out torque		[...]
f. Frame size		[...]
Brakes		[...]
a. Type	[...]
b. Size		[...]
c. Torque rating		[...]

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Description	Units	Design Parameters
Lifting hook		[...]
a. Type	[...]
b. Material		[...]
d. Type & details of control		[...]
Wheels		[...]
a. Numbers	...	[...]
b. Diameter		[...]
c. Material & hardness		[...]
d. Max. wheel load		[...]
e. Wheel base		[...]
f. Wheel type		[...]
Rail:		[...]
a. Size	.....	[...]
b. Length		[...]
c. Radius of curvature		[...]
e. Hardness of rail		[...]
Manual Hoist		
Capacity	.....	[...]
Quantity	.....	[...]
Height of Lift	m	[...]
Class of Duty	.....	[...]

3.2.11 Effluent Treatment Plant

[The effluent treatment plant has been designed to collect and treat the waste water effluent from all the sources in the power plant to enable it to be reused in the power plant to achieve zero discharge. The main sources of plant effluent are, blow downs from the Boiler and CW System, effluent from neutralizing pit of Water Treatment Plant, coal pile area run off , clarified recycled water from ash pond, effluent from plant drains and oily wastes from transformer yard , fuel oil unloading area & tank farm area. Coal pile area run off is first led to a settling tank where coal particles settle down and the clear water is pumped to the Central Monitoring Basin (CMB). Oily wastes are first treated in oil /water separator, from where; the clear water is led to CMB. The combined design flow rate to CMB is [...]] m3/h. The CMB has been designed for a

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holding capacity of two hours. Chemical dosing is done at CMB to achieve pH correction. The treated water from CMB is partly utilized for horticultural & service water applications while rest of the water is further treated at a Lamella Clarifier, Pressure Filter, Ultra Filters, Micro Filters and RO plant. The permeate from RO Plant is recycled to the CW pump house Fore- bay and the reject from the RO Plant is utilized for meeting the requirement of coal dust suppression and wetting of fly ash. The system details are given below]

Description	Units	Design Parameters
Influents to ETP		
Blow down from CW System	m ³ /h	[....]
Blow down from the Boiler	m ³ /h	[....]
Flow from Neutralizing Pit of DM Plant	m ³ /day	[....]
Flow from wash drains of Boiler, Turbine Halls and other Buildings.	m ³ /day	[....]
Recycled water from the ash pond	m ³ /h	[....]
Oil free water from oil/ water separator	m ³ /day	[....]
Clear Water from the settling tank of coal pile area	m ³ /day	[....]
EFFLUENT TREATMENT PLANT		
Holding Capacity of CMB	hrs	[....]
Flow Rating of Lamella Clarifier	m ³ /h	[....]
Flow Rating of Pressure Filter	m ³ /h	[....]
Flow Rating of Ultra Filter	m ³ /h	[....]
Flow Rating of Micro Filter	m ³ /h	[....]
Flow Rating of RO System	m ³ /h	

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3.2.12 Electrical System

i. Service Transformer

[The Service transformer of Oil/Dry type is designed to cater 100% of Power plant auxiliary load of respective system like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc, or Combination of different system with 2 x100% configuration is followed. The design parameters of the Service Transformer are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type		[Oil/Dry.....]
Transformer application		[..Service
Installation		[...Indoor/Outdoor.]
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Rated frequency	Hz	[.....]
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap		[.....]
Winding connection and vector group		[.....]
System fault level	kA	[HV.....]; [LV.....]
Insulation Level:		
a) One minute Power		

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Description	Units	Design Parameters
frequency withstand voltage b) Impulse withstand voltage	kV KV(peak)	[.....] [.....]
System earthing (a) HV (b) LV		[.....] [.....Solidly earthed.....]
Type of tap changer a) Range of Taps b) No of Steps		[.....Off Circuit.....] [.....] [.....]
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at a) Full load b) 75% load	%	[.....]

ii. LV Switchgear (PMCC/MCC)

[The LV Switchgear is provided with two incomers and bus coupler or single bus with one incomer with outgoing feeders intend for specific Auxiliary services system like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc,. The design parameters of the LV Switchgear /MCC are furnished below:

Description	Units	Design Parameters
Make/Manufacturer		[.....]

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Description	Units	Design Parameters
Rated voltage, phases & frequency	V, Hz	[.....]
System neutral earthing		[.....]
Maximum system voltage	V	[.....]
One minute power frequency Voltage		[.....]
Continuous current rating of bus bars		[.....]
Short Circuit rating of Bus bar with duration	kA & sec	[.....]
Bus bar Material	Al/Cu	[.....]
Type- Fully Draw out/Fixed		[.....]

iii. DC System

[The DC system required for Balance of Plants system like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc, will be provided with 2 x100% battery with Battery Charger. The design parameters of the DC system comprising of Battery and Battery Charger are furnished below: However DC system for Main plant BTG package is covered under TG Package.

Description	Units	Design Parameters
BATTERY		
Make/Manufacturer		[.....]
DC System Voltage	V	[220V.....]
Battery Type		[.....]

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Description	Units	Design Parameters
AH Rating/Rated Capacity	AH	[.....]
Number of cells		[.....]
End Cell Voltage	V	[.....]
Expected fault level at bus due to battery	kVA	[.....]
AH Efficiency at Rated load	%	[.....]
BATTERY CHARGER		[.....]
Make/Manufacturer		[.....]
Type of Battery Charger		[...Float & boost/Float cum Boost.....]
Battery Charger Rating	Amp	[.....]
AC Input Voltage , Phase , Frequency	V, Hz	[.....]
Short Circuit Level	kA/Sec	[.....]
Efficiency of Charger	%	[.....]
Guaranteed Efficiency		[.....]
a) At 50% load	%	[.....]
b)At rated load	%	[.....]
Power Factor		[.....]
a) At 50% load		[.....]
b)At rated load		[.....]

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iv. Non Segregated Phase Bus Duct (NSPBD)

[The Non Segregated Phase Bus Duct (NSPBD) connects Service Transformer to LV Switchgear. The design parameters of the NSPBD are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type of bus duct		[.....]
Rated voltage and No. of phase	V	[.....]
Material of Busbar and Enclosure		[.....]
Rated Current	A	[.....]
Designation (From and To)		[.....]
Type of cooling (NSPBD)		[.....]
Maximum temperature rise of conductor over 50°C ambient	°C	[.....]
Maximum temperature rise of enclosure over 50°C ambient	°C	[.....]
One minute power frequency voltage withstand	KV (RMS)	[.....]
Continuous current rating at 50°C design ambient air temperature	A	[.....]
One second short circuit withstand rating	KA (RMS)	[.....]

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Description	Units	Design Parameters
Momentary short circuit withstand current	KA (Peak)	[.....]

v. MV Cables

[The MV cables of 6.6kV UE Voltage grade is used for feeding MV motors as well as service transformers. The design parameters of the MV Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]

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Description	Units	Design Parameters
Type of End Sealing		[.....]

vi. LV Cables

[The LV cables of 1.1kV Voltage grade are used for feeding LV motors as well as for sub distribution system boards. The design parameters of the LV Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]

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Description	Units	Design Parameters
Type of End Sealing		[.....]

vii. Control (Core) Cables

[The Control cables of 1.1kV Voltage grade are used for Protection, CT, VT connection and feedback/interlock signals. The design parameters of the Control Cables are furnished below:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]

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Description	Units	Design Parameters
Type of End Sealing		[.....]

viii. MV/LV Motor

[The design parameters of MV/LV motors used for Mechanical Balance of Plant packages like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc, are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Application		[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Frame Size		[.....]
Type of Cooling		[.....]
Installation		[.....]
Duty Type		[.....]
Load Factor		[.....]
Full load current		[.....]
Starting current & Starting PF	Times Normal current	[.....]
Winding connection	Star/Delta	[.....]
Full load speed		[.....]
Power factor and Efficiency		[.....]

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Description	Units	Design Parameters
Class of insulation		[.....]
Method of starting :		[.....]
Main terminal box details		[.....]
Space Heater Details		[.....]
CT details if provided with differential protection		[.....]
RTD/BTD Details		[.....]

ix. Actuator

[The design parameters of Electrical Actuators used for Mechanical Balance of Plant packages like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc, are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Application		[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Installation		[.....]
Duty Type		[.....]
Load Factor		[.....]
Type		[... Integral/Non Integral.....]

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Description	Units	Design Parameters
Class of Insulation		[.....]

x. Illumination System

[The illumination system is categorized mainly as Normal, Emergency and DC lighting. The illumination system of indoor area/Building (Other than Boiler area, TG Building, Ash Handling Plant and Coal Handling Plant, switchyard and transformer yard), Outdoor area and Road lighting for Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, Chimney, AC and ventilation etc. are covered in this package. Aviation lighting for cooling tower and chimney also covered in this package. Lighting Distribution Board (LDB) is normally getting supply from 415V PMCC. Each LDB is provided with lighting transformer for isolation of lighting circuit from power circuit and also for limiting short time current rating. Outgoing circuits of LDB will feed Lighting panels which is placed local to fixtures. It is envisaged that separate LDB for indoor as well as for outdoor area. Emergency Lighting system is same as normal system however it will get supply from Emergency 41V PMCC backed up with DG set. The Design parameters of Illumination System and its major components comprising of LDB with transformer, Lighting Panel, Lighting Fixtures, Lighting wires and Lighting Poles are furnished below]:

Description	Units	Design Parameters
Lighting System:		
Voltage		[.....]
a)AC system		[.....]
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
b)DC system		[.....]
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]

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Description	Units	Design Parameters
One Minute Withstand Voltage	V	[.....]
System Short-Circuit Level		[.....]
a) 415V AC	kA(rms)	[.....]
b) 220V DC	kA(DC)	[.....]
LDB/LP:		
Manufacturer Name		[.....]
Mounting a)LDB b) LP		[...Floor.....] [...Wall.....]
Installation		[.....](For each application ie for Indoor/Outdoor and area)
Type, No of Circuits/Feeder rating		[.....]
Lighting Transformer:		
Make of Transformer		[.....]
Type of Transformer		[...Dry.....]
Rating	KVA	[.....]
Voltage Ratio		[.....]
Impedance	%	[.....]

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Description	Units	Design Parameters
Lighting Wires:		
Make		[.....]
Voltage Grade	V	[.....]
Conductor Material	Cu/Al	[.....]
Size	Sq.mm	[.....]
Lighting Fixtures:		
Make		[.....]
Type of Luminaries		[.....]
Ballast Type		[.....]
Lighting Poles:		
Make		[.....]
Type of Poles		[.....]

xi. Cable Carrier System

[The Cable Carrier system is described as below: Indoor Buildings are provided with Cable cellar/Trench and outdoor areas are provided with Pipe cum cable rack/Duct bank/Trench. Separate Tray is envisaged for MV cables. LV cables, Control cables and Instrumentation cables in the order that MV cables Tray at the top followed by LV, Control and Instrumentation Tray. Ladder type tray is used for MV, LV and Control cables, however Perforated Tray to be used for Instrumentation cables. The Cable carrier system of indoor area/Building (Other than Boiler area, TG Building, Ash Handling Plant and Coal Handling Plant, switchyard and transformer yard), Outdoor area and interplant cable carrier system for like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc are covered in this package. However complete interplant cable carrier system if required is the

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responsibility of BOP package contractor. The Design parameters of Cable Carrier System are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Size of Tray	mm	[.....]
Material		[.....]
Application		[.....] (i.e. MV/LV/Control/Inst.)
Type of Tray		[.....] (i.e.Ladder/Perforated)
Thickness of Tray	mm	[.....]
Thickness of Galvanization	mm	[.....]
Tray Cover Size	mm	[.....]
Cable Tray Accessories		
Tee	mm	[.....] {List out all size}
Cross	mm	[.....]{List out all size}
Bends	Deg	[.....]{List out all size}
Reducer	mm	[.....] to [.....]{List out all size}
Steel Supports		

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Description	Units	Design Parameters
a) ISMC b) ISA	mm	[.....]{List out all size} [.....]{List out all size}

xii. Earthing and Lightning System

[Above ground earthing system for mechanical BOP like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc are covered in this package. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form a integrated single earthing system. Lightning system for mechanical BOP system like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation etc. are covered under this package. The Design parameters of Earthing and Lightning System are furnished below]:

Description	Units	Design Parameters
Earthing System:		
Make/Manufacturer		[.....]
Main Earthing Conductor a) Material b) Dia		[.....] [.....]
Treated Earth Pit/Earth Rod(Dia and Length)	mm & m	[.....]
Size of Earth Conductor a) MV Switchgear b) LV Switchgear c) MV Motors d) LV Motors {List out KW rating wise} e) Control panel, LPBS Etc. f) Transformer Body	mm x mm	[.....]{List out size of Flat Earth conductor used for different equipments of Power plant and no of points }

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Description	Units	Design Parameters
g) Transformer Neutral List out Transformer wise} h) Any other panel/Equipments		
Lightning System:		
Air Termination Rod		[.....]
a) Dia & Length b) Material		[.....]
Down comer		[.....]
a) Material b) Size		[.....]
Lightning Electrode with test link		[.....]
a) Material b) Dimension(Length and Dia)		[.....]

3.2.13

Control & Instrumentation

[The existing control and instrumentation system of balance of plant systems generally consist of an old control system such as local control panels, relay based hardwired control systems and few signals exchange through hardwired means with existing Plant DCS and requires large scale replacement of field instruments, devices, transmitters, switches, cables, valves and actuators, junction box and local control cabinets etc owing to obsolescence of the existing equipments of various packages of balance of plants. Integrated microprocessor based open loop control, sequential control and data acquisition system for balance of plant Systems such as Pre-Treatment System, DM Plant, Fuel Oil System, Compressed Air System, CW System, ACW/CCW system and Miscellaneous Systems in hierarchical levels with integrated unit monitoring systems in the upper level are therefore to be envisaged for the plant.]

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3.2.14 Civil Works

Bidder shall go through the details of the existing Buildings / Structures / Foundations / Facilities mentioned hereunder (but not limited to) for thorough understanding of conditions of the same. In order to assess the quantum of Civil / Structural / Architectural R&M work within the package, Bidder shall also carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions at site and identification of modification requirements in any other structure or foundation not included here. Conditional details of important buildings / structures / foundations / facilities which require major modifications have been described below:

{Details of the existing buildings / structures and their foundations in the Balance of Plant area like Raw Water Intake Pump House & Pipe Line, Cooling Water Channels, Forebay, CW Pump House, D. M. Plant Building, Neutralizing Pit and Laboratory Building, Chemical Building, Clarified Water Pump House, Electro-chlorination/Gas Chlorination Building, Effluent Treatment Plant Building, Guard Pond, Cooling Tower, Fire Water Pump House & Reservoir, Fuel Oil Unloading Area & Pump House etc. shall be indicated in this section. Also the available GA/Construction Drawing including Load Data shall also be provided.}

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4 SCOPE OF SUPPLY & SERVICES

4.1 The scope of supply and services to be provided by the Bidder shall include all such activities as required to meet the target and intent of this specification. The scope shall generally cover, but will not be limited to the following:

- (i) Replacement of some of the existing components with new components of improved and better design.
- (ii) Incorporation of new systems / components wherever required in line with the Specification.
- (iii) Refurbishing / Retrofitting of some of the components in the existing equipment/system.
- (iv) All types of civil/structural works like modification and strengthening of foundation of existing and upgraded equipment, making new structures or foundations (if applicable), dismantling, restoration, supply and erection of any temporary supports or any other construction work required for implementation of renovation work.

All structural modifications/strengthening of existing structures or buildings of *[Raw Water System, Circulating Water System, Water Treatment Plant and Effluent Treatment Plant, Cooling Tower, Fire Protection System, Fuel Oil Handling System etc.]*, including supply, fabrication and erection of any new structure and provision of any additional platform if required for access to new equipment or existing equipment as specified.

Supply of all materials, equipments, machinery and manpower required for civil/structural R&M works.

Site enabling works as per the requirements to support civil/structural R&M works.

- (v) Design, engineering, submission of design calculations for review and approval, manufacturing, inspection and testing at suppliers' works, packing, forwarding to site, unloading, erection, supervision, pre-commissioning, testing and commissioning and performance testing of the equipment / systems and works indicated in clause No. 4.6 of this technical Specification.
- (vi) Mandatory spares, start-up and commissioning spares. The general requirements in respect of various types of spares are given in Clause 9 of this section of Technical Specification.
- (vii) Packing, transportation and transit insurance of all materials required for renovation / replacement work as per this Specification from the supplier's/sub supplier's works to *[Name of the Plant]*, unloading, preservation and storage at site. Packing, transportation, transit insurance, clearance from all concerned agencies etc. of all components/materials required to be forwarded from *[Name of the Plant]* to Bidder's facilities and back to *[Name of the Plant]*.

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- (viii) Dismantling of the systems, reassembly and re-erection / reinstallation along with associated inspection, testing, commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.
- (ix) Dismantling of the systems, handling and storage of dismantled equipment, reassembly and re-erection / reinstallation along with associated inspection, testing, commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.
- (x) Materials which are removed from the existing machines but are not re-used during the re-assembly of the machines as well as those components which are found to be beyond refurbishment shall be the property of Owner and shall be deposited at Owner's designated stores. Bidder shall prepare a record of all such dismantled material and hand it over to the Owner.
- (xi) Loading, transportation, unloading and disposal of scrap to the designated storage/disposal yard.
- (xii) Erection of all material supplied new for renovation (including erection of components, replacing old components). Re-erection of any component / equipment removed for modification so as to make complete unit consisting of BOP systems including electrical & control and instrumentation equipment /system ready for commissioning.
- (xiii) All gas cutting / dismantling, edge preparation, welding, bolting etc. and conductance of all NDTs like radiography, ultrasonic testing, MPI, die penetration testing etc. Any new matching pieces, piping, hangers & supports etc. required for assembly of equipment/ systems, as per system requirements shall also be included in the scope of the Bidder.
- (xiv) All Pre-commissioning activities as may be required such as hydraulic testing, air & gas tightness test, steam blowing for steam piping under fuel oil system, floating of safety valves, oil flushing etc. including erection and dismantling of all temporary systems like piping / tanks etc. and Conductance of all demonstration tests including performance test.
- (xv) Assisting and coordinating with Owner in tuning various control loops finalizing protection and control requirements of all Systems under BOP package.
- (xvi) Insurance for all items / activities in line with the provisions of General Condition of Contract of Volume-I.
- (xvii) Installation, Interconnection laying and termination of all Bidder supplied cables, testing and commissioning of all equipment/systems furnished by the Bidder.
- (xviii) Civil / Mechanical work (such as grouting, cutting, welding etc.) related to mounting of New Cabinets, CRT / Keyboards, laying & termination of associated Cables.

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- (xix) Supply of all necessary tools, tackles, commissioning spares, test instruments and deputing of experienced personnel for completion of the above erection, testing and commissioning work.
- (xx) Dismantling of existing C&I cabinets along with associated cabling, for various systems under BOP package for retrofitting the new C&I systems, based on requirement as described in clause No. 4.6.
- (xxi) Providing all site execution and supervision by qualified and experienced engineering personnel during execution of all works under the scope of Bidder. Also providing all facilities and qualified personnel for implementing the approved quality assurance programme.
- (xxii) Dismantling of the existing Instrumentation and Control cables and relaying of new cables as may be required.
- (xxiii) The Bidder shall conduct all shop and site tests as per the requirements of this Specification and Owner approved "Quality Assurance Program" to be finalized before the award of this Contract. Facilitating inspection, witness of shop and site tests by the representatives of Owner shall be in the scope of the Bidder.
- (xxiv) Performance Guarantee tests after successful completion of initial operation.
- (xxv) Electrical

The scope of electrical system of package for Balance of Plant will include all electrical equipment listed below (if applicable).

[Note: Scope of work of auxiliary system for BOP shall be suitably modified with respect to specific project and accordingly list of attachments shall be enclosed]

a) [All 415 V MCCs for BOP package as required and ACDBs/PDBs and DCDBs for drives and equipment covered in BOP package.

For technical details and requirement, bidder shall refer Attachment E4 "415 V Switchgear, MCC and DBs"

b) 6.6 / 0.433 kV transformers, 415 V non segregated phase bus ducts.

For technical details and requirement, bidder shall refer Attachment E3 "LV MCC and DBs" and Attachment E5 "415 V Non segregated phase bus duct".

c) Welding sockets in BOP area with necessary Welding DBs.

d) Control stations / Local Push Button stations.

e) HV/LV A.C. motors and motorized actuators for all the drives in the scope of BOP package and DC Motors and DC starters as required in BOP area. For technical details and requirement of motors, bidder shall refer Attachment E1 "Motors" and Attachment E2 "Motorized Actuators"

f) HV/LV power and control cables with termination kits for all auxiliaries in BOP area. For technical details and requirement of HV and LV cables, bidder shall refer Attachment E7 "HV cables" and Attachment E8 "LV cables".

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- g) 220V DC System with all auxiliaries. For technical details and requirement refer Attachment E6"220V DC System"*
- h) Illumination System including Lighting Transformers, MLDBs, Lighting DBs/ Lighting Panels for the BOP area.
For technical details and requirements of Illumination system, bidder shall refer Attachment E9"Illumination system".*
- i) Grounding system for the BOP area and grounding connection to all equipment in BOP area.*
- j) Lightning Protection system for BOP buildings and other equipment/buildings covered in BOP area. For technical details and requirements, bidder shall refer Attachment E11"Earthing and Lightning protection system".*
- k) Complete cable racks with necessary supporting structures and foundations within BOP area, cable trays with support system, cable trenches and accessories in BOP area. For technical details and requirements, bidder shall refer Attachment E10"Cable Carrier System".*
- l) Variable frequency drives for HV and LV system of BOP package, if any.
For technical details and requirements, bidder shall refer Attachment E13"Variable Frequency Drives".*
- m) Emergency Diesel Generator
For technical details and requirements, bidder shall refer Attachment E15"Emergency Diesel Generator".*

(xxvi) Construction Water

[Construction water shall be made available to Bidder at a single point in a suitable location. The Bidder shall arrange at his own cost the required pumps, distribution pipe line network for further distribution as required to carry out construction work.]

(xxvii) Construction Power

[Construction power shall be made available to bidder at single point at [...] kV level. Further distribution as required to carry out the construction work shall be carried out by Bidder at his own cost.]

- (xxviii)** Providing all other services necessary for meeting the intent and requirement of this Specification. This shall include but not limited to system engineering, furnishing drawings, data, and information for Owner's review, participation in meeting & reviews, System warranty, revision of O&M Manuals etc.

4.2 Tools & Tackles

One (1) set of special tools and tackles required for the maintenance of equipment/systems have to be supplied by the Bidder. These tools and tackles shall be separately packed and brought to site. These shall not be used for

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erection/commissioning purposes and shall be in an unused and new condition, when they are handed over to the Owner. A list of all such special tools and tackles shall be submitted along with the offer.

For C&I system, Bidder shall supply one set of special non standard tools, module testing kit, cables, and any other equipment required for erection commissioning, testing, trouble shooting, calibration, maintenance and inspection of all systems / equipment provided. Any tools required to make changes (DIP shunt cutter, soldering irons, tips, wire wrap guns and bit unwrapping tools, strippers, terminal guard, connector repair tool, dies etc.) shall also be supplied.

Bidder's scope shall also include supply of all Cranes, welding sets and NDT testing equipment, scaffolding, special tools and tackles, jigs and fixtures as may be required during modification / erection and commissioning. Those items specifically brought to site solely for erection / modification purpose and if no more needed for regular maintenance of the equipment, can however, be taken back by the Bidder after completion of the work at site, subject to the approval of Owner.

4.3 Safety

The design of the equipment shall incorporate every reasonable precaution and provision for the safety of all personnel and for the safety and security of all persons and property. The design shall comply with all appropriate statutory regulations relating to safety.

Newly constructed structures and equipment shall be designed and constructed to withstand every foreseeable static and dynamic loading condition, including loading under earthquake conditions, with an adequate margin of safety.

Ready and safe access with clear head room shall be provided to all the newly supplied parts of the plant for operation, inspection, cleaning and maintenance.

- 4.3.1 While carrying out the R&M work as per this Specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items/ equipment supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipment / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipment / foundations / structure and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

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4.4 Training Requirements

Bidder shall include in his offer the training programme for Owner's Operation & Maintenance staff in view of introduction of new systems/ equipment. This training shall be organized before handing over the unit.

4.5 In case there is any difference in scope of work and services as described in this section of the Specifications and individual Specification volumes, then more stringent of the Scope of work and services shall prevail.

4.6 Detail Scope of Work:

4.6.1 Balance of Plant (BOP) System

{Describe in this chapter, all the equipment/components which need to be replaced/refurbished/retrofitted as finalized in the DPR on the basis of RLA/CA and EA report. Scope with regard to Civil, Structural and architectural work as required for the Power Plant due to incorporation of new equipment/components shall also be incorporated in this chapter.}

The Bidder shall include in his scope the following works for the R&M of the Unit, which are based on RLA/CA and EA studies. The overall scope of work shall include but shall not be limited to the scope of work mentioned below. Any other items not specifically mentioned but considered necessary by the Bidder for carrying out the R&M work, shall also be included in his scope so as to meet the intended performance of various equipment & systems.

Table: 4.1

Equipment	Scope of Work	Quantity
RAW WATER INTAKE SYSTEM		
<i>[Vertical Turbine Pump]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Rubber Expansion Joint]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Drain Pump]</i>	<i>[.....]</i>	<i>[.....]</i>

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
<i>[Sluice Gate]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Discharge Butterfly Valve]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Air-Release-Cum-Vacuum Breaker Valve]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Coarse Screen]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Stoplog Gates]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Raw Water Intake Piping]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Other Valves]</i>	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Traveling water Screen]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
RAW WATER SUPPLY SYSTEM (To Supply raw water from Raw water Reservoir to PT Plant)		
[Vertical Pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Rubber Expansion Joint]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Sluice Gate]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Discharge Butterfly Valve]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air-Release-Cum-]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
<i>Vacuum Breaker Valve]</i>	<i>[.....]</i>	<i>[.....]</i>
<i>[Screen]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Stoplog Gates]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Raw Water Supply Piping]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
CIRCULATING WATER (CW), AUXILIARY COOLING (ACW) SYSTEM & COOLING TOWER		
<i>[CW Pump]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[ACW Pump]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[124]	25.09.2015

Equipment	Scope of Work	Quantity
<i>[Rubber Expansion Joint]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Drain Pump]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Butterfly Valve]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Air-Release-Cum-Vacuum Breaker Valve]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Coarse Screen]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Trash Rack]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Stoplog Gates]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[CW & ACW Piping]</i>	<i>[.....]</i>	<i>[.....]</i>

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[125]	25.09.2015

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Valves]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Cooling Tower]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CW Treatment System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CW Chlorination System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
WATER PRETREATMENT PLANT		
[Aerator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Stilling Chamber]	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[126]	25.09.2015

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
<i>[Flash Mixer]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Flocculator]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Sludge Disposal System]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Clarified Water Tank]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[DM Plant supply pumps]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Potable Water Supply Pumps]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Service Water Pump]</i>	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[127]	25.09.2015

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Fire Fighting Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Chemical Laboratory]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Chlorination System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[PT Chemical Dosing System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Cooling Water make-up Pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Preheater Wash Pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[128]	25.09.2015

Equipment	Scope of Work	Quantity
DM PLANT		
[Pressure Vessel]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Blowers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Degasser Tower (DGT)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Degassed Water Storage Tank (DGWT)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Degassed Water Pumps (DGP)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ultra Filtration Unit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Filter Media]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[129]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[DM Water Transfer Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[DM Water Storage Tank]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Resin Details		
[SAC Exchanger]	[.....]	[.....]
	[.....]	[.....]
[WAC Exchanger]	[.....]	[.....]
	[.....]	[.....]
[SBA Exchanger]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[130]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[WBA Exchanger]	[.....]	[.....]
	[.....]	[.....]
[Mixed Bed]	[.....]	[.....]
	[.....]	[.....]
Effluent Treatment Plant		
[Central Monitoring Basin]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ultra Filter]	[.....]	[.....]
	[.....]	[.....]
[Micro Filter]	[.....]	[.....]
	[.....]	[.....]
[RO System]	[.....]	[.....]
	[.....]	[.....]
AIR-CONDITIONING AND VENTILATION SYSTEM		
[Split Air Conditioner]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Refrigerant Compressor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[131]	25.09.2015

Equipment	Scope of Work	Quantity
[Condenser and Evaporator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Centrifugal Fan]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Axial Flow Fan]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Duct Work]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
FIRE FIGHTING SYSTEM		
[Hydrant System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HVW Spray System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[MVW Spray System]	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[132]	25.09.2015

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Hydrant System Pumps & Drive]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Spray System Pumps & Drive]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Jockey Pumps & Drive]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Diesel Engines & Engine Driven Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Inert Gas Extinguisher]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fire Extinguishers & Fire Station Equipments]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Piping]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[133]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Valve]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
PLANT AND INSTRUMENT AIR SYSTEM		
[Instrument air (IA) compressors]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Service air (SA) compressors]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Intercooler, Aftercooler, Moisture Separator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Drying Plant]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[IA & SA Piping, Valves and Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[134]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

Equipment	Scope of Work	Quantity
[IA & SA Valves and Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[IA & SA Pipe Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Drying Plants]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
FUEL OIL SYSTEM		
[Unloading Pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Storage Tank]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pressurizing Pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Heavy Fuel Oil Heaters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[135]	25.09.2015

Equipment	Scope of Work	Quantity
[Oil Strainers for Unloading Pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Oil Strainers for Forwarding Pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[PRDS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HFO & LDO Piping]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Valve]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HFO & LDO Pipe Fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
MILL REJECT HANDLING SYSTEM		
[Pyrite Hopper]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[136]	25.09.2015

Equipment	Scope of Work	Quantity
[Mill Reject Storage Silos]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Receiver]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Compressor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Conveying Pipe Work]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Isolation Gates]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
CRANES / HOISTS		
[EOT Cranes]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[U/S Crain]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[137]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity					
[Electric Hoist]	[.....]	[.....]					
	[.....]	[.....]					
	[.....]	[.....]					
[Manual Hoist]	[.....]	[.....]					
	[.....]	[.....]					
	[.....]	[.....]					
[Steam Piping and Fittings]							
Tag No.	Description	Fluid	Size	Schedule / Thickness	Class	Material	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Low Pressure Piping and Fittings]							
Tag No.	Description	Fluid	Size	Schedule / Thickness	Class	Material	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Motorized Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Travel time	Drg. No.	Qty

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[138]	25.09.2015

Equipment		Scope of Work				Quantity	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Manually Operated Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Qty	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Non Return Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Qty	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Relief Valve]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Qty	
[...]	[...]	[...]	[...]	[...]	[...]	[...]	

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[139]	25.09.2015

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment		Scope of Work			Quantity	
[...]	[...]	[...]	[...]	[...]	[...]	
[...]	[...]	[...]	[...]	[...]	[...]	
[Electric Actuator for Valve]						
Tag No.	Description & Service	Torque (Nm)		Wattage (W)		Qty
[...]	[...]	[...]		[...]		[...]
[...]	[...]	[...]		[...]		[...]
[...]	[...]	[...]		[...]		[...]
[Control Valve]						
Replacement/ Retrofitting of Control Valves		[.....]			[.....]	
		[.....]			[.....]	
		[.....]			[.....]	
[Electrical Works]						
LV Transformers						
[Transformer HV/LV coil]		[.....]			[.....]	
		[.....]			[.....]	
		[.....]			[.....]	
[Tap changer]		[.....]			[.....]	
		[.....]			[.....]	

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[140]	25.09.2015

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of Service transformer(oil type/dry type)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
415 V LV Switchgear (PMCC MCC)		
[Air circuit breaker/MCCB/SFU/M CB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT/PT]	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[141]	25.09.2015

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Numerical relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[AC/DC Starters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Electronic over load relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transducers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ground bus]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Switch socket]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[142]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
<i>[Push button station]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Terminal block]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Any other part/system of LV Switchgear (PMCC/MCC)]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
220 V DC System		
<i>Battery charger</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>Battery system</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>DCDB</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>Air break switch</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[143]	25.09.2015

Equipment	Scope of Work	Quantity
<i>Annunciation system</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Any other part/system DC system]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
415 V NSPBD		
<i>[Bus duct enclosure]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Bus duct conductor]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Support insulators]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Disconnecting link/flexibles]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[support structure]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
<i>[Any other part/system of NSPBD]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
HV Cables		
<i>[Joint and termination kit]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Any other part/system of HV cables]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
LV Power & Control cables		
<i>[Lugs and Glands]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Any other part/system of LV power and control cable]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
HV & LV motors		
<i>[Motor terminals box]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Motor stator winding]</i>	<i>[.....]</i>	<i>[.....]</i>

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Motor Rotor winding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor cooling system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of MV/LV motors]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Motorized Actuators		
[Motor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Position]	[.....]	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
indicator/Transmitter]	[.....]	[.....]
	[.....]	[.....]
[Bearing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Limit switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of motor actuators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Illumination System		
[Distribution boards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting transformer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Aviation warning light]	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[147]	25.09.2015

Equipment	Scope of Work	Quantity
<i>[system]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Emergency light with self contained batteries]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Lamps and fixtures]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Industrial socket outlet]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Fan and regulators]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Switches and switchboards]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Street or road light poles]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[High mast tower]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[148]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Lighting junction box and conduits]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of lighting system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Cable Carrier System		
[Cable Tray]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Conduit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Trench/Duct bank]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Termination/joints]	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[149]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Any other part / system of Cable carrier system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Earthing & Lightning Protection system		
[Electrode]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[GI flat/wire]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air terminals]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Clamp/test links]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Shielding mast]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system]	[.....]	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
<i>of earthing and lightning protection]</i>	[.....]	[.....]
	[.....]	[.....]
Control & Instrumentation Works		
<i>Raw Water Intake Control System</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Pre-Treatment Plant Control System</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>DM Water Control System</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>CW & Cooling Tower Control System</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Compressed Air Control System</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>ACW Control System</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[151]	25.09.2015

Equipment	Scope of Work	Quantity
Fuel Oil Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Fire Fighting Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Miscellaneous Systems Control	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Self Cleaning Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Mill Reject Handling Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
HVAC Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
UPS System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Continuous Stack	[.....]	[.....]

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-I	[152]	25.09.2015

Equipment	Scope of Work	Quantity
Emission Monitoring System	[.....]	[.....]
	[.....]	[.....]
Pressure / DP Gauges	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Temperature Gauges	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Pressure / DP Switches	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Temperature Switches	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
RTD	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Level Transmitters (Ultrasonic Type, Displacer, Radar Type)	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Flow Elements (Orifice)	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
Pressure / Differential Pressure Transmitter	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Control Valves	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Impulse Pipeline & Instrument fittings	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Instrumentation & Control Cabling	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Junction boxes/LIRs	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Time Synchronization System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Any other systems	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
Civil Works		
[Raw Water Intake System (pump house, pipeline etc)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Water treatment system & effluent treatment system (DM plant building, chemical building, storage tanks, electro-chlorination building, effluent treatment plant building, guard pond etc.)]		
	[.....]	[.....]
	[.....]	[.....]
[Circulating water system (cooling water channels, forebay, CW pump house, control room etc.)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Civil Works for Cooling Tower & Tower Basin]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Foundation Work for HVAC equipment]	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Fire detection & protection system (pump house, tank etc.)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Compressor House & Compressor foundation]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fuel Oil Pump House, Pump Foundation, Tank Foundation & Tank firm dyke area Civil & structural works]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other Civil / Structural Work]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

4.6.2 Miscellaneous

- a. In addition to the above listed works, scope of civil / structural / architectural works and supplies shall be as detailed below:

Bidder shall be provided with the existing drawings and documents as listed in Annexure-I by the Owner to facilitate the civil / structural / architectural, refurbishment and replacement works.

Bidder shall carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions of the buildings, structures, foundations & facilities mentioned in this specification and identification of modification requirements in any other structure or foundation not included here.

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Subsequently Bidder shall prepare and submit for approval by Owner, a detailed scheme including methods techniques, requirements etc. for carrying out civil/structural/architectural R&M works to be executed in the plant.

b. The scope of Civil / Structural / Architectural works to be carried out by the Bidder under this package shall generally cover the following:

- Inspection and checking the design adequacy of the foundations of existing structure like [Raw Water Intake Pump House, CW Pump House, DM Plant Building, Laboratory Building, Chemical Building, Clarified Water Pump House, Electro-chlorination Building, Effluent Treatment Plant Building, Cooling Tower, Fuel Oil Pump House, Fire Water Pump House etc.] for all the applicable loads and construction of new foundations / modification of existing, wherever required.
- Inspection and checking the design adequacy of existing structures [such as Raw Water Intake Pump House & Pipe Line, Cooling Water Channels, Forebay, CW Pump House, D. M. Plant Building, Neutralizing Pit and Laboratory Building, Chemical Building, Clarified Water Pump House, Electro-chlorination Building, Effluent Treatment Plant Building, Guard Pond, Cooling Tower, Fuel Oil Pump House, Fire Water Pump House, pipe & cable racks etc.] for any corrosion/damage and rectification / strengthening of the same.
- Construction of any new foundation / building / structure, if any, as per the requirement of the scope under R&M work.
- Carrying out all interior / exterior architectural repair and replacement works [such as flooring, painting, plastering, door/windows, roof finishing, water proofing, sheet cladding, roof sheeting, new false ceiling, glass partitions, lighting works replacement or modification of AC duct where ever applicable] is also included in contractors scope. etc.
- Any other civil related work required in buildings / structures of the package from aesthetics ambience & ease of operation point of view.

In addition to this any other modification/alteration to existing nearby foundation/structural steel/concrete/underground pipes work if required for satisfactory execution of intended work covered under this specification shall be carried out by the Bidder. Supply of all material required for the above work is included in Bidder's scope

c. Supplies for Civil/Structural Work

The Bidder shall supply all material needed for completion of all civil, structural and architectural works as per this specification. The Bidder's scope of supply generally includes but is not limited to the following:

- Supply of cement, steel (for reinforcement as well as for any other use), grout, admixture for RCC work, sand and all other construction/ architectural / building materials as may be required for any repair/modification of existing civil works / foundation or for construction of new foundation / civil works.

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- Supply of structural steel for all structural erection / modification / strengthening.
- Supply of all foundation bolts, and nuts base plates, embedments with lugs, miscellaneous steel where ever needed
- Supply of steel helical springs and viscous dampers for new equipment (if any).

d. Construction Enabling Works

[The owner shall provide the following facilities to the by Bidder to carry out the construction work.

- *Temporary Stores to store construction material.*
- *Fabrication Yard]*

e. Quality Control Laboratory

[To conduct acceptance test on all construction material, weldments, concrete cubes etc laboratory facilities if available in the existing unit shall be used. In case the laboratory facility is not available within the unit, Bidder shall get the testing at his own cost from a reputed test laboratory approved by the Owner.]

- f. Construction Tools & Materials Supplied By the Bidder. The Bidder shall arrange adequate number and type of machinery and equipment for proper setting out and timely completion of the various works covered under the scope of the work. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expense.

The Bidder shall provide all fuels and lubricants required for the operation and maintenance of construction machinery and equipment as well as his transport vehicles at his own cost.

- g. The Bidder shall furnish manufacturer's test certificate for all the manufactured items supplied by him. Representative specimens of the material shall also be submitted to the Owner and shall be tested at a recognised testing laboratory at the Bidder's cost in case Owner so desire.

h. Work Execution and Supervision:

The Bidder shall have at the site accredited and qualified engineers and foremen / supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the works.

- i. The Bidder shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner with full understanding of the importance of work for a R&M project of this magnitude.

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- j. In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accident. He shall also report such accidents to all the competent authorities wherever such reports are required by those authorities.
- k. Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner is not in accordance with the specification / bid document.
- l. During inclement weather, rains etc., the Bidder shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at the Bidder's cost and any damage to works shall be made good by the Bidder at his own expense.
- m. **Safety of Adjacent Plant/Equipment and Civil Structure**
While carrying out the R&M work as per this specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items / equipments supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipments / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipments / foundations / structures and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

4.6.3 Spares

All spares as specified in Annexure-II of this Specification in accordance with Clause No. 9.

4.6.4 Consumable, Oil & Lubricants

All the first fill and consumables such as greases, oil, lubricants, servo fluids/control fluids, gases and essential chemicals etc. as required up to the complete commissioning of the BOP systems, are covered in the scope of Bidder. Suitable standard lubricants as available in India are preferable. Efforts should be made to limit the variety of lubricants to minimum.

4.6.5 Embedded Parts & Fixture

All fixtures, embedded parts, steel embedment including fixing lugs and welding between them, foundation plates, grouting, nuts, bolts etc. for fixing all the equipment, piping on civil works shall be included in scope work of this package. All structures which would be required by the Bidder for supporting the piping shall also be included in scope of work of this package.

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4.6.6 Other Services

The scope of Erection, Commissioning and Testing shall include the following:

- a) Complete pre-commissioning work including tests of facilities such as line flushing, hydraulic testing, chemical cleaning of pressure parts etc and all other tests as mutually agreed in the Bidder's quality assurance programme as well as those identified in the Specification.
- b) Supply of all consumables (except coal and fuel oil for firing) like chemicals for chemical cleaning, passivation, inhibition etc., oil for line flushing, any other consumable as required for above pre-commissioning/ commissioning activities.
- c) Necessary arrangement as requires for the start up of various equipment & systems of BOP package.
- d) Supply of all temporary equipment such as tanks, piping, including supports, valves, pumps and all necessary instrumentation for successful conductance of pre-commissioning and commissioning activities. All temporary equipment and instruments shall be clearly listed out in the Bid.
- e) Providing safety barricades and signage during dismantling, erection and testing etc.
- f) Supply of all labour, skilled/semi skilled supervisors, engineers and any other manpower.
- g) All the erection materials and consumables like shims, welding rods, soldering and brazing alloys, industrial gases, insulating tapes, compounds, chemicals etc. required for the erection and commissioning works.

Note: The temporary equipment specifically brought by the Bidder solely for the pre-commissioning and commissioning work shall, on completion of these activities, remain the property of the Bidder.

The selection of material of all the temporary equipment/instruments shall be compatible with the service conditions expected during pre-commissioning/ commissioning activities.

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5 TERMINAL POINTS & EXCLUSIONS

5.1 Terminal Points

For all terminal points, scope of this contract shall include supply of matching flanges, gaskets, bolts, nuts etc including any isolation valve. Terminal Points mean Engineering, Procurement and Erection in entirety. The terminal points of the complete package to be supplied shall be as follows.

(a) **[Raw water Intake System]**

No Terminal Point. Entire system as specified under scope of work shall be under the scope of Bidder.]

(b) **[CW, ACW, DM Water & other Auxiliary Water Systems]**

[Condenser Cooling Water System (CW system)

Bidder shall terminate the CW piping at the following terminal points

CW Inlet Header near A row of TG Building at : [.... □N, □E]

CW Outlet Header near A row of TG Building at : [.... □N, □E]

Exact elevation of the pipe shall be furnished during detail engineering of battery limit.]

(c) **[DM water make up to CSTs]**

[Bidder shall terminate the DM water lines at the inlet to the flow meter(s) to the Condensate Storage Tanks (CSTs). at □N, □E]

(d) **[Service Water]**

[One no. Stub connection with isolation valve shall be provided by the bidder on service water supply header near Bunker bay first column at 4m elevation for Boiler at □N, □E].

[One no. Stub connection with isolation valve shall be provided on service water supply header Near C row at 4m elevation for TG Building at □N, □E].

[One no. Stub connection with isolation valve shall be provided on service water supply header Near CHP control room at □N, □E].

[One no. Stub connection with isolation valve shall be provided on service water supply header Near Ash Water Pump House at □N, □E].

Bidder has to provide service water lines and valves for all the areas covered under this package.]

(e) **[Drinking Water]**

[One no. Stub connection with isolation valve shall be provided by the bidder on service water supply header [near Bunker bay first column at 4m elevation for Boiler at □N, □E].

[One no. Stub connection with isolation valve shall be provided on service water supply header Near [C row at 4m elevation for TG Building at □N, □E].

[One no. Stub connection with isolation valve shall be provided on service water supply header Near CHP control room at □N, □E].

[One no. Stub connection with isolation valve shall be provided on service water supply header Near Ash Water Pump House at □N, □E].

[Bidder has to provide drinking water lines and valves for all the areas covered under this package.]

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- (f) **[Compressed (Service & Instrument air System) Air System]**
 Service Air Header near A row of TG Building at : [.... □N, □E]
 Instrument Air Header near A row of TG Building at : [.... □N, □E]
 Service Air Header near CHP Control Room at : [.... □N, □E]
 Instrument Air Header near CHP Control Room at : [.... □N, □E]
- (g) **[Fire Water supply for fire protection system of air pre heaters]**
 [From the plant fire hydrant network, Bidder shall provide one stub with an isolation valve at a terminal pressure of about 6 kg/cm² from the ring main near boiler at about [4 m above local grade level at □N, □E] to meet the fire water requirement of RAPH.]
- (h) **Electrical**
- i. **[6.6 kV Power Supply for LT Transformers and MV Motors:** At the terminal of 6.6 kV station/unit switchgear of TG package. All Power and control cables from the terminals of 6.6 kV station/unit switchgears and termination are included in the scope of this package.]
 - ii. **[415 V Emergency Power Supply for BOP package areas:** Power supply at 415V level at the outgoing terminals of 415 V Emergency Switchboard of TG package. All cables from the terminal point are included in the scope of BOP package.]
 - iii. **[Grounding & Lightning:** Above ground earthing and lightning protection for the mechanical BOP packages like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation area etc are covered in this package. Terminal point will be nearest earth riser available to the respective area. Complete plant underground grid is in eBOP package scope of work.]
 - iv. **[Cable Carrier system:** Cable carrier system for Mechanical BOP like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation, fire fighting system etc are covered in this package. Inter package cable carrier system between these packages is also covered in this package. Cable carrier system for all the cable covered for this package shall be in scope of this package.]
- (i) **Control & Instrumentation**
- i. **[I&C Terminal point for Instrument & Control Cabling:** Interface cable from Microprocessor / PLC panel to DCS shall be supplied by others
 Up to terminal blocks of Raw Water Intake System, Continuous Stack Emission Monitoring System, Pre-Treatment Control, DM Water Control, CW & Cooling Tower Control, Compressed Air System Control, ACW/CCW Control, Fuel Oil System Control, Fire Fighting Control, CPU Control, COLTS Control, Self Cleaning Control, Hydrogen Generation Control, HVAC Control, ESP Control, Mill Reject Handling Control panel for plant BOP systems.]
 - ii. **[I&C terminal point for 230V AC supply:** 230 V AC UPS power supply feeder in ACDB shall be made available to bidder at a single point Upto terminal block of Raw Water Intake System, Continuous Stack Emission Monitoring System, Pre-

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Treatment Control, DM Water Control, CW & Cooling Tower Control, Compressed Air System Control, ACW/CCW Control, Fuel Oil System Control, Fire Fighting Control, CPU Control, COLTS Control, Self Cleaning Control, Hydrogen Generation Control, HVAC Control, ESP Control, Mill Reject Handling Control.]

5.2 Exclusions

- (a) *[Turbine Generator & Its Auxiliary Equipment including Feed Cycle Equipment]*
- (b) *[Boiler & its Auxiliaries]*
- (c) *[Coal Handling System]*
- (d) *[Ash Handling System]*
- (e) *[Switchyard]*
- (f) *[Power Transformers]*
- (g) *[Below ground mat]*
- (h) *[Station and Unit MV switchgear]*
- (i) *[Hydrogen Generation Plant]*

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6 GENERAL TECHNICAL REQUIREMENTS

6.1 Codes & Standards

6.1.1 Apart from some specific application, the proposed R&M equipment shall comply with the appropriate Indian Standard / DIN or equivalent international Standard. Specification as listed below in this section and mentioned in detailed Specifications, each incorporating the latest revisions at the time of tendering.

6.1.2 Wherever specified or required the Plant & Equipment shall conform to various statutory regulations such as Indian Electricity Rules/Act, Indian Boiler Regulations, Factories Act, etc.

6.1.3 In the event of any conflict between the codes and standards referred above, and the requirements of this Specification, the requirements, which are more stringent, shall govern.

6.1.4 In case of any change of code, standards and regulations between the date of purchase order and the date, the Bidder proceeds with manufacturing, the Owner shall have the option to incorporate the changed requirements.

6.1.5 List of Reference Codes/Standard

- a)** American Society of Mechanical Engineers (ASME).
- b)** American National Standards Institute (ANSI).
- c)** American Society for Testing and Materials (ASTM).
- d)** American Institute of Steel Construction (AISC).
- e)** American Welding Society (AWS).
- f)** Architecture Institute of Japan (AIJ).
- g)** Bureau of Indian Standards Institution (BIS).
- h)** British Standards (BS)
- i)** Central Board of Irrigation and Power (CBIP) Publications.
- j)** Deutsches Institut für Normung (DIN).
- k)** Electric Power Research Institute (EPRI).
- l)** Emission regulation of Central Pollution Control Board (CPCB)
- m)** Federal Occupational Safety and Health Regulations (OSHA)
- n)** Heat Exchanger Institute (HEI).
- o)** Hydraulic Institute (HIS).
- p)** Indian Electricity Rules.
- q)** Indian Boiler Regulations (IBR).

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- r) Indian Explosives Act.
- s) Indian Factories Act.
- t) Institute of Electrical and Electronics Engineers (IEEE).
- u) International Electro-Technical Commission Publications.
- v) Instrument Society of America (ISA).
- w) International Organization for Standardization (ISO).
- x) International Electro-technical Commission (IEC).
- y) Japanese Standards (JIS).
- z) Japanese Electro-technical Committee (JEC).
- aa) National Fire Protection Association (NFPA).
- bb) National Electrical Manufacturer's Association (NEMA).
- cc) National Electric Code (NEC).
- dd) Power Test Code for Steam Turbines (PTC).
- ee) Ministry of Environment & Forest (MoEF), Govt. of India
- ff) Standards of Manufacturer's Standardization Society (MSS).
- gg) Tariff Advisory Committee (TAC) rules.
- hh) Tubular Exchanger Manufacturer's Association (TEMA)
- ii) CEA regulations
- jj) Cooling Technology Institute (CTI) Codes
- kk) State Pollution Control Board (SPCB) Regulations/Norms

6.2 Name Plates

- 6.2.1 Instruction plates, nameplates or labels shall be permanently attached to each main and auxiliary item of plant in a conspicuous position. These plates shall be engraved with the identifying name, type and manufacturers serial number, together with the loading conditions under which the item of plant has been designed to operate.
- 6.2.2 Items such as valves, which are subject to hand operation, shall be provided with nameplates so constructed as to remain clearly legible throughout the life of the plant giving due consideration to the difficult climatic conditions to be encountered. Nameplates shall be securely mounted where they will not be obscured in service by insulation, cladding, actuators or other equipment. Direction of flow is also to be engraved.
- 6.2.3 All trade nameplates and labels shall be in Bilingual language. All measurements shall be in M.K.S. Units.

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6.2.4 The size and location of nameplates shall be subject to Approval of the Owner.

6.3 Guards and Fences

6.3.1 Effective guards and fences must be provided to prevent injury to operators.

6.3.2 Mesh guards which allow visual inspection of equipment with the guard in place are generally preferable. The guards shall be constructed of mesh attached to a rigid framework of mild steel rod, tube, or angle and the whole galvanized to prevent loss of strength by rusting or corrosion. The guards shall be designed to facilitate removal and replacement during maintenance.

6.3.3 Guards for couplings and rotating shafts shall be in accordance with BS 5304-1975 or similar approved standard. All rotating shafts and parts of shafts must be covered.

6.4 Operation, Maintenance & Availability

6.4.1 Equipment/works offered shall be designed for high availability, high reliability, low maintenance and ease of operation & maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability, availability, operability and ease of maintenance. He shall also furnish details of availability records in plants stated in his experience list.

6.4.2 Wherever required platforms and walkways with access ladders having hand rails shall be provided to facilitate operation and maintenance.

6.5 Materials

6.5.1 In selecting materials of construction of equipment, the Bidder shall pay particular attention to the atmospheric conditions existing at the Site and the nature of material/fluid handled. Wherever deviations are taken in respect of materials specified, the reasons shall be spelt out clearly in the proposal.

All materials shall be new, and shall be of the quality most suited to the proposed application.

6.5.2 As far as possible; materials shall be in accordance with Indian or international standard Specifications. Where such standards are not available, sufficient information shall be provided to allow the Owner to assess the suitability of the material for the particular application.

All materials used shall have performed lengthy satisfactory service in similar or more arduous conditions to those proposed by the Bidder.

6.5.3 All parts which could deteriorate or corrode under the influence of the atmospheric, meteorological or soil conditions at the Site, or under the influence of the working conditions shall be suitably and effectively protected so that such deterioration or corrosion is a minimum over the life of the plant.

6.6 Lubricants, Chemical and Control Fluids

6.6.1 Provision shall be made for suitable efficient lubrication where necessary to ensure smooth operation free from undue wear.

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- 6.6.2 Non ferrous capillary tubing shall be used throughout.
- 6.6.3 Oil baths shall be provided with filling and drain plugs, both of adequate size. An approved means of oil indication including level switches and temperature indication shall be provided.
- 6.6.4 Lubrication points shall be conveniently situated for maintenance purposes. It must be possible to carry out lubrication from a gangway or landing and without the removal of guarding or having to insert the hand into it. Where accessibility to a bearing for oiling purposes would be difficult a method of remote lubrication shall be fitted.
- 6.6.5 The Bidder shall provide a detailed and comprehensive Specification for all lubricating oils, greases and control fluids required for the entire plant. A sufficient supply of these shall be provided by the Bidder for initial commissioning, first fill and till handing over of the unit.
- 6.6.6 The Bidder shall supply a detailed schedule giving the lubricant testing, cleaning and replacement procedures. All equipment and facilities necessary for the testing, cleaning and changing of lubricants and control fluids shall be provided. The Bidder shall endeavour to reduce the varieties and grades of required lubricants, chemicals and control fluids to a minimum, matching them where possible to those already in use in the generating station in order to simplify procurement and minimize storage requirements. All lubricants, chemicals and control fluids shall be of internationally recognized standards and shall be easily obtainable from a large number of Indian suppliers. Bidder shall also indicate the equivalent Indian Standard for the above for easy procurement in future.
- 6.6.7 No lubricant or control fluid shall have toxic or other harmful effects on personnel or on the environment.

6.7 Plant Life and Mode of Operation

- 6.7.1 On completion of the R&M project, the plant/equipment and systems individually and collectively shall be possible to operate continuously with routine maintenance and overhauls for an economic service life of not less than [20/25 years] under the prevailing site conditions and for the type of duty intended.
- 6.7.2 After R&M of BOP System and associated auxiliaries, the unit shall be able to operate to its rated capacity continuously and there shall be no restriction of the operation of the supplied system.

6.8 Packaging & Marking

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing all the materials, the limitations from the point of view of availability of railway wagon sizes in India should be taken account of. The details of various wagons normally available with Indian Railways for transportation of heavy equipment shall be considered by the

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Bidder. The Bidder shall be responsible for all loss or damage during transportation, handling and storage due to improper packing.

The identification marking indicating the name and address of the consignee shall be clearly marked in indelible ink on two opposite sides and top of each of the packages. In addition the Bidder shall include in the marking gross and net weight, outer dimension and cubic measurement. Each package shall be accompanied by a packing note (in weather proof paper) quoting specifically the name of the Bidder, the number and date of Contract and names of the office placing the Contract, nomenclature of contents and Bill of Material.

6.9 Protection

Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures. Coated surfaces shall be protected against impact, abrasion, discoloration and other damages. Surfaces that are damaged shall be repainted.

Electrical and C&I equipment shall be protected against moisture and water damages. All external gasket surfaces and flange faces, couplings, rotating equipment shafts, bearings and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection. All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors.

All piping, tubing and conduit connections on equipment and other equipment openings shall be closed with rough usage covers or plugs. Male threaded openings shall be closed with rough usage covers or plugs. Female threaded openings shall be closed with forged steel plugs. The closures shall be taped to seal the interior of the equipment. Open ends of piping, tubing and conduit shall be sealed and taped.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Bidder's expense.

6.10 Painting

6.10.1 General

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. Surfaces not easily accessible after shop assembly shall be treated before-hand and protected for life of the equipment. Surfaces to be finish painted after installation shall be shop painted with at least two (2) coats of primer. Steel surfaces, which are not to be painted, shall be coated with suitable rust preventive compound subject to the approval of the Owner.

All paints shall be used in accordance with the manufacturer's instructions. No thinners or other substance shall be added to the coating material without the approval of the Owner. The quality and vendor of the paints shall require approval of the Owner.

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All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

All primers shall be well marked into the surface, particularly in areas where pitting is evident, and the first priming coat shall be applied as soon as possible after cleaning, within four hours maximum. If the drying interval between successive coats, which should not exceed one week, has been so long as to endanger the adhesion of the following coat, the paint already applied shall be lightly rubbed down with fine abrasive paper before putting on the next coat.

Paint spraying on large surfaces shall not normally be done indoors, except with the approval of the Owner. Spray guns shall not be used outdoors in windy weather or near unprotected surfaces of a contrasting colour and under no circumstances shall spray guns be used where spray may be carried into or onto exposed electrical equipment.

Paint containers shall not be opened until required and the paint shall be mechanically mixed thoroughly before use, and agitated occasionally during use.

Electrical equipment shall be shop finished with one or more coats of primer and two coats of high-grade oil resistant enamel. The interior of all panels' cabinets and enclosures shall be finished with gloss white enamel.

The Bidder shall furnish sufficient touch up paint for one complete finish coat on all exterior factory surfaces of each item of equipment. The touch up paint shall be of the same type and colour as the factory applied paint and shall be carefully packed to avoid damage during shipment. Complete painting instructions shall be furnished.

Shop primer for steel and iron surfaces which will have a continuous operating temperature below 35 deg C shall be selected by the Bidder, in accordance to the relevant standard. Special high temperature primer shall be used on surface exposed to operating temperature above 35 deg C.

The colour scheme shall be submitted during execution of Contract for approval by the Owner.

6.10.2 Preparation

Oil and grease shall be removed from the surface by washing with a suitable detergent, rinsing with clean water, and drying.

Surfaces to be shot blasted shall be cleaned to Swedish Standard SA 2.5 or equivalent, and all dust remaining after cleaning shall be removed.

The priming coat shall be applied without delay.

6.10.3 Damaged Paintwork

Any damaged paintwork shall be corrected / modified as follows:

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- a) The damaged area, together with an area extending 25 mm around its boundary, shall be cleaned down to bare metal.
- b) A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm around the perimeter of the original damage.
- c) The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

6.10.4 Painting Systems

The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as stated below, unless otherwise specified elsewhere in this Specification.

a) Surfaces Subject to Weathering

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	35 micron DFT per coat

The total minimum DFT shall be 140 micron.

b) Surfaces Inside Buildings

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	25 micron DFT per coat

The total minimum DFT shall be 120 micron.

The type and colour of primer & finish coat shall be selected by the Bidder after approval by the Owner.

6.11 Environment Protection

6.11.1 Environment Protection

The plant & equipment under this R&M project shall be designed for installation and operation in harmony with the surrounding environment and all measures of pollution control shall be ensured by the Bidder to restrict pollution from the liquid effluent and RPM emission within the limits as given below with due consideration of Environment (Protection) Rules.

6.11.2 For Liquid Effluent

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During construction activities, Bidder shall maintain the statutory compliance of State Pollution Control Board and MoEF in respect of pollution control and environmental protection within and around plant boundary. Any specific requirement of State Pollution Authorities over and above shall be maintained.

6.11.3 Noise Level Requirement

The plant & equipment under this R&M project will be designed, constructed and provided with suitable acoustic measures to ensure the noise level criteria as per the following stipulations of MoEF & State Pollution Control Board.

- a) Maximum noise level shall not exceed 85 dB (A) when measured at 1.0 m away from the noise emission source.
- b) Maximum noise level from its source within the premises shall not exceed 70 dB (A) as per Environment (Protection) Rules 1986, Schedule-III, 'Ambient Air Quality Standards' in respect of noise.
- c) Any statutory changes in stipulations regarding noise limitation that may occur in future according to State Pollution Control Board or Central pollution Control Board or Ministry of Environment & Forest regulation during tenure of the Contract, the Bidder shall comply with the updated/amended requirement.

An exception will be made for the plant at startup operations of other big pressure reducing devices operating during emergency periods and for the safety valves.

6.12 Inspection and Testing

6.12.1 Inspection and Tests during Manufacture

- 6.12.1.1 The method and techniques to be used by the Bidder for the control of quality during manufacture of all plant and equipment shall be agreed with the Owner prior to the Award of Contract.
- 6.12.1.2 The Owner's general requirements on quality control and shop tests as mentioned in Section II of Volume-II.
- 6.12.1.3 Owner shall be informed for witnessing the shop tests of any item of the plant or equipment for checking the compliance with the Specification requirement and or related standards prior to leave place of manufacturing.
- 6.12.1.4 Advance notice shall be given to the Owner as agreed in the Contract, prior to the stage of manufacture being reached, and the piece of plant must be held at this stage until the Owner has inspected the piece, or has advised in writing that inspection is waived. If having consulted the Owner and given reasonable notice in writing of the date on which the piece of plant will be available for inspection, the Owner does not attend, the Bidder may proceed with manufacture having forwarded to the Owner duly certified copies of his own inspection and test results.

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- 6.12.1.5 The Bidder shall forthwith forward to the Owner the Test Certificates in [...] copies for approval.
- 6.12.1.6 Under no circumstances any repair or welding of castings be carried out without the consent of the Owner. Proof of the effectiveness of each repair by radiographic and/or other non destructive testing technique, shall be provided to the Owner.
- 6.12.1.7 All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.
- 6.12.1.8 Where accurate alignment is necessary for component parts of machinery normally assembled on site, the Bidder shall allow for trial assembly prior to dispatch from place of manufacture.
- 6.12.1.9 All materials used for the manufacture of equipment covered under this Specification shall be of tested quality. Relevant test certificates shall be made available to the Owner. The certificates shall include tests for mechanical properties and chemical analysis of representative material.
- 6.12.1.10 All pressure parts connected to pumping main shall be subjected to hydraulic testing at a pressure of 150% of design pressure. The duration of the pressure tests shall be sufficient, as approved by the Owner, to show any leakage paths and to permit a thorough examination of the component whilst under pressure.
- 6.12.1.11 All necessary non destructive examinations shall be performed to meet the applicable code requirements.
- 6.12.1.12 Radiography, magnetic particle examination and ultrasonic testing shall be employed wherever necessary/ recommended by the applicable code. At least 10% of all major butt welding joints shall be radio graphed.
- 6.12.1.13 The Bidder shall furnish the quality procedures to be adopted for assuring quality from the receipt of material at site, during storage, erection, pre-commissioning to tests on completion and commissioning of the complete system/equipment.
- 6.12.2 Performance Tests at Site**
- 6.12.2.1 The full requirements for testing the system shall be agreed between the Owner and the Bidder prior to Award of Contract. The completely erected System shall be tested by the Bidder on site under normal operating conditions. The Bidder shall also ensure the correct performance of the System under abnormal conditions, i.e. the correct working of the various emergency and safety devices, interlocks, etc.
- 6.12.2.2 The Bidder shall provide complete details of his normal procedures for testing, for the quality of erection and for the performance of the erected plant. These tests shall include site pressure test on all erected pipe work to demonstrate the quality of the piping and the adequacy of joints made at site.

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7 LAYOUT CONSIDERATION

{Effort should be made to keep the Layout of the newly equipped system / packages under the R&M project unchanged to the extent possible with respect to existing layout to avoid disturbance to the existing equipment & facilities for which any modification/changes are not envisaged based on RLA/LA and EA assessment. However general guidelines, which need to be followed, as required, are given below :}

- 7.1 Trestles to be provided for routing of cables, pipes etc. shall have a clear height of 8.0m at road crossings so as to clear the road spaces, approach to maintenance bays of different equipment. A walkway with hand rails and toe guards of 750mm (minimum) width shall be provided all along length of the trestle for maintenance of cables and pipes. Ladders for approach to these platforms shall be provided near roads, passage ways.
- 7.2 Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized taking into account the fire water sprinkler system wherever provided.
- 7.3 Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 2.5 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment and clear headroom within main structures and cable trays etc.
- 7.4 Fire water pipes in main plant area may be routed in trenches filled with sand and covered with pre-cast RCC covers.
- 7.5 The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards etc. shall be observed while developing the layout.
- 7.6 The available existing layout details of the plant are indicated in the enclosed drawings as Annexure-I. However, Bidder to suggest his own modified layout arrangement which shall be subject to approval of the Owner.

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8 PERFORMANCE GUARANTEES

The term "Performance Guarantees" wherever appears in this Section shall have the same meaning and shall be synonymous to "Functional Guarantees".

Similarly the term "Performance Tests" wherever appears in this Section shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

8.1 General Requirements

- 8.1.1 The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in this technical Specifications.
- 8.1.2 The guaranteed performance parameters furnished by the Bidder in the Bid proposal, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.
- 8.1.3 The Bidder shall demonstrate all the guarantees covered herein under Category I, II & III during functional guarantee / acceptance test. The various tests which are to be carried out during performance guarantee/acceptance test are listed elsewhere in this Section. The guarantee tests shall be conducted by the Bidder at site in presence of Owner.
- 8.1.4 All costs associated with the tests including the cost associated with the supply, calibration, installation and removal of test instrumentation shall be included in the price offered by Bidder.
- 8.1.5 At all times during the Performance Tests the emissions as applicable and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.
- 8.1.6 It shall be the responsibility of the Bidder to make the plant ready for the performance guarantee tests.
- 8.1.7 All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Bidder shall get these instruments calibrated in an independent test institute approved by the Owner. All test instrumentation required for performance tests shall be supplied by the Bidder and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subjected to the approval of the Owner. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.
- 8.1.8 Tools and tackles, thermowells (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the Bidder free of cost.

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- 8.1.9 The Performance/ Acceptance test shall be carried out as per the agreed procedure. The PG test procedure including demonstration tests shall be submitted within *[90 days]* of the date of Notification of Award and finalization of the PG test procedure shall be done within *[180 days]* from the date of Notification of Award. After the conductance of Performance test, the Bidder shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. However, preliminary test reports shall be submitted to the Owner after completing each test run.
- 8.1.10 The PG test procedures shall be submitted for equipment/ system & subsystem under Bidder's scope for all Guarantees under category I, II & III as mentioned below, as per latest Indian and International codes & standard including correction curves, meeting the Specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.
- 8.1.11 The Bidder shall submit for Owner's approval the detailed Performance Test procedure containing the following:
- Objective of the test.
 - Various guaranteed parameters & tests as per Contract.
 - Method of conductance of test and test code.
 - Duration of test, frequency of readings & number of test runs.
 - Method of calculation.
 - Correction curves, as applicable to various system/equipment.
 - Instrument list consisting of range, accuracy, least count, and location of instruments.
 - Scheme showing measurement points.
 - Sample calculation.
 - Acceptance criteria.
 - Any other information required for conducting the test.
- 8.1.12 In case, during performance guarantee tests, it is found that the equipment/systems has failed to meet the guarantees, the Bidder shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Owner. However, if the Bidder is not able to demonstrate the guarantees, even after the above modifications/replacements within *[ninety (90) days]* or a reasonable period allowed by the Owner after the initial performance guarantee tests have been completed, the Owner will have the right to impose the stipulated clauses under Guarantee Category I, II & III as specified in this Specification:

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8.1.13 For Category-I Guarantees

Reject the equipment/system/plant and recover from the Contractor payments already made

(OR)

Accept the equipment/system/plant after levying Liquidated Damages (LD) as specified in Clause No. 5.6 of Volume I. The LDs shall be prorated for the fractional parts of the deficiencies.

8.1.14 For Category-II Guarantees

Reject the equipment/plant/system and recover, from the Contractor, the payments already made. Conformance to the performance requirements under Category-II is mandatory.

8.1.15 For Category-III Guarantees

Reject the equipment/system/plant & recover, from the Contractor, the payments already made.

(OR)

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the Contract price an amount equivalent to the damages as determined by the Owner. Such damages shall however be limited to the cost of replacement of the equipment/systems replacement of which shall remove the deficiency so as to achieve the guaranteed performance.

8.2 Performance Guarantees under Category-I

The performance guarantees which will attract liquidated damages shall be as follows:

- (i) **Total Auxiliary Power Consumption** – The auxiliary power consumption shall be calculated using the following relationship.

$$P_{au} = \sum P_u$$

P_{au} = Guaranteed Unit Auxiliary Power Consumption.

P_u = Power consumed by each of the continuously running equipment of Balance of Plant System under the scope of Bidder.

While guaranteeing the auxiliary power consumption the Bidder shall necessarily include all continuously operating equipment of BOP package. The auxiliaries to be considered shall include but not be limited to the following:

- b) Raw Water Intake Pump
- c) CW Pump
- d) Raw Water Supply Pump located at in plant reservoir

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- e) ACW Pump, if applicable
- f) IDCT, if applicable
- g) Cooling Water make-up Pump
- h) Equipment under Water Pretreatment Plant
- i) Equipment under Effluent Treatment plant
- j) Softening Plant Supply pumps, if applicable.
- k) DM Plant supply pumps
- l) Service water pumps
- m) Degassed Water pumps
- n) Degasser Blower
- o) DM Water Transfer pumps
- p) Chlorination Plant, as applicable
- q) Electrolyser Rectifyer units, as applicable
- r) Equipment of Compressed air system
- s) Equipment under fuel oil unloading and forwarding system
- t) Equipment under HVAC system
- u) Any other continuously running equipment under BOP Package

Note: The Bidder shall furnish a list of equipment to be covered under auxiliary power consumption, which shall be subject to Owner's approval.

- (ii) **Total Chemical consumption:** Chemical consumption of all the Chemicals indicated under Water treatment package. Bidder to indicate the guaranteed chemical consumption with the Bid.

Table: 8.1

Name of the chemical	Guaranteed Chemical consumption, kg
Cation & Anion Exchangers	
HCl Consumption	[...]
NaOH Consumption	[...]
For Mixed Bed	
HCl Consumption	[...]
NaOH Consumption	[...]
For Softening Plant, if applicable.	

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Name of the chemical	Guaranteed Chemical consumption, kg
NaCl Consumption	...
{Any Other Chemical, as applicable}	

- (iii) **Cooling Tower Cold Water Temperature:** LD will be levied for increase in cold water temperature up to [1 deg C] from the guaranteed value with every increment of [0.25 deg C] by a predetermined amount as specified in Volume-I. If increase in temperature is more than [1 deg C] from guaranteed value same shall be treated as per performance guarantee condition defined under category-III.

8.3 Guarantees under Category-II

The Performance Guarantees, conformance to which is mandatory are as follows:

Liquid Effluent: [Liquid Effluent discharge to an outside body from the plant battery limit shall meet statutory requirements State Pollution Control Board.]

8.4 Guarantees under Category-III

The parameters/capabilities to be demonstrated for various systems/ equipment shall include but not be limited to the following:

8.4.1 Noise

All the plant, equipment and systems covered under this Specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency specified.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 651 or BS 5969 or IS 9779.

Equivalent "A" weighted Sound pressure shall be measured all around the equipment at a distance of 1.0 m from the Noise emitting source.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A - weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed the guaranteed value. Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests.

If the noise level recorded is beyond the limits specified above, the Bidder should provide suitable acoustic enclosure to mitigate the noise level to within allowable limits.

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- 8.4.2 Raw Water Intake Pump, CW & ACW Pump
- The specified flow rate of the pump at the specified head and operation in accordance with the certified pump characteristic curve shall be demonstrated. No negative tolerance on design parameter for flow and head is permissible.
 - The pumps shall operate satisfactorily without cavitation, pitting, excessive vibration or noise when the pump is operating in isolation, in parallel and when starting or shutting down a pump with all other pumps in operation.
- 8.4.3 Rated Output of PT Plant: *[..... m³/h]*
- 8.4.4 Suspended Solids and Turbidity at the outlet of Clarifier: *[≤ 20 ppm on Silica scale]*
- 8.4.5 The Quality of treated water from Activated Carbon Filter: *[Residual chlorine and Organics should be below detectable level.]*
- 8.4.6 The Quality of treated water from pressure sand filter: *[Suspended solids and turbidity ≤ 2 NTU on silica Scale]*
- 8.4.7 SAC unit Sodium: *[≤1 ppm as CaCO₃]*
- 8.4.8 Degasser unit – Carbon-di-oxide at the outlet: *[≤5 ppm as CO₂]*
- 8.4.9 SBA unit:
- [Silica at the outlet ≤0.1 ppm as SiO₂]*
 - [CO₂ at the outlet=Nil]*
 - [Conductivity ≤ 6 μmho/cm @ 25 deg C]*
- 8.4.10 MB unit:
- [Rated output between two regeneration.....]*
 - [Conductivity at the outlet ≤ Not greater than 0.1 μmho/cm @ 25 deg C]*
 - [PH within 6.8 – 7.2]*
 - [Total Silica ≤ 0.01 ppm as SiO₂]*
 - [Scale inhibition efficiency should always be 100% for the CW system at the Bidder's specified dosage rate.]*
- 8.4.11 Free oil (in the treated water) at the outlet of oil water separator: *[≤ 10 ppm]*
- 8.4.12 The quality of combined effluents collected in the ETP guard pond will meet the norms stipulated by *[.....State Pollution Control Board]*
- 8.4.13 Total hardness at the outlet of softening plant: *[< 50 ppm]*
- 8.4.14 NDCT
- Increase of temperature more than 1deg C (i.e.deg C) from the guaranteed value of 34 °C.*
- 8.4.15 Fire Protection System
- Capacity, Pumping head, Vibration Level of Fire water and Fire water booster pumps (Hydrant and Spray) of both electrical driven and diesel engine driven and Jockey pumps.

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- 8.4.16 Compressed Air System:
FAD and pressure at the outlet of compressor.
- 8.4.17 Fuel Oil System
Capacity, Pumping head of Fuel Oil Unloading & Forwarding Pump
- 8.4.18 Air Conditioning & Ventilation System
- a) Air-Conditioning:
- Manned Area
- i. Temperature : $[24 \pm 1^{\circ}\text{C}]$
 - ii. Relative humidity : $[50 \pm 5 \ %]$
 - iii. Filtration : $[90\% \text{ down to } 10 \text{ microns}]$
- Unmanned Area
- i. Temperature : $[22 \pm 1^{\circ}\text{C}]$
 - ii. Relative humidity : $[50 \pm 5 \ %]$
 - iii. Filtration : $[90\% \text{ down to } 10 \text{ microns}]$
- b) Pressurized Ventilation:
- i. Temperature: Inside temperature $[\text{not to exceed } 3^{\circ}\text{C}]$ over and above the prevailing ambient temperature.
 - ii. Pressure : A positive pressure of $[\text{minimum } 3 \text{ mm WC}]$ shall be maintained inside the premises.
- c) Exhaust Ventilation:
- Temperature : $[\text{Not more than } 3^{\circ}\text{C rise}]$ above ambient temperature shall be maintained.
- 8.4.19 Cranes, Hoists
- The crane/hoist shall be tested for each motion in each direction under the following conditions as per IS:3177:
- i. With no load.
 - ii. With safe working load.
 - iii. With 25 % over-load in excess of safe working load.

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9 SPARE PARTS

The Bidder shall include in his scope of supply all the necessary mandatory spares, start up and commissioning spares and recommended spares and indicate these in the relevant schedules. The general requirements pertaining to the supply of these spares is given below:

9.1 Mandatory Spares

The list of mandatory spares considered essential by the Owner is enclosed in Annexure-II of this Specification. The Bidder shall indicate the prices for each and every item (except for items not applicable to the Bidders design) in the 'Schedule of mandatory spares' whether or not he considers it necessary for the Owner to have such spares. If the Bidder fails to comply with the above, the cost of such spares shall be deemed to be included in the Contract price. The Bidder shall furnish the population per unit of each item in the relevant Schedules. Whenever the quantity is mentioned in "sets" the Bidder has to give the item details and prices of each item.

Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the R&M Contract unless specified otherwise, and the fraction will be rounded off to the next higher whole number. Wherever the requirement has been specified a 'set' it will include the total requirement of the item for a unit, module or the R&M Contract scope or as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.

All mandatory spares shall be delivered at site at least two months before scheduled date of initial operation of the first unit. However, spares shall not be dispatched before dispatch of corresponding main equipment.

Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise. Price of mandatory spare parts will also be evaluated.

9.2 Recommended Spares

In addition to the mandatory spare parts mentioned above, the Bidder shall also provide a list of recommended spares for [five (5)] years of normal operation of the plant and indicate the list and total prices in relevant schedule. The list shall take into consideration the mandatory spares specified and should be independent of the list of the mandatory spares. The Owner reserves the right to buy any or all of the recommended spares. The recommended spares shall be delivered at project site at least two months before the scheduled date of initial operation of first unit. However, the spares shall not be dispatched before the dispatch of the main equipment.

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Prices of recommended spares will not be used for evaluation of the Bids. The price of these spares will remain valid up to execution of the Contract. However, the Bidder shall be liable to provide necessary justification for the quoted prices for these spares as desired by the Owner.

9.3 Start-up & Commissioning Spares

Start up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system till the handing over of the Plant. The Bidder shall provide all such start up and commissioning spares and keep an adequate stock of the same to be brought by him to the site for the plant erection and commissioning. These must be available at site before the equipment are energized. The unused spares, if any, should be removed from there, only after handing over of the plant. All start up spares which remain unused at the time shall remain the property of the Bidder.

9.4 General Requirements

The Bidder shall indicate the service expectancy period for the spares parts (both mandatory and recommended) under normal operating conditions before replacement is necessary.

All spares supplied under this Contract shall be strictly inter-changeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desiccators packs as necessary.

All the spares (both mandatory and recommended) shall be manufactured along with the main equipment components as a continuous operation as per same Specification and quality plan.

The Bidder will provide Owner with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the Owner to identify and finalize order for recommended spares.

Each spare part shall be clearly marked or labeled on the outside of the packing with its description. When more than one spare part is packed in a single case, a general description of the content shall be shown on the outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.

All cases, containers or other packages are to be opened for such examination as may be considered necessary by the Owner.

The Bidder will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on Vendors for items/ components/ equipment covered under Contract and will further ensure with his Vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such Vendors.

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The Bidder shall warrant that all spares supplied will be new and in accordance with the Contract documents and will be free from defects in design, material and workmanship.

In addition to the recommended spares listed by the Bidder, if the Owner further identifies certain particular items of spares, the Bidder shall submit the prices and delivery quotation for such spares within **[30 days]** of receipt of such request for consideration by the Owner and placement of order for additional spares if the Owner so desires.

The Bidder shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered in the Contract. The Bidder shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the Owner **[at least 2 years]** advance notice so that the latter may order his bulk requirement of spares, if he so desires. The same provision will also be applicable to Sub-Bidders. Further, in case of discontinuance of manufacture of any spares by the Bidder and/or his sub-Bidders, Bidder will provide the Owner, two years in advance, with full manufacturing drawings, material Specifications and technical information including information on alternative equipment makes required by the Owner for the purpose of manufacture/procurement of such items.

The prices of all future requirements of spares beyond **[five (5)]** years shall be derived from the corresponding Ex-works price at which the order for such spares have been placed by the Owner as a part of the mandatory spares or recommended spares. Ex-works order price of future spares shall be computed in accordance with the price escalation formula to be furnished by Bidder indicating base price reference variation indices for material, labour etc. Based on the formula and considering escalation indices prevailing at the time of order of spares, order price shall be worked out. The base indices will be counted from the scheduled date of successful completion of trial operation of the last plant/equipment under the project. The above option for procuring future recommended spares by the Owner shall remain valid for the period of fifteen **[fifteen (15)]** years from the date of successful completion of trial operation of the last plant/equipment. In case the spare parts from the same sub-Vendor are not available due to obsolescence or any other reason, the Bidder shall supply the spares for a period of **[fifteen (15)]** years from an alternative source.

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10 ANNEXURE

10.1 Annexure-I (List of Existing Drawing)

{Available as Built/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned in Annexure-I for their information & familiarization of the existing Unit}

10.2 Annexure-II (Mandatory Spares)

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II}

10.3 Annexure-III (List of Sub-Vendor)

{List of Sub-vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the format given in Annexure-III}

10.4 RLA/CA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.5 EA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.6 Baseline Study Report

{Not attached with this document. This is to be provided by Utilities}

10.7 Geotechnical Investigation Report

{Not attached with this document. This is to be provided by Utilities}

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-I, ANNEXURE-I
LIST OF EXISTING DRAWING**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-I

List of Existing Drawing

{Available as Built/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned below for their information & familiarization of the existing Unit}

i) MECHANICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[General Layout (Plot Plan)]
2	[.....]	[Main plant Layout at + 0.00 M]
3	[.....]	[Main plant Layout – Cross Section]
4	[.....]	[General layout battery limit]
5	[.....]	[Symbol /Legends]
6	[.....]	[Water Balance Diagram]
7	[.....]	[CW Pump House Plan and Section]
8	[.....]	[P&ID of CW System]
9	[.....]	[P&ID for raw water intake pump house and CW makeup system]
10	[.....]	[Raw water intake pump house plan and section]
11	[.....]	[NDCT plan and details]
12	[.....]	[Flow Diagram for Pre Treatment System]
13	[.....]	[Flow Diagram for DM System]
14	[.....]	[Flow Diagram for Effluent Treatment Plant]
15	[.....]	[GA of DM Plant]
16	[.....]	[Water Treatment Plant Layout]

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S.No.	Drawing/Document No.	Title
17	[.....]	[Flow Diagram for Fire Fire Detection and Protection System]
18	[.....]	[Hydrant Layout]
19	[.....]	[Scheme of MVW System For Conveyor Gallery]
20	[.....]	[Scheme of HVWS System for transformers]
21	[.....]	[Scheme of Inergen Gas Flooding System]
22	[.....]	[Scheme of MVW System For Cable Gallery]
23	[.....]	[GA of FWPH & FWST]
24	[.....]	[Flow Diagram for Fuel Oil System]
25	[.....]	[GA of Fuel Oil Pump House & Fuel Oil Tank]
26	[.....]	[Any other Drawing]

ii) ELECTRICAL

S.No.	Drawing/Document No.	Title
1.	[.....]	[Key Electrical SLD]
2.	[.....]	[Protection Details]
3.	[.....]	[SLD for Chimney]
4.	[.....]	[SLD for Cooling Tower]
5.	[.....]	[SLD for Fire Water Pump House]
6.	[.....]	[SLD for Raw Water System]
7.	[.....]	[SLD for Circulating Water System]
8.	[.....]	[SLD for Water Treatment Plant]
9.	[.....]	[SLD for MLDB]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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10.	[.....]	[General Arrangement and Schematic drawing of LV switchgear]
11.	[.....]	[General Arrangement and Schematic drawing of DC system]
12.	[.....]	[General Arrangement and Schematic drawing of Cables]. {Voltage grade as well application wise i.e power , control wise to be provided}
13.	[.....]	[General Arrangement and Schematic drawing of NSPBD]
14.	[.....]	[General Arrangement and Schematic drawing of Cable Carrier System]. {Accessories wise to be provided}
15.	[.....]	[General Arrangement and Schematic drawing of Lighting System]. {Accessories wise to be provided}
16.	[.....]	[General Arrangement and Schematic drawing of Earthing and Lightning System]. {Accessories wise to be provided}
17.	[.....]	[Any other drawings /documents for this package(if applicable)]

iii) CONTROL & INSTRUMENTATION

S.No.	Drawing/Document No.	Title
1	[.....]	[Plant DCS Configuration Drawing]
2	[.....]	[PLC Configuration Drawing of DM Water Plant]
3	[.....]	[PLC Configuration Drawing of Compressed Air System]

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S.No.	Drawing/Document No.	Title
4	[.....]	[PLC Configuration Drawing of Fuel Oil Handling System]
5	[.....]	[PLC Configuration Drawing of Fire Fighting System]
6	[.....]	[PLC Configuration Drawing of Hydrogen Genmration System]
7	[.....]	[PLC Configuration Drawing of Condensate Polishing Unit]
8	[.....]	[PLC Configuration Drawing of Condenser Tube Cleaning System]
9	[.....]	[PLC Configuration Drawing of ESP Control System]
10	[.....]	[PLC Configuration Drawing of Mill Reject Handling System]
11	[.....]	[Instrument Installation Diagram (Pressure Transmitter)]
12	[.....]	[Instrument Installation Diagram (Flow Measurement)]
13	[.....]	[Instrument Installation Diagram (Pressure Gauge)]
14	[.....]	[Instrument Installation Diagram (DP Measurement)]
15	[.....]	[Instrument Installation Diagram (Level Measurement using gauge & switch)]
16	[.....]	[Instrument Installation Diagram (Level Measurement using DP Transmitter & Displacer type Transmitter)]
17	[.....]	[Instrument Installation Diagram (Level Measurement for Open/Close Vessels)]
18	[.....]	[Instrument Source Connection Details – Pressure Measurement on Pipe]
19	[.....]	[Instrument Source Connection Details – Temperature Measurement on Pipe]
20	[.....]	[Instrument Source Connection Details – Flow Measurement]
21	[.....]	[Instrument Source Connection Details – Level Measurement]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No.	Drawing/Document No.	Title
22	[.....]	[Grounding Scheme for Cabinets/Panels]
23	[.....]	[C&I Power Supply distribution cabling Philosophy]
24	[.....]	[C&I Instrumentation cabling Philosophy]
25	[.....]	[PLC based Control System Configuration Diagram]
26	[.....]	[Drive Control Philosophy-Bidirectional drive (ON-OFF Type MOV)]
27	[.....]	[Drive Control Philosophy-Bidirectional drive (Inching Type MOV)]
28	[.....]	[Drive Control Philosophy- LT drive]
28	[.....]	[Drive Control Philosophy- HT drive]
29	[.....]	[Drive Control Philosophy-Solenoid Valve]
30	[.....]	[Drive Control Philosophy-VFD]
31	[.....]	[Any Other Drawing]

iv) CIVIL

S.No.	Drawing No.	Description
1	[.....]	[Geotechnical Investigation Report]
2	[.....]	[Road, drains, trench layouts etc., as available]
3	[.....]	[Design documents of the existing structures]
	[.....]	[Drawings of existing structures & foundations]
4	[.....]	[Drawings for loading data of the existing structures & foundations]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-I, ANNEXURE-II
MANDATORY SPARES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-II

Mandatory Spares

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II. Available Mandatory spares of the existing Unit, which can be used after completion of R&M work, shall also be verified before finalization of the below mentioned Spare List.}

A. MECHANICAL

1. Raw Water Intake System

S.No	Description	Quantity	Remarks
1.0	Pumps		
1.1	Impeller	1 no.	
1.2	Impeller wear ring (if applicable) with fixing screws	1 no	
1.3	Impeller nut with washer	2 sets	
1.4	Casing wearing ring (if applicable) with fixing screws	1 set	
1.5	Line shaft bearings	1 set	
1.6	Line shaft bearing spider	1 set	
1.7	Bowl bearing (if applicable)	1 no	
1.8	Thrust Pad assembly for Pump	1 set	
1.9	Line shafts with fasteners (as applicable)	1 set	
1.10	Shaft sleeves	1 set	
1.11	Gaskets for all column pipes	1 set	
1.12	Gland packings	3 sets	
1.13	"O" rings as applicable	1 set	

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S.No	Description	Quantity	Remarks
1.14	Column pipe fasteners	1 set	
1.15	Line shaft coupling with bolts, nuts and washers	1 set	
1.16	Pump and motor coupling with fasteners	1 set	
1.17	Top shaft with sleeve	1 set	
1.18	Impeller shaft	1 no	
1.19	Stuffing box	1 set	
2.0	Butter fly valve (Quantity indicated is for each size)		
2.1	Valve disc	1 no for each size	
2.2	Disc seal ring.	1 set for each size	
2.3	Gland packing	1 set for each size	
2.4	Shaft	1 no for each size	
2.5	Bearing	1 set for each size	
2.6	Seals, seal clamping bolts.	1 set for each size	
2.7	O-rings & gaskets,	1 set for each size	
2.8	Gear box internals with shaft (if applicable)	1 set for each size	
2.9	Bearings & O-ring for gear box unit (if applicable)	1 set for each size	
3.0	Under slung Crane for Raw water Intake pump house		
3.1	Bearings of each type and size used in gear assemblies, lifting hooks, trolley wheels, etc.	1 set	
3.2	Break drum	1 no.	
3.3	Break lining for LT, CT & Hoisting	1 set	

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S.No	Description	Quantity	Remarks
3.4	Oil seal used in all gear boxes	1 set	
3.5	Input pinion for LT gear box	1 no	
3.6	Input pinion for CT gear box	1 no	
3.7	Input pinion for hoist gear box	1 no	
4.0	Electric hoist (To be repeated for each capacity)		
4.1	Bearings of each type and size used in gear assemblies, lifting hook, trolley wheels .	2 sets	
4.2	Hoist brake liner with rivets for each brake	4 sets	
4.3	Brake shoe with lining for each brake	2sets	
4.4	Brake springs for each size of the brakes	2 nos.	
4.5	Oil seals for all gear boxes in each hoist	2 sets	
5.0	Ventilation Systems		
5.1	Tube Axial Fans		
5.1.1	Fan bearings	1 set for each type	
5.1.2	Fan belt	1 set for each type	

2. Circulating Water System

S.No	ITEM	Quantity	Remarks
1	CW PUMP		
1.1	Impeller	1 no.	
1.2	Impeller wear ring (if applicable) (for each size/type)	1 no.	

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S.No	ITEM	Quantity	Remarks
1.3	Impeller nut (for each size/type)	1 set	
1.4	Casing wearing ring (if applicable) (for each size/type)	2 sets	
1.5	Cover ring	1 set	
1.6	Impeller nose / cap (for each size/type)	2 nos.	
1.7	Bearing of Pumps, Motors and Drives (all bearings including thrust bearing as applicable) each type	1 set	
1.8	Thrust Pad assembly for Pump	1 set	
1.9	Impeller shafts with fasteners (as applicable)	1 set	
1.10	Intermediate shafts with fasteners (as applicable)	1 set	
1.11	Knuckle joint (as applicable)	1 set	
1.12	Shaft sleeves	1 set	
1.13	Gaskets	1 set	
1.14	Gland packings	3 sets	
1.15	"O" rings	1 set	
1.16	Bolts and Nuts	1 set	
1.17	Deflectors	2 sets	
1.18	Press reducing bush	1 sets	
1.19	Rubber bearing	1 sets	
2	Drainage pumps		
2.1	Impeller with nut	1 no.	
2.2	Shaft	1 set	

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S.No	ITEM	Quantity	Remarks
2.3	Shaft Sleeves	2 sets	
2.4	All gaskets	1 sets	
2.5	Wearing rings-Impeller (if applicable)	1 set	
2.6	Wearing rings-Casing (if applicable)	1 set	
2.7	Bearings for pump	1 sets	
2.8	Shaft Coupling with fasteners	1 set	
2.9	Pin and bushes for all couplings	1 set	
2.10	Gland packing	1 set	
3	Butter fly valve (Quantity indicated is for each type/size/rating in CW System)		
3.1	Valve disc (each type & size)	1 no.	
3.2	Disc seal ring (each type & size)	1 set	
3.3	Gland packing (each type & size)	1 set	
3.4	Shaft (each type & size)	1 set	
3.5	Bearing (each type & size)	1 set	
3.6	Seals, seal clamping bolts (each type & size)	1 set	
3.7	O-rings & gaskets (each type & size)	1 set	
3.8	Gear box internals with shaft (each type & size) (if applicable)	1 set	
3.9	Bearings & O-ring for gear box unit (each type & size) (if applicable)	1 set	
4	Electro-hydraulic actuators		
4.1	Complete actuator excluding the oil tank, accumulator cylinders, counter weight	1 set	

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S.No	ITEM	Quantity	Remarks
	<i>and power pack</i>		
4.2	<i>Complete power pack</i>	<i>1 set</i>	
5	Rubber expansion joint		
5.1	<i>Control unit</i>	<i>1 set</i>	
6	Valves (500 NB and below)		
6.1	<i>Complete valve (1 No. or 10% of total no. of valves of each type/size/rating)</i>	<i>1 no.</i>	
7	EOT CRANE		
7.1	<i>Bearings of each type and size used in gear assemblies, lifting hooks, trolley wheels etc.</i>	<i>1 set</i>	
7.2	<i>Brake drum of Each type.</i>	<i>1 set</i>	
7.3	<i>Oil seal used in all gear boxes.</i>	<i>1 set</i>	
7.4	<i>All Brake lining</i>	<i>1 set</i>	
7.5	<i>Input pinion for Hoist Gearbox</i>	<i>1 set</i>	
7.6	<i>Input pinion for CT Gear box</i>	<i>1 set</i>	
7.7	<i>Input pinion for LT Gear box</i>	<i>1 set</i>	
8	Gantry Crane		
8.1	<i>Bearings of each type and size used in gear assemblies, lifting hook, trolley wheels.</i>	<i>1 set</i>	
8.2	<i>Hoist brake liner with rivets for each brake</i>	<i>2 sets</i>	
8.3	<i>Brake shoe with lining for each brake</i>	<i>2 sets</i>	
8.4	<i>Brake springs for each size of the brakes</i>	<i>2 sets</i>	
8.5	<i>Oil seals for all gear boxes in each hoist</i>	<i>2 sets</i>	

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S.No	ITEM	Quantity	Remarks
9	Ventilation Systems		
9.1	Centrifugal Fans		
9.1.1	Fan bearings	1 set	
9.1.2	Filter	2 sets	
9.1.3	Impeller	1 no.	
9.2	Propeller Fans		
9.2.1	Bearings	1 set	
9.3	Wind Turbine ventilators		
9.3.1	Bearings for wind turbine ventilator	1 set	
9.3.2	SS central shaft		
9.3.3	Throat adopters		
9.3.4	Base adopters		
9.3.5	Base flange		
10	Split Air Conditioners		
10.1	Fan Bearing for each type & rating	1 set	
10.2	Filter for each type & rating	1 set	
10.3	Temperature / Speed Controller for each type & rating	1 set	

3. Water Treatment Plant & Effluent Treatment Plant

S.No	Description	Quantity	
1	Clarifier Equipment		
1.1	All Bearings for each type	2 sets	

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S.No	Description	Quantity	
1.2	V-belts/chain and other drives for each type of flocculator	2 sets	
1.3	All Bearings for gear box for each type of clarifier	1 set	
1.4	Oil seals for gear box for each type of clarifier	2 sets	
2	Not Used		
3	Vertical Sump Pumps		
	(These shall be supplied separately for sludge thickener feed pumps,		
3.1	Impeller	1 no.	
3.2	Shaft	1 set	
3.3	Pump bearings	1 set	
3.4	Shaft sleeve	1 set	
3.5	Impeller wearing ring	1 set	
3.6	Casing wearing ring	1 set	
3.7	All fasteners	1 set	
4.0	Dual Media Filter For one vessel		
4.1	Filter sand	10 set	
4.2	Laterals	1 set	
4.3	Strainers	10 nos.	
5	Activated carbon filter (For one vessel)		
5.1	Activated Carbon	10 set	
5.2	Laterals	1 set	

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S.No	Description	Quantity	
5.3	Strainers	10 nos.	
6	Cation and Anion exchange units (Applicable for SAC/ SBA) (For one vessel)		
6.1	Resins for each unit	10	
6.2	Strainers for each unit	10 set	
6.3	Laterals for each unit	1 set	
6.4	Grommets for each unit	10 set	
7	Degasser Air Blower		
7.1	Shaft with keys	1 set	
7.2	Bearings for air blower	1 set	
7.3	Gaskets and oil seals	1 set	
8	Degasser Tower (For one tower)		
8.1	Fill	10 sets	
8.2	Fill support materials	10 sets	
8.3	Water seals fittings	2 sets	
9	Mixed bed Unit (For one vessel)		
9.1	Resins	10	
9.2	Strainers	10 sets	
9.3	Laterals	10 sets	
9.4	Grommets	10 sets	
10	Mixed Bed Air Blower		
10.1	Lobes	1	
10.2	Shaft	1 set	

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S.No	Description	Quantity	
10.3	Bearings for motor and air blower	1 set	
10.4	Gaskets and oil seals	1 set	
11	Motorised agitators		
11.1	Impeller / Propeller including shaft for each type of agitator	1 set	
12	Pumps for Neutralising Pit		
12.1	Impeller	1 no.	
12.2	Shaft	1 set	
12.3	Pump bearings	1 set	
12.4	Shaft sleeve	1 set	
12.5	Impeller wearing ring	1 set	
12.6	Casing wearing ring	1 set	
12.7	All fasteners	1 set	
13	Horizontal Centrifugal Pumps		
	(These shall be supplied separately for DM plant supply pumps, service water pumps, DM transfer pumps, Degasser water pumps, Plant potable water pumps, acid and alkali unloading pump, softening plant supply pumps, brine recirculation pumps, electro chlorination booster pump, and other centrifugal pumps provided)		
13.1	Impeller	1 no.	
13.2	Shaft with keys	1 set	
13.3	Pump and motor bearings	1 set	
13.4	Shaft sleeves	1 set	

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S.No	Description	Quantity	
13.5	Impeller wearing ring	1 set	
13.6	Casing wearing ring	1 set	
13.7	All fasteners	1 set	
13.8	Pump Motor coupling	1 no.	
13.9	Bearing lock nut with washer	1 set	
13.10	Impeller lock nut	1 set	
13.11	O rings, 'V' Rings, 'U' Rings used in pumps as applicable	1 set	
13.12	Oil seals	1 set	
13.13	Constant level oiler	1 set	
14	Complete set of chemical dosing ejectors for each size/duty used	1	
15	Clarifier		
15.1	All Bearings for each type	2 set	
15.2	V-belts/chain and other drives for each type of flocculator	2 sets	
15.3	All Bearings for gear box for each type of clarifier	1 set	
15.4	Oil seals for gear box for each type of clarifier	2 sets	
16	Chemical dosing pumps (for each type of chemical)		
16.1	Plunger / Diaphragm	1 set	
16.2	Pump bearing	1 set	
16.3	'O' Rings / 'U' Rings / 'V' Rings / Gland packing (as applicable)	2 set	

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S.No	Description	Quantity	
16.4	Ball valves	2 set	
16.5	Relief valves	2 set	
16.6	Oil and grease seals	2 set	
<i>Effluent Treatment Plant</i>			
17	Oil water separator		
17.1	Bearings	1 set	
18	Effluent disposal pumps	1 no.	
18.1	Impeller	1 no.	
18.2	Shaft	1 set	
18.3	Pump bearing	1 set	
18.4	Shaft sleeve	1 set	
18.5	Impeller wearing ring	1 set	
18.6	Cashing wearing ring	1 set	
18.7	All fasteners	1 set	
19.	Treated Water Pump for Oil Water Separator.		
19.1	Impeller	1 no.	
19.2	Shaft	1 set	
19.3	Pump bearing	1 set	
19.4	Shaft sleeve	1 set	
19.5	Impeller wearing ring	1 set	
19.6	Cashing wearing ring	1 set	
19.7	All fasteners	1 set	

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4. Spares for CW Chemical Treatment System and Electrochlorination System

S.No	Description	Quantity	Remarks
1	<i>Chemical dosing pumps (For each kind of chemical dosed)</i>		
1.1	<i>Plunger / Diaphragm</i>	<i>1 set</i>	
1.2	<i>Pump Bearing</i>	<i>1 set</i>	
1.3	<i>'O' Rings / 'V' Rings / 'U' Rings/ Gland packing (as applicable)</i>	<i>2 set</i>	
1.4	<i>Ball valves</i>	<i>2 nos.</i>	
1.5	<i>Relief valves</i>	<i>2 nos.</i>	
1.6	<i>Oil and grease seals</i>	<i>2 set</i>	
2	<i>Electrolyser Units</i>		
2.1	<i>Cell house clamp</i>	<i>1 set</i>	
2.2	<i>Cell end plate gasket</i>	<i>1 set</i>	
2.3	<i>Hardware</i>	<i>1 set</i>	
2.4	<i>Electrode Plates</i>	<i>1 set</i>	
2.5	<i>Asbestos Diaphragm</i>	<i>1 set</i>	
2.6	<i>Insulating Material used in cell</i>	<i>1 set</i>	
2.7	<i>Cell Connectors & Fasteners of each type</i>	<i>1 set</i>	

5. Spares for Electric Hoist & Fans

ITEM	DESCRIPTION	Quantity	Remarks
1	<i>Electric Hoist (to be Repeated for Each Type, Rating, Make)</i>		
1.1	<i>All Bearings of each type and size used in all Gear Assemblies,</i>	<i>2 Sets</i>	

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ITEM	DESCRIPTION	Quantity	Remarks
1.2	Hoist brake liners with rivets for each size of brake	4 Pair of each size	
1.3	Brake shoes with lining for each size of brake	2 Pair of each size	
1.4	Brake springs for each size of the brake	2 sets	
1.5	All oil seals for all gear boxes in each hoist	2 Sets	
2.0	CENTRIFUGAL FANS (TO BE REPEATED FOR EACH TYPE, RATING, MAKE)-IF APPLICABLE		
2.1	All Gaskets in one fan	1 Set	
2.2	All Fan Bearings in one fan	1 Set	
2.3	V- Belts in one fan	1 Set	
2.4	Fan Shaft	1 No.	
3.0	AXIAL FANS (TO BE REPEATED FOR EACH TYPE, RATING, MAKE)		
3.1	All Fan Bearings in one fan	1 Set	
3.2	Fan Impeller	1 No.	
4.0	BIFURCATED AXIAL FLOW FANS (TO BE REPEATED FOR EACH TYPE, RATING, MAKE)		
4.1	All Fan Bearings	1 Set	
4.2	Fan Impeller	1 No.	
5.0	TUBE AXIAL FANS (TO BE REPEATED FOR EACH TYPE, RATING, MAKE)		
5.1	All Fan Bearings	1 Set	
5.2	Fan Impeller	1 No.	

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6. Spares for Valves and Specialties

S.No	Description	Quantity	Remarks
1	VALVES AND SPECIALITIES		
1.1	For service air and instrument air system including drains		
1.1.1	For all valves of size below 65mm (for each type, rating & size)		
	Complete valves	5%	
1.1.2	For all valves of size 65mm and above (for each make, type, rating & size)		
1.1.2.1	Complete valves	1 No.	If the quantity is less than 10
		2 No.	If the quantity is equal to or more than 10
1.2	For CW Chemical dosing system, Pre treatment plant, DM plant, Chlorination system, Effluent treatment plant, Service Water System and Potable Water System including all drains and vents.		
1.2.1	For all valves of size below 65mm (for each make type, rating & size)		
	Complete valves	5%	
1.2.2	For all valves of size 65mm and above (for each make, type, rating & size)		
1.2.2.1	Complete valves	1 No.	If the quantity is less than 10
		2 No.	If the quantity is equal to or more than 10
1.3	Butterfly valves		

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S.No	Description	Quantity	Remarks
1.3.1	Complete valves for each size and rating	1 No.	

7. Chemicals

S.No	Chemical Name	Quantity	Remarks
1.	Alum	235 Tons	
2.	Polyelectrolyte	5.0 Tons	
3.	33% Hcl	155 Tons	
4.	48% NaOH	80 Tons	
5.	DWPE	10 Tons	
6.	CW chemical dosing	10 Tons	
7.	Salt	300 Tons	
8.	SMBS	5 Tons	

8. Cooling Tower

S.No	Description	Quantity	Remarks
1.	Spray nozzles	5%	
2.	Hot water distribution line (UPVC)	10% of each size	
3.	Fill mattress	5%	
4.	Distribution pipe end cap	5%	
5.	Drift eliminator	5%	
CT Fan spares in case of IDCT, as applicable			
6.	All Gaskets & sealing rings in each type & rating	1 Set	
7.	All Bearings in each type & rating	1 Set	
8.	Gear Box	1 Set	

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9.	<i>Fan Blades</i>	<i>1 Set</i>	
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9. Fire Protection System

9.1 Hydrant System

S.No	Item Description	Quantity	Remarks
1)	<i>63 mm hydrant valves</i>	<i>10 No.</i>	
2)	<i>Hoses For External Hydrants (15m long with coupling)</i>	<i>10 No.</i>	
3)	<i>Hoses For Internal Hydrants (7.5m long with coupling)</i>	<i>10 No.</i>	
4)	<i>Branch pipes with nozzles</i>	<i>10 No.</i>	

9.2 Fire Water Pumps (for each type and size of pump)

S.No	Item Description	Quantity	Remarks
1.	<i>Impeller</i>	<i>1 no.</i>	
2.	<i>Impeller shaft and keys</i>	<i>1 no.</i>	
3.	<i>Bearings for pump</i>	<i>1 sets</i>	
4.	<i>Shaft sleeves</i>	<i>1 no.</i>	
5.	<i>Casing & Impeller wearing rings</i>	<i>1 set</i>	
6.	<i>Impeller Lock nut with lock washers</i>	<i>2 set</i>	
7.	<i>Pump and motor coupling</i>	<i>1 no.</i>	
8.	<i>Coupling pads/bushes</i>	<i>1 set</i>	
9.	<i>Gasket</i>	<i>1 set</i>	
10.	<i>`O' ring/ 'V' ring/'U' ring (as applicable)</i>	<i>1 set</i>	
11.	<i>Impeller sealing ring</i>	<i>2 nos.</i>	

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9.3 Water Spray System (HVWS & MVWS)

S.No	Item Description	Quantity	Remarks
1	<i>Automatic deluge valve Assembly complete with necessary trims, motor gong and accessories.</i>		
1.1	<i>Size 150 mm NB</i>	<i>2 No.</i>	
1.2	<i>Size 100 mm NB</i>	<i>2 No.</i>	
1.3	<i>Size 80 mm NB</i>	<i>2 No.</i>	
2	<i>Butterfly Valves</i>		
2.1	<i>Size 150 mm NB</i>	<i>2 No.</i>	
2.2	<i>Size 100 mm NB</i>	<i>2 No.</i>	
2.3	<i>Size 80 mm NB</i>	<i>2 No.</i>	
3	<i>Basket Strainer</i>		
	<i>Size 300 mm NB</i>	<i>2 No.</i>	
	<i>Size 250 mm NB</i>	<i>2 No.</i>	
	<i>Size 150 mm NB</i>	<i>2 No.</i>	
	<i>Size 100 mm NB</i>	<i>2 No.</i>	
4	<i>Y Type Strainer</i>		
	<i>Size 150 mm NB</i>	<i>2 No.</i>	
	<i>Size 100 mm NB</i>	<i>2 No.</i>	
	<i>Size 80 mm NB</i>	<i>2 No.</i>	
5	<i>HVW Spray Nozzles</i>	<i>5%</i>	
6	<i>MVW Spray Nozzles</i>	<i>5%</i>	
7	<i>Water motor gong bell</i>	<i>1 No.</i>	

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9.4 Inert gas Flooding system

S.No	Item Description	Quantity	Remarks
1	Clean agent nozzles	2 No.	
2	Automatic and manual release system	1 No.	
3	Cylinder valve with safety pressure relief device	1 No.	
4	Clean agent cylinders	5 No.	
5	Inhibitor	10% or minimum 1 if the quantity is less than 10	
6	Flexible hose	10% or minimum 1 if the quantity is less than 10	

9.5 Fire Water Booster Pumps

S.No	Item Description	Quantity	Remarks
1.	Impeller	1 no.	
2.	Impeller shaft and keys	1 no.	
3.	Bearings for pump	1 sets	
4.	Shaft sleeves	1 no.	
5.	Casing & Impeller wearing rings	1 set	
6.	Impeller Lock nut with lock washers	2 set	
7.	Pump and motor coupling	1 no.	
8.	Coupling pads/bushes	1 set	
9.	Impeller lock nuts	2 nos	
10.	Gasket	1 set	
11.	`O' ring	1 set	

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S.No	Item Description	Quantity	Remarks
12.	Impeller sealing ring	2 nos.	

9.6 Diesel Engine for Main Fire Water Pumps

S.No	Item Description	Quantity	Remarks
1.	Fuel filters- elements & seals	2 Sets	
2.	Lubricating Oil filter - do -	2 Sets	
3.	Belt (where used)	2 Sets	
4.	Engine joints, Gaskets & hoses	2 Sets	
5.	Inlet & exhaust valves	1 Set	
6.	Injection Nozzles	1 Set	
7.	Tool kit	1 Set	

9.7 Diesel Engine for Fire Water Booster Pumps

S.No	Item Description	Quantity	Remarks
1.	Fuel filters- elements & seals	2 Sets	
2.	Lubricating Oil filter - do -	2 Sets	
3.	Belt (where used)	2 Sets	
4.	Engine joints, Gaskets & hoses	2 Sets	
5.	Inlet & exhaust valves	1 Set	
6.	Injection Nozzles	1 Set	
7.	Tool kit	1 Set	

9.8 Fixed Foam System

S.No	Item Description	Quantity	Remarks
1.	Spray Nozzles each type	10 No.	
2.	Flexible glass seal for foam chamber assembly of capacity each type & size	2 No.	

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9.9 Valves

S.No	Item Description	Quantity	Remarks
1	All valves of each Type, Size and Make	10% or minimum 1 No. whichever is higher. Fraction to be rounded to next higher number	

10. Centrifugal Fan

S.No	Item Description	Quantity	Remarks
1.	All Gaskets & sealing rings in each type & rating	1 Set	
2.	All Bearings in each type & rating	1 Set	
3.	V- Belts (if V – Belt driven) in each type & rating	1 Set	

11. Under Slung Crane

S.No	Item Description	Quantity	Remarks
1.	All Bearings of each type and size used in all Gear Assemblies, lifting hook, trolley wheels etc	2 Sets	
2.	Brake shoes with lining for each size of brake	2 Sets	
3.	Brake springs for each size of the brake	2 Sets	

12. Spares for Workshop EOT Crane

S.No	Item Description	Quantity	Remarks
1.	Bearings of each type and size used in gear assemblies, lifting hooks, trolley wheels, CT wheels etc.	1 set	
2.	Brake drum of Each type.	1 set	
3.	Oil seal used in all gear boxes.	1 set	

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S.No	Item Description	Quantity	Remarks
4.	<i>All Brake lining</i>	<i>1 set</i>	
5.	<i>Input pinion for Hoist Gearbox</i>	<i>1 set</i>	
6.	<i>Input pinion for CT Gear box</i>	<i>1 set</i>	
7.	<i>Input pinion for LT Gear box</i>	<i>1 set</i>	

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B. ELECTRICAL

1. Raw Water Intake System and Circulating Water System

S No	Description	Quantity	Remarks
1.	SPARES FOR RAW WATER INTAKE PUMPS		
1.1	Motor bearings	1 Set	
1.2	Motor for lake water pump	1 No.	
1.3	Space heaters	1 Set	
2.	SPARES FOR VALVES AND SPECIALITIES		
2.1	Motor for motor operated valves of each rating	1 No.	
2.2	Limit switches & Torque switches of each rating and type	2 Sets	
3.	CW Pump Motors		
3.1	Motor bearings (set consists of all the bearings used in one motor)	1 No.	
3.2	Winding RTD	1 No.	
3.3	Bearing thermocouple	1 No.	
	Motors & Actuators		
4.	LT MOTORS(OTHER THAN EOT CRANE & HOISTS)		
4.1	Motor of each type and rating	1 No.	
4.2	Bearing (set consists of all the bearings used in one motor)	1 Set	
4.3	Electrical Valve Actuator of each type & rating	1 Set	
4.4	Torque/ Limit switches of each type & rating	1 Set	

2. Pre Treatment, DM Water and Effluent Treatment Plant

a) Spares for Pre Treatment Plant

S No	DESCRIPTION	Quantity	Remarks
1.	Clarifier Equipment	2 Sets	

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1.1	Flash mixer Agitator motor bearings		
1.2	Motor of each type and rating	1 No.	
2.	Chemical dosing pumps (For each type of chemical)		
2.1	Motor Bearing	1 Set	
2.2	Agitator motor bearings	2 No.	
2.3	Motor of each type and rating	1 Set	
3.	Thickener Feed pumps		
3.1	Motor bearings	1 Set	
3.2	Motor of each type and rating	1 No.	
4.	Centrifuge feed pumps		
4.1	Motor bearings	1 Set	
4.2	Motor of each type and rating	1 No.	

b) Spares for DM Plant

S No	DESCRIPTION	Quantity	Remarks
1.	Degasser Air Blower	1 Set	
1.1	Bearings for motor and air blower of each type and size		
1.2	Motors of each type and rating	1 No.	
2.	Mixed Bed Air Blower		
2.1	Bearings for motor and air blower of each type and size	1 Set	
2.2	Motors of each type and rating	1 No.	
3.	Motorized agitators		
3.1	Motor of each type and rating	1 No.	
4.	Neutralizing pump		
4.1	Motor bearings of each type and size	1 Set	

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S No	DESCRIPTION	Quantity	Remarks
4.2	Motor of each type and rating	1 No.	
5.	Horizontal Centrifugal Pumps		
	(These shall be supplied separately for DM plant supply pumps, service water pumps, DM transfer pumps, Degasser water pumps, Plant potable water pumps, acid and alkali unloading pump, softening plant supply pumps, brine recirculation pumps, electro chlorination booster pump and other centrifugal pumps provided)		
5.1	Motor bearings of each type and size	1 Set	
5.2	Motor of each type and rating	1 No.	

c) Spares for Effluent Treatment Plant

S No	DESCRIPTION	Quantity	Remarks
1.	Flash Mixer		
1.1	Flash mixer Agitator motor bearings	2 Sets	
1.2	Motor of each type and rating	1 No.	
2.	Chemical dosing pumps (For each type of chemical)	1 Set	
2.1	Motor Bearing		
2.2	Agitator motor bearings	2 No.	
2.3	Motor of each type and rating	1 No.	
3.	Effluent disposal pumps		
3.1	Motor bearing	1 Set	
3.2	Motor of each type and rating	1 No.	
4.	Treated Water Pump for Oil Water Separator		
4.1	Motor bearing	1 Set	
4.2	Motor of each type and rating	1 No.	

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d) Spares for Softening Plant

S No	Description	Quantity	Remarks
5.	<i>Horizontal Centrifugal Pumps (For each type of pump)</i>		
5.1	<i>Motor bearings of each type and rating</i>	<i>1 Set</i>	
5.2	<i>Motor of each type and rating</i>	<i>1 No.</i>	
6.	<i>Brine Transfer pumps and salt regeneration pump</i>		
6.1	<i>Motor bearings of each type and rating</i>	<i>1 Set</i>	
6.2	<i>Motor of each type and rating</i>	<i>1 No.</i>	

e) Spares for CW Chemical Treatment System and Electro Chlorination System

S No	Description	Quantity	Remarks
1.	<i>Chemical dosing pumps (For each kind of chemical dosed)</i>		
1.1	<i>Motor Bearings of each type</i>	<i>1 Set</i>	
1.2	<i>Agitator motor bearings</i>	<i>2 No.</i>	
1.3	<i>Motor of each type and rating</i>	<i>1 No.</i>	
2.	<i>Spares for Rectifier Transformer</i>		
2.1	<i>Rectifier Unit</i>	<i>1 No.</i>	
2.2	<i>Dry type Rectifier Transformer</i>	<i>1 No.</i>	
2.3	<i>DC bus bar support insulator</i>	<i>10 No.</i>	
3.	<i>Control Panel</i>		
3.1	<i>Indication lamps (LED)</i>	<i>10 No.</i>	
3.2	<i>Control fuses of each type and rating</i>	<i>6 No.</i>	
3.3	<i>Switches of each type and rating</i>	<i>1 No.</i>	
3.4	<i>Selector switch of each type and rating</i>	<i>1 No.</i>	
3.5	<i>Push button</i>	<i>2 No.</i>	
3.6	<i>Auxiliary relay of each type and rating</i>	<i>1 No.</i>	

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3.7	Timer of each range	1 No.	
3.8	Annunciation window lamps	10 No.	
3.9	Meters of each type and rating	1 No.	
3.10	Annunciation cards	5 No.	

3. Fire Protection System

a) FDA System

S.No	FDA System	Quantity	Remarks
1	Fire detectors of each type/ rating.	5 No.	
2	Electronic Card for AP&MFAP of each type	5 No.	
3	Module Unit for LHS system of each type	5 No.	
4	IR Detector of each type	5 No.	
5	Hooters of each type	5 No.	
6	Manual call points of each type	5 No.	
7	Monitoring units	5 No.	

b) Fire Water Pumps

S.No	Item Description	Quantity	Remarks
1	Motor bearings of each type and rating		1 No.

4. Electric Hoist, Crane, HVAC System

S.No	Item Description	Quantity	Remarks
a.	ELECTRIC HOIST (To be repeated for each Hoist)		
	(For the following items each type & rating to be repeated)		
1	Solenoid for electromagnet brake	1 No.	
2	Coil for electromagnet brake	2 No.	
3	Overload relay	1 No.	
4	Power Contactors	2 No.	

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S.No	Item Description	Quantity	Remarks
5	Control Contactor	2 No.	
6	Coils for Contactors	2 No.	
7	Main contacts for contactors	2 No.	
8	Auxiliaries contacts for contactors	2 No.	
9	Motor	1 No.	
10	Bearing for motors	2 Set	
11	Limit Switch	2 No.	
12	VVVF module	1 No.	
b.	UNDER SLUNG CRANE (To be repeated for each crane)		
	(For the following items each type & rating to be repeated)		
1	Power contactors	1 No.	
2	Control Contactors	1 No.	
3	Coils for Power contactors	1 Set	
4	Coils for Control Contactors	1 Set	
5	Overload relay	1 No.	
6	Timer	1 No.	
7	Limit switches	1 Set	
8	MCCB / SFU	1 No.	
9	LED	3 No.	
10	Push button with contact element	1 No.	
11	D.C. rectifier	1 No.	
12	Brake	1 No.	

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S.No	Item Description	Quantity	Remarks
c.	EOT CRANE (To be repeated for each Crane)		
	(For the following items each type & rating to be repeated)		
1	Motor	1 No.	
2	Bearings for motor	1 Set	
3	Power Contactors	1 No.	
4	Control Contactors	1 No.	
5	Overload relay	1 No.	
6	Push buttons with contact element	1 Set	
7	Control Transformer	1 No.	
8	MCB	1 No.	
9	Coil for electromagnetic brakes	1 Set	
10	Main current collector assembly for runway conductors	1 No.	
11	Insulator for runway conductor support	3 No.	
12	Electronic card	2 No.	
13	VVVF Module	1 No.	
14	Tacho generator	1 No.	
15	Auxiliary contact assembly for Master Controller	1 No.	
16	MCCB/SFU	1 Set	
17	Diode bridge	1 No.	
18	Limit switch	1 Set	
d.	GANTRY CRANE		
	(For the following items each type & rating to be repeated)		
1	Solenoid for electromagnet brake	1 Set	

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S.No	Item Description	Quantity	Remarks
2	Coil for electromagnet brake	1 Set	
3	Overload relay	1 Set	
4	Power Contactors	1 Set	
5	Coil for contactors	1 Set	
6	Main contacts for contactors	1 Set	
7	Auxiliary contacts for each type and rating of contactors	1 Set	
8	Motor	1 No.	
9	Bearings for motor of each rating (set consists of all bearings used in one motor)	1 Set	
10	Limit Switch of each type	1 Set	
e.	AC & VENTILATION (To be repeated for each service area)		
1	CENTRIFUGAL FANS		
	(For the following items each type & rating to be repeated)		
1.1	Motor	1 No.	
1.2	Motor Bearing	1 Set	
2	AXIAL FANS		
	(For the following items each type & rating to be repeated)		
2.1	Motors	1 No.	
2.2	Motor Bearings	1 Set	
3	BIFURCATED AXIAL FANS		
	(For the following items each type & rating to be repeated)		
3.1	Motors	1 No.	
3.2	Motor Bearings	1 Set	

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S.No	Item Description	Quantity	Remarks
4	AC & VENTILATION CONTROL PANEL		
	(For the following items each type & rating to be repeated)		
4.1	Switches	5 No.	
4.2	Relays	2 No.	
4.3	Temperature controller	2 No.	
4.4	Temperature sensor	2 No.	
4.5	Solenoid valves	2 No.	
4.6	Push buttons	20 No.	
4.7	Indicating lamps	10 No.	
4.8	Meters	1 No.	
5	WINDOW/SPLIT AIR CONDITIONERS		
	(For the following items each type & rating to be repeated)		
5.1	Motor	1 No.	
5.2	Motor bearings	1 Set	
5.3	Relays/ contactors	1 No.	
5.4	Micro processor panel	1 No.	

5. Other Electrical items spares

S.No	Item Description	Quantity	Remarks
a.	LV TRANSFORMER (oil/dry type)		
	LV TRANSFORMERS -6.6/0.433KV (To be repeated for each service area)		
	(For the following items each type & rating to be repeated)		
1.	HV Bushing	1 Set	

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S.No	Item Description	Quantity	Remarks
2.	LV Bushing	1 Set	
3.	Neutral Bushing	1 Set	
4.	Winding temperature indicator(WTI) with all accessories	2 Nos.	
5.	Dial type Oil temperature indicator(OTI) (for oil type)	2 Nos.	
6.	Tap Changer Contact	1 Set	
7.	Buchholz relay	2 Nos.	
8.	Pressure relief device	2 Nos.	
9.	Set of gaskets (other than that with bushing)	1 No.	
10.	RTD	3 No	
11.	Complete Winding Temperature scanner	1 No	
12.	Current Transformer	2 No.	
13.	Support Insulator	5 Set	
b.	415 V LV SWITCHGEAR/PMCC/MCC		
	(For the following items each type & rating to be repeated)		
1.	Breaker complete with operating mechanism	1 No.	
2.	Closing coil	2 No.	
3.	Tripping coil	2 No.	
4.	Operating mechanism rod	3 No.	
5.	Fixed and moving contact assembly	2 Set.	
6.	Spring charging motor	2 No.	
7.	Breaker Protection Module	1 No	
8.	Gasket	5 Set	
9.	Aux. switch assembly	3 Set	
10.	Limit Position Switch	3 No	
11.	Busbar support insulators of different sizes	3 Set	
12.	Switches	3 No.	
13.	Selector switches of each type and rating	2 No.	

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S.No	Item Description	Quantity	Remarks
14.	Numerical Relay	3 No.	
15.	Auxiliary relay	2 No.	
16.	Interposing relay of each type for DDCMIS	2 No.	
17.	Clustered type LED	5 No.	
18.	Current Transformer	6 No.	
19.	Voltage Transformer	6 No.	
20.	Meters	2 No.	
21.	Power Fuse	5 No.	
22.	Control Fuse	5 No.	
23.	Timer	2 No.	
24.	Check synchronizing relay	1 No.	
25.	Disconnecting type Terminal block for CT wiring	5 No.	
26.	Non-disconnecting type Terminal Block	5 No.	
27.	Electronic overload relays	2 No.	
28.	Single phase control transformer 415V/110V	5 No.	
29.	Intelligent Controller Module	5 No.	
30.	Contactors of each type and rating	1 No	
31.	MPCB	1 No	
32.	MCB	1 No	
33.	MCCB/SFU of each type and rating	1 No	
34.	Push button with contact assembly	3 No.	
c.	6.6 KV SWITCHGEAR (TO BE REPEATED FOR EACH MAKE OF 6.6 kV SWITCHGEAR)		
	SPARES FOR VACUUM CIRCUIT BREAKER		
	(Spares for each rating of Breaker)		
1.	Closing & tripping coils each	10 Nos.	
2.	Spring charging motors	5 Nos.	
3.	Aux. switch assembly, limit position switches	5 Nos. each	
4.	Operating mechanism rods	5 Nos.	

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S.No	Item Description	Quantity	Remarks
5.	Surge suppressor units	5 Nos.	
6.	Vacuum bottles	5 Nos.	
7.	Multi pin plug and socket for control	5 Sets	
8.	Selector Switches of each type and rating	2 Nos.	
9.	Busbar support insulators of each type	20 Nos.	
10.	Switches of each type	5 Nos.	
11.	Moving and Fixed contact Assembly of each rating and type	1 set	
12.	Numerical Relays of each type	1 No.	
13.	Auxiliary relays of each type	1 No.	
14.	Interposing relay for DCS each type	1 No.	
15.	Clustered type LED of each type/color	2 Nos.	
16.	CTs of each ratio , type and rating	3 Nos.	
17.	VTs of each ratio , type and rating	3 Nos.	
18.	Timer each type	1 No.	
19.	Check synchronizing relay	1 No.	
20.	Meters of each type	1 No.	
21.	Contactors of each rating and type.	1 Nos.	
22.	Disconnecting type Terminal block for CT wiring	5 Nos.	
23.	Non-disconnecting type Terminal Block	5 Nos.	
24.	Shrouds each type	5 Nos.	
25.	MCB of each type and rating	5 Nos.	
26.	Shutter mechanism complete of each type	5 Nos.	
27.	Indicating lamps of each type and rating	5 Nos.	
28.	Complete assembled Auxiliary Contactor of each rating	5 Nos.	
29.	Bi-metal thermal overload relays with single phase preventers of each rating	5 Nos.	
30.	Single phase control transformer 415V/110V of each rating	5 Nos.	
31.	Fuses of each type and rating:		

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S.No	Item Description	Quantity	Remarks
	<i>I. Power</i>	<i>10 Nos.</i>	
	<i>II. Control</i>	<i>10 Nos.</i>	
32.	<i>Fuse puller for each type of fuse</i>	<i>5 Nos.</i>	
33.	<i>MCCB of each rating & type</i>	<i>2 Nos.</i>	
d.	ACDB/PDB PANEL (To be repeated for each board)		
	(For the following items each type & rating to be repeated)		
1.	<i>Power Fuse</i>	<i>2 No.</i>	
2.	<i>Control Fuse</i>	<i>5 No.</i>	
3.	<i>Push button with contact element</i>	<i>2 No.</i>	
4.	<i>Ammeter</i>	<i>2 No.</i>	
5.	<i>Voltmeter</i>	<i>2 No.</i>	
6.	<i>Terminal Blocks</i>	<i>2 No.</i>	
7.	<i>MCB</i>	<i>2 No.</i>	
8.	<i>SFU/MCCB</i>	<i>2 No.</i>	
e.	220 V DC System		
	BATTERY CHARGER & DCDB (To be repeated for each service area)		
	(For the following items each type & rating to be repeated)		
1.	<i>Thyristor / SCR</i>	<i>6 No.</i>	
2.	<i>Diode</i>	<i>6 No.</i>	
3.	<i>Contactor</i>	<i>2 No.</i>	
4.	<i>Relay</i>	<i>1 No.</i>	
5.	<i>Selector switch</i>	<i>2 No.</i>	
6.	<i>Control switch</i>	<i>2 No.</i>	
7.	<i>Meter</i>	<i>2 No.</i>	
8.	<i>PCB</i>	<i>2 Set.</i>	

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S.No	Item Description	Quantity	Remarks
9.	Push Button with contact element	2 No.	
10.	Control Transformer	2 No.	
11.	LED indication lamp	5 No.	
12.	Switch Fuse Unit / MCCB	2 No.	
13.	Power Fuse	3 No.	
14.	Control Fuse	3 No.	
15.	Semi conducting Fuse	6 No.	
16.	MCB	2 No.	
f.	415 V NON-SEGREGATED PHASE BUS DUCTS (LT) (To be repeated for each Bus duct Unit)		
	(For the following items each type & rating to be repeated)		
1.	Busbar support insulators of different sizes	2 Set	
2.	Set of seal-off bushings of each type and rating	3 Nos.	
3.	Drain plug with cap	3 Nos.	
4.	Gaskets of each type and ratings	3 sets	
5.	Belleville washers	5 Nos.	
6.	Densal or equivalent	1 kg.	
7.	Space heater set	1 set	
8.	Flexible Connectors (for equipment connection) (Complete set for all types and ratings)	2 Set	
9.	Expansion joints (for conductor for all the phases)	2 Set	
10.	Silica gel breather	2 No	
g.	MOTORS AND MOTORIZED ACTUATORS (TO BE REPEATED FOR EACH SERVICE AREA)		
	(For the following items each type & rating to be repeated)		
1.	Motor bearings	1 Set	
2.	Torque/Limit switch	5 Set	
3.	End Limit switch	5 Set	

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S.No	Item Description	Quantity	Remarks
4.	Position transmitter for inching type	2 No	
h.	ILLUMINATION SYSTEM		
	MLDB/LDB Panel (To be repeated for each board)		
	(For the following items each type & rating to be repeated)		
1.	Temperature surveillance unit for Lighting Transformer	1 No.	
2.	RTD element for Lighting Transformer	1 Set	
3.	Busbar support insulators of different sizes	2 Set	
4.	Power Fuse	2 No.	
5.	Control Fuse	2 No.	
6.	Push Buttons with contact element	5 No.	
7.	Ammeter	1 No.	
8.	Voltmeter	1 No	
9.	Power Terminal Block	2 No	
10.	MCB	2 No.	
11.	MCCB/SFU	2 No.	
	ALDB/LDB PANEL		
	(For the following items each type & rating to be repeated)		
1.	Busbar support insulators of different sizes	2 Set	
2.	Power Fuse	20 No.	
3.	Control Fuse	20 No.	
4.	Push button with contact element	5 No.	
5.	Ammeter	2 No.	
6.	Voltmeter	2 No	
7.	Electronic energy meter	2 No.	
8.	Terminal Blocks	5 No	
9.	MCB	5 No.	
10.	SFU/MCCB	5 No.	

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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C. CONTROL & INSTRUMENTATION

S.No	Item	Quantity/Unit	Remarks
1	Programmable Logic controller (PLC) for Raw Water Treatment & DM Water Plant, Compressed Air System, Fuel Oil System (Common for MBOP package)		
a	Power Supply Unit/Module for PLC and I/O	10% of each type & Model, minimum 1 no whichever is higher	
b	Input/ Output modules	10% of each type & Model, minimum 1 no whichever is higher	
c	Central Processor Unit Module	1 no. of each type & Model	
d	Communication Module	1 no. of each type & Model	
e	Interface Module	1 no. of each type & Model	
f	PLC Backplane I/O Bus without modules	1 no. of each type & Model	
g	Network adapters/converter, LIU,OLM, Network/ Ethernet Switch and other network hardware used	1 no. of each type & Model	
h	Display Units (LCD/LED/TFT)	1 no. of each type & Model	
i	Installation Software (for OWS, EWS, Controllers, Firewall Security and any supporting softwares)	1 no. copy of CD/DVD of each requirement	
j	Interconnecting Cables with connectors (within panels)	1 no. of each type	
k	Batteries for RAM battery back-up	1 set for each type and model no. of CPU	
l	Printer Paper	5000 sheets of each type	
m	Printer Cartridge / Toner/ Ribbon	5 Nos. of each type	
2	Programmable Logic controller (PLC) for Fire water pump house (Common for BOP package)		
a	Power Supply Unit/Module for PLC and I/O	5% of each type & Model, minimum 1 no whichever is higher	
b	Input/ Output modules	5% of each type & Model, minimum 1 no whichever is higher	
c	Central Processor Unit	1 no. of each type & Model	
d	Communication module	1 no. of each type & Model	
e	Interface Module	1 no. of each type & Model	
f	PLC Backplane I/O Bus without modules	1 no. of each type & Model	
g	Network adapters/converter, LIU,OLM, Network/ Ethernet Switch and other network hardware used	1 no. of each type & Model	
h	Interconnecting Cables with connectors (within panels)	1 no. of each type	

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Item	Quantity/Unit	Remarks
i	Batteries for RAM battery back-up	1 set for each type and model no. of CPU	
3	Programmable Logic controller (PLC) Miscellaneous System: Hydrogen Genration Plant, Condensate Polishing Unit, Condenser Tube Cleaning System, ESP Control System, Mill Reject handling System.		
a	Power Supply Unit/Module for PLC and I/O	10% of each type & Model, minimum 1 no whichever is higher	
b	Input/ Output modules	10% of each type & Model, minimum 1 no whichever is higher	
c	Central Processor Unit Module	1 no. of each type & Model	
d	Communication module	1 no. of each type & Model	
e	Interface Module	1 no. of each type & Model	
f	PLC Backplane I/O Bus without modules	1 no. of each type & Model	
g	Network adapters/converter, LIU,OLM, Network/ Ethernet Switch and other network hardware used	1 no. of each type & Model	
h	Interconnecting Cables with connectors (within panels)	1 no. of each type	
i	Batteries for RAM battery back-up	1 set for each type and model no. of CPU	
4	UPS (Common for MBOP Package)		
a	Silicon Controlled Thyristors, Diodes & Power Transistors	100%	
b	Capacitors	1 set	
c	CT's, CVT's, VT's, Chokes, AC/DC isolators, Contactors, Timers, Relays	10% of each type and rating	
d	Fuses of Each Type & Ratings	100%	
e	Fuse Free Circuit Breakers	5%	
f	Electronic Modules	10%	
g	Lamp Holders With Series Resistors	10%	
h	Cooling Fans	1 nos of each type	
i	Digital/Analog panel meters/indicators	1 nos of each type	
j	Relays of all types including overload relays	10%	
5	Field Instruments for for Water Treatment Plant, Compressed Air System, Fuel Oil Handling System (Common for MBOP package)		
a	Pressure Transmitter	10% of each type & Range	
b	Diff. Pressure Transmitter (for DP, Flow, Level)	1 no. in each type and range	
c	Temperature transmitter	10% of each type & Range	

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S.No	Item	Quantity/Unit	Remarks
d	RTD (single/Duplex type), Thermocouple	10% of each type & Range	
e	Temp. Switches	10% of each type & Range	
f	Pressure Gauge, DP Gauge	10% of each type & Range	
g	Temperature Gauge	10% of each type & Range	
h	Level Gauge	10% of each type & Range	
i	Pressure Switch	10% of each type & Range	
j	Differential Pressure Switch	10% of each type & Range	
k	Level Switch (Capacitance/RF Type/Float/Displacer etc)	10% of each type & Range	
l	Level transmitter (Ultrasonic, Radar type)	1 no. in each type and range	
m	Flow switches, Flow Transmitter (Electromagnetic, Ultrasonic type)	10% of each type & Range	
n	Flow Meter / Flow Indicator / Flow Transmitter / Rotameter	1 no. in each type and range	
o	Flow Elements: orifice/Anubar/Venturi/Nozzle	1 No. of each type & Range	
p	Control Valves	1 No. of each type & Range	
q	Pneumatic power Cylinder	1 No. of each type & Range	
r	Solenoid Valve with coil	1 No. of each type & Range	
s	Dew point Meter	2 No. of each type & Range	
t	Vibration sensors	2 nos. in each type and range	
u	Accessories for Transmitters & Gauges(valve manifold, snubber, isolation valve, drain valve etc.,)	2 nos. in each type and range	
v	Pneumatic Valve Actuator spare kit(including diaphragm, piston, gaskets, O-rings etc.,)	2 sets for each type and size of actuator	
w	Position Limit Switch	10% of each type & Range	
x	Solenoid Valve with coil	10% of each type & Range	
y	Pneumatic Valve Actuator spare kit (including diaphragm, piston, gaskets, O-rings etc.,)	2 sets for each type and size of actuator	
z	Smart Valve Positioner	10% of each type & model	
aa	Air Filter Regulator	10% of each type & range	
ab	All Analysers, Hydrogen leak detector, Dew point Analyser	1 No. sensor / detector of each type, 1 No. spare kit for each analyser	
8	Process connection Piping (Common for complete BOP package including all auxiliary plants)		

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S.No	Item	Quantity/Unit	Remarks
a	2 way, 3 way valves for instruments	10% of each type, size, rating, class, material & model	
b	Fittings	10 Nos. of each type, rating, material & size	
c	Valve manifolds (2way, 3 way & 5way)	10 % of each type, rating & model	
d	Air Filter Regulator	10 % of each type, model & range	
e	Impulse piping & tubing	5 nos. of standard Length of each size, rating & material	
9	Instrumentation cables & Accessories (Common for complete MBOP package including all auxiliary plants)		
a	All Instrumentation Field Cables from Instrument to JB and JB to DCS/PLC (including compensating cable)	5% of total installed Length (In running meter) if total installed length < 1000 metres or 1 no. of 1000 metre. Drum if total installed length > 1000 metres, of each type, pair & size	
b	Fiber optic cable	1000 metres of each type and size	
c.	Communication cable from PLC to RIO	1000 meters in each type and size	
d	Communication cable from PLC to OWS/EWS	500 meters in each type and size	
10	Cabinets, Panels & Junction Box (Common for complete MBOP package including all auxiliary plants)		
a	Terminal Blocks	5% of each type & rating (for types of total quantity > 100 nos.)	
b	MCB	10% of each type & rating	
c	Fuse	50% of each type & rating	
d	Junction box	1 no. of each size & material	
e	LED Indicator	10% of each type, Colour & voltage rating	
f	Panel/Cabinet cooling fan	5% of each type & model	
g	Panel/Cabinet door switch	5% of each type & model	
h	Panel/Cabinet CFL	5% of each type & model	
11	Analyzers for Water Treatment Plant (Common for MBOP package)		
a	Conductivity Analyzer	1 probe unit complete with cell, sensor, temperature sensor, 1 transmitter	
b	pH Analyzer	1 probe unit complete with cell, sensor, temperature sensor, 1 transmitter	
c	Standard solution, Reagents	1 Standard size Bottle of each type, concentration	
d	Silica Analyzer	1 probe unit complete with cell, sensor, temperature sensor, 1 transmitter	
e	Turbidity Analyzer	1 probe unit complete with cell, sensor, temperature sensor, 1 transmitter	

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LII-GETS12021-G-00129-003	02	Tender Document for Selection of R&M Contractors–Balance of Plant Volume-II, Section-I, Annexure-II	[41]	25.09.2015

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Item	Quantity/Unit	Remarks
f	Sodium Analyzer	1 probe unit complete with cell, sensor, temperature sensor, 1 transmitter	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-I, ANNEXURE-III
LIST OF SUB-VENDOR**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-III

List of Sub-vendor

{List of approved vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the given format.}

A. MECHANICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

B. ELECTRICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors–Balance of Plant Volume-II, Section-I, Annexure-III	[2]	25.09.2014

C. CONTROL & INSTRUMENTATION

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

D. CIVIL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors–Balance of Plant Volume-II, Section-I, Annexure-III	[3]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-A
DETAILED TECHNICAL SPECIFICATION-
MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-II, Part-A	[i]	15.01.2016

VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-II, Part-A	[ii]	15.01.2016

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SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
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4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
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10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-II, Part-A	[iii]	15.01.2016

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
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1 RAW WATER INTAKE SYSTEM

1.1 General

[The consumptive water for the plant is sourced from [...] river/sea located at a distance of [...] km from the plant boundary. The raw water is pumped from the intake water pump house to the in-plant raw water reservoir, which has a storage capacity of [...] days.]

1.2 Brief System Description

- i) The Raw Water intake system is required for pumping [river/sea] water to [the in-plant raw water reservoir] as a make up to the thermal power plant. The [river/sea] water analysis is indicated in the Section-I of this volume.
- ii) [River/Sea] water after passing through de-silting chamber is received into the intake chamber through bar screen (to remove any floating debris) is further inducted into the intake sump of the pump house through Coarse Screen/ Travelling Water Screen. Provision of guide channels for Stop Log Gate and coarse screen shall be provided in each pump chamber. Stop log gates shall be provided to isolate the pump pit during maintenance of RW intake pumps. A Sluice gate shall be provided at the lake water entry to Intake chamber. Provision of de-silting arrangement shall be provided.
- iii) From the intake pumps the water shall be pumped through [buried HDPE] pipe line to the raw water reservoir located inside the plant from where water shall be pumped by Raw Water Supply Pump to clarifier provided in the raw water treatment plant.
- iv) The water after processing in the water treatment system is stored in the [Clarified water storage tank / Storage tank of softening plant]. From the [clarified water storage tank/soft water storage tank], the water is taken for the CW makeup, DM Plant and for various other services of the plant.

1.3 Codes & Standards

S.No	Code	Description
1	HIS	Hydraulic Institute Standards, USA
2	IS 1710	Vertical wet pit turbine pumps for clear and fresh water
3	IS 5120	Technical Requirement of Roto dynamic Special Purpose Pumps
4	ISO 2548	Acceptance tests for centrifugal, mixed flow and axial pumps.
5	JIS B 8301	Testing methods for centrifugal pumps, mixed flow pumps and axial flow pumps
6	JIS B 8302	Measurement methods of pump capacity
7	JIS B 8327	Pump performance testing method using model
8	BS-3435	Measurement of electrical power and energy in acceptance testing.

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1.4 Design and Construction Requirements

a) Design Criteria of Raw Water Intake and Raw Water Supply Pumps

- i. The pumps shall be vertical, constant speed and wet pit and non pull out type suitable for continuous heavy duty.
- ii. Type of Pump/construction and type of discharge arrangement and impeller shall be as specified in Design data sheets furnished at the end of this section.
- iii. The pumps shall be designed to meet the duty conditions specified in Design data sheets furnished at the end of this section. The pumps shall be suitable for handling [river] water whose analysis is given in the Section-I of Volume-II.
- iv. The pump shall be directly driven by a constant speed squirrel cage induction motor.
- v. The pump shall have a flanged discharge connection.
- vi. Suitable arrangement shall be provided to take care of the discharge hydraulic thrust. This may be achieved either by sizing pump discharge head and base plate adequately to take care of the discharge hydraulic thrust or by providing a thrust block assembly to restrain the discharge hydraulic thrust.
- vii. The design, construction and speed of the pumps shall be such as to minimize cavitation and ensure a long and trouble free service.
- viii. Pump speed shall not exceed that indicated in the enclosed Pump data sheet furnished at the end of this section. "Net Positive Suction Head (NPSH) required" shall be at least 1 m less than "NPSH available" during all operating conditions including run out condition.
- ix. The pumps shall have stable head capacity characteristic continuously rising towards shut off conditions.
- x. The design shall ensure equal load sharing among the pumps operating in parallel. All these pumps shall be identical to one another, shall have identical characteristic curves and shall be capable of running in parallel continuously without any restrictions.
- xi. The pump shall operate satisfactorily in isolation and in parallel with the other working pump without cavitation, any deleterious effects, undue vibrations and noise at all water levels, from minimum to maximum. The impeller shall be of non-over-loading type to restrict motor overloading during single pump operation.
- xii. The pump shall also be designed to withstand the seismic loads as given in Project Information.
- xiii. The shaft shall be designed such that the complete pump and motor assembly satisfies the following:
- xiv. The operating speed shall not be too close to the first critical speed, i.e. N should be less than 0.8 NC1 or N should be more than 1.3 NC1 where N is the Operating Speed and NC1 First Critical speed.
- xv. Also, critical speed of pump-motor assembly shall be more than the maximum reverse run away speed.

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- xvi. The length of shaft and column sections shall not exceed 3.0 m.
- xvii. The impeller shall be fastened to the shaft such that the connections withstand maximum torque and thrust that may occur under all operating conditions including maximum reverse rotation. The line shaft bearings shall be spaced so as to ensure smooth operation and to contain the vibration within permissible limits. The bearings shall be amply proportioned to give long and satisfactory life.
- xviii. Self water lubrication shall be used for the line shaft bearings only if the water to be pumped is clear water. In case forced water lubrication is provided, spare capacity of lubricating water pumps shall be provided.
- xix. The maximum efficiency of the pump and motor at design point shall be limited to the value indicated in design data sheet. No credit will be given during evaluation for pump and motor efficiency beyond specified efficiency.
- xx. Design life (minimum) of equipment supplied by contractor shall be [20/25] years.

1.5 Construction Features

- a) Material and construction of the pump shall be such as to resist corrosion and erosion and give a long and satisfactory life. The materials used in construction of the various components shall not be inferior to those given below.

S. No	Description	Technical Requirement
1)	Impeller	Austenitic stainless steel ASTM A743/CF8M Grade
2)	Suction bell	Cast Iron IS: 210 Grade FG 260; S-0.1% max. P-0.15% max.
3)	Casing	Stainless steel
4)	Wearing rings or Equivalent part [(Indicate the name of the Part)]	Stainless steel of suitable grade as per manufacturer's proven practice
5)	Pump shaft	Hardened stainless steel conforming to ASTM A 276 Gr. 410.
6)	Line shaft	Hardened stainless steel conforming to ASTM A 276 Gr. 410
7)	Shaft coupling	Stainless steel type 410, ASTM 276, Heat treated and hardened.
8)	Shaft sleeve	Stainless steel type 410, ASTM 276, Heat treated and hardened.
9)	Line shaft bearing	Cutless rubber with bronze retainer /Thordon type bearing
10)	Column pipe	Fabricated steel as per IS: 2062 with 2

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S. No	Description	Technical Requirement
		coats of epoxy coating.
11)	Shaft enclosing tube	Fabricated steel as per IS: 2062.
12)	Discharge elbow	Fabricated steel as per IS: 2062
13)	Matching flanges	Fabricated steel as per IS: 2062
14)	Thrust pads	Mitchel / Kingsberry or equivalent
15)	Bolts, nuts and lock washers	Stainless steel AISI type 304 for those coming in contact with water and for others, material shall be high-tension carbon steel.
16)	Base plate and Soleplate	Fabricated steel as per IS: 2062
17)	Gaskets	Wire reinforced rubber gasket / Neoprene rubber / Compressed asbestos fibre (CAF).
18)	Gland packing	Impregnated Teflon
19)	Ladder, platform and related accessories.	Fabricated steel as per IS : 2062

- b) A ladder and platform arrangement shall be provided for each pump and motor for inspection and maintenance of the thrust bearing and for approach to any other part of the pump / motor requiring frequent inspection.
- c) The line shaft bearing shall be spaced so as to ensure smooth operation. The bearing shall be amply proportioned to give long and satisfactory life.
- d) Bearing lubrication:
The type of lubrication shall be as given bellow. All interconnected piping, valves, instruments and fittings for bearing lubrication shall be in contractor's scope of supply/work.
- i) Pump design shall be such that line shaft bearings are below minimum water level. However, in case, pump design does not permit the same, the Bidder shall use "Thordon type bearing" which are above minimum water level.
- ii) Water required for cooling of pump-motor guide and thrust bearing shall be taken from main pump discharge through a filter. Necessary piping valves, instrumentation etc. shall be included in Bidder's scope of supply/work
- e) Thrust Bearing:
- i) Pump design with single thrust bearing at motor top or separate thrust bearings at pump and motor (as per bidder's standard practice) is acceptable.
- ii) The thrust bearing shall be rated for continuous operation. Thrust bearing shall be of oil-lubricated, centrally pivoted tilting pad type (Mitchell or Kingsbury) capable of absorbing axial thrust in both directions of rotation. For removing heat from pump thrust bearing oil bath, cooling coil made out of cupro nickel alloys or

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stainless steel shall be provided. Water required for cooling of thrust bearing shall be taken from main pump discharge. Necessary filters, piping, valves, accessories, specialties as required for such cooling purpose is in the scope of supply of the bidder. The hot water outlet from the cooling coil shall be led to the sump. However the pump shall be suitable for starting without cooling water for thrust bearing.

- f) Impeller and Rotating Assembly
 - i) Each pump set rotating assembly shall be dynamically balanced. Each half coupling shall be statically balanced on its shaft
 - ii) The design, construction and speed of the pumps shall be such as to minimize cavitation and ensure a long and trouble free service.
 - iii) The impeller shall be fastened to the shaft such that the connections withstand maximum torque and thrust that may occur under all operating conditions.
- g) Pump Shaft
 - i) The shaft shall be designed to transmit the maximum rated power at the pump operating speed and shall be of ample stiffness to minimize deflection of the shaft during closed valve starting conditions.
 - ii) The shaft shall preferably have all components key driven including impeller, thrust and journal collar and coupling.
 - iii) The line shaft coupling shall be of muff type or approved equivalent.
- h) Column pipe :

The pump column pipe shall be provided with flanged joints to permit easy disassembly. Column pipes shall be provided with seating/lifting lugs.
- i) Shaft Sleeves:

Shaft sleeves shall be provided to protect the shaft from wear. Suitable locking arrangement shall be provided for all bolted connections.
- j) Stuffing Box:

The stuffing boxes shall be of sufficient depth to permit ample packing. The space between the motor and the stuffing box shall be sufficient to permit removal of the gland packing and insertion of new gland packing without dismantling the pump.
- k) Wearing Rings :

Replaceable wearing rings/casing liners shall be provided in the impeller and in the casing as per manufacturer's standard practice.
- l) Coupling :

The pump shall be connected to the motor shaft by a suitable coupling. Coupling bolt and nuts shall be provided with locking devices to prevent the nut

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from becoming loose. Suitable arrangement shall be provided to adjust the vertical clearance of impeller.

m) **Base Plate :**

Each pump shall be provided with a heavy structural steel base plate. Separate heavy steel sole plates shall be provided for grouting and shall be designed to permit removal of entire pump along with discharge elbow head and base plate without disturbing the sole plate or grout.

n) **Vibration limits:**

The vibration limits of the pump set when measured at motor end shall not exceed the value as per the stipulation of HIS.

o) **Pump Motor Rating:**

Continuous motor rating (at 50 deg C ambient) for pump shall be at least ten percent (10%) above the maximum load demand of the driven equipment in the complete operating range (including shut off condition, in case pumps are envisaged to be started with the discharge valve closed) to take care of the system frequency variation or 115% of the load demand when the pump is operated at the rated head & capacity.

1.6 **Operation Philosophy**

- a) The Pumps shall be operated and controlled from the Operator interface screen of PLCs provided by the bidder in the Pump house. The pumps shall also be operated from the Unit control room. The start/stop commands of all associated auxiliaries / drives including all the motor operated discharge butterfly valves shall be through PLC where all interlocks and permissive shall be implemented and start/stop signals shall be issued to MCC/Switchgear.
- b) A local push button switch shall be used for emergency tripping of the drive motor.
- c) The pump can be started either with pump discharge valve partially open (10% open condition) or in closed position depending upon bidder's standard practice.
- d) In case of high pressure at pump discharge due to accidental closure of any of the butterfly valves in the system, an alarm shall be generated.
- e) In case of normal stopping, when a pump control switch is turned 'OFF', the butterfly valve at its discharge first closes (25-30)% before the respective pump motor is de- energized.
- f) On tripping of motor due to any reason, the butterfly valve at the discharge shall close fully automatically.
- g) If water level in pump sump is low, an alarm shall be initiated. Pump shall trip in case of very low level of water in the intake sumps and very high discharge header pressure.

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- h) The Bidder shall provide duplex temperature elements for bearing and simplex elements for winding temperature monitoring points. Pump shall trip in case of attaining very high winding temperature of motor and very high temperature of bearings. Alarm shall be provided for high motor winding temperature and high motor/ pump thrust bearing temperature.
- i) The operation philosophy as detailed above is suggestive only and in case the bidder deviates from the above, the Bidder shall furnish the complete control and interlock scheme for system / equipment proposed by him along-with the bid. The control and interlock scheme to be adopted will be finalised in consultation with the successful Bidder after award of contract and shall be subject to Owner's approval.

1.7 Raw water intake piping:

The diameter of MS pipe shall be [.....] NB for individual pump discharge line and [.....] mm ID (internal diameter) for the pipe line from common discharge header with pressure rating of [.....]. The material grade for HDPE pipes shall be PE 100 as per ISO: 4427 Part-2 (Table-2) and for the MS pipe shall be IS 3589/AWWA C200. Raw water piping from the flange connection with steel piping portion in the common header of RW intake Pumps shall be routed buried up to the flange connection of over ground MS pipe.

1.7.1 Make up Water Piping from [Clarified Water/Soft Water] Tank:

The internal diameter of [HDPE/MS] pipe shall be [.....] NB with pressure rating of [.....], HDPE Pipe of Material grade PE 100 as per ISO: 4427 Part-2 (Table-2) shall be provided for the piping from the [clarified / soft water] tank routed buried up to the steel pipe connection portion. From there MS pipes of grade IS 3589/AWWA-C200 with flow meter and Butterfly valves shall be provided to form the makeup valve station before the water is let into the fore bay.

1.7.2 Air Release Valve

A suitably sized automatic air-release cum vacuum breaker valve with isolation valve shall be provided on the discharge pipe of each pump.

In the pipe header, air release valve and isolation valve shall be provided by the bidder based on the transient analysis. Air release valves shall be of kinetic air valve type as per IS: 14845. Material of construction for air release valve shall be Austenitic Ductile iron to ASTM-A-439 Gr-D2 and spindle material shall be stainless steel (SS 316). Wherever air release valves are to be provided the pipe line shall be taken above ground and the air release valve and its isolation valve shall be properly supported.

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1.7.3 Manhole

Each pump shall be provided with minimum 500 mm dia man hole in the discharge piping. These man holes shall be designed with flanged sealing covers to maintain leak tightness. Suitable access provision (Rung ladder) shall be made inside the manhole above flow path area.

1.8 Design Data Sheet:

Raw water intake pump

S.No	Description	Design Parameters
1.	Total Number of Pumps	[3x50%]
2.	Number of operating pumps	[2 (Two)]
3.	Number of stand by pump	[1(one)]
4.	Rated Discharge, each	[.....] cu.m/hr
5.	Total Head at rated flow(system head)	[....] m
6.	Operating Speed (Max)	Not to exceed 1000 RPM
7.	Type of pump	Pull out/ Non Pull out type
8.	Type of Discharge	Above Floor
9.	Type of Impeller	Semi-open/enclosed impeller
10.	Type of lubrication	Self Water / Forced Water
11.	Local Control panel location	As given in the existing drawing of "Intake pump house plan and section"

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2 CIRCULATING WATER & AUXILIARY COOLING WATER SYSTEM

2.1 General

The Circulating Water (CW) system shall be complete in all respects with mechanical, electrical, control & instrumentation systems and related civil work as applicable for safe, efficient and trouble free operation of the system.

[The Bidder shall carry out the physical model study for the CW sump and pump model study and the reports shall be submitted to owner for approval. Transient studies for CW piping system shall be conducted to ensure that the pipe thickness is adequate for water hammer and pressure rise problems due to sudden trip of CW pumps considering all the possible conditions of operation. Further pressure balancing shall be provided for proper flow of CW water, when hot ACW water enters hot CW return pipe.]

Tentative parameters of CW pumps each have been elaborated elsewhere in this section. CW System is designed to *[operate unit wise]*. The circulating water to the condenser of each unit is delivered by *[2 x 50%]* capacity vertical turbine type with *[1 no common standby for both the units]*. The cooling water shall be conveyed to the condenser through cooling water piping. *[The auxiliary cooling water (ACW) to the PHE for each unit shall be supplied from [1x100%] ACW pump with a common standby for both the unit located, which is located at the CW pump house]*. CW & ACW pumps shall be installed in individual chambers connected to a common CW forebay. Each pump chamber shall have provision for installing coarse screens and stop log gates. Hot water from the condenser and the auxiliary cooling water heat exchangers shall return to the cooling tower through a common return cooling water piping. The cooled circulating water from the cooling tower basin shall flow by gravity through individual cold water channel up to the common CW forebay and then to common CW sump. CW pumps shall be installed in a CW pump house built over CW sump. The blow down from the CW system shall be tapped off from condenser outlet line for maintaining the required COC of *[....]* in the CW system.

2.2 Codes & Standards

The design, manufacture, inspection and testing shall comply with all currently applicable standards. In particular, the equipment shall conform to the latest edition of the following standards:

S.No	Code	Description
1	HIS	Hydraulic Institute Standards, USA
2	IS 1710	Vertical wet pit turbine pumps for clear and fresh water

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S.No	Code	Description
3	IS 5120	Technical Requirement of Roto dynamic Special Purpose Pumps
4	ISO 2548	Acceptance tests for centrifugal, mixed flow and axial pumps.
5	JIS B 8301	Testing methods for centrifugal pumps, mixed flow pumps and axial flow pumps
6	JIS B 8302	Measurement methods of pump capacity
7	JIS B 8327	Pump performance testing method using model
8	BS-3435	Measurement of electrical power and energy in acceptance testing.

2.3 System Description

The Circulating Water (CW) System proposed for the plant is *[Once-through type system / closed re-circulating type with Natural Draft Cooling Towers (NDCT) / Induced Draft Cooling Tower]*. The CW pumps shall deliver the cooling water to condenser for its cooling and the Auxiliary cooling water(ACW) required for Plate Heat Exchanger(PHE) provided for cooling the primary side of cooling water of Turbine Generator (TG) and Steam Generator (SG) and other auxiliaries. / *{Alternate Arrangement may be decided based on existing arrangement: Dedicated ACW pump which is located at CW pump house supplies the required ACW to PHE provided for cooling the primary side of cooling water of Turbine Generator (TG) and Steam Generator (SG) and other auxiliaries.}*. The hot circulating water shall be cooled in the Cooling Tower. The COC in the CW system shall be maintained to *[.....]* by allowing blow down taken from the hot water return headers. The makeup water to the CW system shall be supplied from Clarified Water Storage tank *[by gravity / by make-up water pump]*. The CW pump house and CW fore bay shall be common for the *[two (2) units]*.

2.4 Design Criteria

a) Design Criteria

- The CW pumps shall be vertical, constant speed, wet pit, mixed flow design, with single stage impeller, suitable for continuous heavy duty operation and shall be directly driven by a constant speed squirrel cage induction motor.
- Type of Pump/construction type of discharge arrangement *[(above floor/below floor)]* and impeller *[(open / semi open / closed)]* shall be as per existing plant design as briefed in Section-I of Volume-II.
- The pumps shall be designed to meet the duty conditions specified in Design data sheets.

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- iv) The pumps shall be suitable for handling water having chemical analysis and turbidity as given in Water Analysis at Section-I of Volume-II. Design density of water shall be taken as 1gm/cc. The pump shall have a flanged discharge connection.
- v) Suitable arrangement shall be provided to take care of the discharge hydraulic thrust due to an untied expansion joint. This may be achieved by sizing pump discharge head and base plate adequately to take care of the discharge hydraulic thrust. No thrust block assembly is acceptable.
- vi) The design, construction and speed of the pumps shall be such as to minimize cavitations and ensure a long and trouble free service. The suction specific speed required (i.e. specific speed calculated with NPSH required) of the pump shall not exceed 12,000 (US Units). Net positive suction head required shall be less than Net positive suction head available with a minimum margin of 1.0 m during all operating conditions including run out condition. The suction specific speed available (i.e. specific speed calculated with NPSH available) shall not be greater than 8500 US units at minimum water level. Bidder shall note that the design suction specific speed available shall be based on actual operating experience of the Bidder and the detailed experience list shall be enclosed justifying the selected suction specific speed available. Pump speed shall be based on the above suction specific speed available.
- vii) The pump shall have stable head capacity characteristics continuously rising towards shut off conditions. The Bidder shall indicate characteristics of the maximum and minimum diameter impellers, which may be fitted to the pump casing.
- viii) The design shall ensure equal load sharing among the pumps operating in parallel. All the pumps shall be identical to one another and shall have identical characteristic curves and shall be capable of running in parallel continuously without any restrictions.
- ix) The maximum efficiency of the pump at design point and motor efficiency (including thrust bearing loss if applicable) shall be limited to 88 % and 96% respectively for furnishing Guaranteed Auxiliary power consumption and for selection of motor rating. No credit shall be given during evaluation for pump/motor efficiencies beyond specified limit.
- x) The pump shall operate satisfactorily in isolation and in parallel with all other working pumps without cavitations, any deleterious effects, undue vibrations and noise at all water levels, from minimum to maximum. The impeller shall be of non-over-loading type to restrict motor overloading during single pump operation. Pumps shall be able to operate satisfactorily and continuously at run out capacity conditions as determined with the help of system resistance curves.
- xi) Various levels to be considered in system shall be same as applicable for the existing pumps given above.
- xii) The pump and motor (complete assembly) should be designed for withstanding the runaway speed attained with reverse rotation caused by reverse flow continuously even when all the remaining pumps are in operation. Necessary

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speed switches to detect reverse rotation shall be provided to prevent motor switching on while rotating in reverse direction. The indication on local control panel shall also be provided.

- xiii) The system resistance curves shall be drawn for the pump by the Bidder. Bidder shall check the pump performance for single pump operation and confirm that the NPSH and submergence requirements are satisfied with various water levels.
- xiv) The pump shall also be designed to withstand the seismic loads as given in Project Information.
- xv) The shaft shall be designed such that the complete pump and motor assembly satisfies the following: The operating speed shall not be too close to the first critical speed, i.e. N should be less than $0.8 NC1$ or N should be more than $1.3 NC1$ Where N is the Operating Speed and $NC1$ First Critical speed.
- xvi) Also, critical speed of pump-motor assembly shall be more than the maximum reverse run away speed.
- xvii) Design life (minimum) of equipment supplied by Bidder shall be [20/25] years.
- xviii) Recirculation arrangement for the CW pumps shall be provided from the common header such that the recirculation can be operated for any pump. The capacity of the recirculation should be 50% of individual pump.

b) Reverse rotation

The pump motor assembly shall be designed to take care of the following transient conditions -

- Reverse rotation of the assembly due to system back flow under power failure condition.
- Reverse rotation of the assembly due to back flow when running pump trips and its discharge valve fails to close fully and also parallel pump operating at its rated capacity.
- Prevention of starting of pump motor under reverse rotation condition.
- Starting of pump with its discharge valve fully closed (if motor rating requirement is within 115% of duty point rating) or discharge valve crack open condition without reverse rotation of pump assembly.

c) Manhole

Each pump shall be provided with minimum 800 mm dia man hole in the discharge piping. These man holes shall be designed with flanged sealing covers to maintain leak tightness. Suitable access provision (Rung ladder) shall be made inside the manhole above flow path area.

d) Air Release Valve

A suitably sized automatic air-release-cum-vacuum breaker valve(s) shall be provided on the discharge pipe of each pump. Further Air release valves shall be provided on the CW duct based on transient analysis study. The number and size of air release valves shall be based on the transient analysis study.

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In the pump discharge as well as in the CW duct, isolation valve shall be provided by the Bidder below the Air release valves to isolate the Air release valves. Air release valves shall be of automatic type as per IS: 14845.

The air release valves shall be double air valve/kinetic air valve with two orifices and two floats. The float shall not close the valve at higher air velocities. The Orifice contact joint with the float shall be leak tight joint.

The valve shall efficiently discharge the displaced air automatically from ducts/pipes while filling them and admit air automatically into the duct/ pipes while they are being emptied. The valve shall also automatically release trapped air from ducts/ pipes during normal working at the normal working pressure.

e) Operation Philosophy

The Pumps shall be operated/controlled from PLC based control system. Each pump control module shall consist of hand switches, indicating lamps, audio and visual alarm windows, process parameter indicators like pressure, temperature, flow, pump speed, lube oil temperature, motor cooling water temperature (if applicable) pump and motor vibration, motor supply voltage, motor current etc.

Pump can be started only when either at least one of the flow circuits through the respective condenser to the discharge duct and cooling tower is established or re- circulation line to pump sump is open.

The pump can be started either with pump discharge valve partially open or in closed position depending upon Bidder's standard practice. A local push button switch shall be used for emergency tripping of the motor. In case of high pressure at pump discharge for prolonged period (bidder to indicate the time limit), due to accidental closure of any of the butterfly valves in the CW system, the pump shall trip. In case of normal stopping, when a pump control switch is turned 'OFF', the butterfly valve at its discharge shall first close (25-30) % before the respective pump motor is de-energized.

On tripping of motor due to any reason, the butterfly valve at the discharge shall close fully automatically. Low flow of either pump or motor bearing cooling water when the pump is running shall give alarm(s) and trip the pump with alarm in case of sustained low value over a preset time. If water level in pump sump is low as well as for high level, an alarm shall be initiated. Pump shall trip in case of very low level of water in the intake sumps and very high discharge header pressure. Also, in the case of low water level in the pump sump, the makeup water valve should automatically open and let the water into the leading channel of the forebay. The makeup water valve shall automatically close when the level reaches high in the pump sump. The operation philosophy as detailed above is suggestive only and Bidder shall furnish the complete control and interlock scheme for the system/equipment proposed by him along-with the bid. The control and interlock scheme to be adopted shall be finalised in consultation with the successful Bidder after award of contract and shall be subject to Owner's approval.

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2.5 Constructional Features

i) Materials of Construction

Material & construction of the pump shall be such as to resist corrosion & erosion and give a long and satisfactory life to the plant. The materials used in construction of the various components shall not be inferior to those given below. Cathodic protection shall be provided for CW pumps in case of Sea Water application.

S.No	Description	Technical requirement	Material for Sea Water
1)	Suction Bell & Casing	2% Nickel Cast Iron, IS: 210 Grade FG 260; S-0.1% max. P-0.15% max.	ASTM A276 TP316L / ASTM A439 Type D2
2)	Casing Liner	----	----
3)	Impeller	Stainless steel-316	ASTM A890 Gr. 1B
4)	Wearing rings	Stainless steel of suitable grade as per manufacturer's proven practice.	As per manufacturer standard practice
5)	Pump shaft	Hardened stainless steel conforming to ASTM A 276 Gr. 410	A351 Gr. CG6MMN
6)	Line shaft	Hardened stainless steel conforming to ASTM A 276 Gr. 410	A351 Gr. CG6MMN
7)	Shaft coupling	Stainless steel type 410, ASTM A 276, Heat treated and hardened.	Monel
8)	Shaft sleeve	Stainless steel type 410, ASTM A 276, Heat treated and hardened.	A351 Gr. CG6MMN
9)	Line shaft bearing	Cutless rubber with bronze retainer / Thordon type bearing.	Cutless rubber with bronze retainer / Thordon type bearing.
10)	Bearing guide spider.	Fabricated steel	
11)	Column pipe	Fabricated steel as per IS: 210 Gr FG 260 with 2 coats of epoxy coating.	ASTM A276 TP316L
12)	Shaft enclosing tube (if applicable)	Fabricated steel as per IS:2062	ASTM A276 TP316L
13)	Discharge elbow	Fabricated steel as per IS:2062	ASTM A276 TP316L
14)	Distance piece	Fabricated steel as per IS:2062	ASTM A276 TP316L

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S.No	Description	Technical requirement	Material for Sea Water
15)	Matching flanges	Fabricated steel as per IS:2062	To match pipe material
16)	Thrust pads	Carbon steel with white metal lining.	Carbon steel with white metal lining.
17)	Bolts, nuts and lock washers	Stainless steel AISI type 304 for those coming in contact with water and for others, material shall be high-tension carbon steel.	AISI 316L
18)	Base plate and	Fabricated steel as per IS:2062	Fabricated steel as per IS:2062
19)	Soleplate	IS: 2062	IS: 2062
20)	Gaskets	Wire reinforced rubber gasket / Neoprene rubber / asbestos free	Wire reinforced rubber gasket / Neoprene rubber / asbestos free
21)	Gland packing	Impregnated Teflon	Impregnated Teflon
22)	Ladder, platform and related accessories.	Fabricated steel as per IS:2062	Fabricated steel as per IS:2062

A ladder and platform arrangement shall be provided for each CW & ACW pump and motor for inspection and maintenance of the thrust bearing.

The line shaft bearing shall be spaced so as to ensure smooth operation. The bearing shall be amply proportioned to give long and satisfactory life.

- Bearing lubrication: The type of lubrication *[(self water or forced water as the case may be)]* shall be as specified in data sheet. All interconnected piping, valves; instruments and fittings for bearing lubrication shall be in Bidder's scope
- Water required for cooling of thrust bearing shall be taken from main pump discharge through filter. Necessary piping valves, instrumentation etc. shall be included in Bidder's scope.
- CW system is a recirculating type with cooling towers, thereby there is a possibility of dust ingress in cooling towers. The lubricating system shall be suitably designed to prevent such dust ingress into pump bearings.

ii) Journal & Thrust Bearings

The main pump guide bearing shall be babbitt lined bronze bearing sleeve located as close to the impeller as possible. Guide bearings shall be oil lubricated. The guide bearing & thrust bearing shall be protected against water splashes and in particular against gland packing leaks.

The guide bearing shall be of journal bearing type. It shall be out of water, cooled & lubricated by self circulated oil. The bush bearings (if provided) shall be

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lubricated with filtered pump fluid. The guide bearing shall be lubricated by an automatic oil circulating system. The guide bearing housing shall be of axially split design so as to facilitate ease of maintenance.

- Bearings shall be suitable for reverse rotation up to the maximum speed of 125% of rated speed and shall be suitable for continuous operation at all duties from closed-valve to maximum run out.
- All bearings shall be out of water and should be easily accessible for maintenance purpose. Adequate access shall be provided for maintenance of bearings.
- The design of the lubricating system shall be such that the bearing performance is not affected by small changes in oil levels. Maximum and minimum operating oil levels shall be distinguished by a generous quantity of oil between the defined oil levels.
- The bearing lubricating system shall be designed to permit easy filling and drainage of lubricating oil. Easy access shall be provided for the addition of lubricating oil with the pumps in service. All associated pipe work shall be of stainless steel.
- For removing heat from pump thrust bearing oil bath, cooling coil made out of cupro-nickel alloys suitable for clarified water shall be provided. Hot water outlet from this bearing shall be led to the sump.
- The bearing bracket shall be designed to ensure maximum rigidity of the bearing support. (The bearing support shall be centered on & bolted to the casing cover).
- Pump design with single thrust bearing at motor top or separate thrust bearings for pump and motor (as per Bidder's standard practice) is acceptable. In case the thrust bearing is located in the pump it shall be located just above the guide bearing and the coupling shall be flexible type in such a case.
- Thrust bearing shall be of oil-lubricated, centrally pivoted tilting pad type (Mitchel or Kingsbury) capable of absorbing axial thrust in both directions of rotation continuously. Water required for cooling of thrust bearing shall be taken from main pump discharge. Necessary, filters, piping, valves, accessories, specialties as required for such cooling purpose is in the scope of Bidder. However pump design shall be suitable for starting without cooling water for thrust bearing.
- The thrust bearings shall be rated for continuous operation with thrust as developed when impeller clearance is worn out up to four times the clearance when pump is new and working under shut off condition.

iii) Pump Shaft

- The shaft shall be designed to transmit the maximum rated power at the pump operating speed and shall be of ample stiffness to minimize deflection of the shaft during closed valve starting conditions.

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- The shaft shall preferably have all components key driven including impeller, thrust and journal collar and coupling.
- Since the pump floor and motor floor are at different elevations, pump shaft and motor shaft shall be connected by an intermediate shaft as per the standard design of the manufacturer.
- Intermediate shaft should be designed to take care of misalignment of pump and motor shafts. Intermediate shaft motor end and pump end couplings should be designed for easy assembly and dismantling. They should also provide rigidity for transmitting full torque of the motor with minimum transmission losses.
 - **Shaft Sleeves**
Shaft sleeves shall be provided below the bearings to protect the shaft from wear. Suitable locking arrangement shall be provided for all bolted connections.
 - **Stuffing Box**
Gland packing shall be provided at the top of the line shaft. Shaft sleeves shall be provided at the stuffing box. The stuffing boxes shall be of sufficient depth to permit ample packing. The packing glands shall be split type to facilitate repacking of the stuffing boxes. The space between the motor and the stuffing box shall be sufficient to permit removal of the gland packing and insertion of new gland packing without dismantling the pump.
 - **Wearing Rings**
Replaceable wearing rings/casing liners shall be provided in impeller and casing. Design of wearing rings / casing liners may be as per manufacturer's standard practice.

iv) Gland sealing

- Pump shaft when it comes out of the volute casing shall be sealed with gland packing type stuffing box. A seal flushing system shall be provided which shall supply the glands with flushing water both during pump start-up / shutdown and also while the pump is running.
- Special design provision (i.e. inflatable seal) to be made in the stuffing box housing for replacing gland packing without dewatering of draft tube and volute casing under HHWL condition.
- The Bidder shall make necessary arrangement for proper draining of gland sealing water from casing cover.

v) Coupling

The pump shall be connected to the motor shaft by a suitable coupling. Coupling bolt and nuts shall be provided with locking devices to prevent the nut from becoming loose at normal and reverse rotation. Suitable arrangement shall be provided to adjust the vertical clearance of impeller. Bidder shall give necessary details of a proven arrangement in the offer.

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vi) Base Plate

Each pump shall be provided with a heavy structural steel base plate. Separate heavy steel sole plates (or curb rings) shall be provided for grouting and shall be designed to permit removal of entire pump along with discharge elbow head and base plate without disturbing the sole plate or grout. The sole plates shall be blasted clean to a near white finish. Further, the design and material of foundation bolts and base plate shall be such that it can take care of all shearing forces/ stresses developed due to sudden closure of butterfly valves. The Bidder shall furnish the calculations for shearing forces and moments on foundation bolts.

vii) Vibration limits

The vibration limits of the pump set shall be within the limits specified by HIS. Bidder should clearly bring out the location and type of vibration pickups recommended and provided by him for monitoring purposes along with the values of High/High - High vibration for alarm / trip etc.

viii) Pump Motor Rating

Drive motor sizing criteria shall be the highest of the followings:

- 10% margin over the pump shaft input power at the rated working condition.
- 5% margin over the maximum pump shaft input power required within its operating range including the shut off point.
- Pump shaft input power required considering overloading of the pump assuming single pump operation in the event of tripping of the other pump(s) operating in parallel. Refer Volume-II, Part-B for further details of motors.

ix) Hydraulic Transient Analysis

For the complete CW system, Bidder shall carry out a detailed hydraulic transient analysis by method of characteristics using an industry approved computer programme. Bidder shall decide the following based on the hydraulic transient analysis for entire CW System respectively:

Pump discharge valve closing sequence and rate of closure for pump stopping and pump tripping conditions which shall be incorporated in overall control system in unit control room.

Size, location and quantity of air release valves in the discharge pipe and CW duct.

Pump discharge valve opening sequence and rate of opening during pump start-up condition.

Further, study should also consider stopping/ tripping of a working pump and starting as an event for analysis of the system.

The transient study shall also include power failure condition i.e. all the running pumps trip but the discharge valves remain open.

The report for transient analysis should consist of methodology adopted, characteristic curves/ data for various boundary conditions, complete input data used for execution of software for various events and the complete data and shall

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be submitted to the Owner for approval. Based on the recommendations of such a study, Bidder shall take corrective measures and provide suitable surge suppression devices in CW System/intake system.

x) Model Test of CW Pump

- For the offered pump, Bidder should carry out the model test after the completion of the detail engineering. The model test should be conducted as per Japanese standard JIS-B-8327 (latest version) and specific speed of the model tested should lie within $\pm 5\%$ of the specific speed of the pump offered
- Bidder shall conduct the test as per the procedure given below at no extra cost to the Owner.
- A homologous model of the CW pump shall be tested at manufacturer's works in the presence of Owner's representative to predict the performance of the prototype. Model test shall include the cavitation test & Net Positive Suction Head Required (NPSHR) test. In general these tests shall be conducted as per Japanese standard JIS-B8327 (latest version).
- It is preferable to have the model pump head same as the head of the prototype pump, and should be run at such a speed that the specific speed is the same as that of the prototype.
- The model ratio and the procedure to be followed for model test shall be mutually discussed and agreed before conducting the test.
- Bidder shall submit a procedure for ensuring & demonstrating the similarity of the impeller vane profile/volute profile for the model pump & the prototype.
- All the relevant dimensions of the diffuser and impeller including clearances and profile shall be measured for model pump and prototype pump and control should be exercised to ensure repeatability of these parameters on all subsequent pumps.

2.6

Sump Model Study

{This section shall be incorporated, if, the sump modification is envisaged.}

a) Purpose

- (i) The physical sump model study shall be carried out as per guidelines of Hydraulic Institute Standards to finalize the prototype sump and fore bay dimensions. The sump model study shall cover in particular the following aspects:
- Study of swirl in each sump.
 - Check the formation of different types of vortices in forebay and pump chambers.
 - Study the flow pattern in approach channel, forebay and pump chamber and draft tube for turbulence, formation of hydraulic jump, back flow etc.
 - Study velocity distribution in approach channel, forebay area, pump bays,

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draft tube etc.

- Check the adequacy of dimensions of the pump house and distances between the screens.
- (ii) The model shall be based on Froude's law of similitude and shall be tested for following two more flow conditions, viz.
- At twice the prototype maximum Froude number, i.e., the Froude number of the model is two times that of the prototype.
 - At equal velocity criterion, i.e., the velocity is same both in the model and prototype.

The successful bidder shall give details of any other studies to be done by the pump vendor, the methodology and place of study, the agency involved in the study and the layout enclosed based on the pump offered.

- (iii) Model study shall be conducted either by the successful bidder at their premises or in the premises of a reputed institution. Successful bidder shall submit a list of projects for which model studies have been conducted by them or a list of institutions wherein the model study can be conducted which shall be approved by the Owner.

b) Construction of Model

- i) Model shall be constructed from carbon steel, transparent elastomeric material or any other material found to be suitable for the purpose.
- ii) The scale used shall be 1:10. Model shall be built such that it includes low water level and highest water level in the sump.
- iii) Model shall be constructed for complete pump house, forebay and intake channel. Model shall be flexible so that the effect of changes in sump design can be conveniently studied by trying various configurations.
- iv) The Model shall be built above the ground with bottom and side walls of transparent material near pump chambers.
- v) In the model, provision of current meters to collect velocity profile in horizontal plane and vertical plane in each pump chamber entrance, coarse screen inlet and exit and Pump Inlet shall be made.

c) Operating Conditions/Requirements

- i) Contractor shall submit a write-up on the sump model study to be carried out which shall cover the different aspects such as model scale, test velocities, flow rates, water levels and pump operation combinations that shall be studied regarding the sump behavior and also the evaluation criteria. After approval of the same, model study shall be carried out.
- ii) The operating conditions for the CW pumps shall be as specified in the data sheet for CW pumps.
- iii) The Model shall be tested for various combinations at low water level and high water level covering all conditions. The combinations shall be selected to cover

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wide range of pumps operating conditions. The Owner shall witness the tests.

d) Acceptance Criteria

- i) The acceptance criteria shall be as per the HIS.
- ii) Velocities through screens shall be less than 0.7 m/s.
- iii) Detailed report on the sump model test containing the objective, description of test conducted, observations, modifications suggested in the prototype sump (if any), final drawing of the prototype sump (incorporating modifications if any) and drawing for the test set-up, photographs and a video CD shall be submitted by the Contractor to the Owner.
- iv) The Bidder shall note that all engineering activities related to the sump/ pump house shall be taken up only after the approval of sump model study report.
- v) The prototype sump, fore bay, leading and approach channel dimensions shall be based on the model study including all the modifications and corrections carried out in the model.

2.7 Performance Tests

Performance tests shall be carried out at works and at site.

a) General

- i) The following shop tests will be conducted as applicable on the various components. All such tests will be documented and forwarded to Owner:
- ii) Radiography test for Impeller
- iii) DP test on machined surface of impeller
- iv) Visual examination and dimensional check
- v) Chemical composition test for complying with the material specification
- vi) DP test for wearing ring
- vii) DP and Ultrasonic test for pump shaft and coupling
- viii) After the assembly of the various components of the pump, the static and dynamic balancing tests for rotating assembly will be conducted.

b) Performance Guarantee Tests at Works

The following tests shall be conducted at works:

After installation of the pumps at shop, each CW pump, shall be subjected to performance test and performance shall be verified. The test shall include establishing the pump performance curves (Head - Capacity, Power - Capacity, Efficiency - Capacity) and verifying the guaranteed parameters in the presence of Owner's representative and pump manufacturer. The test results of each pump will be evaluated individually and corrections, if any, for the deficiency in guaranteed parameters shall be carried out by the bidder. The following procedure shall be followed for conducting the tests at works:

- i) Bidder shall make all the arrangements for carrying out tests at shop and all costs associated with the above test arrangement shall be borne by the Bidder.

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- ii) Performance guarantee test shall be carried out as per requirements of Hydraulic Institute standard (HIS) of USA and approved test procedure. Performance test at design duty point shall be done keeping minimum submergence of the pump identical to that specified for the site conditions.
- iii) Bidder shall submit details of the proposed testing arrangement, methodology of flow measurement etc for Owner's approval. The details shall be enclosed with the bid.
- iv) It may be noted that during the performance tests, no negative tolerance will be permitted on head, capacity and the pump efficiency.
- v) The test shall also include measurement of vibration, noise level and bearing temperature rise.
- vi) Calibration of instruments to be used in the test shall be carried out by an independent agency. Calibration of instruments should be carried out prior to the test. The calibration certificate of the instruments should be valid for the period of test. The following laboratories are acceptable for calibration of various instruments:
 - Flow Control Research Institute (FCRI)
 - Indian Institute of Technology
 - Institute for design of electrical measuring instruments (IDEMI)
 - Electronic Research & Testing laboratory (ERTL)
 - National Physical Laboratory (NPL)
 - National Test House (NTH)
 - Any other equivalent Government Institute / laboratory to be approved by Owner
- vii) The test result shall be evaluated at actual speed achieved and speed correction shall be made only if there is a supply frequency variation with respect to 50 Hz.

c) Performance Guarantee Tests at Site

The following tests shall be conducted at site.

- i) Flow measurement at site shall be carried out using re-circulation line. If additional temporary pipelines / RCC chamber are required to be provided for testing the pump for the complete measurement range, the same shall be provided by the Bidder.
- ii) All interlocks and protections relating to the pumps, motors and motorized valves shall be demonstrated /tested as per control logic.
- iii) Parallel operation of the pumps shall be demonstrated / tested. There should be equal load sharing between pumps running in parallel with no abnormal vibrations, sound or hunting of head and flow. Load sharing between any pumps running in parallel should be within 10%.
- iv) Opening and closing time of discharge butterfly valve shall be checked and it should be as per the approved data sheet. The capacity of the accumulator shall be checked by opening and closing of valve after switching off the electric supply

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to the oil pump. It should be able to open and close the valve as per the specification requirement.

2.8

Stop log Gates, Sluice Gate, Coarse Screens and Trash Rack

S. No	Item	CW & ACW system	RW intake system
1	Stop log gate	[.. Nos.]	[.. Nos.] for intake sumps
2	Sluice gate	-	[.. No.] no for intake channel
3	Coarse screen	[.. Nos.] (1 no for each pump chamber)	[.. Nos.] (1 no for each pump chamber)
4	Trash rack	-	1 no. for intake channel
5	Lifting beam For stop log gate / coarse screen	[.. Nos.] No.	[.. Nos.] No
6	Storage rack for stop log gate	[.. No.] for each stop log gate	[.. No.] for each stop log gate

a) General

- i) Stop log gate assembly [comprising identical and interchangeable of adequate size to suit the pump chambers (height x width)] properly matched to withstand the water pressure and to have no leakage between connection joints, complete with seals and hooks for hoisting and lowering the unit etc.
- ii) Each chamber shall be provided with coarse screen assembly. Coarse screen assemblies [comprising identical and interchangeable of adequate size to suit the pump chambers (height x width)] properly matched complete with hooks for hoisting and lowering the unit etc be installed in circulating water sump. Screen shall be suitably strengthened so that even with 50% chocking, there is no distortion of the frame.
- iii) Lifting beam complete with automatic engaging and disengaging type hooks and counter-weights; guides & guide shoes to be operated in unison with stop log gates/coarse screens as described above for handling the units with correct engagement.
- iv) One (1) set of guide bar and sills for gates and screens for guiding them to operate in the center of the slot and the arrangement shall be common for all.
- v) Sets of Track-cum-side seals for the stop log gates/coarse screens for Circulating water sump shall be supplied and erected to enable smooth movement of bearing pads and seals. Proper number of pads & seals shall be provided so as to provide very smooth operation for a prolonged period.
- vi) Portable Dewatering submersible pumps shall be provided in order to drain pump sump during maintenance.

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b) Stop Log Gates & Sluice gate

Stop log Gate

- i) The Stop log gates shall be designed in accordance with the provisions of IS: 5620, in general and in accordance with the specification indicated herein. The Stop log assembly shall be made in identical interchangeable units. The gates shall be designed corresponding to the maximum water level and wave effect with full hydrostatic pressure with the downstream completely empty.
- ii) Permissible stresses in various components shall not exceed those specified under Appendix-B of IS: 5620 for wet conditions (accessible) column and those mentioned in these specifications.
- iii) The stop log gates shall be normally kept stored in storage area near fore-bay/pump sump and as required these shall be moved and lowered in the balance condition for attending to any maintenance or repair jobs of the water bays or the associated civil structure. All the stop log assembly units shall be identical and interchangeable for each size except the bottom unit.
- iv) All the units shall have music note type side seals and bottom seal. Suitable arrangement shall be made at the top of the units for sealing the bottom seal of the unit to be placed above it. The skin plate and bottom seal clamp plate shall be suitably chamfered to prevent damage to bottom seal.
- v) Suitable drain holes shall be provided on all the horizontal girder webs and horizontal stiffeners. Each stop log unit shall be provided with three (3) guide shoes, one (1) near the top and one in middle and the other near the bottom at each end. Lifting points should be suitable for the automatic engaging and disengaging hooks provided on the lifting beam. Two (2) suitable guide rods equidistant shall also be provided on the units at the webs of the top horizontal girders to match the guide bush (pipe) provided at the bottom of the lifting beam to facilitate lowering of lifting beam correctly to engage the stop log.
- vi) The stop log assembly units are required to be lifted / lowered under balance conditions of load. The lifting operation shall be done only after the water level on both sides has equalized for which suitable filling valve shall be provided in the stop log units only under each lifting lug so that before the lifting beam lifts the stop log, water fills the dewatered portion through the filling valves and balances the water pressure on both the sides.
- vii) In closed position, the stop log assembly units shall be completely water tight with the design water head.
- viii) The stop log assembly and its accessories shall be so designed that the stresses in the different members due to dynamic loads during closing and opening operations and static loads in the closed position do not exceed the permissible stresses specified hereunder. The frames and anchors shall be designed as per IS: 5620. The bearing plates shall be of mild steel and surface shall be machined. This shall slide on the machined structural steel track plates provided on the embedded parts.

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Sluice Gate

The manual sluice gate shall conform to the applicable IS/AWWA standards for the size of the gate.

Sluice gates shall be cast iron, fully bronze mounted and will have side wedges, top wedges and bottom wedges or a flush bottom seal. Flush bottom type seal shall have a neoprene bottom seal and standard bottom shall have bottom bronze wedges.

Disc or Slide

The disc shall be cast iron, one-piece construction, rectangular with integrally cast vertical and horizontal ribs

Frame

Gate frame and guides shall be cast in one piece and shall be flat back or flange back as designated in the gate schedule. The back of the frame shall be machined to a plane.

The guides shall be cast as an integral part of the frame and shall be sufficiently long to retain at least one-half of the vertical height of the disc when in the fully opened position. Guides shall be capable of safely withstanding the full thrust due to water pressure and wedging action. Guide grooves shall be accurately machined to provide free movement of the disc tongues and to insure proper engagement of the wedging devices.

Wedges

The wedges shall be solid cast bronze and keyed to the cast iron pads to maintain adjustment by preventing undesirable rotation or lateral motion. They will be attached to the disc with 304 or 316 stainless steel studs, nuts, washers and adjusting screws with locking nuts. Silicon bronze studs, nuts and adjusting screws with locking nuts shall be used when specified

Seat Facings

All seat facings shall be malleable extruded bronze of a composition, which will resist dezincification and will increase in wearing ability with cold working.

Flush bottom Seal

Gates so designated in the gate schedule shall be provided with a flush bottom seal. All gate parts shall be identical to those defined in other paragraphs of this specification except for the bottom of the slide and the seal assembly along the invert of the waterway opening. The dovetail facing along the bottom edge of the disc and frame shall be omitted. A neoprene seal shall replace the bottom dovetail and wedging devices. The neoprene seal shall be epoxied into the stainless steel bottom cross member (sill).

The top surface of the seal shall be flush with the invert of the gate opening. The full length of the bottom edge of the disc shall be accurately machined to make

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contact with the seal when the disc is closed. The seal shall be replaceable without removal of the gate disc

Stem

Operating stem shall be of Type 304(L) or 316(L) stainless steel minimum 1-1/4 inches diameter and attached to the disc by stem mounting clips or thrust nut and pocket. Stem shall be designed to transmit in compression at least 2-1/2 times the rated output of the operating mechanism with a 40-pound effort on the crank or hand wheel. Stems shall be provided with adjustable stop collars to prevent over travel on manually operated gates.

Stem Guides

Stem guides shall be bronze bushed ASTM A126 class B cast iron.

Seals

Neoprene "J" seal can be bolted to the cast frame for additional sealing capabilities on the unseating side. Hardware shall be Type 304 or 316 stainless steel.

c) Lifting Beam for Stop log Gate/Coarse Screen

- i) The lifting beam shall be made from rolled structural steel I- beam/ channel sections or fabricated from angle iron frames. The depth of lifting beam/frame should be sufficient to prevent bending of lifting beam in between the side guides. It shall have suitable guide shoes at both ends. Two (2) guide bushes corresponding to guide stems on stop log/coarse screen units shall be provided for correct engagement with the stop log unit.
- ii) Two (2) automatic engaging and disengaging type hooks with counter-weights etc shall be provided corresponding to lifting lugs on the units, for grappling and un-grappling of stop log/coarse screen, assembly units under water.
- iii) It should be assembled in shop and its operation specially that of automatic engaging and disengaging hook shall be checked for its correct operation.
- iv) The lifting beam shall be designed to cater for the following requirements:
 - Double point lifting shall be envisaged in the design of lifting frame.
 - The depth of beam/frame shall be normally 0.6 of its length. However, this may be reduced with suitable end arrangement preventing bending of frame in the guides.
- v) Counter-weights shall be provided for automatic grappling and un-grappling.
- vi) The hook made out of plate shall be checked for automatic grappling and un-grappling and shall be suitably designed for the load of heaviest stop log/coarse screen unit with adequate margin of impact, sticking of stop log units etc. The pin of hook shall be suitably designed for load for which hook is being designed.
- vii) The top pin of the lifting frame/beam shall be designed for the load of lifting frame, load of stop log/coarse screen unit with adequate margin of impact, sticking of stop log unit etc.
- viii) Two (2) guides on either side with their bottom chamfered shall be provided for

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guiding the lifting frame into the slot and clearances of guide and guide shoes shall be kept the same as adopted in the stop log units.

- ix) The pilot shall be provided at the bottom of lifting frame to prevent rotation of stop log/coarse screen units during handling.
- x) The lifting frame shall be checked for its verticality and for satisfactory operation of grappling and un-grappling of its hook.

d) Coarse Screens

Coarse screens of conventional design shall be installed at each bay of the Circulating Water sump to stop objectionable debris and floating matter from entering the CW Pumps.

Design Considerations & Operating Requirements

- i) The coarse screen shall be designed for 50 percent choking condition and the structural supporting members shall be designed for a differential head of 2m.
- ii) The design shall be checked for additional force due to horizontal and vertical seismic coefficient. An increase of 33 percent over the normal allowable stresses may be allowed for the structural members and 25 percent for bolts and nuts etc. for earthquake condition.
- iii) The screens shall always remain in position, under water, to stop objectionable large debris and floating matter.
- iv) Screens shall be lowered and lifted only under balanced conditions of head. The lifting operation shall be only for maintenance/painting requirements or for cleaning of screen in case of excessive choking.
- v) The screens and its components shall be so designed that the stresses in different members due to dynamic loading during closing and opening operations and static loading in the closed position do not exceed the permissible stresses.

Arrangement of Screens Parts

- i) Each unit of coarse screen to be provided shall consist of vertical and horizontal frame. The screen shall be 12 gauge AISI-304 stainless steel crimped wire bolted on rolled structural steel frame with flat all round pitch of Clear opening of the screen shall be 10 mm x 10 mm.
- ii) As the screen units shall always remain submerged under water, a lifting beam/frame with automatic engaging and disengaging hooks shall be used for lifting and lowering purposes. The lifting frame shall also be guided in the embedded track-cum-guide.
- iii) The screen shall mainly comprise of following components:
 - Load bearing horizontal members.
 - End frame members
 - Screen
 - Lifting points
 - Pilot Rods/pipe

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- Rest pads

S. No.	Component	Materials	Specification
1.	Structural parts	Rolled Steel	IS: 8500 IS 2062
2	Wire Mesh	12 gauge stainless steel	-
2.	Side guide-cum-track	Structural steel of convenient shapes	IS: 2062
3	Mechanical fasteners	Electro galvanized high tensile steel	IS: 3167

e) Design and Manufacturing requirements of Trash rack

- Trash rack screens shall be provided at the beginning of the intake chamber. The grooves in the chamber for the stop log gate in the upstream of the trash rack shall be so designed that it shall accommodate the trash rack or the stop log gate. The racks shall be designed by the Bidder to suit the system requirements.
- Trash rack shall be of Type-3 of IS: 11388 designed for 2M differential water head and as per the data sheet furnished in Chapter 19.
- The rack shall be installed in such a way that the projected bar screen surface will be facing the flow direction.
- Ragged edges, welds, protruding bolts or other fasteners, which might cause injury to personnel, shall be removed or otherwise protected.
- The racks shall be delivered to site ready for installation.

Applicable Codes and Standards

IS-5620	Recommendations for structural design criteria for low head slide gates.
IS-4682 - Part-1	Code of practice of lining vessels and equipment.
IS-9349	Recommendations for structural design of medium and high head slide gates.
IS-11855	General requirements of rubber seals for hydraulic gate
IS-15466	Rubber seals for hydraulic gates.
HIS	Hydraulic Institute Standards, USA

2.9 Butterfly Valves

a) General

- The butterfly valves to be provided in the intake pumps discharge pipes, CW & ACW pump discharge pipes, Recirculation lines and in the makeup water valve station of CW system shall be of flanged construction and shall be complete with

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electric motor actuators, matching counter flanging, bolts, nuts, gaskets, lifting lugs, sole plate for supporting feet in the valve body etc.

- ii) The valves shall be suitable for installation in any position (horizontal / vertical etc.)
- iii) The valves and all accessories shall be designed so as to guarantee an easy disassembling and maintenance.

b) Design & Construction Requirements

- i. Butterfly valves shall be of flanged construction and shall be complete with actuating mechanism, matching counter flange, bolts, nuts, gaskets, lifting lugs, sole plate for supporting feet in the valve body etc.
- ii. The valves shall be designed for water quality as per service requirement for the design pressure / temperature as specified and in accordance with BS 5155/AWWA-C-504. For sizes not covered in AWWA-C-504, the dimensions given in AWWA-C-504 shall be extrapolated to arrive at final values.
- iii. The valves shall be bi-directional bubble tight shut-off, high performance type.
- iv. The valves shall be preferably triple eccentric or minimum double-eccentric valves with low torque requirement.
- v. The valves shall have externally retained, blow out proof stem design feature to arrest stem coming out from disc. Stem shall not come in contact with flowing fluid.
- vi. The valves shall be suitable for installation in any position (horizontal / vertical etc.).
- vii. The shaft shall be connected to the disk through keys or taper pins or screws of stainless steel. The connections shall be designed so as to avoid looseness during the operation; moreover, they shall be provided with suitable disassembling systems.
- viii. Sealing seat material shall be either on body or on disc and its shape shall be hollow musical note type or superior giving reliable leak-tightness. Seat shall be in-situ replaceable type.
- ix. Integrally cast adjustable travel stop is to be provided on the valve body.
- x. Actuator torque shall be minimum 1.25 times the required maximum valve torque. Maximum valve torque requirement shall be worked out considering bi-directional sealing, disc differential pressure equivalent to valve rating pressure and hydraulic forces on disc due to change of direction of flow within one diameter length upstream and downstream.
- xi. High strength stub shaft shall be provided with minimum 1.5 times diameter penetration into disc hubs with close tolerance fit and secured with adequate number and capacity lock pins.
- xii. The valve shall be provided with one or two thrust bearings to hold the valve disc securely in the centre of the valve. The material of bearing shall be self-lubricated type with low coefficient of friction. Bearing shall be provided beyond the shaft seal. The housing for this bearing shall be rigidly attached to the valve body.

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- xiii. The disc shall rotate from the full open to the tight shut position. The disc shall be contoured to ensure the least possible resistance to flow and shall be suitable for throttling operation. While the disc is in the throttled position, valve shall not create any noise or vibration.

All butterfly valves shall have permanent arrow inscription indicating the flow direction on the valve body.

- xiv. All valves shall be complete with:-

- Graduated position indicator (located in a visible place for the operation);
- Adjustable mechanical stop limiting devices to prevent over travel of valve disk in open and closed position.

- xv. Material of Construction:

The material of construction of the butterfly valve shall be suitable for the circulating water quality. The materials for normal condenser cooling water / PHE cooling water are given below.

S. No.	Valve Component	Materials Specification
1	Body	2% Ni-CI or IS-2062, IS-210Gr260
2	Disc	2% Ni-CI or IS-2062
3	Spindle/Shaft	ASTM A276 Type316
4	Seal	PTFE
5	Retaining Ring	ASTM A276 Type316
6	Key	AISI 1018
7	Packing	NBR/EPDM

c) Electro Hydraulic Actuators For Butterfly Valve in the CW pumps discharge piping :

- i. Each electro-hydraulic actuator shall be provided with its own power pack. Each actuator shall consist of a double acting cylinder, control cabinet and accessories to cater for the following operational requirements:
- ii. In the closed position the valve shall be held closed by a substantial counter weight or by any other mechanical device.
- iii. Start-up sequence of pump shall initiate powered opening of butterfly valve hydraulic actuator. The actuator shall be adequately sized to open or close the valve against an unbalanced pressure equal to pump shut-off pressure in either direction within the time period as specified. The necessary limit switches shall be provided on the valves so that at a pre-determined position, the pump circuit

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- breaker shall be closed to start the pump.
- iv. Valve shall remain open during normal running of the pump. No disc flutter shall take place in the position nor shall there be any creep in this fully open position.
 - v. A limit switch shall be provided (set at about 3 deg from open position) to sense the creeping. Switch shall start the oil pump and return the valve to the fully open position.
 - vi. When the valve is fully open and electric supply to the valve control system fails the butterfly valve shall remain open while the CW pump continues to deliver water.
 - vii. This operator shall provide 90% closure of the valve in the 5 to 20 seconds variable time duration and balance 10% closure in 20 to 60 seconds variable time duration. Final setting shall be carried out based on the surge analysis.
 - viii. In the hydraulic pack, each valve operation like crack open, fully open, partial close, fully close and emergency close shall be controlled by independent solenoid valve.
 - ix. In case of any fault causing pump motor trip, the corresponding butterfly valve shall start closing at a fast rate initially and thereafter at a slow rate. The emergency closing facilities shall be duplicated each with its own solenoid valve in the hydraulic circuit.
 - x. Provision for local manual operation shall also be made.
 - xi. The lower part of the cylinder shall have a fixed orifice especially designed to achieve a minimum valve closing time in case of failure of oil pipeline.
 - xii. A locking device shall be provided so that the valve can be maintained in open/shut position during maintenance and inspection.
 - xiii. The hydraulic controls for each valve shall be housed in an independent cabinet located in the operating floor near the valve. This shall consist of 2 nos. (1 working + 1 no. standby) pumping unit, oil tank, and accumulator of adequate capacity to hold the valve disc at any position and to prevent any surge including disc flutter during valve travel and to fully open position. Accumulator shall also have enough capacity for one cycle (open & close operation) of operation without external electric AC power. The hydraulic power pack shall consist of necessary pressure switches, pressure gauges, flow regulators, solenoid valves; transformers, rectifiers etc. DC power supply for solenoid valves, contactors, relays, fuses, indicating lamps, push buttons etc. for control of solenoid valves and pumping units; throttle valve, filters, non-return valves etc. shall be arranged in a logical circuit to meet the operation requirement.
 - xiv. The electrical controls for the valve such as relays, contactors and fuses shall be housed in the common control panel (local) for CW pumps or in a separate panel.
 - xv. Each butterfly valve shall have four limit switches, each capable of being set at any point between full open to full close position to meet desired functions. In addition, one more extra limit switch to be set at an intermediate position shall be provided. Each limit switch shall have 2 NO. and 2 NC contacts. Limit switch

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enclosure shall conform to NEMA 4 x standard.

- xvi. Each butterfly valve shall have two nos. non-contact type 24 V DC 4-20 mA output position transmitters.

d) Inspection and Testing for Butterfly Valves

Shop Test

Physical and chemical tests on materials shall be done to ensure the quality of the material offered. Test procedures and sampling shall be guided by the applicable test Codes and Standards. Components for which material test has been done and approved shall be stamped for identification. Mill certificates for the materials for valve casings, support plates, flanges etc. shall be submitted to the Owner.

Visual examination and dimensional check

Hydrostatic test

- i) Body – At twice the pressure rating
- ii) Seat & disc test, Bi-directional – At rated pressure
- iii) Air leak test – 6 kg/sq.cm
- iv) Disc strength test as a design proof test - At twice the pressure rating
- v) Cycle test as design proof – As per AWWA C-504 - 00

Hydraulic actuator

- i) Hydraulic cylinder pressure test – At twice the pressure rating
- ii) Hydraulic cylinder piston seals – At 1.1 times operating pressure
- iii) Hydraulic pumps pressure test – At twice the pressure rating
- iv) Hydraulic pump and motor assembly performance test – Flow Vs Head & Efficiency
- v) Solenoid valve – Pressure test & operational test
- vi) Valve & actuator assembly performance check – 10 cycle operation check (all valve assemblies).

2.10

Rubber Expansion Joint

- i) The design, manufacture and performance of rubber expansion joints shall be in accordance with applicable statutes, regulations and safety codes in locality where the equipment shall be installed. The equipment shall also conform to the latest editions of Fluid Sealing Association.
- ii) For operating conditions and design requirements refer to design data sheet enclosed.
- iii) Features of Construction

• **General**

- All parts of expansion joints shall be amply proportioned for all stresses

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that may occur during continuous operation and for any additional stresses that may occur during installation and also during transient conditions.

- The expansion joints shall be single bellow rubber expansion joints. The arches of the expansion joints shall be filled with soft rubber. The design shall be suitable for the pressure and type of fluid as specified in the Design data sheet enclosed.
- The tube (i.e. inner cover) and the cover (outer) shall be made of natural or synthetic rubber of adequate hardness. The shore hardness shall not be less than 60 deg A for outer and 50 deg A for inner cover.
- The carcass between the tube and the cover shall be made of high quality cotton duck, preferably, square woven to provide equal strength in both directions of the wave. The fabric plies shall be impregnated with age resistant rubber or synthetic compound and laminated into a unit. Reinforcement, consisting of solid metal rings embedded in carcass, shall be provided.
- The split retaining rings shall be of 10 mm thick ASTM A36 or equivalent tested quality stainless steel. Steel washers shall be provided at the bolt holes where retaining rings are split. For de mineralized water service, the retaining rings shall be rubber lined.
- Expansion joints shall be complete with stretcher bolt assembly. The expansion joints shall be suitable to absorb piping movements and accommodate mismatch between pipelines.

- **Main Body**

The expansion joints shall be of heavy-duty construction made of high grade abrasion resistant natural or synthetic rubber compound. The basic fabric for the 'duck' shall be either a superior quality braided cotton or synthetic fiber having maximum flexibility and non-set characteristic.

- **Reinforcement**

The expansion joints shall be adequately reinforced, with solid steel rings, to meet the service conditions under which they are to operate.

- **Retaining Rings**

All expansion joints shall be provided with stainless steel retaining rings for use on the inner face of the rubber flanges, to prevent any possibility of damage to the rubber when the bolts are tightened. These rings shall be of split and beveled type for easy installation and replacement. The rings shall be drilled to match the drilling on the end rubber flanges and shall be in two or more pieces.

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- **End Flanges**

The expansion joints shall have integral fabric reinforced full-face rubber flanges. The bolt hole on one flange shall have no eccentricity in relation to the corresponding bolt hole on the flange on the other face. The end rubber flanges shall be drilled to suit the companion pipe flanges as per data sheet.

- **Outer Cover**

All exposed surfaces of the expansion joint shall be given a 3mm thick coating of neoprene. This surface shall be reasonably uniform and free from any blisters, porosity and other surface defects.

- **Control units**

Each control unit shall consist of two (2) numbers of triangular stretcher bolt plates, a stretcher bolt with washers, nuts and lock nuts. Each plate shall be drilled with three holes, two for fixing the plate on to the companion steel flange and the third for fixing the stretcher bolt.

2.11 CW system piping, recirculation piping & makeup water piping (steel portion)

a) Design And Manufacturing/Requirements for CW piping

- Pipe stubs as required shall be "Set on Stubs" having welded end connection with suitable reinforcement and with flanged and blind flanged fittings.
- The pipes shall be either spiral welded as per the relevant IS or it shall be either rolled and welded as per IS: 3587 out of MS plates.
- Piping laid over-ground shall be supported on concrete pedestals, to be designed and constructed/erected by the Contractor.
- Piping system shall be provided with vacuum rings, if required, to safeguard the system should there be an accidental event of occurrence of vacuum inside the piping. Design criteria for such shall be full vacuum condition.
- Pipes shall be provided with vents and drains at all high and low points respectively.
- The velocity of water in the pipes shall not exceed 2.2 m/s.

b) Construction Requirements

- The bidder shall prepare all the necessary drawings like GA drawings, isometric drawings for construction and get Owner's approval. Welding shall be used throughout for joining pipe, except where flanged, screwed or other type joints are specified. All piping shall be erected true to lines and elevations as per the approved drawings.
- Wherever measuring instruments are located on piping, necessary pipe stub shall be erected by the bidder. In the general routing and layout drawings, irrespective of whether the stubs for measuring instruments are shown therein or not, necessary number of such stubs as per the system requirement shall be

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erected by the successful bidder during execution of contract.

- iii. The Bidder shall properly set-up necessary level plates for erection of piping. The R.L. of any one of these reference plates shall be determined by Owner and intimated to the bidder. Any further transfer of level from that reference plate for erection of piping shall be Contractor's responsibility.
- iv. While erecting the field run of pipes, the bidder shall check the accessibility of valves, instrument-tapping points and maintain minimum headroom requirement and other necessary clearances from the adjoining work areas.
- v. All pipes lines shall be given proper slope towards the drain point. All drips and drain lines for piping whether shown in the drawings or not shall terminate on the ground floor at suitable point near to the surface drain unless otherwise noted.
- vi. Adequate number of flanged manholes shall be provided in 800 NB and above pipes for internal inspection. Fabricated pipes shall be gradually lowered into the excavated trenches with the help of suitable hoists, A-frame, cranes etc. Pipes shall not be rolled down into the trenches.
- vii. Facilities for draining CW pipes including drain pit, submersible drain pump shall be provided.
- viii. Double air release cum vacuum breaker valves with isolation valve of suitable size shall be provided for each of the discharge pipes.

c) Fabrication and installation

Welding

Following welding methods are permissible in the shop or field for general welding, with butt welds being of multi pass construction using filler metal:

- i) Manual Shielded Metal Arc (SMAW)
- ii) Submerged Arc (SAW)
- iii) Gas Tungsten Arc (GTAW)
- iv) Gas Metal Arc (GMAW)
- v) Filler metal for all piping welds shall be of such composition that the deposited metal shall conform to the minimum specification for the base metal.
- vi) Welding shall not be carried out when the surfaces of the parts to be welded are wet from any cause and during periods of rain and high winds unless the welder and work are properly shielded.
- vii) All welds shall be of continuous single V with finished head of size equal to thickness of plate. Pipe circumferential weld shall be done in such a way that the longitudinal welds become staggered in any two consecutive sections. No backing ring shall be used for circumferential butt welds.
- viii) Pipe sections in straight lengths delivered at erection site shall be of largest practicable dimensions/shapes in order to minimize the number of field joints.
- ix) All temporary welded attachments used for erection purposes shall be removed by mechanical cutting or air-arc burning up to a distance of at least 3.2 mm from the base metal to preclude damage. The remainder of the attachment shall be

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ground flush with the base metal surface. Under no condition temporary attachments are to be removed by hammer blows.

- x) All fillet welds shall not be less than the nominal thickness of the thinner member and not greater than 15 mm.

d) Installation/erection

- i. CW piping outside the CW pump house shall be laid below ground with a minimum earth cover of 1.50 m.
- ii. CW piping inside the CW pump house shall be installed on supports/pedestals.
- iii. For details of excavation, back filling and disposal of soil refer Part-D, Section-II of Volume-II.

e) Inspection And Testing

Inspection of all welds shall be carried out in accordance with IS:822- 'Code of Practice for Inspection of Welds'.

Welded joints shall be subjected to following non-destructive examinations:

- (i) Root Pass - 100% DP as per IS:3658/1991
- (II) Final Pass - 10% Radiography at random
- (iii) Acceptance standard shall be ASME /ANSI B 31.1.

f) Wrapping And Coating

i) General

This part of the specification covers the supply of material, application, inspection, testing etc. of external protection for CW piping.

ii) Codes and Standards

- | | | |
|---------------|---|---|
| AWWA C-203-97 | : | AWWA standard for coal tar protective coatings linings for steel water pipe lines- Enamel and Tape-Hot applied. |
| IS 10221 | : | Code of practice for coating and wrapping of underground mild steel pipelines |

iii) Coating System & Thickness

The wrapping and coating system shall consist of surface preparation, applying primer on the cleaned surface, followed by the application of wraps and coats spirally or circumferentially on the surface keeping proper tension and maintaining good adhesion with an overlap of about 12 mm.

The number and thickness of coating shall be conforming to IS 10221 based on prevailing soil resistivity at site Sacrificial anode type cathodic protection shall be provided as per IS: 8062 (Part II) or any equivalent international standard as applicable based on the soil resistivity prevailing at site.

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Surface Preparation

i. General

Before the pipe is blasted, all oil, grease or other contaminants shall be removed by flushing with a suitable solvent and wiping with clean rags. The use of dirty or oily rags or dirty solvent shall not be permitted.

Prior to cleaning operation, the pipes shall be visually examined to ensure that all defects have been repaired or removed.

The abrasive blast material shall be free of impurities such as clay, dirt, debris, oil, grease, salts or other contamination.

All metal surfaces shall be cleaned by blasting. Blasting operations shall remove all rust, scale and other impurities from the steel surface. The surface shall be blast cleaned to near white metal finish as per SSPC SP10. Shot blast operation, if adopted, shall be done using automatic abrasive blasting equipment.

The cleaned and blasted pipe shall be protected from and shall be maintained free of oil, grease and dirt that might fall on the pipe.

ii. Primer

The primer shall be cold applied immediately after the pipes have been blasted and cleaned.

Application of the primer shall be by hand brushing, spraying or other suitable means and shall be in accordance with the instruction for application. It shall be applied at a rate recommended by the manufacturer, in a uniformly thick film free from runs, drips, bubbles, sags, dust, grease or foreign matter.

Primer shall completely cover the circumference of the pipe and all surfaces which are to be coated. Any excess of primer shall be brushed out immediately before the primer sets. The priming coat shall not be applied when the pipe is wet or moist.

During periods of cold weather, when the temperature of the steel is below 7 °C or at any time when moisture collects on the steel, the steel shall be warmed to temperature of approximately 30-38 °C, which shall be maintained long enough to dry the pipe surface prior to application of primer.

All missed spots or areas covered with insufficient primer shall be touched up immediately by hand brushing. Primer which has been applied too heavily such as the base of the welds shall be brushed out before the primer sets.

During or after drying of the primer coat, the pipe shall be handled with care. All reasonable precautions shall be taken to prevent excessive dust deposition on primer pipe.

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Pipes on which the primer after being applied becomes contaminated by dust before it is dry shall be reprimed, or shall be re-cleaned and re-primed. In no case shall third application of primer be made without having removed all the previous coats. The cost of re-cleaning and re-priming shall be borne by the Bidder.

g) Requirements of Coal Tar Enamel Preparation

- i) The solid coal tar enamel, prior to being cut, shall have its surface freed from all contamination of whatever nature and shall then be cut into pieces.
- ii) Enamel shall be delivered to the heating kettles entirely free of all contaminants including pieces of metal, wood, grass, leaves, sand or gravel.

Heating

- i) The coal tar enamel shall be heated in the kettles provided in sufficient number to maintain a continuous supply of hot enamel. Kettles shall be of the mechanically agitated type.
- ii) The kettles or patch pots shall be equipped with fuel oil, kerosene or gas burners.
- iii) Each kettle shall be equipped with an accurate easily readable thermometer.
- iv) While heating, flames from the burners shall be kept low until the enamel on the bottom of the kettle has melted and then agitators shall be started. The flames shall be increased gradually until about one half of the charge has been melted. Full heat shall then be applied until the optimum application temperature has been reached as per instructions of the manufacturer of the enamel. The burners shall then be adjusted to maintain the optimum application temperature of enamel.
- v) Enamel in patch-pots shall be heated with the same care as described above.
- vi) All enamel conveying lines shall be insulated or heated if required using suitable means to maintain the application temperature of coal tar enamel.
- vii) The maximum temperature to which the enamel can be heated and the maximum time the enamel may be held in the kettles at application temperature shall be in accordance with the enamel manufacturer's recommendations.
- viii) Coal tar enamel preparation and supply shall be as per AWWA-C-203-97.
- ix) In the event of an interruption or short shut-down due to weather conditions or other unavoidable causes, the burner flames shall be decreased immediately. The temperature of the charge shall be reduced to approximately 40 °C less than the application temperature until operation starts-up again. The kettle lids shall be kept tightly closed during the shut-down period and the mechanical agitators kept in continuous operation. The enamel shall be drained into suitable clean containers.
- x) Care shall be exercised to ensure that the enamel in the mechanically agitated

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kettles is brought back to the optimum temperature before application is resumed. Enamel which has been previously heated to application temperature then drawn from the kettle or patch-pot may be reheated provided it has been kept clean.

Coating of Straight Sections of Pipes (Coal tar Enamel, Inner Wraps and Outer wrap)

- i) Enamel shall be applied by pouring on the revolving pipe and spreading to the specified thickness. Enamel shall be applied so that each spiral resulting from the spreading operation shall overlap the preceding spiral producing a continuous unbroken layer free from defects, skips or holidays. Operators shall be required to make all necessary adjustments to ensure a continuous layer of enamel without undue loss of temperature at the point of application.
- ii) Defects such as bubbling or foaming shall be a cause for shutting down operations until air pockets have been removed from pumps and supply lines and required adjustment have been completed.
- iii) The first coat of coal tar enamel, glass-fibre mat shall be applied in a continuous end-feed machine, or in a lathe-type machine or by other suitable wrap-application equipment. The roll of glass-fibre mat shall be under tension sufficient to embed the mat in the enamel before the latter sets or cools. The second coat of hot coal-tar enamel shall then be applied simultaneously with the second layer of glass-fibre mat in a manner similar to the one described above. The impregnated outer wrap shall then be applied immediately behind the glass fibre reinforcement in a tight uniform spiral. Similarly the third coat of enamel and glass fibre material shall be applied.
- iv) The overlap at the edges of all wrappings shall be at least 12 mm. The wrapper shall be applied neatly and smoothly with bleed out between laps and shall be free of wrinkles and buckles.
- v) The coating shall be continuous for the full length of the pipe, however cut- back of maximum length of 225 + 25 mm on each end of the line pipe shall be provided.
- vi) When the protrusion of weld seam interferes with this thickness, the thickness of the coating above weld seam shall meet the requirements specified in AWWA-C-203-91.

Coating & Wrapping of Field Joints, Bends & Fittings

- i) In general the procedure to be followed for surface preparation, priming and Coating & Wrapping shall be the same as that specified for straight sections of the pipe except that the application of the coal tar enamel and inner and outer wraps may be manual. However the total thickness of coating & wrapping of the field joints, bends& fittings shall not be less than that of the straight section of the pipe.
- ii) At all the field erected joints, the overlap between the two pipe pieces or bends shall not be less than 50 mm.

White Wash

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The final white wash coat over the outer wrap shall be applied immediately following final inspection and acceptance of the coating and wrapping on each pipe.

h) Materials

- Primer - The primer shall be fast drying synthetic primer for cold application certified to meet AWWA-C-203.
- Coal Tar Enamel - The coal tar enamel shall compose of a specially processed coal tar pitch combined with an inert mineral filler. The coal tar enamel shall conform to AWWA-C-203. The enamel shall contain no asphalt of either petroleum or natural base.
- Inner Wraps - The inner wrap glass fibre reinforcement material shall have a nominal thickness of 0.5 mm (0.020 inch) and shall conform to AWWA C-203. The glass fibre reinforcement material shall be reinforced in the longitudinal direction.
- Outer Wrap - The outer wrap material shall be a coal tar impregnated asbestos felt or glass fibre felt. The material shall conform to the requirements of AWWAC-203-91 Section-2.4.

Samples of the proposed fibre glass reinforcement and impregnated outer wrap along with test certificates as per AWWA C-203 shall be submitted to the Owner for approval prior to the start of the coating operations.

The white wash used as a final coat shall be manufactured in accordance with the "White Wash Formula" as specified in AWWA C-203, Section 2.6.

Requirement of Pre-Fabricated Tape (Alternative to coal tar wrapping and coating)

The pre-fabricated tape shall conform to the following specification:

- Compound : Plasticised coal tar base
- Reinforcement : Synthetic substrate (FRP tissue reinforced with glass fibres).
- Separator : Plastic
- Thickness : Minimum 4.0 mm without any negative tolerance.
- Min. Weight : 1.25 kg/sq.m/mm thickness
- Adhesion Test : It should pass as per AWWA-C-203-97 Section-4.6.8 or IS-10221-1982.

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Holiday Test Voltage : It should pass @ 15 kV (Max.) for 4mm thickness.

Direct Impact Test : It should pass as per BIS.DOC.SMDC and AWWA-C-203 and IS-10221 Insoluble content in Petrol as per (%by weight) IS-2796:1996: 95% minimum

Application of Pre-fabricated tape as an alternative to coal tar wrapping

The tape shall be hot applied.

The primer shall be applied on the cleaned surface of the pipe with a brush in such a manner that it covers the pipe surface well. When the primed pipe surface gets tacky but not DRY, the tape shall be applied spirally on the surface keeping proper tension and maintaining good adhesion with an overlap of about 12 mm.

The tape while being unrolled shall be warmed up by a blowlamp or a gas flame, the surface to be applied on the pipe being heated. The heating shall be done just to soften the compound when a film shall appear on the surface; Excessive heating is to be avoided.

The total thickness of the tape after application shall not be less than 4 mm Sufficient time (at least 48 hours) is to be allowed before undertaking adhesion test.

i) Inspection General

The Owner / Consultant's representative shall test the coating and any repair subsequently made to it. The testing shall be carried out prior to laying of pipes in the trench. Final acceptance of all coating and wrapping work shall be determined by Owner representative. pipes which have been cleaned and primed or coated and wrapped without having been inspected and approved by the Owner inspector shall be rejected.

Holiday Detection

All coated and wrapped pipes shall be subjected to a test with an electric holiday detector as specified in AWWA-C-203-97.

The holiday detector shall be supplied, correctly operated and always maintained in good working condition along with adequate supply of spare parts. Any delay caused by the incorrect functioning of the holiday detector shall not be entertained.

The operating voltage of the holiday detector shall be determined as per IS: 10221.

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Any pipe having three (3) or more holidays shall be rejected. Similarly any pipe having any one holiday bigger than 0.1 m² shall be rejected. All defective places shall be plainly marked with chalk immediately after they are detected visually or by the holiday detector.

For pipe with pre-fabricated tape, the test voltage which the pipe should pass with holiday detector kit is 15 kV for 4 mm thickness coating.

Measuring Coating Thickness

- i) All pipe coatings shall be tested for thickness as per AWWA-C-203-97.
- ii) The thickness shall be measured by pushing the point of an approved pit depth gauge or micro tester through the coating and wrapping.
- iii) The specified minimum thickness shall be present throughout the piping.
- iv) Testing the adhesion of the coating
- v) At least two tests a day shall be carried out on finished coating after 72 hours from completion of coating. The test shall be carried out as per AWWA-C-203-97/IS 10221.
- vi) The areas where the coating has been removed for testing by the inspector shall be repaired by the Contractor at his own expense.

2.12

Design Data Sheets

a) CW & ACW pumps

S.No	Detail	Description
CW Pumps		
1.	Total Number of Pumps	[2x50%] for [..x...] MW units
2.	Number of operating pumps per unit	[2 (Two)] per unit
3.	Number of stand by pump	[1] One Common for both units
4.	Rated Discharge flow of each pump	[.....] cu.m/hr corresponding to 105% of the (CW flow rate for condenser design corresponding to the turbine VWO, 3% MU operating mode
5.	Total Head at rated flow (system Head) *	[.....] m (Static Head + 110% of the Dynamic head)

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S.No	Detail	Description
6.	Operating Speed (Max)	Not more than 350 rpm (Synch.)
7.	Type of pump	Vertical mix flow wet pit pump
8.	Type of Discharge	Mixed Flow
9.	Type of Impeller	Semi-open/enclosed impeller
10.	Type of lubrication	Self Water/
11.	Minimum water level	As given in the existing drawing of "CW pump house plan and section"
12.	Maximum water level	As given in the existing drawing of "CW pump house plan and section"
13.	Normal water level	As given in the existing drawing of "CW pump house plan and section"
14.	Sump Invert level	As given in the existing drawing of "CW pump house plan and section"
15.	Operating floor level (Motor floor level)	As given in the existing drawing of "CW pump house plan and section"
16.	Center line of pump discharge flange	As given in the existing drawing of "CW pump house plan and section"
17.	Maximum Efficiency at design point to be considered for arriving at the guaranteed power consumption at motor terminals and rating of motor	
	a) CW pump	86%
	b) CW motor	96 %
18.	Local Control panel location	CW Pump House
ACW Pumps		
•	Total Number of Pumps	[2x100%] for [..x...] MW units
•	Number of operating pumps per unit	[1 (One)] per unit
•	Number of stand by pump	[1] One Common for both units

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S.No	Detail	Description
•	Rated Discharge flow of each pump	[.....] cu.m/hr corresponding to
•	Total Head at rated flow (system Head) *	[.....] m (Static Head + 110% of the Dynamic head)
•	Type of pump	Vertical mix flow wet pit pump
•	Type of Discharge	Mixed Flow
•	Type of Impeller	Semi-open/enclosed impeller
•	Type of lubrication	Self Water/
•	Minimum water level	As given in the existing drawing of "CW pump house plan and section"
•	Maximum water level	As given in the existing drawing of "CW pump house plan and section"
•	Normal water level	As given in the existing drawing of "CW pump house plan and section"
•	Sump Invert level	As given in the existing drawing of "CW pump house plan and section"
•	Operating floor level (Motor floor level)	As given in the existing drawing of "CW pump house plan and section"
•	Center line of pump discharge flange	As given in the existing drawing of "CW pump house plan and section"
•	Local Control panel location	CW Pump House

Note:

The total head at rated flow specified is equal to total pressure (including velocity head available at the center line of the pump discharge flange) + level difference between minimum water level in the sump to the center line of pump discharge.

b) Rubber Expansion Joint

S.No.	Parameter	CW / ACW Pumps	Raw Water Pumps
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S.No.	Parameter	CW / ACW Pumps	Raw Water Pumps
1.	Quantity	[...]	[...]
2.	Type	Restrained type with tie rods	Restrained type with tie rods
3.	Ends	Flanged, drilled to match the pump discharge.	Flanged, drilled to match the pump discharge.
4.	Maximum working Pressure	Pump shut-off pressure	Pump shut-off pressure
5.	Maximum Flow	As per system requirement.	As per system requirement.
6.	Location	Indoor	Indoor
7.	Material of Construction		
a)	Bellow	High-grade natural rubber compound with neoprene compound outer and inner.	High-grade natural rubber compound with neoprene compound outer and inner.
b)	Carcass	High grade abrasion resistance Natural rubber compound with Reinforcement of canvas rayon implies and steel annular rings.	High grade abrasion resistance Natural rubber compound with Reinforcement of canvas rayon implies and steel annular rings.
c)	Bellow exterior	3 mm thick neoprene compound outer cover.	3 mm thick neoprene compound outer cover.
d)	Bellow interior	3/4 mm thick neoprene compound outer Cover.	3/4 mm thick neoprene compound outer Cover.
e)	Metal reinforcement	SS Steel annular rings.	SS Steel annular rings.
f)	Control rod assembly	Limit rods IS : 1367 Gr. 6.6 - Stretcher plate IS 226/IS:2062	Limit rods IS : 1367 Gr. 6.6 - Stretcher plate IS 226/IS:2062

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S.No.	Parameter	CW / ACW Pumps	Raw Water Pumps
g)	Retaining ring	10 mm thick split ring	10 mm thick split ring
h)	segments	Stainless steel in 4 segments.	Stainless steel in 4 segments.
i)	Counter flanges	IS:2062 fabricated in 4 segments, welded	IS:2062 fabricated in 4 segments, welded
j)	Fasteners	Fixing bolts, nuts with double washers IS: 1363. Bolt property class 4.6 and nut class 4.0.	Fixing bolts, nuts with double washers IS: 1363. Bolt property class 4.6 and nut

c) Butterfly Valve

i. Quantity:

S.No	Description	Quantity for CW & ACW system (min.)	Quantity for RW intake system (min.)
1	[...] mm Electro hydraulic operated BFV for pump discharge	[...]	[...]
2	[...] mm Electric actuated BFV for recirculation pipe	[...]	[...]
3	[...] mm Electric actuated BFV for makeup Valve Station	[...]	[...]
4	[...] mm Gear operated BFV for makeup Valve Station	[...]	[...]
5	[...] mm Electric actuated BFV for pump discharge	[...]	[...]
6	[...] mm Manual gear operated BFV Isolation valve before clarifier	[...]	[...]
7	[...] mm Manual gear operated BFV At the outlet of soft water tank	[...]	[...]

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ii. Construction:

S.No	Material of Construction	Fabricated Construction
1.	Body	2% NiCr to IS:Gr. FG 210 (IS 2062 Gr.B)
2.	Disc	ASTM A 351 Gr. CF8M
3.	Cover plate (top and bottom)	IS 2062
4.	Retainer ring	ASTM A 351 Gr. CF8M
5.	Shaft (top & bottom)	A 216 Type SS 316 or AISI 410
6.	Disc seal	Nitrile Rubber / Equivalent
7.	Bearing	Phosphor or Leaded bronze
8.	Internal bolting	AISI 304
9.	External bolting	IS 1367
10.	Hand wheel and Hand wheel nut	IS 2062
11.	Bottom Cap	IS 2062
12.	O' Ring	Nitrile Rubber
13.	Bearing Bush	IS 318 Gr. LTB2 (SELF LUBRICATED)

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3 WATER TREATMENT AND EFFLUENT TREATMENT PLANT

3.1 General

All the equipment, system and/or components offered by the Bidder shall be of proven type / design with adequate margin (typically 10% on both capacity and head) for operational plant life of [20/25] years.

All valves shall be arranged in the front of the vessel like exchangers and at a height suitable for easy manual operation. In case the height of any hand wheel/lever of a valve is more than 1200 mm above the floor, pedestal for operation shall be provided. However, the Bidder shall provide the hand wheels within 1200 mm to avoid pedestals.

All equipment supplied shall allow access by means of staircase and platforms with hand rails to facilitate connecting up, inspection, maintenance and repair and shall operate satisfactorily under such variations of load, pressure and climatic conditions as may occur in working.

Platform shall be provided at suitable height for easy operation & maintenance of PSF, ACF, SAC, SBA and MB.

Supports for all equipments and platforms, walkways, stairways for access to all equipment, valves etc. shall be provided, as required.

A platform of 1000 mm width interlinking all vessels with staircase shall be provided. The staircase and platform shall have handrails for safe climbing and access.

All platforms and stairways shall have minimum clear width of 1,000 mm. All platforms, stairways, landings etc. shall have railings and guards. Extruded FRP Platforms shall be provided.

Bidder to note that all the values, capacities specified in the design data sheets at the end of this specification are to be considered as final. Any discrepancy in the prevailing sections shall be ignored.

3.2 Codes & Standards

The Design, manufacture, shop testing, erection, testing and commissioning of piping and valves shall conform to the latest revisions of the following codes and Indian Standards or equivalent international codes, in addition to other standards mentioned in the tender documents subject to any modification and requirement as specified hereinafter.

IS : 1520	Horizontal Centrifugal Pumps for clear cold fresh water.
IS : 5120	Technical requirements of roto dynamic special purpose pumps.
API : 610	Centrifugal pumps for general refinery service.
IS : 5639	Pumps Handling Chemicals & corrosion liquids.
IS : 5659	Pumps for process water.

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HIS	Hydraulic Institute Standards, USA
ASTM-1-165-65	Standards Methods for Liquid Penetration Inspection.
IS:1710	Vertical Turbine Pumps for clear cold fresh water.
PTC: 82	Centrifugal Pumps Power Test Code.
IS: 803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks
IS: 816	Code of practice for use of metal arc welding for general construction in mild steel.
IS: 817	Code of practice for training and testing of metal arc welders.
IS: 822	Code of procedure for inspection of welds.
IS:1363	Black hexagonal bolts, nuts and locknuts (dia 6 to 39 mm) and black hexagon screws (dia to 24 mm).
IS:1367	Technical supply conditions for threaded fasteners.
IS:2062	Specification for weldable structural steel.
IS:2002	Steel plates for pressure vessels for intermediate and high temperature service including boilers
IS: 2825	Code of unfired pressure vessels.
IS: 3133	Manhole and inspection opening for chemical equipment.
IS:4049	Specification for formed ends for tanks and pressure vessels
IS:4682	Code of practice for lining of vessels and equipment for chemical processes Rubber Lining.
BS:2594	Specification for carbon steel welded horizontal cylindrical storage tanks

3.3 Pre-Treatment System

3.3.1 Pretreatment plant would be complete with *[(1x100%)]* Conventional Clariflocculator /Solid Contact Clariflocculator with associated chemical storage handling and dosing system, sludge handling system, RCC clarified water storage tank, all piping, valves and instruments.

3.3.2 *[Layout for pre-treatment plant shall be designed by Bidder in such a way that all units (e.g. stilling chamber, flash mixer, clarifier, inlet channel, operating floor etc.) shall be interconnected by at least 1 M wide walkway at appropriate elevations with hand-railing on both sides and stair case at ground level.*

The clarifiers shall be designed to take care of an over loading of 20% over the design flow/capacity.]

3.3.3 Pre-treatment plant shall be designed such that anyone/ all clarifiers can be bypassed if required.

3.3.4 Pre-treatment Plant should be designed to run continuously.

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3.3.5 Only metric codes shall be followed.

3.3.6 Stilling Chamber

The Stilling chamber for the clarifier shall be designed to minimize the turbulence of incoming water by reducing its velocity. Intake water shall be let into the stilling chamber at the bottom end and flow shall be from bottom to top. The velocity of water rise through the stilling chamber shall be $[0.05 \text{ m}^3/\text{m}^2/\text{h}]$ to avoid any turbulence of the incoming water and volume of stilling chamber shall have a retention time of $[1 \text{ minute}]$. Number of stilling chamber, design capacity and material of construction shall be as described in "Technical Data Sheets".

- i) Each of the unit shall be a combination of flash mixer, a flocculation chamber all in a single unit. Design adopting separate flash mixer, flocculation chamber and Settlers/Clarifiers are also acceptable.
- ii) Number of Flash mixers, flocculation chambers, and settlers - design capacity of these items and material of construction shall be as described in "Data Sheets".
- iii) These units shall consist of multiple compartments/zones, viz. flash mixers, flocculation, pre-settling cum clarifier compartment and underflow compartment/zone. The water dosed with coagulant is led into the clarifier's flash mixer compartment, where a turbine type rapid mixer shall be provided to facilitate complete and effective mixing of coagulant in the incoming water. The well-mixed water is led into the flocculation chamber.
- iv) The fine floc particles formed in the flash mixing stage area gently contacted with each other in order to agglomerate them so that large and more rapidly settling particles are produced. A specially designed flocculating mixer shall be provided in the flocculation chamber to enhance flocculation of the feed solids by slow mixing. A portion of the suspended solids shall be separated directly in the pre-settling zone and the remaining flocculated particles are removed in the inclined plate settler. The overflow clarified water is collected in the clarified water storage tank is then filtered in the next stage.
- v) The underflow chamber shall receive the sludge-laden water. Sludge gets settled and is collected in a sludge hopper from which it can be easily discharged. The sludge from the bottom of the clarifier is discharged to the location as described elsewhere.

3.3.7 Flash Mixing Tank

- i) The mixing tank of each clarifier shall consist of one or more compartments each with a vertical shaft rapid mixer. The mixers shall be sized to provide effective rapid mixing for the designed volume. Flash mixer shall be provided with minimum retention time of $[1 \text{ minute}]$ at the design capacity.
- ii) The impeller assembly shall consist of three or four blades bolted to a shaft assembly. The mixer shall be of high shear mixer to accomplish rapid dispersion of the coagulant.
- iii) Rapid mixer to be a single speed mixer comprised of vertical shafted mixer with at least 75% length of the mix chamber height, gear reducer and motor. The mixer shall have an intermediate guide support. All seals and bearings shall be above the water surface.

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- iv) The mixer shaft shall be designed for the maximum power output of the drive unit. The mixer shaft and its bearing shall be capable of withstanding the entire static and dynamic thrust load and radial load with a factor of safety of 2.0.
- v) The mixers drive gear shall be combination of helical and spiral bevel gear reducers constructed to AGMA 420 class II 24 hour service.
- vi) Coagulant shall be dosed in the channel leading to the flash mixer through a distributor.
- vii) A platform shall be provided for the inspection of the flash mixing compartment. Platform floor grating shall be coated for corrosion resistance and access to the platform shall be provided by ladder. A cage shall be included if the ladder exceeds 20 feet. The platform shall have a handrail to protect personnel.
- viii) Suitable sampling connections shall be provided for performance monitoring.

3.3.8

Flocculation Tank

- i) The flocculation tank of the clarifier shall consist of a turbine/propeller type mixer to enable a gentle mixing action. Flocculation Chamber shall be provided with minimum retention time of [15 minutes] at the design capacity.
- ii) Flocculate shall comprise of mixer paddles, variable gear reducer and motor. The mixer paddle shall be designed with a maximum peripheral speed not exceeding 0.6 m/sec.
- iii) The mixer shaft and its bearing shall be capable of withstanding the entire static and dynamic thrust load and radial load with a factor of safety of 2.0. The gear drive must be built in accordance AGMA 420 class II 24 hour service.
- iv) The mixer shaft shall have a rigidly mounted intermediate support/s. All seals and bearings shall be above the water surface.
- v) Flocculation mixing tank shall have a chemical injection pipe connection for injection of polyelectrolyte directly below tank.
- vi) A platform shall be provided for the inspection of the flash mixing compartment. Platform floor grating shall be coated for corrosion resistance and Access to the platform shall be provided by stair case. The platform shall have a handrail to protect personnel.
- vii) Suitable sampling connections shall be provided for performance monitoring

3.3.9

Clarified Water Storage Tank and Pump House

The water from the main clarifier would be stored in a Clarified Water Tank.

One no. clarified water storage tank shall be provided along with clarified water pump house. Clarified water pump house shall accommodate CT make-up pump, DM plant supply pumps, Chlorination water pumps, service water pumps, APH wash pumps, fire fighting pumps etc. The clarified water storage tank shall be provided with access rungs and dewatering pits.

3.3.10

PT Plant Clarifier Sludge Disposal System

- i) One number sludge pit shall be provided to collect the sludge from all the clarifiers.

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- ii) [2 x 100%] thickener feed pumps will pump the sludge to [1 x 100%] capacity sludge thickener. [2 x 100%] centrifuge feed pumps will supply the sludge from sludge thickener to the centrifuge. Clear water from the thickener and centrifuge will be led back to the guard pond. The centrifuge shall be located at a suitable height to enable truck disposal. [1 x 100%] centrifuge with transfer chute will be envisaged for disposing the sludge into the trucks.
- iii) Each section of the sludge pit shall be provided with agitation by recirculation (jetting nozzles) system and air agitation system.

3.3.11 Filter Backwash Water Disposal System

Filter backwash water shall be led to the sludge pit. The bidder shall supply all necessary pumps, piping, valves and other accessories as required to transfer this water back to the sludge pit.

3.3.12 DM Plant Supply Pumps

[Three Nos. (3x 50%)] with minimum capacity of [100 cum/hr] shall be provided to supply clarified water from DM clarified water tank to DM Plant.

The total dynamic head (TDH) of the pumps shall be obtained by conducting detailed system resistance calculations. A minimum of ten (10) percent margin shall be provided on the calculated frictional losses.

3.3.13 Softening Plant [if Applicable]

- i) The softening plant will consist of three streams with each stream consisting of [four (4) softeners (3 working and one stand by)]. Hence in total the softening plant will consist of [twelve (12) softeners (9 working and 3 standby)]. The regeneration time is [8 hours].
- ii) Sodium Sulphite dosing system will be provided to dechlorinate the clarified water before inlet of the softeners.
- iii) [Four (4) (3W + 1S)] softening plant supply pumps will supply clarified water to the softeners. These pumps will take suction from the clarified water storage tank and supply clarified water to the softeners.
- iv) Sodium Chloride will be used for regeneration of the softeners. The regeneration system will consist of salt storage facilities, salt saturators, brine solution preparation cum measuring tanks, salt transfer pumps, salt regeneration pumps and spent brine recirculation system.
- v) Salt will be unloaded from trucks and stored in a salt saturator. [The salt saturator will be divided into four compartments with each compartment to store one week's salt solution requirement of one stream of softeners (4 Nos.)]. Each compartment will be provided with water jet piping all around the compartment. The water will be tapped from service water pump discharge so as to impinge the jet of water on the salt in order to prepare the salt solution at a concentration of 26%. Water jet nozzles will be mounted suitably so as to dissolve the complete salt unloaded into the compartments. From the salt saturator, the salt solution will be led into a common inlet channel from where the salt solution will flow to salt filters by gravity. The filters will be of gravity type. Filter backwashing will be tapped off from the softener supply pump. After filtration, salt solution will be

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stored in an underground fresh brine sump. From the fresh brine sump, salt solution will be pumped using fresh brine transfer pumps to brine measuring tanks in the softening plant.

- vi) Spent brine recirculation system consisting of spent brine storage sump and spent brine recirculation pumps and piping will be provided to reduce the fresh brine consumption.
- vii) Soft water will be stored in a soft water storage tank. From this tank, make up to CW forebay will be fed by gravity through HDPE piping. A tapping shall be provided in the tank.
- viii) 1 no. Flow meter in one of the makeup water lines
- ix) Salt regeneration waste from the softeners will be led through drains to the plant effluent guard pond.
- x) Sulphite Dosing System
Sodium Sulphite dosing system will essentially include but not limited to the following
Two nos. Sodium Sulphite solution preparation cum measuring tanks with the tank capacity each to store one day's requirement of the total softening plant capacity with motorised agitators and dissolving basket, drains, overflow arrangement, level switch, level gauge etc.
[Two (2) (2 x 100% cap.)] Sodium Sulphite dosing pumps with drive motors.
Three Nos. resin transfer units, one for each stream.
- xi) Four salt (three compartments normally working and one stand by) saturator compartments, with each compartment to store one week's brine solution requirement of one stream of softeners. Each compartment will store brine solution at a concentration of 26%.
- xii) [Four (4) Nos.] brine filters of gravity type (three normally working and one stand by) for filtering salt solution. Each filter will have a capacity of [100 m³/h] of salt solution.
- xiii) [2 x 100%] capacity filter air blowers for brine filters. In addition to this a connection from service air line with an isolation valve shall also be provided.
- xiv) Fresh brine storage sump of capacity one day's regeneration requirement of all softeners.
- xv) [3 x 50%] fresh brine transfer pumps to transfer brine solution from fresh brine storage sump to brine measuring tanks. The capacity of the pump will be sized to transfer brine required for two softener regenerations in [30 minutes].
- xvi) [Three (3) nos]. brine preparation cum measuring tanks with each tank to store two softener regenerations. Two tanks will normally be in operation and one will be a stand by.
- xvii) [3 x 50%] fresh brine regeneration pumps with each pump to cater to two softeners.
- xviii) Mixing tees and accessories.
- xix) Spent brine recirculation arrangement (at a ratio of 70:30 for optimizing on the salt consumption) consisting of a spent brine recirculation tank of capacity to

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store spent brine from one stream regeneration. 3 x 50% capacity spent brine recirculation pumps to cater to one stream regeneration.

- xx) Soft water storage tank (RCC) shall be two compartments of effective capacity [5000 m³].

3.3.14 Performance Guarantee Parameters for Pre-Treatment Plant

Bidder to guarantee the following parameters for Pre-Treatment Plant:

Clarified Water Output : [....] m³/h

Turbidity at the outlet of Clariflocculator. : ≤ [....] ppm

Turbidity at the outlet of Filter : ≤ [....] ppm

3.3.15 Test to be conducted at Site

All the sub-systems covered under Pre-Treatment Plant shall be checked for the performance guarantees in a manner acceptable to the Owner. The PG test shall be conducted after successful commissioning of the unit. The bidder shall demonstrate pre-determined gross output and effluent analysis during PG Test. If any of these is not achieved, the bidder shall rectify the plant at his own cost within specified days of notification and test the plant again for performance guarantee. All needed standard calibrated instruments and devices shall be arranged by the Bidder as required.

3.4 Demineralization (DM) Plant

- a) Clarified water shall be pumped to Pressure Sand Filters (PSF), Activated Carbon Filter (ACF), weak acid cation exchanger (if applicable), Strong Acid Cation Exchanger and Degasser. One portion of Filtered Water from ACF is stored in filtered water Tank for Potable Water use. After Degasser, water is collected in the degassed storage tank. Degassed water pumps will feed water to the Weak Base Anion (if applicable), SBA and Mixed Bed. Final DM water is collected in the DM storage tank.
- b) Backwashing of Pressure Filters shall be done using filtered water from the filtered water tank located above the DM plant building. Backwash waste water shall be disposed to the sludge sump of PT plant.

Potable water System

- c) [2 x 100%] duty potable water supply pumps shall draw water from Filtered Water storage tank and shall supply water to the various consumers up to the terminal points indicated by providing necessary pipelines, valves etc. Adequate chlorine shall be dosed in the tank before pumping.

Potable water lines with valves shall be provided for the different users of this package.

d) General Requirement

- i. All the vessel internals of ion – exchanges units and Degasser units such as inlet distributor, regenerant distributor, under drain system etc. shall have proven design.

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- ii. In case strainer-on-plate design is used for under drain system, an additional manhole in addition to as specified in the Technical data sheet shall be provided to give access below the bed plate for all units of filters, ion exchange units etc.
- iii. All valves used with vessels shall be suitably arranged in the front in accessible position, for manual operation in case of emergency.
- iv. The valves under automatic operation of Water treatment and Effluent Treatment Plant shall be operated pneumatically by diaphragm actuator. Valves shall be spring to close or spring to open or double acting type as may be required by process consideration. The valves on effluent outlet as well as regenerant inlet of filters and ion-exchangers shall be of spring to close (Air to open) type only. Limit switches shall be provided for all the valves.
- v. Rotary type actuators for butterfly valves are also acceptable.
- vi. All streams shall be designed to run continuously at its rated capacity and simultaneously under parallel operation.
- vii. Suitable permanent flushing connections shall be provided for all pipelines carrying acid and alkali.
- viii. All the tanks shall be provided with vent, overflow, drain and sample connections. Effective capacity for chemical tanks & water retaining structures/tanks/sumps means the capacity between the bottoms of the overflow nozzle to the top of the outlet nozzle. Outlet nozzle centre line shall be kept at least 200 mm from the Invert Level of the chemical tanks / water retaining structures / tanks/sumps. A minimum free board of 300 mm shall be provided in all the water retaining structures of PT Plant (such as stilling chamber, all the channels, Clarifiers, Clarified water storage tank, filtered water reservoir, filtered water sump, sludge sump, backwash water collection sump, etc) above the maximum water level / overflow level as the case may be excluding the thickness of the slab / beam thickness if any.
- ix. For all pumps, while calculating the pump head, 10% margin shall be considered on friction losses.
- e) **Pressure Sand Filters (PSF)**
 - i. PSF shall be designed for surface flow rate not more than 15 m³/ m²/h.
 - ii. The inlet distribution and under drain collecting system shall be so designed as to give uniform distribution and flow without channeling and obstruction. The under drain system may either be of header lateral or manufacturer's standard design to be approved by the Owner.
 - iii. Number of filters to be backwashed at a time and Service cycle (duration of operation of filters between two successive backwashing of filters) shall be as specified in Technical Data Sheet. Requirement of backwashing shall be identified from differential pressure drop across filters or based on totalized filtered water treated by respective filters.
 - iv. Air blower shall be used for air scouring of filter bed. Specified airflow rate shall be checked and air blower of adequate sizes accordingly shall be provided for the type of sand being used as filter media.
 - v. The bed depth, excluding support material, shall be minimum 1200 mm and at least 75 % free board shall be provided over the bed depth.

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- vi. Back washing of the filters should be done once in [20 hrs] using filtered water.
- vii. The design backwash water quantity shall not exceed 2% of the treated water flow over service cycle of each filter.
- f) **Activated Carbon Filters**
 - i. ACF shall be designed for surface flow rate not more than 15 m³/hr/ m².
 - ii. The bed depth, excluding support material, shall be minimum 1200 mm and at least 75 % free board shall be provided over the bed depth.
 - iii. The inlet distribution system shall be header lateral type. The vessel shall be lined internally with rubber lining back washing of activated carbon filters should be done once in [20 hrs] using filtered water.
- g) **Ion Exchange Units**
 - i. The inlet distribution, under drain collecting systems and regenerant inlet distribution system / middle collector shall be so designed as to give uniform distribution and flow without channeling and obstruction. The inlet distribution system shall preferably be header lateral type. Material of construction shall be mild steel with rubber lining (MSRL)
 - ii. Under drainage system shall be header lateral or strainer-on-plate type. In case of header lateral system, header shall be mild steel "rubber lined inside" (MSRL) and lateral of polypropylene.
 - iii. For Mixed-Bed Exchanger, separate distributor shall be provided for influent and regenerant entry. The influent and alkali regenerant distributor and acid regenerant distributor shall be as per design data sheet.
 - iv. The interface collector & distributor shall be of suitable acid / alkali resistant material. The under drain collector system shall be header lateral or strainer-on-plate type and shall be adequately designed to ensure uniform distribution of flow.
 - v. The regenerant distributor and middle collector shall be as per design data sheet. All internal studs / nuts / washers shall be of AISI 304 L for alkali service and Hastelloy-B for acid service.
 - vi. At least 100% free board shall be provided over resin bed below the backwash outlet nozzle and in straight portion of vessel to allow for expansion during backwashing and for addition of extra resin, if required.
 - vii. Suitable sample connection shall be provided for all the units.
 - viii. All the Ion Exchangers shall be provided with two additional nozzles for hydraulic transfer of resin as and when necessity arises. The nozzle shall be provided with manual valves of 100 mm NB.
 - ix. Each exchanger unit shall be provided with resin traps on treated water outlet line. Resin traps shall also be provided both on the backwash and regenerant outlet lines. The resin trap in these backwash and regenerant lines shall be flanged at one end and will be connected at end of the respective pipeline. The other end shall be open to the drain so that the flow can be seen to check the chocking of the trap.
 - x. Surface Flow Rate for Ion exchangers shall be as indicated in Technical data sheets.

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h) **Regeneration System**

- i. The period between regeneration shall be 20 hours for WAC, SAC, WBA, SBA. The period between regenerations for MB shall be 7 days.
- ii. The ion exchange resin shall be regenerated by employing optimum regeneration level to prevent leakage of ions. Cation resins shall be regenerated by hydrochloric acid (30-33% w/v technical grade IS: 265) and anion resins by sodium hydroxide (48% w/v rayon grade in flakes or lye form as per IS: 252). The strength of acid regenerant and alkali regenerant at the cation and anion bed inlet shall be selected accordingly.
- iii. The process calculation shall be furnished by the bidder in the bid indicating the various steps of regeneration, regeneration level employed, total and used exchange capacity of resins, resin quantity provided etc. The bidder shall also furnish relevant resin literature & curves indicating various parameters and exchange capacity & regeneration levels selected along with the process calculations in the bid.
- iv. Further the bidder during detailed engineering is required to furnish process calculation along with the operating exchange capacity and regeneration levels vetted by resin manufacturer and the resin performance curves applicable for this plant.
- v. Regeneration facilities offered shall be complete with acid/alkali measuring tanks, ejectors for dosing of chemicals as specified. Acid or alkali from the measuring tank shall be injected to exchangers by means of hydraulically operated ejector at suitable strength as specified in Technical Data sheets.
- vi. Automatic block and bleed valves shall be provided at the regenerant inlet line(s) to each exchanger of Mixed (MB) Bed.
- vii. Suitable sampling connection shall be provided for acid/ alkali storage, preparation & handling equipments.

i) **Exchange Resin**

- i. Cation and anion resin shall be of reputed make and must have been in use capable of producing water of quality as specified or better.
- ii. Cation and anion resin charge shall consist of material properly selected washed, processed and graded to provide the guaranteed capacity and life and shall have adequate abrasion resistance during its guaranteed life.
- iii. The cation exchanger resin used in the mixed bed exchanger shall be strongly acidic, high capacity polystyrene resin in the bead form.
- iv. The anion exchanger resin used mixed bed shall be strongly basic, high capacity resin (Type-I) in bead form. The anion resin shall be able to withstand a temperature of 60 °C (minimum) continuously.

j) **Degasser System**

- i. Degasser tower shall be designed to reduce dissolved CO₂ in treated water to the level as indicated in the guarantees. Blowers shall be provided to remove CO₂ from water.
- ii. A storage tank to store degassed water shall be provided for the two degasser towers.

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- iii. Degassed water pump shall be provided to supply water to the downstream exchangers in the chain.

k) **Drain Neutralization System**

The neutralization pit shall be of RCC construction in twin compartment. Minimum effective storage volume of each pit shall be sufficient to store all waste water from one cation, anion and mixed bed unit with 50 % margin. However the minimum effective capacity of [.... m³] shall be provided. Provision of baffles shall be made to mix the wastes by recirculation and acid/alkali dosing. A pipe network with holes of required diameter, connected to MB Blowers shall be laid at the bottom of neutralization pit for mixing the effluent before discharge.

- i. The capacity of waste recirculation and disposal pumps shall be selected as per the requirement of emptying one neutralizing pit in maximum three hours.
- ii. The capacity of each acid/alkali measuring tank shall be sufficient to hold acid/alkali for one neutralization with 30% margin.

l) **Performance Guarantees of DM Plant**

Bidder to guarantee the following parameters for DM plant:

DM Water Quality

Conductivity : 0.1µs/cm maximum

Total Silica : 0.01ml/l as SiO₂

pH : 6.8-7.2

Period between regeneration : 20 hrs

Output between regeneration : [.....] m³ net/stream

100% Acid Consumption : [.....] liter/regeneration/stream

100% NaOH Consumption : [.....] liter/regeneration/stream

m) **Tests to be conducted at Site**

All the sub systems covered under DM Plant shall be checked for the performance guarantees in a manner acceptable to the Owner. The PG test shall be conducted after successful commissioning of the unit. The bidder shall demonstrate pre-determined net output and effluent analysis during PG Test. If any of these is not achieved, the bidder shall rectify the plant at his own cost within specified days of notification and test the plant again for performance guarantee. All needed standard calibrated instruments and devices shall be arranged by the Bidder as required.

n) **DM Water storage tanks**

Two Nos. each of [1500 m³] capacity shall be provided. These shall be vertical, cylindrical, shell type atmospheric tanks with flat bottom. These tanks shall be complete with 500 mm dia manholes, overflow, air vent, drain, sample connections, CO₂ absorber, float type level indicator, staircase, platform, interconnecting both tanks with platform, handrails rungs inside the tank etc. Additional outlet connections shall be for connecting additional DM water pumps. Calculations for tank thickness shall be

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submitted for approval. Tank level control shall be provided for dry running protection of DM water pumps.

3.5 Service Water System

a) System Description

The general service water system shall be designed to distribute service water to the various users throughout the plant. The service water pumps will take suction from clarified water tanks. The discharge pipe and its branch-offs will form the distribution bus to cater requirements at various location.

[Three (3) nos. service water pumps (2 working + 1 standby)] shall be provided to meet the makeup water requirement for CHP, HVAC makeup and other service water requirement of the. A recirculation line between the service water pumps outlet and clarified water tank shall be provided. Service water pipelines are to be provided in the terminal points indicated for various users in the relevant section. Service water pipelines are also to be distributed among the different users of this package.

b) Design Criteria

Service water system shall operate on continuous basis. Accordingly, the bidder shall make provision of recirculation from pumps discharge line with suitable regulating valve.

The pumps and their drives shall also meet the requirements specified elsewhere in the specification for water System Pumps.

3.6 Effluent Treatment Plant

a) General

The Wastewater System [common for all the units] shall provide collection, treatment and utilization of treated water as per the process mentioned under Clause 3.6 c). The treated water (permeate of RO System) shall be recycled to CW system / raw water reservoir. The reject of RO System shall be used for dust suppression, ash slurry conveying, gardening and other purposes.

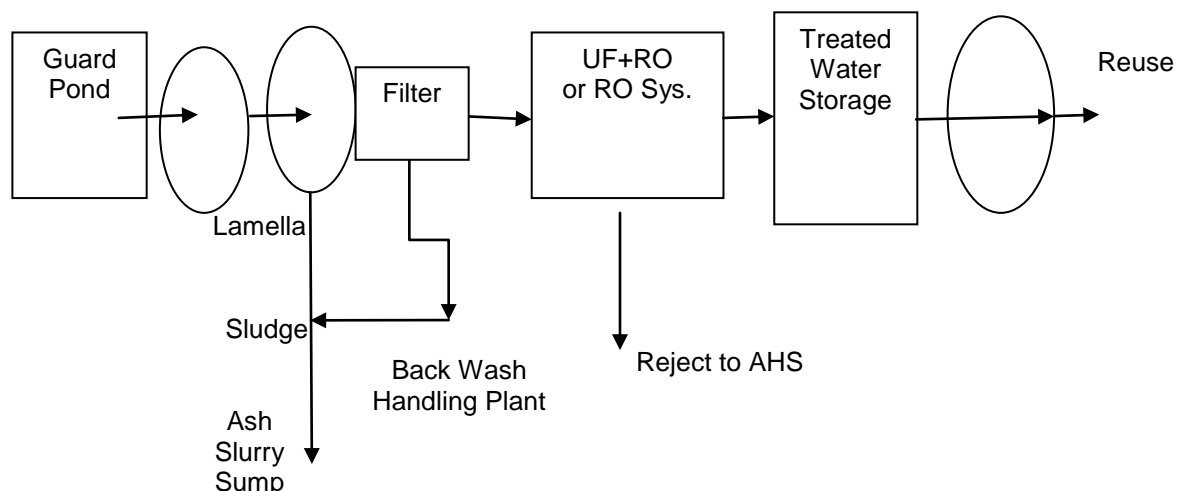
The source of the plant wastewater (Effluent) includes the following:-

- i) Clear water from Oily Water Separator.
- ii) Excess Cooling Tower Blow Down
- iii) DM plant regeneration waste from Neutralization pit.
- iv) Waste water from softening brine filters.
- v) The steam condensate drains of blow down tanks shall be terminated at Guard pond by others.
- vi) Clear water from CHP.
- vii) Miscellaneous equipment and chemical drains.

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- viii) Effluent disposal pumps [(2 x 100%) (capacity each ... m³/h, head of ... mwc)] shall be provided in a structural roof shed for pumping the Guard pond water to further gardening and other purposes.
 - ix) Treated effluent pumps [(2 x 100%) (Capacity each m³/h), head of ... mwc] shall be provided in a structural roof shed for pumping the clear water from oil water separator to Guard pond.
 - x) pH correction system consisting of acid dilution cum measuring tank and alkali dilution cum measuring tank with [2 x 100%] acid dosing pumps and [2 x 100%] alkali dosing pumps with all relevant discharge valves and interconnecting piping up to the guard pond.
 - xi) One number hand pump will be provided for filling up of chemicals from jerry cans (packaged container) to the dosing tanks will be provided. This pump will be separately provided for acid and alkali.
 - xii) The Guard Pond shall be a ground level reservoir of RCC construction, open at top, with 2.5 to 3.0 m water depth with necessary counter forts etc., and crack free design with MS hand rail all around. The internal surface shall be treated with solvent free epoxy coating. The guard pond shall be of [3000 m³] capacity with two compartments. Minimum free board of 300 mm shall be provided.
- b) Storage, Handling and Dosing Facilities
- Dosing system shall be provided as per the details indicated in the design data sheets.
- All the dosing equipment will be housed [in the PT Chemical house (Two storied)]. This building will be adequately sized to store all the Chemicals at least for seven days operation. Suitable handling provision, adequate ventilation, illumination and disposal/ drainage arrangements shall also be considered in this building for these chemicals.
- c) Process of Treatment of Effluent
- The surplus process effluent water collected in the guard pond is to be treated and reused for zero liquid discharge (ZLD) plants. To achieve this treatment system, comprising of following (as minimum) shall be provided.
- The Capacity of the treatment system shall not be less than the design quantity of surplus effluent as per the plant water effluent.
- i) Lamella Clarifier Feed Pumps (1Working+1Standby)
 - ii) Lamella Clarifier with its dosing system
 - iii) Pressure/Gravity Filter (One Standby)
 - iv) Reverse Osmosis (RO) System (2x50% streams or (UF+RO) System (2x50% streams) each with their dosing, cleaning and flashing system.

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- v) Minimum recovery from UF & RO streams shall be [90%] and [80%] respectively.
- vi) Maximum TDS at the outlet of RO shall not exceed [7 ppm].
- d) Performance Guarantee Parameters for Effluent Treatment Plant
The major effluent limits at the outlet of RO system of ETP shall be as under:
 - Total dissolved solids- < [...] ppm
 - pH-[...]
- e) Test to be conducted at site
All the sub systems covered under ETP shall be checked for the performance guarantees in a manner acceptable to the Owner. The PG test shall be conducted after successful commissioning of unit. The bidder shall demonstrate effluent analysis during PG Test. If any of the performance guarantees is not achieved, the bidder shall rectify the plant at his own cost within specified days (elsewhere) of notification and test the plant again for performance guarantees. All needed standard calibrated instruments and devices shall be arranged by the Bidder as required.

3.7 Common Equipments

3.7.1 Water System Pumps

Water system pumps shall be either vertical or horizontal type centrifugal pumps with directly coupled drive motor. Unless otherwise specified in the respective clause, the water system pumps shall meet the following requirements:

a) Design and Construction

Pumps shall be of vertical shaft, submerged suction, mixed flow / radial flow design complete with bowl, column and head assembly and drive assembly or pumps shall be of horizontal, centrifugal type. Replaceable shaft sleeves shall be

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furnished. The shaft sleeve shall be securely locked to shaft to prevent loosening while in operation. Replaceable type wearing rings shall be provided for both casing and the impeller. The pumps shall be equipped with vacuum tight mechanical seals.

Water for motor cooling and thrust bearing cooling, if required, shall be tapped from the pump discharge. The pump suction bell diameter shall be such as to limit the flow velocity at the maximum flow to within 1.5 m/sec.

Drive motor shall be directly coupled to the line shaft of the pump. The pump shall be provided with an approved mechanical device to prevent reverse rotation on loss of drive motor power and failure of discharge valve to close, except where specified otherwise.

All continuous running centrifugal pumps shall be provided with Pneumatic operated valves for both suction and discharge.

The Water System pumps shall conform to the following requirements:

Type	Centrifugal, Horizontal	Centrifugal, Vertical
Casing	Axially split type	Volute
Impeller type	Closed	Axial / mixed flow
Drive transmission	Direct coupled	Directly mounted on top
Seal	Mechanical seal/ Self water/ gland	Mechanical seal/ Self water/ gland
Lubrication	Oil/Grease/Self liquid	Oil/Grease/Self liquid
Coupling	Spacer type	Spacer type
Operating range	40% to 120% of rated flow	40% to 120% of rated flow
Pump characteristic	Non overloading type & stable	Non overloading type & stable
Shut off head	About 15% more than rated head	About 15% more than rated head

b) **Materials of Construction**

The materials furnished below are indicative only. Bidder shall select the specific material for particular service to suit the quality of water to be handled, unless otherwise specified in the respective section.

Type	Horizontal, Centrifugal
Impeller	SS 304
Casing	CI to IS 210 Gr. 260
Shaft & Shaft Seals	SS 304
Shaft sleeve	SS 410
Impeller & Casing Rings	SS 304
Bolts	Cadmium plated high tensile steel
Nuts	Cadmium plated high tensile steel

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Type	Horizontal, Centrifugal
Base plate	Fabricated steel to IS 2062

3.7.2**Piping, Valves & Fittings**

All the piping systems shall be designed to operate without replacement and with normal maintenance for an estimated plant service life of [20/25] years and shall withstand the cyclic fluctuations in the operating parameters which can be normally expected during the service life.

Please refer relevant section for further details.

This section of specification covers all low pressure piping handling fluids like raw water, clarified water, potable water, cooling water, DM water, LDO, Compressed air etc.

a) Design Basis

Pipe lines carrying water, chemicals, air etc. shall be sized generally for the following range of velocities.

Service	Below 50 mm	50-150 mm	200 mm & above
Pump suction	-	1.2 - 1.5	1.2 - 1.5
Pump discharge	0.8 - 1.0	1.2 – 1.8	1.5 - 2.5
Header	-	1.2 – 1.8	1.5 - 2.5
Compressed air below 2 Kg/cm ² (g)	10 – 15	10 – 20	10 – 25
Compressed air 2 Kg/cm ² (g) & above	10 – 20	10 – 25	15 – 25

Pipe line under gravity flow shall be restricted to a flow velocity of 1 m/sec generally. Channels under gravity flow shall be sized for a maximum flow velocity of 0.6 m/sec.

For calculating the pump head, at least 10% margin shall be provided over the pipe friction losses.

b) Piping Materials and Sizes

All piping system shall be capable of withstanding the maximum pressure and temperature in the corresponding line. The pressure rating of individual piping system component such as valves, flanges etc shall however be not less than that specified.

c) Fittings

Fittings to be used for all types of piping shall conform to relevant IS/BS ANSI Standards and in conformity with the parent pipe standard.

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Inside surface of all the fittings used for the rubber lined application shall be made suitable for rubber lining.

Galvanised pipe application- fittings shall be galvanised as per IS: 4736.

d) **Following items shall be included for piping under this package:**

- i) Pipes, bends, elbows, tees, branches laterals, crosses, reducing unions, couplings, cap, expansion joints, flanges, blank flanges, saddles, shoes, sampling connections etc. necessary for making a reliable piping system.
- ii) Valve, gates, dampers, etc.
- iii) Strainers and filters.
- iv) Instrument tapping connection, stubs and thermo-wells, root valves.
- v) Matching flanges, pipe spools and matching pipes to connect to equipment, instruments, etc. as necessary.
- vi) Gaskets, ring joint, bracing rings, jointing material etc. as required.
- vii) Bolts, nuts, fasteners as required for interconnecting piping, valves and fitting as well as for terminal points.
- viii) Pipe supports like pedestals, Anchor blocks (for buried / over ground piping), brackets, hangers, clamps, trestles, etc.
- ix) Secondary steel for pipe supports and embedded steel. Also pipe supports and necessary embedment required to be embedded in concrete for underground/above ground pipes.
- x) Painting, anti-corrosive coatings, wrapping and coating, thermal insulation, etc. inside and outside of pipes as necessary.

e) **End Connections**

Unless otherwise specified, following types of end connections shall be used:

- i) Pipes 50 NB and smaller shall have socket welded joints for chlorine line. For water, air and other services where steel pipes are used, joints of this size range shall be Socket welded/screwed/flanged type (for rubber lined pipes).
- ii) All unlined steel pipes, 65 NB and above (other than CI pipes and air service pipes) shall be jointed by butt welding. All rubber lined pipes shall have flanged joints.
- iii) Butt welding edge preparation shall be done as per ANSI B 16.25. The Bidder shall furnish all welding electrodes and welding rods including special ones, if any.
- iv) Steel pipe flanges shall be generally slip on flat face type. Weld neck flanges shall be used when flange follows immediately after a butt welding or where it is required with respect to service conditions. When weld neck or socket weld flanges are used, their bore must be made the same as that of the pipe being welded to. Socket welded or threaded flanges may be used, with the appropriate piping system for connection of pipe to the flanged equipment.
- v) All the piping flanges and counter flanges shall conform to ANSI B 16.5 Cl. 150 (minimum).
- vi) For easy handling & removal of equipment, valves etc. and for maintenance purposes, break up flanges for 65 NB and above sizes and suitable type of

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compression flexible coupling for flanged joints of 50 NB and below size shall be provided. The over ground piping wherever routed inside building, shall have a clear head room of minimum 2.0 metre from operating floor.

f) **Piping Layout**

- i) Pipes shall be generally routed above ground but where specifically indicated/specified, the pipe may be laid in trenches or buried. Buried piping shall be generally installed so that the top of pipe is 1.0 metre below the ground level unless otherwise specifically mentioned. At the road crossings, the underground pipes shall be laid minimum 1.5 metre below the ground level. Full length of buried piping shall be provided with 100 mm thick sand bed.
 - ii) Except raw & circulating water pipes no other buried pipes are acceptable.
 - iii) Complete supporting system for the pipe line shall be designed, fabricated and supplied by the Bidder. Inside the building, the overhead portion of the pipe line may be supported from the building structures. No support shall be taken from the brick wall. Outdoor, pipes other than buried pipes shall run on steel trestles. Crossing of the road shall be on a pipe bridge with a clear height of at least 6.5 metres (minimum) over the road surface. All the steel structure for the pipe bridge, and the supporting posts/trestles along with all necessary hangers, clamps, connecting steel, fixing bolts, nuts etc. shall be supplied and erected by the Bidder. All pipe racks shall be provided with 750 mm (Minimum) clear width walkways.
 - iv) Hangers and supports shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting strength and allow pipe line movements as necessary. All guides, anchors, braces, dampener, expansion joint and structural steel to be attached to the building/structure, trenches etc. shall be provided.
 - v) Mitre bends shall not be accepted for steel pipes of 250 NB and below. For sizes 300 NB and above, the mitre bends shall conform to BS: 534.
 - vi) For rubber lined pipes of acid service, lining should be applied in two (2) layers, giving a total thickness not less than 3 mm.
 - vii) Pipe coming under purview of IBR should meet its requirements and getting the IBR approval shall be under bidder's scope.
 - viii) A commercial grade of 'E' type glass fibre should be used conforming to IS: 11320-1985 IS: 11273-1985 IS: 11551-1986, IS-12709, 1994 for Glass Fibre Reinforced Plastic Pipes (GRP pipe). No glass fibre reinforcement shall penetrate the interior surface of pipe line. Each pipe length shall have sufficient strength to withstand Class AA type vehicular loading in addition to the overburden of backfill load. The pipeline shall be designed for 2500 N/M2 stiffness class (min.).
- g) **Valves**
- i) All valves shall be suitable for service conditions i.e. flow, temperature and pressure under which they are required to operate. The valves shall be of standard pressure rating as per the relevant code/ standard.
 - ii) Either Butterfly type or sluice/gate valves shall be used for isolation purposes in raw water, Clarified & Filtered water application. Butterfly valves shall be of

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double flanged or lugged water type of low leakage rate confirming to AWWA-C-504 class 150 or EN-593 Class 150.

- iii) Manually operated valves shall be provided with reduction gear unit for valves of size 250 NB and above. Valve provided with motorised or pneumatic actuator shall be provided with a hand wheel for manual operation.
- iv) All the valves shall be equipped with adjustable mechanical stop-limiting devices to prevent over travel of the valve disc in the open and closed positions. The valve operators (Hand wheel or Gear reduction unit or Motor actuator etc.) shall be designed as per relevant International Standard.
- v) Ball valves or Globe Valves may also be provided for the application of Raw/ Clarified / Filtered water services for sizes 50 NB and below.
- vi) Butterfly valves or proven patented diaphragm valves shall be used for the services of demineralised water application for isolation purposes.
- vii) Plug valves shall be used for the application of lime slurry /lime solutions.
- viii) Sluice valve/knife edge type slide valves shall be used in the sludge and drain pipe line.
- ix) For air services, globe valves or ball valves may be used for sizes 50 NB and below. For sizes higher than 50 NB, either Butterfly valve or Ball valves shall be used.
- x) Check valves for Raw / Clarified / Filtered water may be offered in Gun metal construction and with threaded ends for sizes 50 NB and below conforming to IS: 778 or Equivalent.
- xi) For Chlorinated water application check valve of Lift Ball type may be used in PVC construction (in case of PVC pipes). In case of rubber lined pipes, the check valves of swing check type shall be of lined construction.
- xii) The safety valves / relief valves at the downstream of positive displacement type metering pumps shall be of the standard type manufactured by the pump manufacturer and the material of construction shall suit the fluid handled.

S.No	Service	Type of Valves and Material of Construction
1	Dematerialized water	<p>Piping pressure rating # 150</p> <p>Type of Valves</p> <p>For Isolation</p> <p>a) Butterfly or Saunder's Patented Diaphragm Valves up to DN 200 mm.</p> <p>b) Butterfly type for Sizes DN 250 mm & above</p> <p>For Regulation /Control</p> <p>a) Globe type for Sizes up to DN 50 mm.</p> <p>b) Globe or Butterfly type for Sizes DN 65 mm to 200 mm</p> <p>For non-return / Check</p> <p>a) Lift Check type / Swing Check / Dual Plate type for sizes up to DN 40 mm.</p> <p>b) Swing Check or Dual Plate type valve for sizes DN 50 mm</p>

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S.No	Service	Type of Valves and Material of Construction
		<p>& above</p> <p>Material of Construction Valves:</p> <p>Diaphragm Valves</p> <p>a) Body shall be Cast Iron to IS : 210 Gr FG 260 OR Cast Steel to ASTM. A 216 GR. WCB and Body shall be internally lined with Soft Natural rubber, Ebonite or Polypropylene</p> <p>b) Diaphragm shall be Reinforced rubber, Hypalon/approved equivalent</p> <p>c) Stem, Compressor& Bush shall be Stainless steel Construction</p> <p>d) Hand wheel shall be of Cast Iron</p> <p>Butterfly Valves</p> <p>a) Body shall be Cast Iron to ASTM A 48 Cl.40; BS:1452 Gr.220 SG Iron -BS:2789.;Cast Iron IS:210 Gr.FG260 OR Cast Steel to Cast Steel -ASTM. A 216 GR. WCB; BS:1504 Eq. OR Fabricated Steel as per ASTM A515 Gr.60/80 IS:2062, Gr.B/IS:2002.Gr for higher sizes as specified in Technical Specification and <u>Body shall be internally lined with natural rubber, Ebonite or Polypropylene</u></p> <p>b) Disc shall be Cast Iron IS:210, Gr.260; Cast Iron– ASTM A 48 Cl.40; BS:1452, Gr.220, SG Iron -BS:2789 OR Cast Steel -ASTM A 216 Gr. WCB; BS:1504 Eq.Gr OR Fabricated Steel as per ASTM A515 Gr.60/80 IS:2062, Gr.B/IS:2002 higher sizes as specified in Technical Specification and <u>Disc shall be internally lined with PVDF, natural rubber or Polypropylene.</u> Alternatively Disc of Stainless Steel -316 construction is also acceptable.</p> <p>c) Shaft shall be of Stainless steel to ASTM. A 296 Gr. CF8M/AISI 316/ AISI 420 /BS 970 Gr.316; BS:970 Gr.420 S45.</p> <p>d) Seat rings shall be Nitrile rubber or Hypalon</p> <p>Globe Valves</p> <p>a) Body & Disc shall be Cast iron : IS:210 Gr FG 260 or Eqvt <u>and internally lined with natural rubber, Ebonite or Polypropylene.</u></p> <p>b) Stem shall be Stainless steel AISI 410/ 13% chrome steel</p> <p>c) Packing shall be PTFE</p> <p>d) Seat & Seat rings shall be Nitrile rubber or Hypalon</p> <p>e) Hand wheel shall be Cast Iron or Eqvt</p> <p>Check Valves</p> <p>a) Body & Cover, Hinge Disk/Door shall be Cast Iron IS:210 Gr. FG 260 / BS:1452 Gr.220 or Eqvt and <u>shall be lined with natural Rubber, PTFE or Viton or Stainless Steel – 316</u></p>

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S.No	Service	Type of Valves and Material of Construction
		<p>b) Hinge Pin and Door/Disc Pin shall be of Cast steel ASTM A 216 Gr. WCB and shall be coated with PVDF, or suitable elastomer or Stainless Steel – 316</p> <p>c) Disc facing ring and Body Seat rings shall be Stainless Steel</p> <p>d) Bearing bushes shall be SS – 316. e) Material of construction of spring in dual type valve shall be of INCONEL or better</p>
2.	Acid (Hydrochloric) Service	<p>2.1 – Type of Valves For Isolation Diaphragm Valves For non-return / Check Flap type/Swing Check type /Dual Plate type</p> <p>2.2 -Material of Construction Valves: Diaphragm Valves a) Body shall be Cast Iron to IS: 210 Gr FG 260 OR Cast Steel to ASTM. A 216 GR. WCB and Body shall be internally lined with Soft Natural rubber, Ebonite or Polypropylene b) Diaphragm shall be shall be of reinforced TEFLON, EPDM/Black Butyl/approved equivalent c) Stem, Compressor & Bush shall be Stainless steel Construction d) Hand wheel shall be of Cast Iron Check Valves a) Body & Cover, Hinge Disk/Door shall be Cast Iron IS:210 Gr. FG 260 / BS:1452 Gr.220 and internally lined with natural Rubber, PTFE or Viton or Hastalloy –B b) Hinge Pin and Door/Disc Pin shall be of steel with PVDF, or suitable elastomer c) Disc facing ring and Body Seat rings shall be SS – 317 L or resilient materials such as natural rubber, PTFE or Viton d) Bearing bushes shall be PTFE or Equivalent e) Material of construction of spring in dual type valve shall be of INCONEL or better</p>
3.	Alkali Services	<p>3.1 – Type of Valves For Isolation Diaphragm Valves For non-return / Check Swing Check type /Dual Plate type</p> <p>3.2 -Material of Construction Valves: Diaphragm Valves a) Body shall be Cast Iron to IS: 210 Gr FG 260 OR Cast Steel to ASTM. A 216 GR. WCB and Body shall be internally</p>

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S.No	Service	Type of Valves and Material of Construction
		lined with Soft Natural rubber, Ebonite or Polypropylene b) Diaphragm shall be shall be of reinforced Neoprene/Hypalon/ /approved equivalent c) Stem, Compressor & Bush shall be Stainless steel Construction d) Hand wheel shall be of Cast Iron Check Valves The complete valve shall be of stainless steel construction (AISI-316)
4.	Coagulant Aid (Ferric Chloride), Anti-Oxidant& Anti-Scalant	4.1 – Type of Valves For Isolation a) Diaphragm Valves b) Ball Valves in CPVC pipeline For non-return / Check Swing Check type /Dual Plate type
		4.2 -Material of Construction of Valves: Diaphragm Valves a) Body shall be Cast Iron to IS: 210 Gr FG 260 OR Cast Steel to ASTM. A 216 GR. WCB and Body shall be internally lined with Soft Natural rubber, Ebonite or Polypropylene or Stainless Steel b) Diaphragm shall be shall be of reinforced Neoprene/Hypalon/ /approved equivalent c) Stem, Compressor& Bush shall be Stainless steel Construction. d) Hand wheel shall be of Cast Iron Ball Valves in CPVC Pipe lines a) Body , Ball & stem shall be of CPVC b) Seat ring & Packing shall be EPDM / or equivalent Check Valves The complete valve shall be of stainless steel construction (AISI-316)
5.	Chlorinated Water Service	5.1 --Type of Valves a) Butterfly Type / Ball Valve in CPVC lines b) Diaphragm Valves in rubber lined steel pipes
		5.2 --Material of Construction Butterfly / Ball Valves a) Body : CPVC b) Shaft : Carbon Steel Nickel plated c) Disc/ Ball Stem : CPVC d) Seating Rings : Viton

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S.No	Service	Type of Valves and Material of Construction
		e) Packing (Ball Valve) : PTFE f) Bush / O-ring (Butterfly type) : PTFE Diaphragm Valves a) Body shall be Cast Iron to IS: 210 Gr FG 260 OR Cast Steel to ASTM. A 216 GR. WCB and shall be internally lined with Soft Natural rubber, Ebonite or Polypropylene b) Diaphragm shall be shall be of reinforced rubber /Hypalon/ approved equivalent c) Stem, Compressor & Bush shall be Stainless steel Construction d) Hand wheel shall be of Cast Iron

3.8

Design Data Sheet

Water Pre-treatment, Clarified Water Distribution System

i)

Stilling Chamber

Items	Specification
Number	[One (1) per clarifier]
Purpose	To dampen out any turbulence of the incoming water and for prechlorination.
Material	R.C.C.
Capacity	Shall be suitable to provide minimum [five (5) minutes] retention time to react with chlorine.
Specialties	Suitable draining arrangement shall be provided for the stilling chamber and drain lines shall be extended up to the sludge pocket for final disposal to the common sludge sump. Pre-chlorination of raw water shall be carried out at stilling chamber.

Bidder shall provide suitable nos. of diffusers at stilling chamber.

ii)

Flash Mixer

Items	Specification
Number	[Two (2) nos., one for each clariflocculator]
Type	Rectangular with vertical baffles
Material of Construction	R.C.C.
Agitator	
Type	Motor driven through reduction gear
Number	One for each flash mixer

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Items	Specification
Isolation gates along with hand wheels	At the Inlet and Outlet as well as in between the flash mixers to isolate any one of them and for change over and/or maintenance.
Capacity, each	Suitable to provide minimum [one (1) minute] retention time
Draining	Suitable sludge draining arrangement shall be provided for each flash mixers upto nearest sludge man hole for final disposal to common sludge pit/pits.

iii) **Solid Contact Type Clarifier**

Items	Specification
Material of inlet from flash mixer to Flocculation tank	Hume pipe as per IS:458, P1Class
Number required	[Two (2)] Each shall be capable of handling maximum designed flow rate and reducing turbidity to the specified limit.
Type	[Solid Contact Type]
Material of Construction	R.C.C.
Rated net output capacity	[....m ³ /hr]
Guaranteed output	Oil free, Turbidity < 20 NTU (at rated capacity)
Retention time (minimum)	[50 minutes]

iv) **Softening Plant [(if applicable)]**

Items	Description
System Designation	Softening Plant for CW System
Number of Streams	[Three]
Number of Units per stream	[4 (3W+1S)]
Total number of Softeners	[12]
Tag Numbers	[.....]
Location	inside RCC building
Materials of Construction	
Shell and Dished Ends	IS 2062 Gr,B/IS 2002 Gr.2 with 4.5 mm thick rubber 3x1.5mm thick lining with 65±5 scale-A

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Items	Description
External Painting	As per painting section mentioned elsewhere.
Design Data	
Mode of operation	Auto
Design Net Capacity per unit	[... m ³ /hr]
Net output between regenerations	[... m ³]
Type of Regeneration	Co Flow
Type of Resin	Strongly Acidic (Sodium Form)
Regeneration Temperature	Ambient
Total Hardness in outlet water	< 50 mg/l as CaCO ₃
Shell and Dished Ends end thickness	As per IS 2825, 6 mm for shell and 8 mm for dish min/ASME Sec. VIII Div 1
Design Pressure	[...] kg/cm ² (g) and full vacuum
Test Pressure	[...] kg/cm ²
Pressure drop across unit including valves, specialties and instruments	[...] mwc (max)
Rotameter	One per unit or one per stream online or bypass rotameter required

v)

DM Clarifier (If Applicable)

Items	Specification
Material of inlet from flash mixer to Flocculation tank	Hume pipe as per IS:458, P1Class
Number required	[One (1)] and shall be capable of handling maximum designed flow rate and reducing turbidity to the specified limit.
Type	[Solid Contact type]
Material of Construction	R.C.C.
Rated net output capacity	[...] m ³ /hr

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Items	Specification
Guaranteed output	Oil free, Turbidity < 20 NTU (at rated capacity)
Retention time (minimum)	30 minutes for flocculation zone and 150 minutes for clarification zone

vi)

Sludge thickener feed Pumps

Items	Specification
Number	[Two (2) nos., normally one (1) working and one (1) stand-by.]
Type	Vertical Sump Pump
Location	Indoor, at sludge sump-cum pump house.
Liquid to be pumped	Sludge water mixtures
Rated Capacity	[...] m ³ /hr
Duty	Intermittent, suitable for parallel operation
Range of operation	70% to 120% of rated capacity
Design standard	As per IS 5659 & IS 5120
Material of Construction	
Casing	Double Casing
Casing	CI 210 Gr. FG 260
Impeller	SS316
Shaft sleeve	SS316
Stuffing box	ASTM A-743 Gr.CF3m or equivalent standards
Impeller shaft	SS 410
Pump Motor Selection	While selecting the motor for Criteria pump, 15% (min.) margin over BKW of Pump at rated duty point shall be taken and standard motor with next higher kW rating available shall be selected. This shall in no way be less than maximum power required by pump.
Instrumentation	
Pressure Gauge	One (1) no. for each pump (with sealing diaphragm)
Interlock required for Pump operation	Yes

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vii)

Sludge Thickener and Centrifuge

S.No	Items	Specification
1	Thickener	
	Quantity	[1 x 100%]
	Capacity	Bidder to provide as required based on the consistency. However the minimum capacity will be [... m ³ /h].
	Minimum Consistency at outlet	6%
2	Centrifuge Feed Pumps	
	a) Number	2 x 100%
	b) Type	Screw Type
	c) Materials	Stator: CI: IS 210 Gr. FG 260, Rotor: SS 304 and Shaft: SS 410
	d) Capacity	Bidder to provide based on the system requirement. However the minimum capacity will be [... m ³ /h].
	e) Head	By Bidder
	f) Fluid to be handled	Thickened Sludge
3.	Centrifuge	
	Type	Bowl
	Quantity	2 x 100%
	Capacity	Bidder to provide as required based on the consistency. However the minimum capacity will be [... m ³ /h].
	MOC of centrifuge	SS 304 wetted parts with tungsten carbide lining
	Minimum Consistency at outlet	20%

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viii) **DM Plant supply pumps and Service Water Pumps**

Items	Specification			
Service	Clarified Water	Clarified Water	Clarified Water	Clarified Water
Designation	DM Plant Supply Pump	Service Water Pump	Service Water for in-plant consumption	Softening Plant supply pumps
Duty	Continuous	Continuous	Continuous	Continuous
Location	Indoor	Indoor	Indoor	Indoor
No. of Pumps required	[Three (3)]	[Three (3)]	[Two (2)]	[Four (4)]
No. of Pumps working	[Two (2)]	[Two (2)]	[One (1)]	[Three (3)]
No. of Pumps Standby	[One (1)]	[One (1)]	[One (1)]	[One (1)]
Liquid handled	Clarified Water	Clarified Water	Clarified Water	Clarified Water
Design Water Temperature	50 °C	50 °C	50 °C	50 °C
Normal water level (m)	Bidder to indicate based on specification guidelines	Bidder to indicate based on specification guidelines	Bidder to indicate based on specification guidelines	Bidder to indicate based on specification guidelines
Minimum water level (m)	By Bidder.	By Bidder.	By Bidder.	By Bidder.
Maximum water level (m)	By Bidder.	By Bidder.	By Bidder.	By Bidder.
Pump performance requirements :				
Performance Standard	IS -6595 Part I/equivalent	IS -6595 Part I/equivalent	IS -6595 Part I/equivalent	IS -6595 Part I/equivalent
Minimum Flow capacity,	[... m ³ /h]	[... m ³ /h]	By bidder	By bidder
Speed. RPM	By Bidder	By Bidder	[... m ³ /h]	[... m ³ /h]
Total dynamic head (mlc)	By Bidder	By Bidder	By Bidder	By Bidder
Range of operation	Preferably between 70% to 130% of	Preferably between 70% to 130% of	Preferably between 70% to 130% of	Preferably between 70% to 130% of

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Items	Specification			
Service	Clarified Water	Clarified Water	Clarified Water	Clarified Water
	rated capacity	of rated capacity	rated capacity	rated capacity
Design and constructional features :				
Design standard	IS-6595 Part I	IS-6595 Part I	IS-6595 Part I	IS-6595 Part I
Pump type	Horizontal Centrifugal	Horizontal Centrifugal	Horizontal Centrifugal	Horizontal Centrifugal
Impeller type	Closed	Closed	Closed	Closed
Reverse flow through pump to be considered for pump design	Yes	Yes	Yes	Yes
Type of gland lubrication and sealing	By Bidder	By Bidder	By Bidder	By Bidder
Type of coupling	Flexible	Flexible	Flexible	Flexible
Bearing cooling	By Bidder	By Bidder	By Bidder	By Bidder
Material of construction :				
Casing	BS3468 GR S2W or any other equivalent standards	BS3468 GR S2W or any other equivalent standards	BS3468 GR S2W or any other equivalent standards	BS3468 GR S2W or any other equivalent standards
Impeller	ASTM A-743 Gr.CF3m or any other equivalent standards	ASTM A-743 Gr.CF3m or any other equivalent standards	ASTM A-743 Gr.CF3m or any other equivalent standards	ASTM A-743 Gr.CF3m or any other equivalent standards
Shaft sleeve	By Bidder	By Bidder	By Bidder	By Bidder
Shaft bearing	By Bidder	By Bidder	By Bidder	By Bidder
Base plate	By Bidder	By Bidder	By Bidder	By Bidder
Stuffing box	ASTM A-743 Gr.CF3m or any other equivalent standards	ASTM A-743 Gr.CF3m or any other equivalent standards	ASTM A-743 Gr.CF3m or any other equivalent standards	ASTM A-743 Gr.CF3m or any other equivalent standards

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Items	Specification			
Service	Clarified Water	Clarified Water	Clarified Water	Clarified Water
Impeller shaft	SS 316	SS 316	SS 316	SS 316

DM Plant

Items	Specification
No. of DM Streams	[Two]
No. of parallel streams	[Two (2)]
No. of working streams	[Two (2)]
No. of standby streams	[Nil]
Water source	Filtered Water
Installation	Indoor
Normal operation	Semi-automatic
Net permeate water output	[... m ³ /h] minimum from two streams

i)

Pressure Sand Filters

Items	Specification
No. of filters in the system	[Two (2)]
No. of filters working	[Two (2)]
Time between successive back washing	[20 hours]
Filtering material	Sand and Anthracite
Design code	IS 2825/ASME Sec. VIII Div.I
a. Feed Flow / module (Net output)	[... m ³ /h]
b. Design surface flow-rate at normal condition	15 m ³ /m ² /hr
c. Pressure indicator	
Location	Inlet and outlet of each unit
Number	Two (2) per unit
d. Flow indicator	
Location	Inlet of each unit
Number	One (1) for each unit
Type	Rotameter

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Items	Specification
e. Backwash water source	Filtered water from filtered water storage tank
f. Inter connection of units	Outlet of filters shall be connected to a common header so that any one of filter can be used for any stream
Material of Construction	
Filter vessel	MS as per IS: 2062 Gr.B/2002 Gr.2
Rubber lining	4.5 mm (3 layers of 1.5 mm)
Hardness	65 ±5 Shore A to IS 4682 Part I
Frontal piping	MS as per IS: 2062

ii)

Activated Carbon Filters

Items	Specification
No. of filters in the system	[Two (2)]
No. of filters working	[Two (2)]
No. of standby filters	[Nil]
Time between successive back washing	[20 hours]
Filtering material	Activated Carbon
Design code	IS 2825/ASME Sec. VIII Div.I
Net Flow	By bidder
i) Design surface flow-rate at normal condition (Maximum)	15 m ³ /m ² /hr
ii) Pressure indicator	
Location	Inlet and outlet of each unit
Number	Two (2) per unit
i) Flow indicator	
Location	Inlet of each unit
Number	One (1) for each unit
Type	Rotameter
ii) Backwash water source	Bidder to indicate
iii) Inter connection of units	Outlet of filters shall be connected to a common header so that any one of filter can be used for any stream

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Items	Specification
Material of Construction	
Filter body	MS as per IS: 2062 Gr.B/2002 Gr.2
Rubber lining	4.5 mm (3 layers of 1.5 mm)
Hardness	65 ±5 Shore A to IS 4682 Part I
Frontal piping	MS as per IS: 2062

iii)

Air Blowers

Item	Specification
Numbers	[Two (2)] for Pressure Sand Filter
Service	Air required for Pressure Sand Filter
Type	Centrifugal, oil free
Duty	Continuous
Capacity, each for Pressure Sand Filter	100% requirement
Head to be developed	By Bidder.
Material of construction	
Casing	CS
Lobes / impeller	CS to BS 970, EN9 Forged
Shaft	CS to BS 970 EN 9 forged
Safety valve	SS/Brass
Testing & inspection	
Material test required	Casing, Impeller / Lobe, shaft
Code for testing	IS 4894
Rotor balancing	Required.

iv)

Filtered Water tank (Potable)

Items	Specification
a) Service	Potable water
b) Number	One (1)
c) Effective capacity	[...] m ³
d) Type	Vertical, Cylindrical
e) Design Code	IS-803
f) Location	Above DM Plant Building
g) Free board, mm (minimum)	300 mm

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Items	Specification
h) Bottom shape	Flat bottom
i) Material of construction	MS to IS 2062
j) Inside protection	Suitable epoxy paint to achieve a minimum 200 micron.
k) External painting	As per painting section indicated elsewhere.
l) Overflow, drain and sample connection	Required
m) Manhole (Davit type)	Required of size 500 mm
n) Special Fittings	
• Seal for overflow	Required
• Additional nozzle connections	Required
• Conservation vent valves	Required
• Air breather with KoH seal	Required
• Special feature	Required
o) Instrumentation	
• Level indicator	[Two (2)]
• Type	Dial
• Level switch	Three(3 nos – high, low & very low along with potential free contacts and connection to DAS of main plant
• Level integrator transmitter	One(1) no with signals for connection to DAS of main plant
p) Associated piping	Bidder to indicate

v)

Potable Water Supply Pumps

Item	Specification
Service	Filtered Water
Designation	Potable Water Supply Pump
Duty	Continuous
Location	Indoor
No. of Pumps required	[Two (2)]

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Item	Specification
No. of Pumps working	[One (1)]
No. of Pumps Standby	[One (1)]
No. of Pumps working parallel	-
Liquid handled	Filtered Water
Design Water Temperature	
Pump performance requirements :	
Performance Standard	IS -6595 Part I/equivalent
Min. Flow capacity, (Cu.M/Hr.)	8
Speed. RPM	By Bidder
Static head of pumping system (MLC)	Refer to Notes below
Pump shut off head (MLC)	Bidder to indicate
Range of operation	Preferably between 70% to 130% of rated capacity
Design and constructional features :	
Design standard	IS-6595 Part I
Pump type	Horizontal Centrifugal
Reverse flow through pump to be considered for pump design	Yes
Material of construction :	
Casing	BS3468 GR S2W or any other equivalent standards
Impeller	ASTM A-743 Gr.CF3m or any other equivalent standards
Stuffing box, glands, and lantern ring	ASTM A-743 Gr.CF3m or any other equivalent standards
Pump Shaft	SS 316
Performance test required for determining	H Vs. Q curve, P Vs. Q curve, N Vs. Q curve NPSH Vs. Q curve

vi) **DM Plant Ion Exchange Vessels**

Items	Specification		
Description	Strongly acidic cation exchanger (SAC)	Strongly basic anion exchanger (SBA)	Mixed bed exchanger (MB)
Pressure Vessels			

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Items	Specification		
Description	Strongly acidic cation exchanger (SAC)	Strongly basic anion exchanger (SBA)	Mixed bed exchanger (MB)
Type	Vertical, welded, cylindrical shell type, dished ends		
Number required	[Two (2) nos. both working]	[Two (2) nos. both working]	[Two (2) nos. both working]
Net outflow/unit,	[... m ³ /h]	[... m ³ /h]	[... m ³ /h]
Vessel Details			
Design surface flow rate	30 m ³ /m ² /hr	30 m ³ /m ² /hr	40 m ³ /m ² /hr
External painting	As per painting specification - DFT 200 micron		
Material of Construction			
Shell material	Carbon steel as per IS-2062 (with 3 layers of 1.5 mm each (total 4.5 mm) rubber lining)		
Dished ends	Boiler quality steel as per IS-2002 Gr. 2A		
Code for design and fabrication of vessel	ASME Sec VIII Division I & IS 2825		
Design Pressure, kg/cm ² (g)	Shut-off head of DM plant Supply pump plus static suction head with 5%margin over the sum total of shut-off and static suction head	Shut-off head of Degassed water pump plus static suction head with 5%margin over the sum total of shut-off and static suction head	Shut-off head of Degassed water pump plus static suction head with 5%margin over the sum total of shut-off and static suction head
Hydrostatic test Pressure	1.5 times design pressure		
Design Temperature			
Influent Distributor material of construction	SS-316/MSRL	SS-316/MSRL	SS-316/MSRL
Interface Collector			
Material of construction	SS-316/MSRL	SS-316/MSRL	SS-316/MSRL
Location	150 mm below the top of total resin bed i.e. at the interface of inert and effective resin beds	150 mm below the top of total resin bed i.e. at the interface of inert and effective resin beds	At interface of cation & anion resin beds
Regenerant Distributor : material of	MSRL / Hastelloy-C	MSRL	For caustic : SS-316 For Acid : MSRL

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Items	Specification		
Description	Strongly acidic cation exchanger (SAC)	Strongly basic anion exchanger (SBA)	Mixed bed exchanger (MB)
construction			
Under Drain System			
Type	Header Lateral or strainer on plate, designed to avoid any non-uniformity of flow		
Special Feature	For strainer on plate system, an additional manhole shall be provided to give access below the bed plate. For header lateral system, no sub fill shall be used which may come in contact with water		
Cleats for internal supports	SS-316		
Resin Traps	Two (2) nos. Carbon Traps required	Two for each vessel. One at backwash & rinse outlet and the other at service outlet	
Manhole	Two (2) in each vessel (minimum). Davit type. Size : minimum 500 mm		
Hand hole	One (1) in each vessel of minimum 150 mm size for taking out inside media		
Sight Windows	Two (2) nos minimum in each vessel (one at resin top level and the other in backwash space). Two (2) nos minimum in each vessel (one at resin top level and the other in backwash space).	Three (3) nos. minimum for each vessel, one at backwash space, one and other at interface of cation & anion resins.	
Fill material	Strongly acidic cation exchange resin	Strongly anion exchange resin	Strongly acidic cation exchange resin and strongly basic anion exchange resin.
Bed Depth			
Effective (Minimum), mm	1000	1000	Cation Resin: 500 Anion Resin: 500
Buffer, mm	100 (At the bottom of effective resin bed)	-	
Inert, mm	150 (At top of effective bed)	150 (At top of effective bed)	-
Supporting Medium, mm	-		
Percentage (of bed depth) Free board to be provided for	80%	100%	
Note: (Chemical consumption for inert and buffer layers shall not be included under the guaranteed chemical consumption figures)			
Regenerant	HCL	NaOH	HCL & NaOH
Regeneration Mode	Counter current	Counter current	Co-Current
Regenerant Injection			
System	By water jet ejector. Power	By water jet ejector.	By water jet ejector.

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Items	Specification		
Description	Strongly acidic cation exchanger (SAC)	Strongly basic anion exchanger (SBA)	Mixed bed exchanger (MB)
	water shall be taken from discharge header of Degassed water pumps	Power water shall be taken from outlet header of strongly basic anion exchangers	Power water shall be taken from outlet header of Mixed Bed.
Material of Construction	Hard ebonite lined.		
Dilution ratio	Suitably selected by the bidder to ensure desired concentration for dosing.		
Accessories	Each ejector shall be provided with flow indicator on power water supply line as well as flow indicator (with contacts for interlock) on discharge line. Temperature indicator on each discharge line shall be provided for caustic dosing line to anion exchangers.		
Regeneration level	By Bidder.		
Thickness of Shell and Dished End		6mm and 8mm	
Instrumentation			
Inlet flow rate indicator			
Type	Bypass rota meter		
Number	One / unit		
Flow indicator integrator, indicating recorder			
Location & type	At the outlet line of each unit. Integrator electronic type with digital display, 6 digits with counter manual reset type, indicator analogue type, recorder continuous analogue type.		
Numbers	One (1) / unit		
Whether panel mounted	Yes, with local flow rate indicator only		
Indication	At panel with interlock. The integrator alarm set point shall be independently manually adjustable.		
Differential pressure transmitter			
Location	Outlet of each unit		
number	One per unit		
Conductivity Indicator			
Sensing element	At service end and rinse outlet		
Number	Two / unit		
Alarm required	Yes, with necessary interlock		
Location	At panel, with digital indication		
Local indication	Required		
Conductivity Comparator			
Number	One / unit		
Location	At panel with digital display of conductivity value		
Alarm required	Yes, with interlock		
Conductivity measured	Across cation buffer layer		

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Tender Document for R&M of Unit No.[..] of [Name of the Power Plant]	[Logo of Utility]
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Items	Specification		
Description	Strongly acidic cation exchanger (SAC)	Strongly basic anion exchanger (SBA)	Mixed bed exchanger (MB)
Location indicator facility	Required for service water conductivity		
Conductivity monitor complete with cell			
Sampling	Outlet of unit and rinsing line for each unit		
Number	Two (2) per unit		
Indication, alarm and interlock	Required on panel, with LED digital display		
Recorders	Required for service line		
Local indication	Required for conductivity		
Silica analyzer recorder			
Sampling point			Outlet of each MB unit
Number			One analyser, with analyser output recorder and automatic stream selection facility
Whether panel mounted			Yes, analyser to be housed in a separate cubicle.
Alarm & indication			At panel with LED digital display facility and interlock.
pH recorder			
Sampling points			Outlet of MB units., common
Number			One with pen recorder along with panel pH indication facility
Alarm indication and recorder			At panel
Local indication			required
Sodium analyser			
Location	Outlet of units with changeover facility		
Number	One (1) for three (3) units		

vii) **Air Blowers for MB exchanger and Neutralization Pit**

Item		Specification		
Numbers		[Two (2)]		
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Item	Specification
Service	Air required for Mixed Bed
Type	Centrifugal, oil free
Duty	Continuous
Capacity of each blower for Mixed Bed	100% requirement
Head to be developed	By Bidder.
Material of construction	
Casing	CS
Lobes / impeller	CS to BS 970, EN9 Forged
Shaft	CS to BS 970 EN 9 forged
Safety valve	SS/Brass
Testing & inspection	
Material test required	Casing, Impeller / Lobe, shaft
Code for testing	IS 4894
Rotor balancing	Required.
Accessories required	
Common base plate (MS lubricated) Foundation bolts	Required
Suction filter suction and discharge silencers / dampers	Required
Vibration isolators, anti vibration pad	Required
Coupling guard, pulleys	Required
Safety and non return valve	Required
Oil seals, plugs, bearings, inspection door etc.	Required

viii) **Degasser Tower (DGT)**

Items	Specification
Number required	[2x50%] mounted on degassed water storage tank.
Type	Forced draft type, vertical, cylindrical packed column with counter current flow of water and air.
Normal flow rate per tower	As required
Maximum & minimum capacity	120% and 20% of normal capacity
Fill material	Polypropylene Packing rings

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Items	Specification
CO ₂ content in	Not more than 5 ppm as CO ₂ effluent water
Design Code	IS-803
Location	Outdoor
Size (Diameter x height)	Suitable to ensure specified treated water quality. Adequate effective internal cross-sectional area shall be provided to handle the required flow at minimum velocity.
Distributors and Collectors	Non clogging, non-corrosive type. Designed to distribute water in uniform manner and water should cascade over the packing elements.
Manhole (Davit type)	Minimum one (1) no. 500 mm NB
Staircase, Platform and Hand Rails	Required. To be mounted on RCC platform over the degassed water storage tank.
Material of Construction (Shell, Distributors, collectors, Nozzles etc.)	CS to IS 2062 or SA 515 Gr. 70
External painting	Two (2) coats of epoxy based primer required followed by three (3) coats of epoxy finish paint. DFT 200 micron
Inside Protection	Rubber lining
a) Shell	Natural rubber - 4.5 mm thick in 3 layers
b) Distributors, Collectors	Rubber lined .
Degasser air discharge duct	Suitably extended to avoid acid water dripping on nearby buildings and vessels

ix)

Degassed Water Storage Tank (DGWT)

Items	Specification
Number required	One (1)
Design Code	ASME Section-VIII Div.1.
Location	Outdoor
Type	Horizontal Cylindrical shell type with dished ends.
Useful capacity	[...] m3
Free Board	Minimum 300 mm
Material	Carbon steel with rubber lining (natural rubber - 4.5 mm) in 3 layers.

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Items	Specification
External Painting	Epoxy finish paint (3 coats) after two (2) coats of epoxy primer DFT 200 microns
Inlet, outlet, Vent, overflow, drain	Required.
Manhole (Davit type)	Minimum two (2) nos. for the tank of 500 mm NB (minimum)
Staircase, platform and Handrails	Required
Instrumentation	
Level Indicator	Required, Minimum three/tank, gauge glass (Reflex type) with overlap.
High, low and very	Three with alarm and interlock low level switches per tank
Level Indicator-cum-Controller	
Type	Level indicator - cum - controller (Panel mounted) with analogue level display facility
Number	Two (2)
Transmitter	Two (2), D/P type
Auto-manual	Required facility
Control valve	Required with set point, measured value, deviation and valve position indication.
Number	Four (4) nos. globe type
Body	SS-316
Plug & Stem	SS-316
Seat	SS-316
Actuator	Pneumatic Diaphragm
Inching	Required on "Manual Mode" alongwith facility A/M station in control panel and % valve position indicators

x)

Degassed Water Pumps (DGP)

Item	Specification
Number	[Three (3) nos. (2W+1S)]
Type	Horizontal, centrifugal
Location	Indoor
Duty	Continuous

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Item	Specification
Capacity	[... m ³ /h]
T.D.H.	To be decided by the Bidder
Material of Construction	
Casing	SS to AISI 316
Impeller	SS to AISI 316
Shaft & shaft sleeve	SS to AISI 316
Packing seal	Mechanical type
Common base plate	Required
Casing & Impeller Type	End suction, closed impeller type
Range of operation	From 30% to 120% of rated capacity
Design standard	IS 5659, IS 5120
Rated Speed	1500 RPM (Maximum)
Permissible Tolerance	As per IS-1520, IS-5120 in rated head and power
Noise level for pump	85 DB at a distance of 1.5 M from motor set motor

xi)

Air Blowers

Item	Specification
Numbers	[Two (2) per degasser tower (2 x 100 %)]
Service	Air required for Degasser tower
Type	Lobe type
Duty	Continuous
Capacity, each for Degasser tower	100% requirement
Head to be developed	By Bidder.
Material of construction	
Casing	CS
Lobes / impeller	CS to BS 970, EN9 Forged
Shaft	CS to BS 970 EN 9 forged
Safety valve	SS/Brass
Testing & inspection	
Material test required	Casing, Impeller / Lobe, shaft
Code for testing	IS 4894
Rotor balancing	Required.

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DM Water Transfer and Distribution Systemi) **DM Water Transfer Pumps**

Items	DM Water Transfer Pumps
Service	D.M. Water
Designation	Demineralized Water Transfer Pumps
Duty	Continuous
Location	Outdoor
No. of Pumps Required	[3]
No. of Pumps Working	[2]
No. of Pumps Stand-by	[1]
Suction Lift/Head Available (MLC)	Flooded Suction shall be ensured.
Pump Performance Requirements	
a) Flow Capacity	[... m ³ /h]
b) Total Dynamic Head as per IS-5120 at Rated Capacity (mlc)	[... mlc]
c) Rated Speed (rpm) (max.)	By Bidder
d) Range of Operation	Preferably 70% to 130% of Rated Capacity
e) Suction specific speed	Should be within 9000 US unit
Design standard	Hydraulic Institute Standard / IS-1520 / Equivalent Standard
a) Type of Gland Lubrication and Sealing	By Bidder
b) Bearing Cooling (if required)	By Bidder
Shaft Sealing Arrangement	Stuffing Box
Type of Pump-motor Connection	Direct
Type of Coupling	Flexible
Material of Construction	
a) Casing	ASTM-A-296 Gr. CF8M
b) Casing Liner	ASTM-A-296 Gr. CF8M
c) Diffuser	ASTM-A-296 Gr. CF8M
d) Impeller	ASTM-A-296 Gr. CF8M

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Items	DM Water Transfer Pumps
e) Wearing Rings	ASTM-A-296 Gr.C 440
f) Shaft	AISI-410
g) Shaft Sleeve	ASTM-A-276 Type-316
h) Base Plate	Fabricated Steel as per IS-2062
l) Shaft bearings	Heavy duty sleeve/ Ball/Roller
j) Wetted Fastener	Stainless steel AISI 304

ii)

DM Water Storage Tank

Item	Specification
Number required	[Two (2)]
Design code	IS 803 and API 650
Location	Outdoor
Capacity of each tank	[... m ³]
Free Board (Minimum) mm	300
Type and pressure class	Vertical, Cylindrical, atmospheric, shell type with flat bottom, roof with rafters
Material of construction and Thickness	M.S. as per IS 2062 Min. 8 mm thick plate.
Internal Painting	Epoxy finish paint (3 coats) after two (2) coats of epoxy primer DFT 200 microns
External Painting	Aluminium paint (3 coats) after two (2) coats of epoxy primer DFT 240 microns
Overflow, drain	Required with air breather and over-sample connection flow seats
Manhole (Davit type)	Minimum two (2) nos. each of 500 mm NB
Staircase, platform, and Handrails	Required with interconnecting platform
Level Indicator	
Number	One for each tank

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Item	Specification
Type	Dial type
Level Switch	
Number	Three (3) for each tank, 1(high, low and very low) for alarm and interlock
Centralized Panel	Required through diaphragm seal DP mounted level indication type level transmitter with local and recording indication for each tank
Special Fitting	
Seal for overflow	Required
Co2 absorber	Required
Additional Nozzle	Four (4) per tank and suitably connection blanked with blank flanges Two (2), (each of 200 mm NB) per tank near the tank bottom and two (2), (each of 100 mm NB) per tank at tank inlet nozzle level
Conservation vent	One on each tank valves.
Air breather with KOH	One on each tank seal

Chemical Storage & Dosing Systemi) **Coagulant Unloading Cum Transfer Pumps**

Item	Specification
Purpose	To pump Coagulant from Tankers to Bulk Coagulant Storage Tanks and as well as to transfer Coagulant from Bulk Coagulant Storage Tanks to Coagulant Preparation tanks
Chemical to be used	Ferric Chloride of 35 – 45 % concentration
Dosage Rate	
Type	Horizontal Centrifugal
Numbers required (Working +Standby)	<i>[Two (2) (1 W+ 1 S)]</i>
Duty	Intermittent

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Item	Specification
Capacity of pump	To be suitable for dosing requirement
Head	As required
Maximum Pump Speed	1500 rpm
Material of Construction	
a) Casing	FRP/ PP / CPVC
b) Impeller	FRP/ PP / CPVC
c) Shaft	As per manufacturer's standard
d) Shaft Sleeve	As per manufacturer's standard
Type of Shaft Sealing	Mechanical Seal as per Mfr Std
Sets of Hoses with coupling & Diaphragm type Isolation Valves	
a) Number of Sets Required	Two (2)
b) Size of hose/ Valve	80 mm NB
c) Length of hoses	20 meters (minimum)
d) Material of hose	Chemical resistant, UV inhibited PVC
Accessories Required for Pump	Coupling guard, drain plugs, vent valves etc

ii)

Bulk Coagulant Storage & Preparation Tanks

Description	Bulk Tanks	Preparation Tanks	Preparation Tanks
Purpose and Capacity	To store one month requirement of Coagulant for both Main Clarifier and DM Clarifier (if applicable)	To prepare & store one day requirement of Coagulant for Main Clarifiers	To prepare & store one day requirement of Coagulant for DM Clarifier (if applicable)
Chemical to handled	Ferric Chloride of 35–45% concentration	Ferric Chloride of 5 % concentration	Ferric Chloride of 5 % concentration
Number of tanks	[Two (2)]	[Two (2)]	[Two (2)]
Design Dosage rate	Minimum 30 ppm		
Design Quantity of Water to be dosed	As per system requirement		
Capacity of each tank	To store 15 days	To hold 12 hours	To hold 12 hours

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Description	Bulk Tanks	Preparation Tanks	Preparation Tanks
	requirement	requirement	requirement
Type of Tank	Vertical or Horizontal atmospheric vessel ; Covered	Vertical, atmospheric; Covered	Vertical, atmospheric; Covered
Material Construction of	MSRL	MSRL/ FRP	MSRL/ FRP
Number of agitators	NA	One per tank	One per tank
Shaft Material of Agitator	NA	SS 316 L	SS 316 L
Impeller Material of Agitator	NA	SS 316 L	SS 316 L
Accessories	Manholes / Hand holes, Filling Connection, Vent, overflow, drains, platform, ladders etc as applicable		

iii)

Coagulant Dosing Pumps

Description	Parameters/ Data
Purpose	For dosing Coagulant solution
Chemical to dosed	Ferric Chloride 5 % concentration
Type	Simplex hydraulically operated Diaphragm type
Numbers required (Working +Standby)	[Two (2) (1 W+ 1 S) for Main Clarifier and Two (2) (1 W+ 1 S) for DM Clarifier (if applicable)]
Duty	Continuous
Design Quantity of Water to be dosed	As Required.
Design flow rate of each dosing pump	To suit minimum dosage rate of 30 ppm for Main Clarifier. Minimum dosage rate for DM Clarifier (if applicable) 30ppm
Head of dosing pump	As required
Capacity control	0 --100% automatic
Pump stroke speed per minute	100 maximum
Material of Construction	
a) Liquid end (pump head valve, valve housing, etc) ,valve spring	PP / FRP/CPVC

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Description	Parameters/ Data
b) Diaphragm	TEFLON
c) Packing	As per manufacturer's Standard suiting to Chemical
d) Shaft	As per manufacturer's Standard suiting to Chemical
Accessories	Check valves, Pressure Dampeners, Safety Relief valves etc as required

iv) **Hypo Chlorite Dosing Pumps for Potable Water, if applicable**

S. No.	Description	Parameter
1)	Number	[2x100%.]
2	Other details	As per above continuous dosing pumps

v) **Bulk Coagulant Aid Storage & Preparation Tanks**

Description	Bulk Storage	Preparation Tanks	Preparation Tanks
Purpose	To store one month requirement of Coagulant-aid for both Main Clarifier and DM Clarifier (if applicable)	To prepare & store one day requirement of Coagulant –aid solution for Main Clarifier (if applicable)	To prepare & store one day requirement of Coagulant –aid solution for DM Clarifier (if applicable)
Chemical to handled	Polyelectrolyte - 100% Solution	Polyelectrolyte - 5% Solution	Polyelectrolyte - 5% Solution
Method of storage / Preparation	To be stored in the form of 50 Kg Carboys In Tanks		
Number of tanks	NA	[Two (2)]	[Two (2)]
Design Dosage rate	----- Minimum 2 ppm -----		
Design Quantity of Water to be dosed	As Required		
Design Storage Capacity to be considered	To store 30 days requirement of the plant	Each tank to hold 12 hours requirement	Each tank to hold 12 hours requirement
Type of Tank	NA	Vertical, atmospheric	Vertical, atmospheric
Material of	NA	MSRL/ FRP	MSRL/ FRP

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Description	Bulk Storage	Preparation Tanks	Preparation Tanks
Construction			
Agitator & Number	NA	One per tank	One per tank
Agitator shaft Material	NA	SS 316 L	SS 316 L
Agitator Impeller Material	NA	SS 316 L	SS 316 L
Accessories	Two numbers of hand pumps for transferring chemical from carboys to preparation tanks	Manholes / Hand holes, Filling Connection, Vent, overflow, drains, valves operating platform, ladders etc as applicable	Manholes / Hand holes, Filling Connection, Vent, overflow, drains, valves operating platform, ladders etc as applicable

vi)

Coagulant Aid Dosing Pumps

Description	Parameters/ Data
Purpose	For dosing Coagulant aid solution
Chemical to be dosed	Polyelectrolyte solution of 5 % concentration
Type	Simplex hydraulically operated Diaphragm type
Numbers required (Working +Standby)	[Two (2) (1 W+ 1 S) for Main Clarifier and Two (2) (1 W+ 1 S) for DM Clarifier (if applicable)]
Duty	Continuous
Design Quantity of Water to be dosed	As per system requirement
Design flow rate of each dosing pump	To suit minimum dosage rate of 2 ppm
Head of dosing pump	As required
Capacity control	Automatic
Pump stroke speed per minute	100 maximum
Material of Construction	
a) Liquid end (pump head valve, valve housing, etc) ,valve spring	PP / FRP/ CPVC

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Tender Document for R&M of Unit No.[.] of [Name of the Power Plant]	[Logo of Utility]
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b) Diaphragm	TEFLON
c) Packing	As per manufacturer's Standard suiting to Chemical
d) Shaft	As per manufacturer's Standard suiting to Chemical
Accessories	Check valves, Pressure Dampeners, Safety Relief valves etc as required

vii)

Bulk Acid Storage & Preparation Tanks

Description	Bulk Storage	Preparation Tanks	Preparation Tanks	Preparation Tanks
Purpose	To store one month requirement or Two (2) tankers capacity whichever is higher	To prepare & store one day requirement for Cation Exchanger	To prepare & store for Mixed Bed	For Neutralisation Pit
Chemical to be handled	Acid – 30 to 33%	Acid – 30 to 33%	Acid – 30 to 33%	Acid – 30 to 33%
Number of tanks	[Three (3)]	[Two (2)]	[Two (2)]	[One (1)]
Design Storage Capacity to be considered		Useful capacity of each tank will be at least 120 % of regeneration requirement of one stream of SAC.	Useful Capacity Of Each Tank Shall Be At Least 120 % Of Regeneration Requirement Of One Stream Of Mixed Bed Units	As required
Type of Tank	Vertical, atmospheric; Covered	Vertical, atmospheric;	Vertical, atmospheric;	Vertical, atmospheric;
Material of Construction	FRP	FRP	FRP	FRP

viii)

Acid Unloading and Transfer Pump

Description	Parameters/ Data
Purpose	For unloading and transferring Acid solution
Chemical to be dosed	Acid – 30 to 33%

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Type	Centrifugal Pump
Numbers required (Working +Standby)	[Two (2) (1 W+ 1 S)]
Head	[...] mwc
Capacity	[... m ³ /hr]

ix) Bulk Alkali Storage and Preparation Tanks

Description	Bulk Storage	Preparation Tanks	Preparation Tanks	Preparation Tanks
Purpose	To store one month requirement or Two (2) tankers capacity whichever is higher	To prepare & store one day requirement for Anion Exchanger	To prepare & store one day requirement for Mixed Bed	For Neutralisation Pit
Chemical to handled	Alkali 48%	Alkali 48%	Alkali 48%	Alkali 48%
Number of tanks	[Three (3)]	[Two (2)]	[Two (2)]	[One (1)]
Design Storage Capacity to be considered		Useful capacity of each tank will be at least 120 % of regeneration requirement of one stream of SBA.	Useful Capacity Of Each Tank Shall Be At Least 120 % Of Regeneration Requirement Of One Stream Of Mixed Bed Units	
Type of Tank	Vertical, atmospheric; Covered	Vertical, atmospheric;	Vertical, atmospheric;	Vertical, atmospheric;
Material of Construction	MSRL/ FRP	MSRL/ FRP	MSRL/ FRP	MSRL/FRP

x) Alkali Unloading and Transfer Pumps

Description	Parameters/ Data
Purpose	For unloading and transferring Alkali solution
Chemical to be dosed	Alkali – 48%
Type	Centrifugal Pump

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Numbers required (Working +Standby)	[Two (2) (1 W+ 1 S)]
Duty	Continuous
Head	[...] mwc
Capacity	[... m ³ /hr]
Capacity control	Automatic
Pump stroke speed per minute	100 maximum

xi)

CW Chemical Dosing System

Need for dosing the following chemicals in the CW System shall be examined, depending on make-up water analysis and cycle of concentration:

- Antiscalent or Corrosion inhibitor
- Oxidising biocides (typically chlorination)
- Sulphuric acid to minimize alkalinity of circulating water preferably in 175-200 mg/l as CaCO₃ range

Sl. No.	Description	Parameters/ Data	
1)	Type of chemical	*Anti Scalant / Corrosion Inhibitor/ Non Oxidizing Biocide / Dispersant	H ₂ SO ₄
2)	Chemical Dosing Tank		
	a) Number	[1]	[1]
	b) Capacity	To store 1 day's requirement	To store 1 day's requirement
	c) Material of construction	GRP	GRP
3)	Chemical Dosing Pumps		
	a) Number	[2 x 100%]	[2 x 100%]
	b) Capacity/pump	By Bidder	By Bidder
	c) Head	By Bidder	By Bidder
	d) Material of construction (all wetted parts)	SS 316	FRP/CPVC
	e) Stroke length adjustment	0-100%	0-100%
4)	Accessories to be provided	Suction strainer of SS 316, Ball check valve, Built in type common base plate with foundation bolts,	Mixing Tank, Disposer, Ball check valve, Built in type common base plate with foundation

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Sl. No.	Description	Parameters/ Data	
		companion flanges with gaskets, nuts & bolts and flexible coupling.	bolts, companion flanges with gaskets, nuts & bolts and flexible coupling.
5)	All interconnecting piping between equipment with isolation valves, fittings and other accessories etc.	To be provided	To be provided
6)	Safety shower and Eye Wash fountain.	1 No each.	-
7)	Cooling water make up quality	[As applicable for Plant]	[As applicable for Plant]
8)	Cooling water range	[...]°C	[...]°C
9)	Cooling water flow	[.....] m ³ /h	[.....] m ³ /h
10)	Cycle of concentration	[...]	[...]
11)	Location of dosing system	Adjoining to CW PH fore - bay	Adjoining to CW PH fore-bay

*Note: For Oxidising Biocides (typically Chlorination), please refer Chapter-4.

Data Sheet for Bulk Storage of H₂SO₄

S.No.	Description	Bulk Storage
1	Purpose	To store one month requirement or Two (2) tankers capacity whichever is higher
2	Chemical to be handled	Acid-98%
3	Number of tanks	Two (2)
4	Type of Tanks	Horizontal, Cylindrical
5	Material of Construction	Carbon Steel (IS-2062)

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Technical Particulars of Tanks and Accessories

S.No	Detail	Description
1.	Designation	Filtered Water Tank
2.	Service	Potable Water
3.	Construction	Vertical Cylindrical
4.	Steel	As per IS: 2062 Gr.B
5.	Plate Thickness	
	Shell	8 mm (min)
	Flat End	8 mm (min)
6.	Corrosion Allowance	2.0 mm
7.	Liquid to be stored	Filter water (chlorinated)
8.	Roof/ End Shape	Flat End
9.	Design Pressure	Full of water + Atm. Pressure
10.	Design Temp	50 deg C

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4 [ELECTRO CHLORINATION]

4.1 General

a) Mechanical

- i. [Three (3) nos. (3 x 50% capacity)] plant supply pumps of horizontal centrifugal type each complete with drive motor and other accessories. Clarified water shall be taken from soft water storage tank. Pumps shall be located in a RCC pump house
- ii. [Three (3) nos. (3 x 50% capacity)] auto backwash type strainers with mesh size of 0.5 mm.
- iii. [3 X 50 % electrolyser] modules factory assembled, pre-piped, pre-wired and mounted on the structure. The Hypo chlorite generators shall be of bipolar electrolytic type each of 15 Kg/hr capacity (minimum). Each electrolyser module shall have minimum number of units connected in series or parallel.
- iv. [3 Nos. transformer-rectifier] each matching the generating module and consisting of 1 No. transformer, dry type and 1 No. thyristor rectifier and 1 Set of DC current conductors (bus duct) between the rectifier cubicle and the electrolyser module.
- v. Hypo chlorite storage, degassification and distribution system consisting of [2 tanks] complete with all accessories and [two (2) centrifugal blowers] each complete with drive motor to supply dilution air for venting the hydrogen from the hypo chlorite storage tank.
- vi. Hypo chlorite solution injection pumps each complete with drive motor.
- vii. 1 No. electrolyzer acid cleaning system consisting of an acid circulation tank and [2 x 100 %] capacity centrifugal pumps complete with drive motors.
- viii. Hypo chlorite solution diffusers and mixing system.
- ix. Flow meters and throttling valves in the hypo chlorite dosing line.
- x. All integral and interconnecting piping, valves, all types of pipe support, including pipe racks, etc for the entire electro chlorination system.

b) Electrical

Required nos of drive motors suitable for operation on 415 V system complete with all standard accessories including motor terminal box and cable glands. For detailed Specifications refer Technical Specification for Medium Voltage Squirrel-Cage Induction Motors, Part-B, Section-II, Volume-II.

c) Instrumentation

- i. Pressure/ differential pressure and temperature gauges and switches, pressure transmitters, differential pressure transmitter with stubs, thermo wells, root valves, impulse lines, siphons, gauge cocks, drain lines, drain valves and other items for any equipment under this specification, other important sub-systems and auxiliaries that relate to system performance and safety of the equipment and for the purpose of monitoring critical parameters.
- ii. Motor operated valves, pilot solenoid operated on/off pneumatic control valves etc along with limit torque switches and other accessories as necessary for the

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proper function of the system or as mentioned in other sections of the specification.

- iii. Local control station with push buttons/ indicating lamps near each drive, motor operated valve, solenoid operated valve etc according to operating philosophy.
- iv. Operation and control of the electro-chlorination system shall be from the PLC.

4.2

Codes and Standards

The following specific standards apply to the supply under this specification. In case of conflict with standards, this specification shall prevail over listed standards.

- BS: 5156 - Specification for Diaphragm valves
- ASTM F 437 - Standard specification for threaded chlorinated poly vinyl chloride (CPVC) plastic pipe fittings, schedule 80
- ASTM F 441M - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
- ASTM D351 7 - Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe
- ASTM D4161 - Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
- BS 5480 - British Standard Specification for Glass reinforced plastics (GRP) pipes, joints and fittings for use for water supply or sewerage.
- BS 4994 - Specification for design and construction of vessels and tanks in reinforced plastics.

4.3

Design and Manufacturing Requirements

4.3.1

System Description

The function of the electro chlorination system is to generate sodium hypochlorite that will be effective in preventing bio fouling.

[Clarified Water/Soft water] shall be strained to remove solid particles using strainers with automatic backwash facility for cleaning of filtering element. The generation of available chlorine from soft water in the form of diluted hypo chlorite solution shall be carried out in the hypo chlorite generator by partial electrolysis process. The direct current required for the electrolytic cells of hypo chlorite generators shall be provided by the transformer rectifiers.

Soft water containing the products of electrolysis which are essentially, sodium hypo chlorite solution and hydrogen gas shall be transferred from the generating module to degassifier cum hypo chlorite storage unit. The unit equipped with air blowers shall dilute the hydrogen to non-explosive concentrations. The hypo chlorite solution shall be dosed to the soft water by means of dosing pumps.

The deposits caused by the soft water hardness inside the generators shall be periodically removed by dissolving them in a diluted solution of hydrochloric acid circulated through generators by centrifugal pumps. At the end of cleaning cycle, the acid solution shall be recovered in a tank.

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4.3.2 Design Requirements**i. Hypo chlorite Generator Unit**

The following dosing regime shall be planned for the Circulating Water System:

- Continuous dosing at the rate of 2 ppm of chlorine into a flow of [..... cu m³/h].
- Shock dosing at a rate of 5 ppm of chlorine for 30 minutes in every shift of 8 hours.
- Necessary chlorination for the PT and Potable water.

ii. Rectifier and transformer

- DC Power supply unit shall be provided each matching the generating module.
- The transformer unit shall be of cast resin dry type.
- The rectifier unit shall be of solid state type, dry silicon controlled rectifiers and diodes.

iii. Degassifier

- Air Blowers shall be sized so as to dilute the hydrogen to non-explosive concentrations.
- Horizontal centrifugal type air blowers, each having capacity to meet the demand of all the pressure filter units shall be provided.
- Among these two, one will be in normal operation the other will remain as standby.
- Blowers shall be oil free type complete with drive motors, suction filters, silencers, discharge dampers and associated ducting works. Discharge pressure gauges shall be provided for each blower.
- Blowers along with drive motors shall be suitable for complete outdoor location. The motor shall have IP 55 protection.

iv. Horizontal Centrifugal Pumps

- The pump shall be capable of developing the required total head at rated flow under continuous operation. Also the pumps shall be capable of being operated to give satisfactory performance at any point on the H-Q characteristic curve over the operating range of at least 30% to 120% of rated flow.
- The pumps shall have a stable H-Q characteristic curve continuously rising towards the shut off and with a highest head at shut off condition.
- The pumps shall be designed for a water inlet temperature of at least [45 °C] and it shall be ensured that the pumps do not cavitate at this temperature.
- The material of construction of various components shall be as indicated in relevant equipment data sheets enclosed along with this specification. These are to be considered as minimum requirement and it is the responsibility of the Bidder to select and offer proper material of construction for the required service.

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- Assembly and dismantling of each pump with drive motor shall be possible without disturbing the grouted base plate or alignment.
- Continuous motor rating (at 50 °C ambient) shall be at least fifteen percent (15%) above the maximum load demand of the pump in the entire operating range including the run out condition to take care of the system frequency and voltage variation. Other design and construction features of the drive motor shall be as specified elsewhere, under standard electrical specifications.

v. **Storage Vessels**

- The storage tanks [(2 nos)] shall be sized so that it holds the total amount of solution required for the shock treatment operation for one shift. Minimum [40 m³] each.
- The tank shall be of vertical cylindrical design with bolted top flange cover. The tank shall be provided with overflow, inlet feed funnel, discharge/outlet pipe and level gauge.
- Design temperature of vessels shall be 10 °C higher than the maximum temperature that any part of the vessel is likely to attain in course of operation.
- The hypo chlorite and acid storage tanks shall be of FRP/GRP,
- Gaskets shall be full-face type.
- Nozzle wall thickness shall be as per relevant code for design to be followed for the vessel.
- Nozzle projection from tank wall/shell and roof shall be as per IS:803.
- Manholes shall be provided in all vessels for providing easy access into the same. The size shall be minimum 500 mm and it shall be provided with cover plate, nuts, bolts and gaskets to ensure leak tightness at the test pressure.
- All foundation bolts, inserts etc. will also be included
- All vessels shall be provided with lifting lugs, eye bolts etc. for effective handling during erection.
- Gauge glass or gauge type or float operated level indicator of specified design, shall be provided to indicate the level of content of the vessel.
- Suitable seal shall be provided with the vent line of atmospheric tanks containing fuming liquids and also to prevent contamination from atmospheric air.

vi. **Piping, Fittings and Valves**

- The pipes handling cooling water shall be of MS construction (IS: 1239, Heavy class or FRP. The pipes handling hypo chlorite solution and acid shall be of CPVC).
- Pipes & fittings shall be suitably painted and protected considering soft water service and saline environment.
- Gate, globe and check valves shall be used respectively for isolation,

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regulation and non-return services in general.

- For pressure rating, material of construction, design and testing code etc. of various valves, valves data sheet shall be referred to.

- Piping:**

Material of Construction for pipes carrying various fluids should be as below:

Sl. No.	Service	Material
1.	Soft water	FRP/GRP
2.	Hydrochloric acid	
	a) Strong (30%)	CPVC
	b) Dilute	CPVC
3.	Hypo chlorite solution	CPVC

- All piping system shall be capable of withstanding the maximum pressure in the corresponding line.
- Hangers and support shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipeline movements as necessary. All guides, anchors, braces, damper, expansion joint and structural steel to be attached to the building/structure, trenches etc. shall be provided.

- Fittings:**

All the fittings in the electro chlorination plant shall be of CPVC/GRP. All fittings of blower air line will be made of PVC. All bolts, nuts and washers on the piping will be galvanized carbon steel, Gaskets shall be of EPDM,

- Valves:**

All manual and motor actuated valves in the electro chlorination plant shall be made up of CPVC. All valves shall be suitable for service conditions i.e. flow temperature and pressure under which they have to operate. All sampling valves and analysing instrument isolation valves shall be needle type.

- Dosing Pumps**

- The dilute Hydrochloric acid dosing pumps shall be horizontal centrifugal type and arranged to operate under flooded suction conditions.
- The rated capacity of hypo chlorite dosing pumps shall be selected based on continuous dosing and shock dosing regimes adopted.
- The pumps shall be capable of varying the discharge over the entire range of operation.
- The pumps shall be capable of operation either intermittently or continuously. Necessary relief valves and discharge pressure gauges shall be provided for each dosing pump.
- The rated capacity of dilute hydrochloric acid dosing pumps shall be

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suitable for the cleaning cycle.

- *The material of construction for casing and impeller shall be of Titanium.*
- *Minimum 15% margin over pump input shall be taken and standard motor with next higher kW as available shall be selected. This shall in no be less than the maximum power required by the pump.*
- *The pump and motor shafts shall be connected with an adequately sized flexible coupling of proven design with a spacer to facilitate dismantling of the pump without disturbing the motor, Necessary coupling guards shall also be provided.*
- *The material of construction of various components shall be as indicated in relevant, equipment data sheets enclosed along with this specification.*
- *The pumps shall generally be employed with mechanical seals, which shall be so arranged that replacement of seal should be possible with minimum downtime.*
- *A common base plate mounting both pump and the motor shall be provided. The base plate shall be of fabricated steel (minimum 6 mm thickness) and of rigid construction, suitably ribbed and reinforced.*

4.3.3 Operating Conditions

- i) *The control system will be designed for operator free fully automatic control. Fully automatic control shall mean that sending a start signal will initiate a start sequence within the control system to start soft water booster pumps, strainers, air blowers and hypo chlorite dosing pumps and energize the rectifier-cum-transformer units and the generator to produce hypo chlorite and deliver this to the injection points for continuous and intermittent chlorination.*
- ii) *The control system shall monitor safety interlocks for flow, level control etc. and allow the necessary time delay to establish system equilibrium before moving to the next step in the start sequence.*
- iii) *ON/OFF/TRIP status of all pumps, blowers, agitators and drive motors for other equipment under Bidder's scope of supply, ammeters for drive motors wherever required shall be displayed in control panel.*
- iv) *All drive motors shall be provided with arrangement of local starting and stopping. Local starting shall be possible through remote/local selector switch in control panel or in MCC. Tripping of drive motors locally shall be permissible irrespective of position of remote/local selector switch. Provision for locking the local stop push buttons after tripping the motor from local push button shall be there.*
- v) *Annunciation panel showing tripping of different motors, level alarms from level switches in Hypo chlorite dosing tank shall be located in the Instrument Control Panel.*
- vi) *Hypo chlorite generator room shall be properly ventilated by continuously running ventilation fans.*
- vii) *All plant status information shall be made available at local control panel.*

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4.4

Design Data Sheet

S. No.	Detail	Description
1.0	Electrochlorination Plant supply pumps	
a)	Number	[Three (3) (2 in operation + 1 as stand by)]
b)	Description for each equipment	
i)	Location	Indoor
ii)	Fluid to be handled	Soft water
iii)	Duty	Continuous
iv)	Type	Horizontal Centrifugal
v)	Type of impeller	Open
vi)	Design standard	As per Tender Specification
vii)	Service temperature In deg C	50 maximum
viii)	Rated Capacity (cum. Per hr)	By Bidder
ix)	Range of operation	30% - 120%
x)	Permissible tolerance in rated capacity (%)	As per applicable code
xi)	Suction Condition	Flooded
xii)	Head to be developed at rated Capacity	Head to be indicated by Bidder to meet the requirements as per Tender specification
xiii)	Permissible tolerance in efficiency at rated capacity (%)	As per applicable code
xiv)	Lubrication	Self-water lubricated.
xv)	Material of construction	
	* Casing	Stainless Steel
	* Impeller	Stainless Steel
	* Shaft seal	Mechanical
xvi)	Type of drive	Electrical Motor
xix)	Equipment and Motor on common base plate	Yes
2.0	Strainer	
a)	Number to be provided	[Three (3)]
b)	Description for each unit	
i)	Type	Auto backwash type
ii)	Fluid to be handled	soft water

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S. No.	Detail	Description
iii)	Rated capacity	50%
iv)	Mesh size of the screen in mm	0.5
v)	Material of construction	Body & Screen -SS 316 L
3.0	Hypochlorite Generator	
a)	Number to be provided	Three (3) [2 In operation + 1 standby]
b)	Description for each unit	
i)	Type	Tubular shells arranged electrically in series.
ii)	Rated generation capacity of each unit as available chlorine in kg per hr	[...] kg/hr (min)
iii)	Range of generation control	20% - 100%
iv)	Material of construction	
	• Anode	Titanium coated with metal oxide
	• Cathode	Titanium
	• Shell	Filament wound FRP
4.0	Rectifier – cum- transformer	
4.1	Transformer Unit	
a)	Number to be provided	[Three (3) (2 in operation + 1 standby)]
b)	Description for each unit	
i)	Type	Cast resin dry type
ii)	Duty	Continuous
iii)	Frequency of supply in Hz	50
4.2	Rectifier Unit	
a)	Number to be provided	[Three (3) (2 in operation + 1 standby)]
b)	Description for each unit	
i)	Type	Solid state controlled rectifier.
ii)	Range of control	
	• Voltage in percentage	10-100%
	• Current in percentage	10-100 %
iii)	Accuracy of current fine percentage	control in ± 1 %
5.0	Hypo chlorite Storage Tank	
a)	Numbers required	[Two (2)]
b)	Description for Unit	

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S. No.	Detail	Description
i)	Type of Tank	Vertical cylindrical with flat bottom
ii)	Type of fluid to be handled	Hypo chlorite Solution
iii)	Capacity in cu.m.(each tank)	40
iv)	Design Code	As per Tender Specification
v)	Material of Construction	FRP/GRP
vii)	Instruments	
	Level Indicator	
	• Number	Two (2).
	• Type	Electronic transmitter type.
	Level Switch	
	• Number	Two (2).
	• Type	Very Low.
	• Alarm	Required.
	• Interlock	Required.
6.0	Degassifier Blowers	
a)	Number	[Two(2) [1w + 1 R] for each tank]
b)	Description for each equipment	
i)	Location	Indoor,
ii)	Fluid to be handled	Atmospheric air.
iii)	Service	To supply air to hypo chlorite storage tank for hydrogen dilution
iv)	Duty	Continuous
v)	Type	Horizontal centrifugal.
vi)	Rated Capacity in cum per hr	Bidder to indicate
vii)	Material of construction	
	• Casing	Carbon Steel
	• Impeller	Carbon Steel
	• Shaft	Hardened Carbon Steel-EN 8.
viii)	Type of drive	Electrical Motor
xi)	Equipment and Motor on common base plate	Yes
xii)	Tests and Inspection	
	• Material Test required for	Casing, impeller, shaft and shaft sleeve

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S. No.	Detail	Description
xiii)	Instruments	
	Pressure gauge	
	• Number	One (1)
	• Location	At discharge
	• Type	Bourdon type
	Flow switch	
	• Number	One(1)
	• Location	At discharge
	• Alarm	Required
	• Interlock	Required
xiv)	Special features	Suction air filter is required to be provided.

	<u>Hypo Chlorite Dosing Pumps</u>	
For Continuous Dosing		
1)	Number	[3x50%.]
2)	Description for each equipment	
	Location	Indoor.
	Fluid to be handled	Hypo Chlorite Solution
	Duty	Continuous
3)	Type	Horizontal Centrifugal
	Type of impeller	Closed
	Design standard	As per Specification
	Service temperature	50 °C Maximum
	Rated Capacity (cum. Per hr)	By Bidder
	Range of operation	30-120%
4)	Permissible tolerance in rated capacity	As per applicable code.
5)	Suction Condition	Flooded
7)	Head to be developed at rated capacity	By Bidder
8)	Permissible tolerance in efficiency	As per applicable code
9)	at rated capacity(%)	
10)	Material of Construction	
	Casing	Titanium

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	<u>Hypo Chlorite Dosing Pumps</u>	
<i>For Continuous Dosing</i>		
	<i>Impeller</i>	<i>Titanium</i>
	<i>Shaft Seal</i>	<i>Mechanical</i>
11)	<i>Equipment and motor on common base plate</i>	<i>Yes</i>

	<u>Hypo Chlorite Dosing Pumps</u>	
<i>For Shock Dosing</i>		
1)	<i>Number</i>	<i>[3x50%]</i>
2)	<i>Description for each equipment</i>	
	<i>Location</i>	<i>Indoor.</i>
	<i>Fluid to be handled</i>	<i>Hypo Chlorite Solution</i>
	<i>Duty</i>	<i>Intermittent</i>
3)	<i>Type</i>	<i>Horizontal Centrifugal</i>
	<i>Type of impeller</i>	<i>Closed</i>
	<i>Design standard</i>	<i>As per Specification</i>
	<i>Service temperature</i>	<i>50 deg C Maximum</i>
	<i>Rated Capacity (cum. Per hr)</i>	<i>By Bidder</i>
	<i>Range of operation</i>	<i>30-120%</i>
4)	<i>Permissible tolerance in rated capacity</i>	<i>As per applicable code.</i>
5)	<i>Suction Condition</i>	<i>Flooded</i>
6)	<i>Head to be developed at rated capacity</i>	<i>By Bidder</i>
7)	<i>Permissible tolerance in efficiency at rated capacity (%)</i>	<i>As per applicable code</i>
8)	<i>Material of Construction</i>	
	<i>Casing</i>	<i>Titanium</i>
	<i>Impeller</i>	<i>Titanium</i>
	<i>Shaft Seal</i>	<i>Mechanical</i>

OR

4 [GAS CHLORINATION SYSTEM]

4.1 System Description

Chlorination system shall be provided for the following systems:

- i. Condenser cooling (CW) / Auxiliary cooling (ACW) water systems

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ii. Raw water (RW) system (pre-treatment plant)

iii. Potable water system

Chlorination for CW / ACW system shall be provided to check the microbiological growth, which interferes with the heat transfer and performance of the cooling tower. The chlorination system for the CW / ACW systems shall be common. Chlorination shall be done in the CW pump house at inlet to the pump channels.

Chlorination for RW system shall be provided to neutralize the BOD which interferes with the performance of the clarifier and downstream water treatment. It also oxidizes the iron and manganese, if still not oxidized in aerator. Chlorination for the RW system shall be done in the stilling chamber of the clarifier.

Chlorination for potable water shall be provided to oxidize the microbiological organisms. Chlorination for the potable water shall be done in the potable water pump suction piping.

4.2

Statutory Requirements

All requirements of the latest statutory regulations in force, State Pollution Control Board; Central Pollution Control Board; Department of Environment, Govt. of India, Indian Explosives Act. Indian Factories Act, Indian Boiler Regulation etc. as applicable shall be strictly adhered to.

The Bidder shall be responsible for obtaining necessary approval and making whatever additions/modifications considered necessary by the respective Statutory Authorities to bring the installation conformity with the latest Statutory Regulations in force. All works related to approval from Directorate of Explosives/Nagpur for chlorination system is in Bidder's scope apart from other statutory authorities of State and Central.

4.3

Design and Construction

The chlorination system shall be designed for the following:

a. CW / ACW system:

- Continuous dosing @ 2 ppm
- Shock dosed @ 5.0 ppm (maximum) for a average period of about 30 minutes per shift of 8 hours. Shock dosing at inlet of all pumps of one unit shall be done simultaneously. Continuous dosing shall be discontinued for the period when the shock dosing is being done.

b. Raw water system

- Continuous dosing @ 8 ppm minimum. However this must be reviewed in line with the raw water analysis.

c. Potable water system

- Dosing @ 2-5 ppm so that the residual chlorine is 0.2 ppm.

Number of chlorine tonners shall be adequate to cater the chlorine consumption requirement for 15 days.

The chlorinators will be connected to evaporators which individually in turn will be connected with chlorine ton containers. The chlorination system will be complete

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with chlorine ton containers, booster pumps, strainers, piping and diffuser systems up to dosing points and all other necessary accessories and auxiliaries.

The water to the booster pumps will be supplied from circulating water pump discharge header (for CW / ACW system), from service water (for RW system) and from potable water system (in case of dosing to the potable water system).

All the necessary equipments such as Chlorinators, Evaporators, Chlorine Ton Containers, etc. will be located in the Chlorination Building (for CW / ACW system), in the chemical house (for RW system) and in the nearest building in case of the potable water system. However there may be site specific changes in respect of the chlorination equipment locations.

Following redundancy will be provided:

Chlorinator: one number for each service.

Pumps : One number for each duty

4.4

Electricals

Required nos of drive motors suitable for operation on 415 V system complete with all standard accessories including motor terminal box and cable glands. For detailed Specifications refer Technical Specification for Medium Voltage Squirrel-Cage Induction Motors, Part-B, Section-II, Volume-II.

4.5

Control and Instrumentation

Pressure/ differential pressure and temperature gauges and switches, pressure transmitters, differential pressure transmitter with stubs, thermo wells, root valves, impulse lines, siphons, gauge cocks, drain lines, drain valves and other items for any equipment under this specification, other important sub-systems and auxiliaries that relate to system performance and safety of the equipment and for the purpose of monitoring critical parameters.

Motor operated valves, pilot solenoid operated on/off pneumatic control valves etc along with limit torque switches and other accessories as necessary for the proper function of the system or as mentioned in other sections of the specification.

Local control station with push buttons/ indicating lamps near each drive, motor operated valve, solenoid operated valve etc according to operating philosophy.

Operation and control of the electro-chlorination system shall be from the PLC.

4.6

Chlorine Ton Container / Cylinder

For each chlorine ton containers, two (2) nos. eductor pipes shall be provided, each terminating into an isolating valve of 25 mm (nominal) size. Valve shall be as per IS 3224 and BS 341 [Part 1]. One eductor tube will be used for chlorine gas withdrawal while the other shall deliver liquid chlorine.

Each chlorine ton container shall be placed on two (2) nos. metallic brackets, each provided with two (2) roller supports. These brackets will be mounted on civil foundation and all necessary anchor bolts, inserts, nuts etc. will also be furnished by the Bidder. However, the Chlorine Cylinder will be mounted on trolley with chain as holding material.

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Each chlorine ton container shall be provided with approved colour band for identification of its content.

4.7 Pipe Manifold with Accessories

Flexible connector with valved ends joining chlorine ton container to the pipe manifold shall be constructed of annealed copper tubing, cadmium plated.

Copper tubing with suitable expansion loop shall be provided with silver soldered copper nipples on each end.

Alternatively, flexible metal hose, constructed of corrugated metal with monel tire braid and monel nipples may be supplied. Tubing shall be hydraulically tested to 40 Kg/Sq.cm (g).

Piping for handling chlorine shall be as simple as possible, with minimum of screwed and flanged joints. Piping shall be well supported and adequately sloped to allow drainage. Low spots shall be avoided. Suitable allowances shall be provided for pipe expansion due to change in temperature.

PVC or similar materials, shall not be used in liquid chlorine and pressurised chlorine gas lines. However, PVC can be used in chlorine gas line operating under vacuum.

For chlorinated water service line, MSRL pipes shall be used.

Suggested steel pipe and fittings for dry chlorine service both liquid and gaseous under pressure shall be as follows :

Pipe : Carbon Steel ASTM A106 Gr. B Seamless Schedule 80

Fittings : Carbon Steel ASTM A105 Gr. 1 2000 rating

Flanges : Carbon Steel ASTM A181 Gr. 1 Class 300

Piping and fittings for conveying chlorine gas under vacuum including vent lines and fittings from all points of chlorine gas, vent, leak off and pressure relief to outside discharge which could be exposed to wet chlorine shall be schedule 80 PVC as per IS 4985.

Suggested copper and copper alloy tubing and fittings for dry chlorine service upto the manifold should be as follows :

Copper tube : Copper water tube type K, soft as per ASTM 88

Fittings : Wrought copper solder joint fittings (joints should be made with a brazing alloy containing no tin)

Valves for liquid and gas service on the chlorine supply side of the installation shall preferably be approved by the Chlorine Institute, USA. The specifications should be as follows:

Type	:	Ball/rising stem globe
Body	:	Steel/Bronze (silver plated)
Seat	:	Teflon/Monel
Ball	:	Monel
Stem	:	Monel
Disc.	:	Hastealloy/Monel
Gasket	:	Bonded asbests fibre

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Packing : Oil free graphitized asbestos

Globe valves upto 40 mm NB size shall be 300 ASA (minimum), outside screw and yoke, with forged body and renewable seat. Valves 50 mm and larger shall be cast body. Valves handling chlorine under vacuum or chlorinated water shall be made of PVC or PVC lined body. Type may be ball or diaphragm.

Chlorine shut off valves shall be electrical/pneumatically operated, arranged to shut off on operating power/air failure.

Expansion chambers shall be provided in all pipelines carrying liquid chlorine which may become stagnant due to closure of isolating valves. The expansion chamber shall be sized for a minimum 20% of the piping volume in which it will be installed. Connection to the chamber shall be through a rupture disc. (set at 28 Kg/Sq.cm approx.). Expansion chamber shall be mounted between two shut off valves. Expansion chamber shall be provided at the highest level of the Piping. Suitable pressure switch shall be provided to initiate a high pressure alarm.

Socket welded joints shall be used in PVC service. Teflon tape/ Litharge/Glycerin cement shall be used in all screwed joints.

If chlorine line is run in a pipe rack, where it saves space, with other pipelines carrying flammable materials, the chlorine lines should be protected from fire, resulting from leak or break in one of the other lines as given in Chlorine Institute, USA.

All piping above the ground shall be suitably protected from the atmospheric corrosion by adequate painting system or adequate insulation system.

PVC line, in case of chlorine solution piping, if any, all joints shall be socket type with solvent welding. For these pipes, laid on the sand level, insulation shall be provided to prevent solar effect and mechanical damages on the pipe.

All fasteners for chemical area shall be of SS 316 material.

Chlorinator surrounding pipe, valve, panel should be of chlorine corrosion proof material.

Evaporators

Electrically heated constant temperature water bath type evaporator shall be provided to vaporise liquid chlorine into gas form for further feeding into the chlorinator. Each evaporator shall be sized with ample safety factor to allow for partial filling of the chlorine chamber with junk. Heating element shall be immersion type, 3 phase, 415V, 50 Hz.

Hot water bath shall be vented to atmosphere. It shall have provision for incorporating the electrical immersion heaters. Minimum water level shall be maintained automatically by a solenoid valve. Filtered water, after passing through strainer, will be used as make up. Drain plug shall be provided for maintenance. Water level indicator shall be provided.

Chlorine vaporiser body shall be constructed of seamless steel tubes as per ASTM A 106, Grade B. Minimum 3 mm corrosion allowance shall be provided in tube wall. Flanges shall be of IS:2002, Grade B plates. Welding shall be 100% radiographed and stress relieved. Vaporiser shall be hydraulically tested at 40

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Kg/Sq. cm (g) for leak tightness. Fabrication shall conform to ASME code for Boilers and Pressure vessels (Section VIII, Div. I) or IS:2825.

One (1) no. control cubicle containing necessary contactors, fuses, push buttons, indicating lamps, ammeter, and other instruments for each evaporator shall be supplied and mounted integrally with the evaporator. Instrumentation shall include chlorine pressure gauge, dial thermometer, adjustable range control thermostat and relay in addition to the accessories mentioned.

Evaporator shall provide some degree of superheat to prevent mist in the downstream side.

An electrically interlocked motor operated shut off valve shall be provided in the gas discharge line from the evaporator to interrupt the flow of gas to the chlorinator when temperature of the evaporator drops below a preset value.

Evaporator shall be equipped with a suitable type of cathodic protection system that protects the water bath tank and outside of evaporator. A local ammeter shall be mounted on the evaporator as an indication of the degree of cathodic protection.

The outside of the water bath shall be properly insulated. The entire chlorine evaporator shall be constructed of materials completely resistant to the corrosive attack of liquid chlorine, wet or dry gas and chlorine area atmosphere.

Strainer

For each chlorinator two (2) no. 100% capacity strainers (one operating, one standby) shall be provided to trap any liquid chlorine "Mist" and solid impurities from reaching the chlorinator. The filter shall incorporate an "inertial" trap which will hold any liquid present. The filter part shall be of removable element design. Vent for chlorine strainers shall be provided and the same shall be terminated outside the room.

Pressure Regulating Valves

Spring loaded silver diaphragm type pressure regulating valve shall be mounted external to the chlorinator in the chlorine gas supply line from evaporator. Thus, chlorinators are subjected to less gas pressure during operation. The material of construction of the pressure regulating valve should generally conform to the requirements of the Specification specified elsewhere. All flange sealing should be done by lead gasket.

4.8

Chlorinator

The chlorinator shall be of vacuum solution feed type. Good control and metering of gas shall be the essence of the design.

The chlorinator system shall provide the following functions for accurate control safety of operation.

- a) *Inlet chlorine pressure reducing valves to reduce the pressure to a constant sub atmospheric pressure (automatic).*

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- b) Automatic pressure vacuum relief valve.
- c) Indicating meter (rotameter).
- d) Chlorine feed rate adjuster (manual).
- e) Chlorine metering orifice.
- f) Vacuum differential regulating valve (automatic).
- g) Automatic Drain Relief Valve/Spring loaded check valve.
- h) Injector vacuum gauge.
- i) Injector power water supply system.

Suitable automatic shut off arrangement should be provided to prevent air entry into the chlorine solution line. The chlorine injector shall be suitably designed to prevent "Water Suck Back" into the chlorinator.

Each chlorinator shall be provided with one (1) control panel containing necessary instrumentations for safe and trouble free operation of the chlorinator.

Material of construction for the major components should be as follows:

- a) Pressure/vacuum regulator
 - i) Body : PVC
 - ii) Diaphragm : Teflon
 - iii) Plug : Silver
- b) Feed rate adjuster
 - i) Plug : Silver
 - ii) Seat : Silver
- c) Injector
 - i) Body : Rubber lined mild steel
 - ii) Nozzle : Solid ebonite
- d) Chlorine gas pressure: Schedule 80. Seamless steel piping
- e) Chlorine gas vacuum : PVC piping
- f) Cabinet : Fiber glass moulded design, steel frame with epoxy paints.

The entire chlorinator shall be constructed of material completely resistant to the corrosive attack of wet or dry chlorine gas, chlorine solution, and chlorinator area atmosphere.

4.9 Chlorinated Water Diffuser and Mixing System

Chlorinated water should be led from the source to the point of application via pipelines of suitable material as specified elsewhere in this specification.

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Diffusers should be constructed of rubber lined perforated steel tubes/polypropylene. For MSRL diffusers, the perforations shall be rubber lined to protect the steel at the holes. The diffuser shall be designed so that each hole takes 4 to 7 Lpm flow at a 3 to 4 m/sec. velocity.

Diffusers should be located in strategic locations so that effective mixing of chlorine solution takes place with water to be treated. All diffusers should be located well below the lowest water level so that these are never exposed to atmosphere.

All fittings, brackets, etc. to locate the diffusers shall be of rubber lined steel construction.

Blow off vent line shall be provided at inlet of the diffuser to vent air or gas in this line.

Interconnecting Piping, Valves, Fittings and Accessories

Accessories

Bidder shall include in his scope of supply all pipe lines, valves, fitting. All piping and fittings, including special accessories shall be sized for operation of all the units.

The pipes handling cooling water shall be of MS construction (IS:1239, Heavy Duty). The pipes handling air shall be Schedule 40 or Standard galvanised steel A 53 Gr. A, screwed or flanged.

Safety & Supervisory Instrument

Two (2) sets of gas masks along with breathing apparatus with one hour air tank complete with full mask, full vision face pieces, air flow regulating valves and all accessories shall be provided. In addition, two (2) nos. cannister type breathing apparatus shall be provided in which the moisture content from the wearer exhaled air react with granular chemical in the breathing apparatus and liberates oxygen. The released oxygen enters a breathing bag from which the wearer can inhale. Full technical details of equipment furnished shall be indicated.

Four (4) sets of electronic type leak detector system shall be provided in Chlorination Building near fore bay for unit 1, 2 & 3, i.e. two (2) nos. for common Chlorine Ton Container Storage Room for CW / ACW. Chlorination and two (2) nos. for Chlorination Room of CW / ACW Chlorination.

Two (2) sets of orthotolidine impregnated paper type leak detector system shall be provided in the chlorine storage area to detect leakage of chlorine.

Four (4) nos. of ammonia bottles containing commercial grade ammonia solution (26 deg. Be) shall be provided.

Two (2) emergency kits shall be provided for attending leakage of chlorine. The emergency kit shall contain tools, e.g. gaskets, yokes, hoods, clamps, studs, tie tools, mild steel channels, spanners, screws to fit chlorine containers. The gaskets shall be designed to fit in controlling/stopping leakage from chlorine containers. valves and chlorine container fusible plugs. The accessories shall conform to the details specified by Alkali Manufacturer's Association/Chlorine Institute, U.S.A. Residual chlorine level testing facility shall be provided in the inlet channel to C.W. pumps.

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One (1) no. of Weather Cock shall be provided for monitoring the direction of air flow.

Necessary nos. of safety and supervisory instruments complete with gas masks and two (2) nos. of chlorine leak detectors, one (1) no. in Chlorine Ton Container Storage area and one (1) no. in Chlorination area for Raw Water Chlorination System. For technical details subsection as specified elsewhere may be referred to.

4.10

Chlorine Absorption System

During leakage of Chlorine in the Chlorination room (housing chlorinator and evaporator) and/or in the chlorine ton container storage room (where ton containers are kept) air from these rooms will be sucked by means of exhaust fans and will be passed on to the absorption tower through FRP Ducting where it will be counter currently scrubbed with 20% W/W (maximum) caustic soda solution before vented to atmosphere. Separate chlorine leak detector shall be provided in both chlorination room and chlorine container storage room, which will give indication/alarm at preset chlorine concentration in air during chlorine leakage.

Normal ventilation system shall be provided for chlorination room and chlorine container storage room. However, during emergency condition of chlorine leakage in these areas, the normal ventilation fans of chlorination room and chlorine container storage room will be stopped and exhaust system will be started automatically by means of suitable interlock arrangement with leak detector system.

The chlorine absorption system consists of exhaust fans, ducting work, absorption tower, caustic solution preparation/ recirculation tank and pumps, and other necessary accessories.

The absorber, to be provided shall be of FRP construction. The absorber shall have a packing material of polypropylene raschig/pall rings. Sucked air from chlorination/chlorine ton container storage room shall be introduced into the absorber from bottom and 20% W/V caustic solution (maximum concentration) will be sprayed from the absorber tower top. The absorber shall be provided with necessary arrangement to prevent rain water entry and shall have suitable baffle plate, along with fill material to keep entrainment loss less than 0.1% of circulating liquid flow. The outlet air from the absorber must not have free residual chlorine more than 0.1 ppm and this is to be guaranteed by the Bidder. The caustic solution flow rate through the absorber system shall be such that one completely leaked chlorine ton container content can be absorbed within one hour (max.) time. The absorber tower shall be designed to withstand a temperature of 80 deg. C.

Necessary exhaust fans along with ducting shall be provided for connecting to absorption tower. The capacity of the exhaust fans shall be adequate to meet the requirement of absorbing one completely leaked container within one hour as mentioned above. These exhaust fans shall preferably be of bifurcated type and shall be FRP lined. At least one standby exhaust fan shall be provided.

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The absorber shall be mounted on the caustic solution preparation recirculation tank. The caustic recirculation preparation tank shall be of MSRL construction fitted with motor driven agitator and dissolving basket. Material of construction of dissolving basket and agitator shall be of stainless steel (SS:316) conforming to ASTM Gr. A 351 CF 8M and MSRL respectively. Minimum capacity of the tank shall be suitable to absorb two (2) nos. completely leaked chlorine ton containers plus 20% margin. Caustic concentration in the tank shall not exceed 20% W/W. The tank shall be provided with caustic charging platform with handrails and staircases, level gauges, overflow, water filling connection, etc. The tank shall be designed to withstand temperature upto 80 deg. C.

For caustic solution preparation and recirculation through the absorber system, the system shall have two (2) nos. each of 100% capacity, horizontal centrifugal caustic recirculation pump. Capacity of each pump shall be based on guidelines as given in above Clause no. plus 20% margin.

Each pump shall have suction strainer along with flushing connection from service water supply system. The material of construction of the pump for the complete wetted parts shall be of CIRL construction. The pump shall have auto start facility from the signal or annunciation of chlorine leak detector system. In addition local and remote manual start stop facility shall also be provided. Complete piping and valving system of the caustic and chlorine solution system shall be MSRL and CIRL diaphragm type only. Pump shall trip at low level of respective caustic solution preparation recirculation tank. The pumps shall be designed to operate at maximum temperature, upto 80 deg. C.

A weather cock shall be supplied and located at the top of each Chlorination building for determining wind direction so that in case of leakage of chlorine the working personnel can move against wind direction.

4.11

Lifting & Handling Devices

Two (2) nos. each electric monorail hoist of three (3) tonne capacity shall be provided for chlorine ton container handling system in each Chlorination Building for CW / ACW Systems. One (1) no. electric monorail hoist of three (3) tonne capacity shall be provided for chlorine ton container handling system for Raw Water Chlorination System. This monorail hoist will be utilised to handle chlorine ton containers. For technical details subsection as specified elsewhere may be referred to.

Two (2) nos. lifting bar of suitable design shall be provided for each monorail to grab ton container (empty or full) during handling for CW / ACW. Systems and one (1) no. lifting bar of suitable design shall be provided for each monorail to grab ton container (empty or full) during handling for Raw Water Chlorination System. This shall be supplied complete with load indicator, which shall be suspension type with minimum capacity of 3000 Kgs. Scale shall have tare adjustment so that amount of chlorine in the ton container can be read directly. Scale shall also have a crane hook with 360 deg. C swivel.

Two (2) nos. Platform type weightier 0 to 3000 Kg. capacity shall also be provided in each Chlorination Building for CW / ACW. Systems and one (1) no.

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Platform type weightier 0 to 3000 Kg. capacity shall also be provided for Raw Water Chlorination System.

4.12

Plant Operation and Control

The operation of the Chlorination System shall be manual. However, the system will be such that the operation of plant can be monitored from the respective control panel, located suitably. The common control panels shall be Relay based and each common control panel should have separate independent modules for the following systems:

- a) Chlorination System
- b) Common Chlorine Absorption System for CW / ACW System

The operation of the pumps will be controlled through local control panel. ON/OFF/TRIP status of all pumps, blowers, agitators and drive motors for equipment under this package will be provided with lamp indication on the respective relay based local control panels in the Control Room. Provision shall also be given for local operation of pumps / drives from local control box. Emergency trip buttons shall be provided for all such devices which need immediate stopping due to any mal-functioning of equipment or due to health / operator hazard. Provision shall be made to operate the Booster pumps through selector switch.

One (1) no. Residual Chlorine Analyser shall be installed at each CW / ACW Sump for chlorine level monitoring. Residual chlorine of the potable water shall be monitored by grab sampling.

The operation of chlorine absorption system in case of chlorine leakage shall be automatic through suitable interlock arrangement with leak detector system.

Chlorinator room and ton container area will be properly ventilated by continuously running ventilation fans. When exhaust fans through scrubber would come into service by detection of sufficient level of chlorine leakage, the normal ventilation fans should stop and restart when exhaust fans stop. Annunciation panel showing tripping of different motors, level alarms from level switches in caustic solution preparation cum recirculation tank, shall be located in the Instrument Control Panel.

Window type audio-visual alarm annunciation facilities to alert the operator due to any abnormal conditions of the process shall also be provided in local control panel.

4.13

Inspection, Testing and Commissioning, Tests at Manufacturer's Works

Shop tests shall include all tests to be carried out at Contractor's works, works of his sub-contractor and at works where raw materials supplied for manufacture of equipment is manufactured. The tests to be carried out shall include but not be limited to the tests described under each specification and following:

- a) Composition of all material, castings, forgings etc.

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- b) Hydraulic test for pressure vessels, pipes, valves, specialties, pump casing etc.
- c) Test to check faults in rubber lining (as per IS:4628 (Part- I) 1968 or its equivalent) and painting.
- d) Static balancing test on agitators.
- e) Static and dynamic balancing test on all impellers.
- f) Performance test (Head, capacity, power) on pumps and blowers.
- g) Tests on motor as per IS : 325 & IS : 4029.
- h) Control panels are to be checked for dimensions, wiring continuity, insulation, tubing leakage etc.
- i) All panel mounted instruments, local instruments and accessories are to be checked for performance, over range protection etc. as per I.S.A. or other relevant standards.
- j) Control valve are to be tested for body/seat/diaphragm chamber leakage, lift characteristics, body, seat bonnet and material composition.
- k) Load test on monorail hoists and cranes.
- l) Calibration tests for weight/load indicator.
- m) Functional test of the control system.
- n) In addition to the tests specified above, tests to be performed for various electrical equipment, as delineated in respective sub-sections.

Tests before Trial Run (Tests at Sites)

Contractor shall carry out tests at site to prove to the Owner that the equipment of the plant complies with the requirements stipulated and is erected in accordance with requirements. Before the plant is put on trial run the Contractor will be required to conduct tests to demonstrate to the Owner that each item of the plant is capable of correctly performing the functions for which it was specified to. These tests may be conducted concurrently with those required under commissioning sequence. Tests required shall in general be as follows:

- a) All piping and valves after installation, will be tested hydraulically at a pressure, one and half times of the maximum attainable pressure in the system, to check against leak tightness.
- b) All valves (Manual/automatic/remotely operated) shall be operated throughout 100% of the travel and these should function without any trouble whatsoever.
- c) All pumps shall be run with the specified fluid from shut- off conditions to valve wide open condition. Head developed will be checked from the discharge pressure gauge reading. Capacity may be checked from flow indicators where applicable. If flow indicators are not available in the system, capacity can be checked from the volume of fluid handled (determined from level indicator reading of concerned tank) and duration of test.

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- d) During the test, the pumps & drive motors shall run smoothly without any undue vibration, leakage through gland, temperature rise in the bearing parts, noise, flow pulsation, etc.
- e) Pumps, blowers, etc. shall be tested at site to run smoothly without undue vibration, flow pulsation, temperature rise in bearing parts, noise etc.
- f) All the rubber lining are to be subjected to the following tests as per IS : 4682 (Part-I)
 - i) Adhesion test
 - ii) Resistance to bleeding
 - iii) Thickness measurement
 - iv) Shore hardness
 Epoxy painting shall be checked by dry type thickness gauge.
- g) Visual check on all structural components, welding, rubber lining, painting etc. and if doubt arises will be tested again.
- h) All testing and calibrating instruments and equipment shall be furnished by the contractor free of cost to the satisfaction of the Purchaser.
- i) All monorail hoists shall be subjected to full working load during all motions without showing any sign of defeat.
- j) All the rotating/moving components like agitators, pumps etc. shall be run at the rated speed with water/chemicals upto the normal water level for a period of twenty four (24) hours. During this period all the components shall function smoothly without any unbalance, vibration, overheating at bearing parts, etc.

Checks on electrical items as mentioned in the Specification for electrical items and works.

4.14 Performance Guarantee Tests requirement for Chlorination Systems

- Necessary pumps shall be started and flow shall be established through all the streams. Valves shall be adjusted so as to have equal and rated distribution of flow through all the streams.
 - Random samples will have to be collected from the downstream of chlorinator and it has to be observed whether the chlorine content of each sample shall be within $\pm 25\%$ of the average value of the samples.
 - Capacity of the chlorinator as indicated by the flow indicator shall be compared with the value determined from the flow rate of chlorinated water. The difference shall not exceed 5%.
 - Capacity of the chlorinator shall be tested both at the highest and lowest gas disposal rates.
 - All pumps shall be guaranteed for capacity, total dynamic head and power consumption.
 - All fans and blowers shall be guaranteed for head and power consumption.
- CW Chlorination System
- Each evaporator shall have a normal capacity not less than approved capacity.

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- Each chlorinator shall be of vacuum solution feed type with a normal approved capacity.
- Chlorine Absorption System for CW and ACW Systems
 - The outlet air from the absorber must not have free residual chlorine more than 0.1 ppm.
 - The caustic solution flow rate through the absorber system shall be such that one completely leaked chlorine ton-container content can be absorbed within one hour (maximum) time.

The capacity of exhaust fans shall be sufficient to suit the above requirement.

- Chlorine Absorption System for Raw Water Chlorination System
 - The outlet air from the absorber must not have free residual chlorine more than 0.1 ppm.
 - The caustic solution flow rate through the absorber system shall be such that one completely leaked chlorine ton-container content can be absorbed within one hour (maximum) time.

The capacity of exhaust fans shall be sufficient to suit the above requirement.

- Various instruments, equipment, chemicals etc. shall conform to the accuracy, ranges and specifications as indicated in specifications of this package.

4.15

Data sheet

Sl. No	Description	Units	CW/ACW system	RW system	Potable water system
1	System process water flow rate	m ³ /hr	As per plant water balance for normal operation		
2	Location of dosing	--	Inlet of pump channel	Stilling chamber	Potable water pump suction
3	Shock dosing rate	ppm	5	NA	NA
4	Shock dosing duration and interval	minutes	30 @ 8 hours	NA	NA
5	Continuous dosing rate	ppm	2	8	2-5
6	Residual chlorine	ppm	0.5	NA	0.2
7	Residual chlorine monitoring	--	Chlorine analyzer required	NA	Grab sampling
8	Requirement of absorption system	---	Yes	Normally no. Concurrence of local statutory body required.	
9	Standby chlorinator	--	Required		

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5 COOLING TOWER**[NATURAL DRAFT COOLING TOWER]****5.1 General**

The hot water from the condensers shall be cooled in one number [Natural Draught Cooling Tower (NDCT)] for each unit.

5.2 Codes and Standards

S.No	Code	Description
1	IS:456	Code of practice for plain and reinforced concrete.
2	IS:800	Code of practice for general construction in Steel
3	IS:875	Code of practice for design loads (other than earthquake) for buildings and structures
4	IS:1893	Criteria for earthquake resistant design of structures.
5	IS:2911	Code of practice for design and construction of pile foundation (All parts).
6	IS:2950 (Part-I)	Code of Practice for design and construction of raft foundations
7	IS:3370	Code of practice for concrete structures for the storage of liquids (All parts).
8	IS:10262	Recommended guidelines for concrete mix design.
9	SP:23	Handbook on concrete mixes.
10	IS:432(Part 1)	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement.
11	IS:1786	High strength deformed steel bars and wires for concrete reinforcement.
12	BS-4485	Specification for water cooling towers
13	CTI	Cooling Tower Institute Standards
14	ACI-334	Reinforced Concrete cooling Tower Shells- practice & commentary

5.3 Design Criteria

The [NDCT] shall be capable of cooling the rated flow of water at following ambient conditions:

- Design ambient wet bulb temperature : [...] deg C
- Design ambient dry bulb temperature : [...] °C
- Cooling Range : [9/9.5/10] deg C

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- Approach : [5] deg C
- Water flow rate : [...] Cu.m/h
- Basic wind speed : [47] m/sec
- Seismic zone : [Zone-...]
- Site elevation : [...] m above MSL
- Barometric Pressure : [1.013]
- Relative Humidity : [...] % (average)

The cooling tower shall be designed for continuous operation throughout the year. All the equipment coming in contact with water shall be designed for the maximum hot water temperature.

The [NDCT] shall be natural draught type and can be cross flow or counter flow type. Cooling tower shall have [PVC film type / splash type fill].

The turbidity level in the cooling water shall be maximum at [...] Cycle of Concentration (COC) as it will handle lake water.

The water distribution system, basin and cold water discharge channel shall be designed to handle 120% of rated water flow without any overflow in basin.

Structural design criteria shall be as per relevant civil specification. For the Technical Requirements of Aviation warning lighting, lightning protection system, earthing, lighting, and cabling, the Bidder is requested to refer relevant electrical specification.

The broad technical parameters of the cooling tower and technological equipment will be as follows:

S.No	Detail	Description
1.	Natural Draught Cooling Towers	[2 Nos. (Two)]
2.	Quantity of water to be cooled per tower	[...] m ³ /h
3.	Cooling Range	[9/9.5/10] deg C
4.	Cold water temperature	[...] deg C
5.	Hot water temperature	[...] deg C
6.	Terminal Temperature Difference	[...] deg C (minimum)
7.	Design wet bulb temperature	[...] deg C
8.	Design ambient relative humidity (average)	[...] %
9.	The max. residual pressure at the	[...] mwc

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S.No	Detail	Description
	cooling tower from ground level	
10.	Quality of makeup water	As per clarified water analysis given in Section-I of Volume-II
11.	Type of fill	[Film Type/Splash Type/Pre stressed RCC Splash fill.]
12.	Design pressure for hot water distribution	[...] kg/cm ²
13.	Maximum drift loss allowable	[0.02 % (Max.)] of Rated Capacity.
14.	Type of Tower	[Counter Flow/Cross Flow] type
15.	Height of basin curb above terrace level	300 mm
16.	Storage capacity of each basin at normal working level (approx.)	To suit the levels indicated in the existing drawing
17.	Tower Operation	Continuous
18.	Profile of the tower shell	Hyperboloid
19.	Materials of Construction	
i)	Shell	RCC
ii)	Fill	Polypropylene
iii)	Fill supports	RCC
iv)	Water distribution nozzles	Polypropylene
v)	Hot Water Pipes	M.S. Fabricated externally coated with anticorrosive paint as specified in Painting chapter pressure class = 6kg/sq cm.
vi)	Hot water distribution piping	UPVC (Standard conforming to ASTM) (both pipe & fittings) (4 kg/sqcm rating)
20.	Valves for drainage	[2 Nos. of 400 mm] diameter gate/slucice valves with extended spindle per tower
21.	Gates	[2 Nos.] at outlet of C.W. channel per tower
22.	Screens	[2 Nos. at outlet of C.W. channel per tower and 2 Nos. as standby]

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S.No	Detail	Description
23.	Chain pulley blocks	[2 Nos. (One 3T CPB for stop log gate and one 1.5T CPB for coarse screen)] at outlet of C.W. channel per tower
24.	Submersible Drain Pumps	[2 Nos. (One per tower)]

5.4

Materials of Construction

The material of construction to be used for various components shall not be inferior to those specified below. Further, all materials shall be so selected to give enduring life considering the water quality in CW system. Wood/timber shall not be used as construction material in any part of the cooling tower.

S.No.	Component Description	Material
i)	Hot water inlet pipes	Mild steel to IS:2062 tested quality with anti corrosive paints
ii)	Hot water distribution system	HDPE / UPVC / FRP or
iii)	Cooling tower basin	R.C.C
iv)	Cooling tower shell structure	R.C.C
v)	Drift Eliminators	Virgin P.V.C. with additives for prolonged life of [20/25] years.
vi)	Louvers	R.C.C
vii)	Fill	Virgin P.V.C with additives for prolonged life of [20/25] years
viii)	Fill Supports	R.C.C.
ix)	Internal support structure for distribution basin	R.C.C
x)	Distribution trough	R.C.C
xi)	Water stops	Virgin P.V.C. with additives for prolonged life of [20/25] years
xii)	Stair case	R.C.C.
xiv)	Miscellaneous steel structure	Galvanized steel flat with painting of epoxy coal tar
xv)	Nozzles/splash cups/orifice	Virgin PVC or Polypropylene

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5.5 Cooling Tower Basin and Shell Structure

Cold water from cooling tower basin shall flow by gravity to open approach channel wherefrom it shall be led to the intake of CW Pump House. The basin, CW fore bay and sump shall extend at least 300 mm above the local ground level. The various levels of the cooling tower basin, cooling tower outlet channels and the leading channel are indicated in the Existing Plant drawing No. [.....].

The basin shall be sloped from centre towards periphery, which in turn shall be sloped towards a collecting sump to be provided on the opposite side of outlet channel. From the collecting sump, the water will be drained by minimum 300 mm diameter GRP drain pipe, embedded below the basin floor, into a sludge sump outside the tower basin. Sludge sump shall be minimum [2.0 m wide x 2.5 m length] and of suitable depth. Drainage of cooling tower basin shall be carried out using portable sump pumps, receptacles and hose pipes. Overflow provision for CT basin shall be given in sludge sump.

Detailed specifications on Civil and structural aspects are given in the relevant sub-section/Part of civil section of the specification.

The water loss in the inlet air openings shall be prevented with provision of adequate number of louvers of proper slope, width and spacing or alternatively by over dimensioning the cold water basin. Louvers, if provided, must be properly designed to give uniform distribution of air with minimum pressure drop.

5.6 Fill and Fill Supports

The fill material shall be arranged in such a way to receive hot water uniformly and easy to maintain/replace. The fill material shall be highly resistant to deterioration and shall be non-combustible. Bidder shall furnish details of PVC fill packing with respect to the non-combustible properties, aging effect, vibration caused by water and wind effects. The properties and make of fill shall be subject to Owner's approval.

The type of fill shall be film type fill. In case of counter flow tower, the fill preferably shall not be extended into the air inlet area.

5.7 Water Distribution System

The hot water distribution to fill packs shall be divided in to minimum two independent segments such that maintenance can be carried-out by isolating relevant segment when rest of cooling tower is in operation. Necessary isolation valves in hot water pipes shall also be provided.

The arrangement of the distribution system shall permit a satisfactory distribution of water over the whole of the tower at all reasonable loads. The distribution of water shall be in troughs/pipes independently supported from the structure and easily removable. The water should be distributed across the plan area of the fill, so that no point varies more than 5% of the average water flow.

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Provision shall be made for easy flushing or cleaning of all troughs/pipes. Hot water pipes shall be properly embedded in the flume or shell, as the case may be, taking into account the forces coming on them.

The distribution troughs/pipes shall not be laid on top of walkways to avoid obstruction to movement to the walkways.

All section of the water distribution system shall have adequate flow capacity to meet the maximum requirements of the thermal design of the tower.

5.8 Drift Eliminators

The maximum drift loss shall be limited to 0.02% of total water in circulation in all ambient conditions. The air pressure drop across the eliminators shall be kept to a minimum by providing proper number of air flow direction changers across the eliminators. The water collected in the eliminators shall be returned to the tower basin and shall not mix with the discharge air system.

The function of drift eliminator is to remove as much drift as practical from the tower exhaust without adding a large airside pressure drop. Drift eliminators remove entrained water from the discharge air by causing it to make sudden changes in direction. The resulting centrifugal force separates the drops of water from the air, depositing them on the eliminator surface, from which the water flows back into the tower. Eliminators are generally classified by the number of directional changes the air has to make. Thus the drift eliminators must be as corrosion resistant as the fills.

5.9 Electricals, Civil and Control and Instrumentation

For Electrical, I&C and Civil part, refer relevant refer Part-B, Part-C and Part-D respectively of Volume-II of this specification.

5.10 Shop Tests

Quality plans for the various equipments/items shall be furnished for Owner's approval. All tests shall be carried out as per the approved Quality plan and test certificates shall be furnished to the Owner for review.

All the material for the various components/parts of the equipment's shall be tested for mechanical and chemical properties including hardness as per the requirements of relevant codes/standards mentioned in this specification.

Galvanised items shall be checked for thickness of coating, weight of zinc coating, adhesion test, visual exam and pierce test (uniformity of coating) as per the requirement of relevant IS codes.

The PVC material for fills shall be tested for the following properties as per the requirement of CTI Bulletin STD-136.

- Tensile strength, yield, elastic modules
- Impact Resistance before and after U.V. exposure of 500 hrs.

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- Heat distortion
- Flammability
- Ultraviolet light Resistance (500 hrs exposure)
- Density as per ASTM or DIN code
- Vicat Softening Temp. As per IS: 6307/DIN 53460

Above tests shall be carried out in a laboratory approved by Owner on representative test samples. The fills shall be checked for dimensions including minimum thickness, length, corrugation height, and load test after gluing.

5.11

Performance Guarantee Tests

Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements. The cold water temperature as indicated in technical data sheets shall be guaranteed for the design conditions of CW flow, range, ambient WBT & RH as specified in technical data sheet.

“Predicted cold water temperature” shall then be arrived at from the guaranteed cold water temperature by correcting the same for the test conditions of range, ambient conditions and corrected circulating water flow using the performance curves furnished by the bidder.

Bidder shall demonstrate by means of test as per relevant test codes that drift loss is limited to 0.02%. To ascertain the fulfillment of Guarantees, performance test shall be carried out on the tower at site. The procedure to be followed and other conditions shall be as given below:

Acceptance test procedure shall cover the determination of the thermal capability and verification of all the guarantees of the cooling tower. The following codes and standards shall be applicable for conducting test unless otherwise modified or supplemented by the enclosed procedure and mutually agreed to between the Owner and the Bidder.

- DIN 1947 – VDI / ATC-105 - Acceptance test code for water cooling towers (latest version)
- B S-4485-Specification for water cooling towers.
- BS-1042-Methods for the measurement of fluid flow in pipes.
- ASME 195-Supplements on instruments and apparatus.

5.12

Conduct of Tests

- The responsibility for conducting the test will be with the Bidder. PG test shall be carried out by the bidder *[within one year]* of successful completion of trial operation of the cooling tower and at a time when the atmosphere conditions are within limits of deviation from the design conditions as specified in this section preferably in the period from *[May to September]*.
- Two numbers of pressure gauges shall be provided in water ducts. Hot water header of the cooling tower shall be provided with pitot tubes along with

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necessary isolating valves, stub connections for measurement of water flow. Pitot tube type elements equipped with traverse mechanism shall be provided to ensure higher accuracy of measurement. One number anemometer for measuring ambient wind velocity shall be furnished. One number mechanically aspirated psychrometer shall be furnished for measurement of wet bulb temperature.

- c) Performance test shall be carried out based on ambient WBT. The performance curves of the towers showing variation in performance with change in ambient wet bulb temperature, cooling range, dry bulb temperature, relative humidity, wind speed, water loading of the tower etc. required to ascertain the performance of the tower shall be furnished along with the bid. Performance curves applicable to 90%, 100% and 110% of the design water flow rate shall be furnished. Each set shall consist of three or more cooling range curves and at least four relative humidity curves, arranged to show the effects of wet bulb temperature, relative humidity and cooling range on outlet water temperature. The range curves shall be presented in uniform increments of 0.5 °C with sufficient scope to cover approximately 20% of design range. The relative humidity curves shall be presented for spaced increments to cover the extent of expected conditions such as 5%, 20%, 40%, 60% and 100% relative humidity. The design conditions shall be indicated on the set applicable to design water flow rate. The dry bulb temperature associated with the wet bulb on each fixed relative humidity graph shall be included. All performance curves shall be based on ambient wet bulb temperature.
- d) Every effort shall be made to run the test under design conditions, or as close to design conditions as possible.

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[INDUCED DRAFT COOLING TOWER]**5.1 General**

The hot water from the condensers shall be cooled in one number [Induced Draught Cooling Tower (IDCT)] for each unit.

5.2 Codes and Standards

S.No	Code	Description
1	IS:456	Code of practice for plain and reinforced concrete.
2	IS:800	Code of practice for general construction in Steel
3	IS:875	Code of practice for design loads (other than earthquake) for buildings and structures
4	IS:1893	Criteria for earthquake resistant design of structures.
5	IS:2911	Code of practice for design and construction of pile foundation (All parts).
6	IS:2950 (Part-I)	Code of Practice for design and construction of raft foundations
7	IS:3370	Code of practice for concrete structures for the storage of liquids (All parts).
8	IS:10262	Recommended guidelines for concrete mix design.
9	SP:23	Handbook on concrete mixes.
10	IS:432(Part 1)	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement.
11	IS:1786	High strength deformed steel bars and wires for concrete reinforcement.
12	BS-4485	Specification for water cooling towers
13	CTI	Cooling Tower Institute Standards
14	ACI-334	Reinforced Concrete cooling Tower Shells- practice & commentary

5.3 Design Criteria

The [IDCT] shall be capable of cooling the rated flow of water at following ambient conditions:

- Design ambient wet bulb temperature : [...] deg C
- Cooling Range : [9/9.5/10] deg C
- Approach : [5] °C
- Water flow rate : [...] Cu.m/h

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- Basic wind speed : [47] m/sec
- Seismic zone : [Zone-...]
- Site elevation : [...] m above MSL
- Barometric Pressure : [1.013]
- Relative Humidity : [...] % (average)

The cooling tower shall be designed for continuous operation throughout the year. All the equipment coming in contact with water shall be designed for the maximum hot water temperature.

The [IDCT] shall be cross flow or counter flow type. Cooling tower shall have [PVC film type / splash type fill].

The turbidity level in the cooling water shall be maximum at [...] Cycle of Concentration (COC) as it will handle lake water.

The water distribution system, basin and cold water discharge channel shall be designed to handle 120% of rated water flow without any overflow in basin.

Structural design criteria shall be as per relevant civil specification. For the Technical Requirements of Aviation warning lighting, lightning protection system, earthing, lighting, and cabling, the Bidder is requested to refer relevant electrical specification.

The broad technical parameters of the cooling tower and technological equipment will be as follows:

S.No	Detail	Description
1.	Induced Draught Cooling Towers	[2 Nos. (Two)]
2.	Quantity of water to be cooled per tower	[...] m ³ /h
3.	Cooling Range	[9/9.5/10] deg C
4.	Cold water temperature	[...] deg C
5.	Hot water temperature	[...] deg C
6.	Terminal Temperature Difference	[...] deg C (minimum)
7.	Design wet bulb temperature	[...] deg C
8.	Design ambient relative humidity (average)	[...] %
9.	Quality of makeup water	As per clarified water analysis given in Section-I of Volume-II
10.	Type of fill	[Film Type/Splash Type/Pre stressed RCC]

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S.No	Detail	Description
		<i>Splash fill</i>
11.	Design pressure for hot water distribution	[...] kg/cm ²
12.	Maximum drift loss allowable	[0.02 % (Max.)] of Rated Capacity.
13.	Type of Tower	<i>[Counter Flow/Cross Flow]</i> type
14.	Storage capacity of each basin at normal working level (approx.)	To suit the levels indicated in the existing drawing
15.	Tower Operation	Continuous

5.4 Constructional Feature

5.4.1 Material of Construction

The material to be used for various components shall be as follows. Wood/ timber shall not be used as construction material in any part of the cooling tower.

S.No.	Component Description	Material
i)	Hot water Header	Mild steel to IS:2062 tested quality with anti corrosive paints/GRP
ii)	Hot water distribution system	PVC (IS 4985 Class 3) / GRP / HDPE (IS 4984 PN6, Grade PE 80) / or RCC/pre-cast open trough.
iii)	Cooling tower basin	R.C.C
iv)	Cooling tower shell structure	R.C.C
v)	Drift Eliminators	Virgin P.V.C. with additives for prolonged life of [20/25] years.
vi)	Louvers	R.C.C
vii)	Fill	Virgin P.V.C with additives for prolonged life of [20/25] years
viii)	Fill Supports	SS:304 channel or RCC
ix)	Recovery Stack	R.C.C
x)	Stair case	R.C.C.
xi)	Miscellaneous steel structure	Galvanized steel flat with painting of epoxy

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S.No.	Component Description	Material
		coal tar
xii)	Nozzles/splash cups/orifice	Virgin PVC or Polypropylene
xiii)	Fan blades	Fiber glass reinforced polyester (hollow cast)
xiv)	Fan Hub	Heavily Galvanized M.S.
xv)	Drive shaft and coupling	Stainless steel conforming to AISI 304 /Carbon fibre composite material with SS 304 couplings
xvi)	Base frame and base plate for gear box and motor	Heavily Galvanized MS

5.4.2 Cooling Tower Basin and Shell Structure

Material of cooling tower basin and super structure shall be as mentioned above. The basin shall be provided with free board of at least 0.3 m above maximum water level. Velocity of water at the outlet of cooling tower should not exceed 1 m/sec. If required, the basin may be suitably depressed to meet this requirement.

5.4.3 Cold Water Basin Drainage Arrangement

- Cold water from the basin shall flow by gravity to Cooling water channel through the outlet channel.
- Provision shall be made to completely drain the basin. For this purpose the basin floor shall slope towards the drain sump in the Cooling Tower.
- Water shall flow from the drain sump into an external sludge sump through a 300 mm NB CI pipe and a CI gate valve of size 300mm NB with extended spindle. Two sludge sumps shall be provided for each tower. One number sludge disposal pump of capacity [150 m³/h] and suitable head shall be supplied for each sludge sump.

5.4.3 Inlet Louvers

The water loss in the inlet air openings shall be prevented with provision of adequate number of louvers of proper slope, width and spacing or alternatively by over dimensioning the cold water basin by minimum 1.0 meter all-around.

5.4.3 Fill and Fill Supports

- Fill shall be of [splash type/film type] and easily installable.
- The fill material shall be highly resistant to deterioration and shall be fire retardant. PVC/PP fill, shall be of proven quality. The make and its properties

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shall be subject to Owner's approval. Bidder shall furnish details of PVC/ PP fill regarding fire retarding properties, ageing effect, vibration caused by water and wind effects. PVC /PP fill shall be white/ cream/ light grey or lighter. Black fills are not acceptable. In case of PVC/ PP fill, the material should be ultra violet ray stabilized and only virgin PVC/ PP material should be used.

- (iii) The type of fill to be supplied for this package shall be of proven design. Necessary supporting data for this shall be enclosed along with the bid.
- (iv) Type Test of PVC/ PP Material: In addition to the routine tests specified elsewhere, ultra-violet exposure for 500 hours on the PVC/ PP material shall be carried out for this contract once as per ASTM-G155/ISO 4892/equivalent, Test Method 3 and Impact resistance test before and after UV exposure shall be conducted as per ASTM D-256.

The above type test shall be carried out by the Bidder at reputed third-party laboratory.

5.4.4 Inlet Water Distribution System

- (i) General Requirements

Hot water distribution system of the tower shall be designed to ensure uniform distribution to all operating cells and also to all areas in a cell. For cross flow type of towers a minimum free board of 50 mm shall be provided with the standby cell not in service. Each cell shall be able to operate independently. For counter flow towers sufficient head room shall be provided between the water distribution system and packing for inspection and maintenance

- (ii) Specific Requirements for cross flow towers

The hot water distribution basin shall be provided with a suitable cover to avoid direct sun rays falling on the distribution trough/ basin to minimize algae growth and to prevent choking of distribution nozzles. The covers provided shall be easily openable for inspection and maintenance of the distribution system.

5.4.5 Drift Eliminators

Drift eliminators shall be designed to keep the drift loss to a maximum of 0.02% of total water in circulation. The drift eliminators shall be of profile type and gluing is not allowed.

5.4.6 Recovery Stack

Recovery stack shall be of proper shape to improve the fan performance. The height of the stack shall be sufficient to recover the velocity and discharge the humid air to a sufficiently high level to minimize recirculation. The maximum efficiency of the stack for velocity recovery to be considered for calculation of fan power consumption shall be 75%. A minimum clearance between the stack and

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fan blades shall be maintained along the entire periphery of the stack to prevent the rubbing of fan blades while rotating.

5.4.7 Fan Deck

- (i) Fan deck shall act as an access platform for the mechanical equipment.
- (ii) Adequate access for roof deck, fan deck, distribution level, drift eliminators shall be provided. For counter flow towers there shall be provision for access to water distribution level of each cell from tower roof deck or through stair case provided at each cased face of the tower. Walkways with platforms and suitable hand and knee rails and toe guards shall be provided inside towers.
- (iii) Handrails shall be provided all around the periphery of the cooling tower fan deck with vertical pipe posts spaced at not more than one meter.

5.4.8 Gear Box

- (i) The fans shall be motor driven through suitable reduction gear. Flexible coupling shall be provided both at motor and reducer to minimize the effect of misalignment on account of any setting and/or warping. Flexible couplings should be pin and bush type. The support structure of the reduction gear shall be rigid. The reduction gear shall be heavy duty type suitable for installation in outdoor and humid environment. The gear drive shall be of spiral bevel or worm type and reduction may be done either in single stage or multi stages.
- (ii) Design rating of the gear box shall be arrived at after considering a service factor of minimum 3.0. In selecting the gear box design rating the thermal derating effects at 50 degree C shall also be considered. Detailed gear box sizing calculation shall be furnished for Owner's approval during detailed engineering. In no case the design thermal rating of the gear box shall be less than 125% of the name plate KW rating of the selected drive motor. Also, the mechanical rating shall be checked so that minimum 25% margin is available at Pull Out Torque of the motor.
- (iii) The piping for oil level gauge/ dipstick and thermometer shall be arranged in such a way that oil can be drained and refilled from outside the stack. This pipe shall have proper supports at frequent intervals and shall be insulated. Further, a breather connection shall be provided in the gear box. The breather provided shall be such that it prevents moisture from entering the gear box. The breather arrangement and details of oil seals shall be to Owner's approval.
- (iv) The gear box design should be such that the temperature of oil shall be within the manufacturer's recommended limits during all operating conditions.
- (v) The gear boxes shall utilize non-hygroscopic oil for lubrication so that its lubricating properties are not lost if contaminated with water vapour.

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- (vi) Each gear box shall be provided with a base plate. The vibration measurement sensors shall be mounted on the gear box.
- (vii) Bidder shall furnish the maximum temperature that the lube oil can withstand and shall guarantee the maximum lube oil temperature when the gear reducer is in operation.

5.4.9 Drive Shaft

The drive shaft shall be of tubular construction and shall be statically as well as dynamically balanced. The design of the shaft shall take into consideration a factor of safety of 2 (minimum) over the torque to be transmitted at design duty conditions. The fan shaft shall be designed in such a way that the first critical speed shall be at least 120% of the operating speed of the shaft. Shaft design requiring intermediate bearings are not acceptable. In case of Carbon fiber composite material, drive shaft shall have the following additional requirements.

- 1) Shaft flanges shall preferably of Carbon fiber composite material.
- 2) Bonding between shaft and shaft flange shall be done by a proven method.
- 3) The Carbon fiber composite material should be ultra violet ray stabilized.

5.4.10 Fans

- (i) Induced draught fans of suitable capacity shall be provided. Fans shall be axial/propeller type with blades which can be adjusted so that pitch can be altered +/- 5 deg. from the normal setting. For adjusting the fan blades, graduated stop marks with suitable locking arrangements shall be provided on the hub so that all the blades can be set to the same angle accurately. The fan blades shall be easily removable. These shall be of aero-foil section and shall provide uniform air velocity from hub to tip with low noise and vibration. Stack shall be provided to eliminate air turbulence in the throat area. Blades, shanks and hubs shall be suitably insulated to prevent electrolytic corrosion.
- (ii) The number of blades shall not exceed twelve (12) and the blade tip velocity shall not exceed 65 m/Sec. Each fan shall be driven by an electric motor.
- (iii) Fans to be supplied for this package shall be of proven design and make and shall be subject to approval of Owner.

5.4.11 Fan Motor

Each electric motor shall be provided with a base plate and a base frame. Fan motor shall have at least 10% margin over the actual power requirement of the gear box when the fan is working at rated duty point and at 50 degree C ambient temperature.

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5.5 Shop Tests

Quality plans for the various equipments/items shall be furnished for Owner's approval. All tests shall be carried out as per the approved Quality plan and test certificates shall be furnished to the Owner for review.

All the material for the various components/parts of the equipment's shall be tested for mechanical and chemical properties including hardness as per the requirements of relevant codes/standards mentioned in this specification.

Galvanised items shall be checked for thickness of coating, weight of zinc coating, adhesion test, visual exam and pierce test (uniformity of coating) as per the requirement of relevant IS codes.

The PVC material for fills shall be tested for the following properties as per the requirement of CTI Bulletin STD-136.

- Tensile strength, yield, elastic modules
- Impact Resistance before and after U.V. exposure of 500 hrs.
- Heat distortion
- Flammability
- Ultraviolet light Resistance (500 hrs exposure)
- Density as per ASTM or DIN code
- Vicat Softening Temp. As per IS: 6307/DIN 53460

Above tests shall be carried out in a laboratory approved by Owner on representative test samples. The fills shall be checked for dimensions including minimum thickness, length, corrugation height, and load test after gluing.

5.6 Performance Guarantee Tests

Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements. The cold water temperature as indicated in technical data sheets shall be guaranteed for the design conditions of CW flow, range, ambient WBT as specified in technical data sheet.

"Predicted cold water temperature" shall then be arrived at from the guaranteed cold water temperature by correcting the same for the test conditions of range, ambient conditions and corrected circulating water flow using the performance curves furnished by the bidder.

Bidder shall demonstrate by means of test as per relevant test codes that drift loss is limited to 0.02%. To ascertain the fulfillment of Guarantees, performance test shall be carried out on the tower at site. The procedure to be followed and other conditions shall be as given below:

Acceptance test procedure shall cover the determination of the thermal capability and verification of all the guarantees of the cooling tower. The following codes and standards shall be applicable for conducting test unless otherwise modified

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or supplemented by the enclosed procedure and mutually agreed to between the Owner and the Bidder.

- DIN 1947 – VDI / ATC-105 - Acceptance test code for water cooling towers (latest version)
- B S-4485-Specification for water cooling towers.
- BS-1042-Methods for the measurement of fluid flow in pipes.
- ASME 195-Supplements on instruments and apparatus.

5.7

Conduct of Tests

- a. The responsibility for conducting the test will be with the Bidder. PG test shall be carried out by the bidder *[within one year]* of successful completion of trial operation of the cooling tower and at a time when the atmosphere conditions are within limits of deviation from the design conditions as specified in this section preferably in the period from *[May to September]*.
- b. Two numbers of pressure gauges shall be provided in water ducts. Hot water header of the cooling tower shall be provided with pitot tubes along with necessary isolating valves, stub connections for measurement of water flow. Pitot tube type elements equipped with traverse mechanism shall be provided to ensure higher accuracy of measurement. One number anemometer for measuring ambient wind velocity shall be furnished. One number mechanically aspirated psychrometer shall be furnished for measurement of wet bulb temperature.
- c. Performance test shall be carried out based on ambient WBT. The performance curves of the towers showing variation in performance with change in ambient wet bulb temperature, cooling range, wind speed, water loading of the tower etc. required to ascertain the performance of the tower shall be furnished along with the bid. Performance curves applicable to 90%, 100% and 110% of the design water flow rate shall be furnished. Each set shall consist of three or more cooling range curves, arranged to show the effects of wet bulb temperature, and cooling range on outlet water temperature. The range curves shall be presented in uniform increments of 0.5 deg C with sufficient scope to cover approximately 20% of design range. The design conditions shall be indicated on the set applicable to design water flow rate. All performance curves shall be based on ambient wet bulb temperature.
- d. Every effort shall be made to run the test under design conditions, or as close to design conditions as possible.

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6 AIR CONDITIONING & VENTILATION SYSTEM

6.1 Codes and Standards

Apart from the specific equipment standards and specifications the following broad references/standards shall be considered while designing the system:

S.No	Code	Description
1	ASHRAE	American Society for Heating, Refrigeration and Air conditioning Engineers
2	ISHRAE	Indian Society for Heating, Refrigeration and Air conditioning Engineers
3	ARI	Air Conditioning and Refrigeration Institute
4	ECBC	Energy conservation Building Code 2007
5	NBC	National Building Code of India 2005
6	ARI 430	Central station Air Handling Units
7	ARI 410	Forced Circulation Air-Cooling and Air Heating coils
8	ARI 550	Water chilling package using the Vapor compression cycle
9	BIS 277	Galvanized Steel Sheets
10	BIS 325	Three phase induction motors
11	BIS 655	Metal Air ducts
12	BIS 7613	Method of testing panel type air filters for air-conditioning and Ventilation process
13	BIS 3588	Electric axial fans
14	BIS 4894	Centrifugal fans
15	UL 555	Fire dampers
16	BIS 7098 Part-1	Power cables
17	BIS 1554 Part-1	Control cables
18	BIS 4237	MCC
19	BIS	For Control panels as applicable

6.2 Schedule of Air Conditioning & Ventilation System

{Indicate in the table below, the desired type of Air Conditioning and Ventilation System with capacity and Quantity}

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i. Air Conditioning System

S. No	System	Type of Air Conditioning	Capacity	Quantity
a)	Central Control Rooms & Control Equipment Rooms			
		[...]	[...]	[...]
		[...]	[...]	[...]
b)	UPS & Battery Charger rooms			
		[...]	[...]	[...]
		[...]	[...]	[...]
c)	Shift in-charge/engineers room			
		[...]	[...]	[...]
		[...]	[...]	[...]
d)	Service Building Senior executives rooms, Various Office Areas, conference room, Entrance Lobbies, Reception area etc			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
e)	Ash Handling System (Ash Handling System Control Room, Ash Handling System UPS &, RIO Room – Compressor House I, Ash Handling System UPS&, RIO Room – Compressor House II, Ash Handling System Silo Utility Building UPS &, RIO Room)			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
f)	Raw Water Intake System & Circulating Water System (Raw Water Intake System PLC Room, Circulating Water System – Control Room & battery charger room)			

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S. No	System	Type of Air Conditioning	Capacity	Quantity
		[...]	[...]	[...]
		[...]	[...]	[...]
g)	Raw Water Treatment, DM Plant & Effluent Treatment Plant (DM Plant Control Room, DM Plant, UPS &, RIO Room for Pre treatment Plant, DM Plant, UPS &, RIO Room for Softening Plant, DM Plant, UPS &, PLC Room for DM Plant, DM Plant, UPS &, RIO Room for Effluent Treatment Plant)			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
h)	Switch Yard Control Room	[...]	[...]	[...]
i)	Fire Water Pump House PLC Room	[...]	[...]	[...]
j)	Any Other Area	[...]	[...]	[...]

The capacity and Quantity indicated above is the minimum requirement. Heat load calculation for the air-conditioning system shall be submitted by the Bidder to arrive at the capacity of the system and accordingly if it requires more than the capacity indicated, same shall be provided within the scope of the Bidder.

ii. **Ventilation System**

Sl. No	System	Type of Ventilation	Type of Equipment	Quantity
a)	Ash Handling System (Switch gear Room & cellar room, Compressor House M/c Room Unit 1, Compressor House M/c Room Unit 2, Silo utility Building, Ash slurry pump house, Battery Room & Toilet of all the above building)			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]

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Sl. No	System	Type of Ventilation	Type of Equipment	Quantity
		[...]	[...]	[...]
b)	Raw Water intake and Circulating Water System			
	i) Raw Water intake system (Switch gear Room, Pump House M/c Room, Battery Room & Toilet)			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
	ii) Circulating Water System (Switch gear and Transformer Room, Pump House M/c Room, Batter Room & Toilet)			
		[...]	[...]	[...]
		[...]	[...]	[...]
c)	Raw Water Treatment, DM Plant & Effluent Treatment Plant (MCC/Switch gear Rooms, Cable Spreader Room, Battery Room, DM Plant Building, Clarified water pump house, softening plant building, Electro chlorination Building, CW chemical dosing pump house, Chemical storage house, Laboratory building (wherever heat is generated), and store room, Toilets)			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
d)	Switch Yard (400 kv GIS Room & 220 kv GIS Room, Battery Room, Stores, Maintenance Room & Toilet, LT Switchgear Room and Cable Galleries)			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
e)	Fire Protection System (Switch gear Room, Fire Water Pump House, Foam pump house and Booster pump houses, Battery Room, Toilet)			
		[...]	[...]	[...]

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Sl. No	System	Type of Ventilation	Type of Equipment	Quantity
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]
f)	Mechanical Workshop and Electrical Repair Shop (Mechanical Workshop and Electrical Repair Shop Building, Switch gear Room, Toilet)			
		[...]	[...]	[...]
		[...]	[...]	[...]
		[...]	[...]	[...]

The quantity wherever indicated is the minimum requirement. Heat load calculation for the ventilation system shall be submitted by the Bidder to arrive at the capacity and quantity of the system and accordingly if it requires more than the quantity wherever indicated, the same shall be provided within the scope of the Bidder.

6.3 Design Criteria

6.3.1 Design Inputs

i. Outdoor Design Conditions:

The outdoor design conditions considered for the site as per ISHRAE Handbook are as follows

Season	Dry Bulb Temp. (°C)	Wet Bulb Temp. (°C)
Summer	[...]	[...]
Winter	[...]	[...]
Monsoon	[...]	[...]

ii. Indoor Design Conditions for Air Conditioned Areas:

The indoor design conditions are as follows:

Dry bulb temperature : 23°C ± 1°C

Relative humidity : 55 ± 5%.

iii. Indoor Design Conditions for mechanically ventilated areas

Inside dry bulb temperature shall be not exceeding ambient summer temperature or based on number of air changes/hr, whichever results in higher air flow rate shall be selected.

Air conditioning system shall be designed generally as per ASHRAE / ISHRAE

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Methodology to provide specified environmental condition for equipment and/or personnel during all modes of plant operation and also as specified in this chapter. Filtering, cooling, heating, humidification/dehumidification of the supply air and its distribution as required shall be done to maintain the specified condition within the specified limits.

6.3.2 Assumptions

- i. Lighting load has been assumed to be minimum of 2 Watts / Sq. Ft
- ii. Computer load has been assumed as 150 watts per Computer.
- iii. Fresh air changes per hour is taken as 1.5 or 35 m³/h per person, whichever results in higher air flow would be considered for AC design systems.

6.3.3 Sizing Criteria

The design methodology is in line with ASHRAE / ISHRAE guidelines and norms. The following input data for lighting heat load, equipment heat load, occupancy as well as resulting capacity shall be considered for sizing the system.

The Ventilation air flow rate shall be estimated considering the following major loads as follows:

- i) Lighting load (kW)
- ii) Equipment heat load including steam piping as well as the dissipated heat, solar transmission through the building wall and glass, and any other sources of heat. (kW)
- iii) Human load (kW)
- iv) Air changes per hour (ACPH) as detailed in the subsequent clauses.
- v) For the summer ambient conditions as furnished to be considered.

6.3.4 Availability Requirement

- a) The equipment selected shall be new and best of its type available with respect to material and workmanship considering the continuous and reliable operation. The equipment shall be maintenance free as far as practicable.
- b) The spares shall be easily available.
- c) All materials used shall be free from surface defects, rust, cracks and deformations.
- d) The finish of the equipment and its components shall be of first class quality.
- e) The components and equipment shall be so selected that the system down time is kept minimum. System design shall be such that fast and easy replacement of components could be possible wherever necessary. To reduce down time, the standby arrangement shall be considered. To the extent possible models and sizes of equipment shall be identical to ensure minimum inventory and interchangeability of parts, equipment and systems.

6.3.5 Redundancy Requirement

- a) Control rooms air conditioned by split air conditioning units / window air conditioners shall have 100% standby provision.

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- b) Premises air conditioned by packaged air conditioners shall be provided with water cooled packaged air conditioners having capacity of 2x100% or 3x50%.
- c) Cooling towers and pumps shall be provided with 2x100% capacity.

6.4 Type and Rating of Equipment

6.4.1 Equipment Selection Criteria

a) Air Conditioning System

Control rooms shall be air conditioned by providing split air conditioning units / window air conditioners including all accessories with 100% standby provision. Window air conditioner may be used if the system capacity is up to 2TR.

The cooling capacity of air conditioning system shall be decided on the basis of heat dissipated in the premises, building heat radiation, illumination heat, occupancy heat, make up air heat etc. in the premises. Fresh air quantity will be based on 1.5 air changes / hour. The system shall have at least 10% margin on capacity.

b) Ventilation System

The capacity of ventilation systems shall be decided on the basis of total heat dissipated in the premises. However minimum 20 air changes per hour for fresh filtered air supply system and exhaust / general air exchange ventilation shall be maintained. The equipment will have at least 10% margin on capacity. Multiple units shall be provided.

Fresh filtered air supply system shall consist of fan & motor unit, dry panel type air filter, air intake louvers, ducting, supply air grills, dampers, electrics, instrumentation & controls and multi louver gravity dampers.

Centrifugal fan shall be used for fresh filtered air supply system. However, axial flow (tube axial) fan may be used for system capacity up to 5000 m³ /h.

Exhaust ventilation system shall consist of fan & motor unit, out let cowl with bird screen / back draft damper & ducting if any etc.

6.5 Design and Construction Details

The equipment will be normally as per general specification of the project. However, brief description of main equipment is given below:

6.5.1 Split Air Conditioner

The Split Air Conditioners shall be generally comprises of the following units:

- a) Hermetic compressor
- b) Air-cooled condenser
- c) Cooling coil & refrigerant circuits
- d) Blower unit with filters
- e) Hand held remote control unit
- i) Outdoor unit comprising compressor with cooling fan, condenser & indoor unit comprising of blower, filter & cooling coil shall be mounted in attractive, corrosion resistant enclosures.

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- ii) The refrigerant compressor shall be hermetically sealed reciprocating / scroll / rotary type operating on Low GHG / ODP refrigerant. It shall be capable of operating continuously in an industrial atmosphere. The Bidder shall indicate the safety measures provided for the compressor and motor.
- iii) The condenser shall be air-cooled copper coil with Aluminium fins type with ample condensing surface. Tubes shall be arranged in a staggering manner for better efficiency.
- iv) The cooling coil shall be of direct expansion type with copper tubes and mechanically bonded aluminum fins; it shall be sufficiently deep for effective cooling.
- v) The refrigerant circuit between outdoor unit and indoor unit shall be carried out as per site conditions. The circuit shall include thermostatic expansion valve, filter drier and liquid line shut off valve. It shall be protected by High - Low pressure start.
- vi) Fan shall be provided to handle the conditioned air. The fan shall be dynamically balanced and its operation shall be smooth and quiet. It shall be complete with direct drive motor. The bearings shall be self-lubricating type.
- vii) The air filter in the indoor unit shall be of dry type. It shall have large surface area and good dust holding capacity. The cleaning efficiency of the filter shall be more than 90% down to 10 microns. The filter shall be of easily replaceable and washable type. A selector switch with "RESET" position shall be provided for running the fan alone with cooling as required. Thermostat shall be provided for control of temperature as per the designed inside conditions.
- viii) The Split AC unit shall conform to IS 1391-1992. Part-II.
- ix) Voltage stabilizers shall be of suitable rating with transformer, high and low voltage cut-off, with built in timer, isolator etc.
- x) Necessary instrumentation and controls with remote control facilities for Split AC shall be provided for the systems.

6.5.2 Package Air Conditioners

Design and Engineering the complete Packaged Air-Conditioner units for the premises shall be in accordance with the stipulations of the specification below considering un-interrupted 24 hours operation in a day.

Under-deck insulation (minimum 25mm thick) with PUF shall be provided wherever roofs are exposed to Sun.

R22, R407C, or any Zero/Low ODP and GWP Refrigerants shall be considered with Scroll/Screw/Rotary type compressors.

Insulation material shall be either Cross Linked Polyethylene (XPE) with K-Value of min. 0.033 W/mk at 240C at density of 33Kg/m³ (minimum 12 mm thick) or resin bonded Fiberglass / Rockwool mattress with K-Value of min.0.033 W/mk at 240 C at density of 48Kg/m³ (minimum 50 mm thick).

Incidental civil works such as making openings in walls/ floors / ceilings for taking out cables / piping / supports etc. and making them good by providing and fixing

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framework for the grills / diffusers etc.

The cooling capacity shall be decided on the basis of heat dissipated by equipment, building heat radiation, illumination heat, occupancy heat, make up air heat etc. in the premises.

System shall be suitable for un-interrupted continuous operation.

Noise level shall be within limit as specified in National Building Code-2005.

a) Water cooled package air-conditioning units.

Air Conditioning System shall comprise of the following:

- i) Water-cooled packaged air conditioner
- ii) Cooling towers
- iii) Pumps
- iv) Ducting
- v) Dampers
- vi) Grills
- vii) Associated water piping and fittings
- viii) Electrics, Instrumentation and controls

The Packaged Air conditioners shall be mounted on attractive, corrosion – resistant, thermally & acoustically insulated cabinets. The refrigerant circuit shall be completely piped at factory & transported with operating charges of refrigerant & oil. The circuit shall include thermostat, expansion valve, distributor, liquid strainer, dehydrator & liquid line shut-off valve. The circuit shall be protected by Hi-Lo pressure stat. The refrigerant used shall be eco-friendly.

Air filters shall be provided for the fresh air as well as total air. The air filter shall be dry panel type. The cleaning efficiency of the filter shall be more than 90 % down to 10 microns. The filter shall be easily replaceable type.

Cabinet of packaged unit shall be provided with suitable openings with flanges for fresh & re-circulated air ducts with hand operated control dampers. Thermostat, humidistat & strip heaters shall be provided for control of temperature & humidity as per the inside design conditions.

The noise level for the package AC unit at 1m distance will be limited to 65dB (A).

b) Humidity Control

The strip heater will be installed in the supply air duct at the discharge end of blower for dehumidification purpose and the strip heater will be interlocked with the blower unit to prevent independent control/ switching of heaters. Safety thermostat shall be installed in the duct line near strip heater for safety precaution.

c) Cooling Towers

Induced draft type, FRP cooling tower shall be provided for the cooling of condenser water.

Cooling tower shall be designed, manufactured and performance tested as per CTI codes.

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The capacity of the cooling tower basin shall be adequate to take care of the entire cooling water required for the air conditioning systems. The makeup water shall be taken from the service water line.

The cold-water basin shall be of FRP construction. Cooling tower basin shall have accessories and connections for makeup, quick fill, drain and overflow. Ball and float valve is to be provided for makeup water line. The makeup water supply pipe shall be positioned at least 2 diameters above the maximum level in the basin.

The structural framework of the tower including all members and connections shall be designed for operating loads and prevailing wind pressure. Steel members shall be of hot dipped galvanized steel and of sufficient sizes to safely withstand all imposed loads. Framework, bolts, nuts and washers shall be non-corrosive type.

All the fasteners shall be of stainless steel. Rubber/neoprene gaskets must be used on all bolted joints as a seal against water leakage.

Motor of induced draft fan shall be of weather-proof construction.

Duct work for air conditioning systems

Air duct for air conditioning systems shall be fabricated as per latest revision of IS:655 /ASHRAE standards.

All longitudinal joints shall have double 'S' seam joint and circumferential joint will be lap joint. All joints are to be airtight. Ducting shall be fabricated at site from GI sheets.

Flanges of sheet metal duct will be of angle iron type riveted with G.I sheet rivet on duct perimeter. Flanged joints should be made air tight with use of felt gaskets. Spacing of duct flanges will be about 3 meters.

Overhead ductwork shall have ceiling suspended type duct hangers comprising rod suspenders threaded at either ends and angle iron horizontal support for duct. There will be no provision of insert plates. The Contractor is required to fix anchor fasteners in the slab to hook up the rod hangers. Spacing for duct supports should be about 2 to 3 meters.

Turning guide vanes are to be provided inside the duct wherever change of direction occurs, to minimise eddy formation.

Bends/ elbows, wherever used, in ductwork shall have radius not less than the depth of ductwork in change of direction.

Manually operated volume control damper is to be provided at each supply air diffuser outlet. Collar piece is to be provided to duct bottom to connect with throat of diffuser. The diffuser should flush with false ceiling.

Sheet metal duct shall be acoustically and thermally insulated.

The space between false ceiling and roof slab shall be used for return air. Return air grill should be provided in false ceiling.

Duct work shall be complete with flanges, stiffeners, fasteners & hangers.

The recommended air velocities in the plenum system are as given below:

Main ducts : 6 to 8 m/sec

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Branch ducts : 4 to 5 m/sec

Branch risers : 4 m/sec

Motor operated fire dampers shall be provided in the air ducts at the supply end. Design of diffusers, grills etc. shall be made by the contractor matching the lighting fittings and interior decorator of the area to be conditioned.

Ducts shall be designed such that return air should come back to AHU without additional fan. In case such fan is unavoidable, tube axial type return air fan shall be envisaged.

d) Insulation

The following items are to be insulated:

- i) Inside surface of the air handling units.
- ii) Supply air duct and return air duct (as required). The insulation thickness to be indicated for duct.
- iii) Refrigerant piping from expansion valves and up to the evaporator and from the evaporator outlet to the compressor unit.
- iv) All drain lines connected with above insulated equipment and piping.

6.5.3 Pressurised Ventilation System

a) Centrifugal Fan

- i) The fan impeller shall be of backward curved blades.
- ii) The fan shall be of rugged steel construction and suitable for industrial duty condition.
- iii) Direct driven fan shall be preferred.
- iv) The fan unit shall be reasonably noise and vibration free Noise level for fan and motor assembly at 1.5 m distance shall be limited to 85 dB (A).
- v) The specification for fan i.e. capacity, total pressure working conditions etc. shall be for 20 deg. C. & 760 mm Hg.
- vi) The fan shall be single inlet single width (SISW) / DIDW type as per requirement.
- vii) The rotating assembly of the fan shall be statically and dynamically balanced.
- viii) Fan housing shall be of welded construction and provided with flanges at inlet and outlet sides for duct connections.
- ix) The fan casing and blade shall not be less than 2.5 mm thick MS sheet. The shaft shall be of EN 8.
- x) Variable inlet vane damper shall be provided at the centrifugal fan inlet.
- xi) Drain connection shall be provided at the lowest point of scroll.
- xii) Fan bearing shall be of self-aligning, heavy-duty type. Bearing shall be selected with ample safety factor for longer life.
- xiii) Sufficient number of suitable vibration isolators of acceptable make shall be provided to ensure isolation of vibration from the equipment to foundation/ adjoining structure.
- xiv) Fabricated steel bracket of M.S.angles, channels and chequered plates shall be provided to take static and dynamic load of the fan and motor assembly.

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- xv) Anchor bolts, nuts, foundation plates and inserts shall be supplied with the fan.
- xvi) The first critical speed of the rotating assembly shall be at least 25 % above the operating speed.
- xvii) The housing shall be provided with lifting eye for ease of handling and bolted type access door.
- xviii) The fresh air intake louvers shall consists of parallel metallic blades. The minimum projected width of blades in horizontal plane shall be 150mm with the blades inclined at minimum 35 degrees.

b) Tube Axial Fan

- i) Fan impeller shall be of aerofoil section. The speed of the TA fan shall be preferably within 1000 rpm and outlet velocity shall be within 12m/sec.
- ii) The impeller shall be directly mounted on the motor shaft and the assembly shall be mounted inside rigid tubular casing.
- iii) The TA fan with Pre-filter shall be provided with rain protection Cowl & Bird screen / wire mesh at the suction side of the TA fan for protection against physical & climatic encounters.
- iv) Terminal box shall also be provided outside the tubular casing for ease of electrical connections.
- v) The connecting flanges shall be provided at both ends of tube.
- vi) Fan to be installed in fire hazardous/acid area shall be spark proof construction and painted with acid resistant paint/anti corrosive lining.
- vii) The impeller shall be of cast aluminium alloy construction of high efficiency aerofoil section blades. The fan impellers shall be cast in one piece finished all over and carefully balanced both statically and dynamically as per AMCA Standard. Finally the assembled rotor shall be dynamically balanced.
- viii) Axial flow fan casings for wall mounted/roof mounted fans and their components shall be suitable for outdoor installation. The casing shall be minimum 2 mm thick. The casings shall be provided with flanges at inlet and outlet. All nuts & bolts associated with it shall be of zinc or cadmium plated. Easily removable inspection cover having galvanized fly nut shall be provided. The covers shall be located such that the grease nipple for all bearings and also motor terminals are easily accessible through the cover.

c) Relief Damper / Gravity Open Louver

Suitable number of Relief Dampers / Gravity open louvers shall be provided for exhausting the Supply air for maintaining a positive pressure of 3mmWc in the ventilated premises.

d) Pre-Filters

- i) Pre-filters shall be provided at the inlet of TA Fan / Centrifugal Fan.
- ii) Size of filters shall be of standard size 610x610x150/50 mm thick.
- iii) Velocity of air across the filter shall be in the range of 2 m/sec.
- iv) Filter panel shall be cleanable and washable type for reuse.
- v) Magnahelic gauge shall be provided for measuring pressure drop across the filter.

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- vi) Cleaning efficiency of the pre filter element shall be 90% down to 10 - micron size of dust particles.
- vii) Filter material shall be enclosed in a sheet metal framework. Filter frame shall be fabricated from 16G MS sheet in welded construction. All leakage areas shall be sealed with suitable sealing compound.
- viii) Proper sealing shall be ensured to prevent leakage of air between mounting frame and filter panels.

e) Volume Control Dampers (If Applicable)

- i) Volume control damper shall be provided to regulate the airflow to the desired capacity.
- ii) The volume control damper shall be multi leaf, opposed acting, aerofoil blade type with external operating link and operating mechanism.
- iii) Size of the volume control damper shall be as per the outlet size of TA Fan / Centrifugal Fan.
- iv) Volume control damper shall have flanges at both ends for its connection.

f) Fire Damper

The Fire damper shall be provided at out-let of the TA Fan / Centrifugal Fan to isolate the served premises in case of fire occurrence. These shall be electrically operated & interlocked with plant's fire protection system.

g) Ducting

The ducting for ventilation and air conditioning systems shall be fabricated from G.I. sheets. The ducting shall be properly reinforced to prevent sagging, buckling or vibration.

The interior of all ducts shall be smooth for free flow of air. Guide vanes shall be provided in all large duct bends for proper flow of air.

The material thickness of the ducting shall be as follows considering the industrial duty conditions

Large side of rectangular Duct/diameter of Circular duct (mm)	Thickness (mm)
0 - 800	1.0
801 - 1500	1.25
1501 and above	1.6

The joints & bracings for ventilation & air conditioning systems shall be as per IS: 655.

All flanged joints shall be provided with asbestos rope of dia. 5 mm for proper sealing of the joints.

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Flanges of sheet metal duct shall be of angle iron type riveted with GI sheet on duct perimeter. Flange joints shall be made air tight with use of felt gaskets. Spacing of duct flanges shall be about 3 meters.

Turning guide vanes shall be provided inside the duct wherever change of direction occurs, to minimize eddy formation. Bends / elbows wherever used in duct work shall have radius not less than the depth of duct work in change of direction.

Collar shall be provided to duct bottom to connect with throat of supply air diffuser.

Access eye / measuring hatch for measurement of air quantity shall be provided in ducting at convenient location.

Duct work shall be complete with flanges, stiffeners, fasteners, hangers, nuts, bolts, washer & gaskets etc.

h) Supply Air Grilles / Diffusers

G.I. sheets not less than duct thickness shall be used for the manufacture of grilles. All grilles / diffusers shall be true to shape and shall be checked with a level gauge before being secured in position.

No distortion or warping is permitted.

All duct-mounted grilles diffusers shall be complete with rubber gaskets and flanged holding frame of suitable design for the intended installation. They shall be mounted on collar extending from the duct. No part of grilles / diffusers shall project into the main duct. Wall / Roof type supply grilles / diffusers shall have one set of adjustable louvers. The front of louvers shall be of horizontal type to adjust vertical deflection.

Each supply grilles / diffusers shall be fitted with built in louver arrangement as per manufacturer's standard design. The grille / diffusers shall be operated with an easily accessible louver to direct and control (fully close position also) the air.

6.5.4

Water pump sets

Pump sets are required for the service of condenser water re-circulation.

Type of pump set is horizontal split casing, unless otherwise stated in the specifications. Flexible coupling should be used to connect pump shaft with motor. Pump motor assembly shall be mounted on a common base frame.

Pump head capacity characteristic shall be gradually rising from operating to shut-off point without any zone of instability. The pump BHP - flow characteristic shall preferably be non-overloading type beyond rated capacity point. Pumps shall be rated for continuous operation. Operating speed of the pumps should not be more than 1500 RPM.

Pump shall be provided with suitable bearings, sized adequately to take maximum imbalance.

Pump and drive motor shall be directly coupled through a flexible coupling. Suitable coupling guard shall be provided for each pump.

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Each pump shall be complete with pressure gauge at the suction and discharge complete with isolating valve. All integral piping required for sealing, cooling, etc. shall be supplied with the pump.

Condenser water pump set will handle water having temperature 35°C.

The pumps shall be designed, manufactured and performance tested as per IS: 9542 - 1980.

The impeller and shaft assembly should be statically and dynamically balanced. Dial type pressure and temperature gauges should be provided for suction and discharge side

Each pump set should be subjected to mechanical running for minimum 4 hours.

6.5.5 Water piping network

Heavy class piping is to be used as per IS: 1239 for interconnecting water piping network.

Copper alloy gate and globe valves are to be used up to pipe sizes 50mm and CI valves are to be used above these pipe sizes.

Pipe fittings like bends, elbows, flanges, sockets, nipples, etc shall be as per relevant IS/BS standards.

Drain piping network is to be included as required for chilled water system, condenser water system, plant room drain, AHU drain, and cooling tower drain with isolation valves at proper places.

Pipe supports shall be of steel, adjustable for height and coated with rust preventive primer and finish coated with Aluminium paint. When pipe and clamp are of dissimilar material, a gasket shall be provided in between.

Spacing of pipe supports shall not exceed the following:

Pipe dia (mm)	Spacing (m)
Up to 25	1.85
32 to 150	2.50
50 and above	3.00

All piping shall be tested to hydrostatic test pressure of at least one and half times the maximum of operating pressure but not less than 7 kg/sq.cm for a period of not less than 4 hours. System may be tested in sections and such section shall be securely capped.

No insulation shall be applied to piping until the completion of pressure testing to the satisfaction of the Owner.

The Bidder shall provide all materials, tools, equipment, instruments, services and labour required to perform the tests and to remove waste materials resulting from cleaning and/after testing.

6.5.6 Condensing unit

a) Cabinet

The condensing unit cabinet shall be of anodized aluminium or GI or Heavy gauge steel suitably treated with two coats of zinc chromate primer and three

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coats of epoxy paint and shall be suitable for mounting in open space, i.e. on terrace.

Compressor

The compressor shall be hermetically sealed and shall be mounted on vibration absorbers. Necessary crank case heaters shall be provided.

Condenser

The air-cooled condenser shall be with copper tubes and aluminium fins with maximum 75dB (A) noise level of fans. Speed of axial fans shall not exceed 960 rpm for fans with impeller diameter above 450mm and 1440 rpm for fans with impeller diameter 450mm and less.

6.5.7 Evaporator unit

The evaporator unit cabinet shall be of GI or aluminium and thermally insulated, suitable drain connection shall be provided for removal of condensate collected in the drain pan. The drain piping shall be properly designed, insulated and routed up to ground level and discharged to the nearby drain. U-trap shall be provided in the drain line to avoid ingress of unwanted air into the system.

Air handling fan

The fan of GI / aluminium shall be centrifugal type with forward curved impeller. The impeller shall be statically and dynamically balanced.

Cooling coil and filter

The cooling coil shall be direct expansion type with copper tubes and aluminium fins. This shall be minimum three (3) rows deep and with minimum three fins per centimeter. The air before it enters the cooling coil shall be filtered by dry and cleanable type filter.

6.5.8 Refrigerant piping and fittings

The refrigeration piping shall be complete with externally equalized thermostatic expansion valve, liquid line strainer, dehydrator and liquid line shut off valve.

For refrigerants R-134a/R22, copper tubes to IS: 10773 shall be used. Fittings, flanges and pipe joints shall conform to the requirements of ANSI B31.5.

The piping shall be designed for an internal pressure representing the most severe condition of coincident pressure and temperature expected in normal operation.

Test pressure for piping shall be 1.1 times of the design pressure. The pressure shall be gradually increased until gauge pressure which is the lesser of one-half of the test pressure and 1.75 kg/cm² (g) is attained and preliminary leak checks shall be carried out. Thereafter, the pressure shall be gradually increased in steps until the test pressure is reached. The pressure shall then be reduced to the design pressure and leakage examination shall be made. The design pressure shall be maintained for 48 hours to 72 hours. A pressure relief valve / device shall be provided on test pressure line having a set pressure slightly above the test pressure. Nitrogen shall be used as a test medium. Oxygen or any combustible mixture of gases shall not be used within the piping for testing. Water or water solutions shall not be used as a test medium.

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Vacuum testing shall be done for medium vacuum of around 40mm of Hg absolute and held with vacuum pump in operation for at least 4 hours. Thereafter unit shall be sealed and vacuum held for at least 12 hours. Vacuum break shall be done using refrigerant and pressure raised to standing pressure in refrigerant cylinder.

The Bidder shall submit test certificate along with the supply of equipment.

6.5.9 Window Air Conditioner

Window type air conditioner shall comprise of hermetically sealed rotary compressor, air cooled condenser, refrigerant piping, fan, instruments and controls, supply air grills with direction deflectors etc. enclosed in an insulated steel cabinet. Provision shall be made in the front panel of the unit for controlling room ventilation and fresh air supply. Air filter installed shall be of HDPE easily cleanable type. The front panel shall be suiting to the interior décor of the room. Window air conditioner shall conform to IS: 1391-1992 Part I.

6.5.10 Return Air Grills

Return air grills shall be square / rectangular / circular in shape. The bottom of grills should flush / match with the false ceiling. Each grill shall be powder coated with appropriate colour to match with the colour of the false ceiling. The grills shall be true to shape and shall be checked with level gauge before being secured in position. No distortion or warping is permitted.

6.5.11 Centrifugal Fan

These are used for ventilation system. The fans shall be of limit load design. The fan shall be of rugged steel construction and suitable for industrial duty condition. Fan housing shall be of welded construction and provided with flanges at inlet and outlet sides for duct connections. The housing shall be provided with lifting eye for ease of handling and bolted type access door.

The fan unit shall be reasonably noise and vibration free in operation. The noise level for fan & motor assembly at a distance of 1 meter in any direction shall be limited to 85 dB (A) from source.

The fan shall be SISW type as per requirement. The fan shall be both statically and dynamically balanced.

The fan impeller shall be of die formed and backwardly curved.

Variable inlet vane (VIV) damper shall be provided at the fan inlet.

Drain connection shall be provided at the lowest point of scroll.

Fan bearing shall be of self aligning, heavy duty type. Bearing shall be selected with ample safety factor for longer life.

Sufficient number of suitable vibration isolators of approved make shall be provided to ensure isolation of vibration from the equipment to foundation.

Fabricated steel bracket of M.S. angles, channels and chequered plates with common base frame shall be provided to take static and dynamic load of the fan and motor assembly.

Anchor bolts, nuts, foundation plates and inserts shall be supplied with the fan and will be non corrosive material of superior quality. The fan shall be designed

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to permit interchange ability of parts and ease of access during inspection, maintenance and repair.

Flexible connections shall be provided at inlet and out let of fan.

The first critical speed of the rotating assembly shall be at least 25% above the operating speed.

Drive motor shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirement at selected speed whichever is higher. Starting torque requirement of fan shall also be considered while selecting the motor.

6.5.12 Dry Panel Filter

Dry panel type air filter shall be of high efficiency cleanable type, constructed out of HDPE (6 ply) supported by layers of GI wire gauge. It shall be corrugated to the depth of filter casing in order to increase the ratio of filtration area to frontal area. It shall be covered by strong GI/MS frame and have space to ensure uniform distribution of air. Filtering panel shall be of standard size which can be mounted on angle frame in multiple number as per capacity of the fan. Face velocity of air shall not exceed 2 m/sec. The resistance of air filter shall not exceed 10 mm wc when dirty. Efficiency of the filter shall not be less than 90% down to 10 microns. The whole filter and frame assembly shall be fixed in a sheet metal casing of not less than 3.15 mm thick M S sheet.

Connecting piece / transition piece / reducer shall connect the filter casing with fan inlet through flexible connection. It shall be fabricated with steel sheet of not less than 3.15 mm thick with drilled flanges at both ends.

6.5.13 Axial Flow (Tube Axial) Fan

These fans shall be of heavy duty type. Fan impeller blades shall be of aerofoil section of cast aluminium alloy. The impeller shall be directly mounted on the motor shaft and the assembly shall be mounted inside rigid tubular casing. Cable termination provision shall be made on tubular casing. The connecting flanges shall be provided at both ends of tube. Tube casing shall be of minimum 2.5 mm thick M S sheet.

The fan to be installed in the fire hazardous / acid area shall be of spark proof construction & motor of flame proof construction and painted with acid resistant paint / anti corrosive lining.

The fan unit shall be reasonably noise and vibration free in operation. The noise level for fan & motor assembly at a distance of 1 meter in any direction shall be limited to 85 dB (A) from source.

Drive motor shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirement at selected speed whichever is higher. Starting torque requirement of fan shall also be considered while selecting the motor.

6.5.14 Axial Flow (Propeller) Fan

These are used for general ventilation of premises emitting heat / fumes. These shall be of heavy duty and wall mounted type. Fan impeller blade shall be

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aerofoil section and mounted directly on the motor shaft. Air entry shall be from motor side. Louver shutter shall be provided at the out let side of the fan to prevent back draft. Consequent loss in capacity shall be taken in to account while selecting the fan.

The fan to be installed in the fire hazardous / acid area shall be of spark proof construction & motor of flame proof construction and painted with acid resistant paint / anti corrosive lining.

The fan unit shall be reasonably noise and vibration free in operation. The noise level for fan & motor assembly at a distance of 1 meter in any direction shall be limited to 85 dB (A) from source.

Drive motor shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirement at selected speed whichever is higher. Starting torque requirement of fan shall also be considered while selecting the motor.

6.5.15 Adjustable louver grills (Supply air Grills)

1.25mm MS sheet / 1mm GI sheet (not less than the duct thickness) shall be used for the manufacture of grills. All grills shall be true to shape and shall be checked with a level gauge before being secured in position. No distortion or warping is permitted.

All duct mounted grills shall be complete with rubber gaskets and flanged holding frames of suitable design for the intended installation. They shall be mounted on collar extending from the duct. No part of grilles shall project into the main duct. The adjustable louver grills shall be provided with volume control damper as well as double deflection flap / grill for direction control.

6.5.16 Self Acting Damper (Gravity Damper)

Self acting dampers are provided to maintain pressurisation inside the premises. The damper shall be of gravity type designed such as not to allow infiltration of air from outside. The damper shall be multi blade type made of aluminium flaps of not less than 24G thickness and MS frame. These shall be designed such that these shall operate when the pressure inside the premises exceeds 2-3 mmwc. It can operate in fully open or partial open positions.

6.5.17 Hangers & Supports for ducting

All duct work shall be provided with adequate supports - hanger type or cantilever type or bracket type - as required to ensure rigid support and to prevent vibration.

The fixing and supports interval shall not exceed 3 meters. Hanger rods having U-bend at one end and threading at other end shall be hanged ceiling by anchor/expansion bolts wherever required. Hangers shall be trapeze type constructed from angle iron (as per size of duct) and hung from steel rods of adequate size. Ducts supported on wall and building structures shall be suitably fixed with angle, rod and flat etc.

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6.5.18 Multi Louver Dampers

Multi louvers damper shall be provided in the supply air ducting. The damper blades / louvers shall be provided with external operating links for manual operation of the damper to control air flow. The damper shall be made of GI sheet with MS frame. The fully close / open / partial closing position of the damper shall be marked on the damper casing.

6.5.19 Thermometer

Wet bulb and dry bulb thermometer shall be provided and installed in the control rooms to measure the premises temperature.

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7 FIRE DETECTION & PROTECTION SYSTEM**7.1 General**

This section of specification covers specification, design basis of fire detection and protection system. A comprehensive fire detection and protection system shall be provided by the Bidder covering all the areas of the proposed power plant. The type of fire detection and protection systems and the areas to which the same are to be provided are described in this sub-section. Indicative numbers of hydrant valves, water monitors etc. are indicated in the tender drawings submitted along with this specification.

The portable and mobile fire extinguishers shall be supplied by the supplier/ Bidder for all the areas/ buildings of the proposed stage of power plant as per the TAC norms.

a) Fire water system

Fire water system shall be designed as per the requirements of TAC / NFPA and other statutory / regulatory bodies.

[Fire Water reservoir shall be provided as a part of Clarified water tank with storage capacity of [...] m3 for fire protection system and shall be designed to meet the requirements of TAC.]

The hydrant system will have dedicated main fire water pumps. Separate Dedicated pumps for Spray System with discharge header interconnected with Hydrant pipe network with a check valve such as water could flow from hydrant network to spray network but not vice versa shall be provided. Both Hydrant as well as Spray Pumps shall have 100% diesel driven standby. Number of Fire Pumps provided shall meet the norms of TAC. Jockey pumps are provided to maintain the leakage losses for the entire fire water network.

Tentative figures for the parameters of Fire Water Pumps has been indicated in this section, although Bidder(s) shall work out the complete details and submit along with the bid for owner's review.

b) *[Pump House:*

Fire water pump house shall install the following:

- i. Fire water pumps – Required number of Motor operated pumps of required rating as working and Diesel Engine driven pumps of similar capacity and head as Standby in line with TAC norms.*
- ii. Jockey pumps - 2 x 100%, motor operated pumps of required rating.*
- iii. Under slung crane of suitable capacity to lift the heaviest component with 10% margin. (Minimum 5 Tonnes).*
- iv. Interconnecting piping / valves as per the plant water system / as assessed by the bidder , LP piping specification and recommendation of TAC / NFPA*
- v. The main fire protection system shall consist of a fire water hydrant system serving the whole station includes*

- *Hydrant system*

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- Medium velocity water spray system
- High velocity water spray system
- Low expansion foam system
- Mobile & potable fire extinguishing system
- Fire alarm and detection system
- Inert Gas Protection System

In general all equipments/system components of complete fire protection & detection system shall have the approval from under writer's laboratories of USA or LPCB –UK or FM – USA or TAC – INDIA. However design and installation of complete system and requirements shall be approved by the agency specified elsewhere in the specification.

- vi. *For situations, which are not covered by the standards, system shall be supplied and installed to ensure effective protection.*
- vii. *The complete fire detection and protection systems shall be as per the guidelines/codes/standards/rules of the NFPA/IS: 3034/OISD etc and all the systems/equipments and installation shall be approved from tariff advisory committee (TAC)-INDIA/ LPA /TAC accredited professionals by the supplier/ Bidder to enable Owner to obtain maximum applicable rebate on insurance premium. The responsibility of getting approval from TAC / LPA /TAC accredited professionals rests exclusively on Bidder. Any other additional equipment not specifically mentioned in the technical specification but are found necessary to meet the requirements of TAC and also for safe and sound operation of the plant are to be included at no extra cost to Owner.*

c) *Fire water source*

The fire water tank shall be in two compartments, of [...] m3 total capacity. The hydrant system shall be fed from the discharge of Motor driven Hydrant pumps of required head and flow as well as diesel Engine driven standby pumps of similar capacity. The pressure in the system will be maintained by 2X100% nos. Jockey pumps.]

7.2 Codes & Standards

The system shall comply with the following regulations:

- a) Tariff Advisory Committee (TAC)
- b) National Fire Protection Association (NFPA) (For system not covered by TAC)
- c) BIS (For the approval of pumps and valves).

7.3 System Description

7.4.1 Fire Protection system

a) Hydrant System

System shall be pressurized continuously to normal working pressure. Hydrant system comprises of hydrant pumps *[(2 motor driven as working + 2 diesel driven as standby)]*, pressurization arrangement *[(2 nos. motor driven jockey pumps, 1w*

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+ 1s)], water mains network, hydrants (landing valves, internal hydrants, external hydrants, water monitors), hoses, hose cabinets, instantaneous couplings etc. Hydrants are located throughout the power station area. In case of fire, hose is coupled to the respective hydrant valves and jets of water are directed to the fire. Hydrant system is pressurized continuously to normal working pressure.

Water monitors are to be provided in the following areas

S.No	Area/Premises/Building
1	ESP
2	Switchyard Area
3	Coal stockyard
4	Fuel Oil Storage Area
5	Coal conveyors having elevation 15m or more.

The Bidder has to provide hydrants for the entire power plant. However, the major premises/areas are indicated.

S.No	Area/Premises/Building
1	TG Building
2	Boiler
3	Bunker Bay
4	Transformer Yard
5	Switch Yard
6	Switch Yard Control Room
7	DG House
8	Compressor House (Unit 1 & Unit 2)
9	Service Building
10	Central Control Room
11	Boiler Fill Pump House
12	Ash hopper Make-up water Pump House
13	Ash Slurry Pump House
14	Vacuum Pump House (Unit1 & Unit 2)
15	ESP Control Room
16	Mill Maintenance Building
17	DM Plant Building

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S.No	Area/Premises/Building
18	Clarified water Pump House
19	Fire Water Pump House
20	Effluent Treatment Area
21	CW Pump House
22	Fuel Oil Pump House
23	Fuel Oil Tank Area
24	Foam Pump House
25	Hydrogen Plant Building
26	Electro Chlorination Building
27	All Transfer Towers
28	Crusher House
29	Coal Handling Plant Control Room
30	Stockpile Area
31	Workshop
32	Electrical Repair Shop
33	Canteen
34	Admin Building
35	Security Office
36	Fire Station
37	Ware House
38	Raw Water Pump House
39	Any other plant facilities

b) HVW and MVW spray system

System shall be pressurized continuously to normal working pressure up to the deluge valves. It shall consist of deluge valves, isolation valves, y-type strainers, spray nozzles/projectors, spray nozzles piping network, detection system, instrumentation, junction boxes, cables etc. The system shall be automatic and shall be activated by a dedicated detection system to be provided for each of the equipment/area. Medium Velocity Water Spray System shall be provided for the following area / equipments:

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S.No	Area/Premises/Building
1	Conveyor No. [.....]
2	Conveyor No. [.....]
3	Conveyor No. [.....]
4	Conveyor No. [.....]
5	Conveyor No. [.....]
6	Cable Galleries in Main Plant Building.
7	Cable Galleries in Coal handling Plant
8	Fuel Oil Tanks

High Velocity Water Spray System shall be provided for the following area / equipments

S.No	Area/Premises/Building
1	Generator Transformer
2	Unit Auxiliary Transformer
3	Station Transformer
4	Inter Connecting Transformer
5	Turbine main oil tank
6	Centralised Oil Purification System
7	Seal Oil System
8	Lube Oil Canal
9	Boiler Burner Front

c) Foam Protection System

The fixed foam system shall consist of foam concentrate tanks, pumps balancing line with automatic controlling valves, foam makers, discharge outlets, interconnection piping, valves, fittings instrumentation, panel and control. In addition semi-fixed system consisting of a separate foam solution ring main around the tank with foam hydrant valves at regular intervals shall also be provided in addition to the water hydrants.

The operation of the fixed foam system shall be automatic with the aid of dedicated fire detection system provided in the tank. The semi-fixed system shall be operated through the foam hydrants/ monitors, portable type foam water monitors (wheeled type with in-built foam maker), hoses and nozzles for extinguishing spill fire in and around the tank area.

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Foam monitors/Hydrants should be provided in the following areas:

S.No	Area/Premises/Building
1	Fuel Oil Storage Area

d) Portable and mobile fire extinguishers

Fire extinguishers shall be installed in all the buildings within the plant boundary as per TAC requirement. The Bidder shall supply the required quantities of fire extinguishers with proper calculations and install the same in every facility of plant as per TAC.

- i) Carbon dioxide of 4.5 kg capacity conforming to IS: 2878 .
- ii) Carbon dioxide of 9 kg capacity conforming to IS: 2878.
- iii) Mobile type carbon di-oxide of 22.5 kg. Capacity conforming to IS: 2878
- iv) Dry chemical powder type of 5 kg. Conforming to IS: 2171
- v) Mobile type dry chemical powder type of 50 kg capacity (as per IS: 10658)
- vi) Foam type of 9 lit. Capacity conforming to IS: 10204
- vii) Mobile foam type of 50 lit. Capacity conforming to IS: 13386

Distribution of these extinguishers in various locations shall be as per the guidelines of TAC-INDIA

7.4.2

Inert gas System

- a) Fire protection system for the unit control rooms and control equipment rooms shall be by means of inert gas extinguishing system.
- b) The system shall be automatic and shall be activated by a dedicated detection system to be provided for each hazard area.
- c) The system shall consist of an IG-541 or IG-55 (as per NFPA 2001) cylinders filled with the agent gas, cylinder mounting accessories, cylinder manifold, automatic discharge valves, discharge piping, nozzles, automatic operating devices, manual actuation devices/ abort switches, associated fire detection /alarm system, audio-visual safety warning devices, instrumentation associated control systems, panels etc.
- d) The Inert gas system shall be provided for the following premises/areas including false floor and false ceiling.

S.No	Area/Premises/Building
1	Central Control Room
2	Electrical Equipment Room
3	UPS Room
4	Computer Room

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7.4.3 Fire Detection, Alarm and Control system

Fire detectors are provided in all areas and buildings of thermal power stations to detect the fire in its incipient stage, give alarm and actuate the fixed fire protection system provided to extinguish the fire. Type of fire detectors for various areas depends upon the fire risks. In addition to automatic fire detectors, manual call points are also provided throughout the power station for manually initiating alarm in case fire is noticed by some body.

- a) The fire detection and alarm system consists of the following components/equipments:
 - i) Main Fire alarm panel in Main control room.
 - ii) Area Panels as required.
 - iii) Repeater panel in Fire station.
 - iv) Various types of fire detectors such as Multi sensor detectors, Heat detectors, IR detectors, LHS cable
 - v) Hooters (Indoor and Outdoor type)
 - vi) Manual Call Points.
 - vii) Isolators.
 - viii) Siren.
 - ix) Response Indicators.
 - x) Ni-Cd Battery and Charger for the panels
 - xi) Control cabling
 - xii) Conduits, junction boxes, glands, earthing & accessories
- b) The fire detection and alarm system shall be microprocessor based analogue addressable type.
- c) In case of detection of fire, the fire signal (audio-visual) of particular area shall appear in the respective Area Panel and Main Fire Alarm Panel, Also it will be annunciated in the fire Station repeater panel.
- d) A central monitoring station shall be provided in central control room covering the complete plant area. A repeater panel shall be provided in fire station building.
- e) In addition, annunciation cum control panels shall be provided at firewater pump house.
- f) Selection of temperature rating of heat detector shall be based on maximum ambient temperature of about 50 °C for outdoor equipments (like transformers, boiler burner fronts, fuel oil tanks etc.) and about 40v °C for indoor equipments (like Coal conveyors, cable galleries, fuel oil pump house etc).
- g) Areas to be covered under fire detection and alarm system
- i) Multi sensor type smoke detection system along with manual call points shall cover all the areas like;
 - All the Electrical premises such as Switchgear/MCC rooms, Pump Houses, LT Transformer area, Cable Galleries etc including workshop and H₂ plant.
 - Main Plant area which includes TG Building, Service Building, ESP control

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room and ESP area , Bunker Bay, DG House, Fuel Oil Pump House and Storage area.

- Administrative Building, Security Office and Parking Area.
- ii) Detectors with response indicators shall also be provided above the false ceiling for the areas having false ceiling.
- iii) Multi sensor Detectors in cable galleries protected by MVW spray system and return air ducts of AC system of main plant, control room / control equipment rooms, inside all cubicles/ panels of control room, control equipment rooms and UPS/Marshalling areas.
- iv) Linear heat sensing cable detection system shall be provided for ignite conveyors and cable galleries covered under MVW spray system.
- v) For fuel oil tanks, Generator seal oil area, Main Oil tank area, Centralized oil purification area, Lube oil canal etc shall be provided with probe type heat detectors. Type of detection system to be employed for fuel oil tanks / pump house shall be approved by chief controller of explosives apart from tariff advisory committee (TAC)-INDIA/LPA/TAC accredited professionals.
- vi) Quartzoid bulb heat detection system for Power Transformers protected by HVW spray system.
- vii) Electrical type heat detectors (rate of rise/fixed temperature) for all battery rooms and Transformer area.
- viii) Infra Red type heat detectors for moving Lignite fire on the Lignite Conveyors.
- ix) Addressable electronic hooters shall have a sound output not less than 80db. Hooter shall be connected in each zone internally as well as externally. External hooters may be clubbed together with respect to common entry/exit point view for cable areas.

7.4.4

Fire water pumps & *[pump house]*

- a) *[Fire water pump house should be provided as separate building close to clarified cum fire water storage tank.]*
- b) The fire water pumps (main hydrant, hydrant booster, jockey pumps, foam system pumps and spray water pumps) shall be of horizontal centrifugal type with positive suction.
- c) Maximum speed of main hydrant, booster pumps, foam system pumps and spray system pumps to be supplied for the fire protection system shall be 1500 rpm. The motor driven pump and the corresponding diesel engine driven pump shall be completely interchangeable in respect of speed, impeller, diameter etc.
- d) The capacities and head of hydrant and spray pumps will be as per the datasheet and recommendations of TAC.
- e) Hydrant ring main shall be fed by Separate pumps. The capacity and head of hydrant pumps shall take into account foam system requirement also. Further 100% standby hydrant pumps of identical capacity shall be provided so that in case any one of the pumps is not available, the total requirement can be met by the standby pump. As per TAC rules, dual power supply arrangement for the motor driven pumps to be provided by the Bidder by suitable means so that maximum discount on insurance premium is available to Owner. This shall be

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achieved by alternate power source such as diesel engines or by any other means. The power supply of electrical driven pumps shall be uninterruptable.

- f) The standby hydrant and spray system pumps shall be of diesel engine driven.
- g) The water pumping arrangement shall be provided with automatic pressurization system with jockey pumps. There shall be [2x100%] capacity jockey pumps.
- h) The operation of the pressurization system shall be automatic and required instrumentation and control shall be provided. Re-circulation line with required valves be provided at for each set of the pumps (one each for set of jockey pumps, set of hydrant pumps, set of booster pumps, set of spray pumps and set of foam pumps).
- i) Booster pumps shall be provided for maintaining required pressure at higher elevation. The capacity of these pumps shall be as per system requirements/ TAC rules. The pumps shall be motor driven and diesel engine driven pumps of identical capacity shall be kept as standby.
- j) Booster pumps shall be provided for maintaining required pressure in hydrant and spray network in lignite stockyard area. Bidder to provide proper calculations for the parameters of the booster pump, to be reviewed by Owner.
- k) The header at the pump discharge shall be provided with suitable number of isolation valves so that none of the ring mains are affected when any of the pumps is taken for repair/ maintenance. In the event of fire, pressure in the hydrant or spray system shall drop due to resulting flow. In this event, water loss in the system will be replenished by jockey pump, however if this is inadequate to meet the demand and results in drop in system pressure further, at preset low pressure set point, first electric driven pump of the respective system shall start automatically. In case of failure of starting of this pump or due to increased demand of flow, the system pressure shall reduce further and this shall enable starting of subsequent pumps of the respective system in a sequential manner through means of various pressure sensing devices such as pressure switches/transmitters. Failure to start a pump shall be indicated as an alarm.
- l) The diesel engine drive of the pump shall conform to the requirements of TAC. Each of the diesel engines shall be provided with batteries and battery chargers.
- m) Battery of the diesel engine shall be lead acid type as per is and shall be large enough to crank the engine twelve times successively, each for a duration of 10 seconds without any charging in between.
- n) The continuous engine brake horse power rating (after accounting for all auxiliary power consumption) and correction for temperature and altitude at the site conditions shall be at least 20% greater than the requirement at the duty point of pump at rated rpm and in no case, less than the maximum power requirement at any condition within the operating range of the pump.
- o) The pumps shall comply with the regulations of BIS/tariff advisory committee (TAC) and shall be approved by tariff advisory committee (TAC)-INDIA/ LPA /TAC or insurance accredited professionals.
- p) The feeding line of the spray system from the header shall be provided with 2x100% capacity basket type filters to avoid any particles in the spray system.
- q) The pumping systems shall be complete with required instrumentation, control,

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recirculation pipe line with valves, non return valves in discharge outlet etc.

- r) The fire water pump house layout shall have sufficient space for the maintenance of the pump and diesel engine. Further the main fire water pump house shall be provided with a electrically operated Under slung crane of capacity capable of lifting heaviest component and the foam pump house and booster pump houses shall be provided with a mono-rail electric hoist of adequate capacity.
- s) Pumps shall be designed for continuous operation at its best efficiency point to meet the specific requirements of the system for which it is to be employed.
- t) Pumps shall have continuously rising head characteristic from its operating point towards shut off without any zone of instability and power capacity characteristic shall be preferably non-overloading type. The main fire water pumps and booster pumps shall be capable of furnishing not less than 150% of flow at 65% of rated head. The jockey pumps shall be as per TAC requirements.
- u) Pumps of each category shall be suitable for parallel operation.
- v) Material of construction of fire water pumps shall be as follows:
 - i) For fresh water application
 - Casing, stuffing : cast-iron grade IS: 210 FG -260 with 2.5% Ni Box
 - Wearing rings : SS
 - Impeller : bronze, IS: 318 GR.-II
 - Shaft : SS-316
 - Shaft sleeve : SS-410
 - ii) Wetted parts of foam pumps shall be of stainless steel construction and foam pumps shall be provided with mechanical seal.

7.4.5

Other facilities

Following facilities/equipment shall be provided:

- a) One foam tender with supplementary agents - carbon dioxide and dry chemical powder conforming to IS: 10460 (latest)
- b) One water tender as per IS:950 (latest)
- c) Fire tenders confirming to IS: 950, class B with standard accessories shall be provided.

7.4.6

Sirens

A siren is provided on TG building unit control room roof capable of being clearly heard over a radius of 2 km all around it for at least 3 minutes continuously over a background noise of Power Station. A highly luminous colored lamp placed over siren shall glow when the siren is switched.

7.4

Design Criteria

7.4.1

General

All equipments/system components of complete fire protection & detection system should have the approval from one of the following:

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- a) BIS
- b) Underwriters Laboratories of USA
- c) VDS - Germany
- d) FM – USA
- e) LPCB – UK

The complete fire detection and protection systems shall be designed in conformity with TAC/NFPA/IS No. 3034/OISD. Fire protection system shall be designed as per the guidelines of Tariff Advisory Committee (TAC) established under Insurance Act 1938 and /or NFPA

7.4.2 Hydrant system

- a) Category of hazard and minimum terminal pressure shall be as per TAC norms.
- b) The Hydrant ring mains shall be interconnected with isolation valves. It shall be possible to enable to take up part of any of the ring mains for maintenance without any loss of system in the balance part.
- c) An isolation valve shall be provided in feeder & terminal pipes serving three hydrants or water monitors or incase the terminal length is 15 meters or more with a single/two hydrant valve.
- d) All the landings of boiler staircases, turbine buildings and other multi storied structures, transfer points in the lignite handling plant, etc shall be provided with hydrant landing valves.
- e) For ESP areas, fixed water monitors shall be provided. Further fixed water monitors shall also be provided for Lignite conveyors having elevation 20 m or more. Both ESP areas and Coal conveyor areas shall also be provided with ground hydrants and landing valves.
- f) For fuel oil storage tank/dykes and fuel oil unloading area, double headed or single headed hydrants and fixed water monitors shall be provided. Each fuel oil storage tank shall be served by at least two water monitors and a hydrant valve. The monitor provided in the fuel oil handling area shall be dual type suitable for foam injection also. Each of the dual water monitor shall be provided with required foam supply/ apparatus etc.
- g) Each of the landing valves and external hydrant valves shall be provided with a hose box. Each hose box shall contain required (two numbers of 7.5 long hose for internal and two numbers of 15 m long hose for external hydrants) hoses, branch (two numbers) pipes and couplings, nozzles (one number), spanners (one set) etc as per TAC guidelines.
- h) All hydrant mains/pipe lines shall be routed underground as per TAC. The underground pipelines shall be provided with coating and wrapping as per IS: 10221/IS: 15337. Road rail, cable trench, cable channels or pipe trench shall be through RCC hume pipes of appropriate pressure class.
- i) External ground level hydrant valves along the Lignite conveyors at specific intervals shall be provided. At locations where height of conveyors is more than 15m water monitors at required intervals shall be provided as per TAC.
- j) Risers with landing valves/ water monitors shall be provided for each of the

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transfer points, bunker floors, crusher house and track hopper at each landings.

- k) Water for the protection of boiler air preheaters, and mills shall be tapped from the hydrant system as required.
- l) Fire hydrant specific data
- i) All hydrant valves should be of stainless steel construction conforming to IS: 5290 or equivalent.
- ii) Hoses shall be of non-percolating flexible type as per IS: 636 (type-A) and or equivalent.
- iii) Branch pipes (stainless steel) shall be universal type (as per IS: 2871 for transformer yard area) and straight jet type (IS: 903) depending on the location. Nozzles shall be of stainless steel

7.4.3

HVW and MVW Spray system

It consists of spray pumps [(2 motor driven + 1 diesel driven as standby)], pressurization arrangement, water mains network, wet detection system comprising QBD, deluge valves, isolation valves, Y-type strainers, spray nozzles/projectors, spray nozzles piping network, detection & control system, piping, valves, other accessories etc. The system is automatic and is activated by a dedicated detection system to be provided for each equipment/area. The system is pressurized continuously to normal working pressure upto the deluge valves.

- a) Minimum running water pressure at any projector/ spray nozzle shall be not less than 3.5kg/sqcm and not greater than 5.0 kg/sqcm for HVW spray system. For MVW spray system, minimum running water pressure at any projector/spray nozzles shall be as given under.

MVW SPRAY SYSTEM - WATER PARAMETERS

S.No	Area	Minimum water density	Minimum Pressure
1	Cable Galleries	12.2 LPM/m ²	2.8 kg/cm ²
2	Lignite Conveyors	10.2 LPM/m ²	1.4 kg/cm ²
3	Oil storage tank	10.2 LPM/m ²	1.4 - 3.5 kg/cm ²

- b) Design discharge density shall be as per the rules of water spray system of tariff advisory committee (TAC) and/or NFPA standards. In addition to these rules /standards, each of the bulk storage tanks of fuel oil shall be provided with cooling arrangement through a separate deluge valve & piping network with a design discharge of 1 LPM/sq.m. Whenever fire is detected in a fuel oil tank, apart from actuation of this MVW system on the detected tank, the cooling water spray at this specified rate of 1 LPM/sq.m shall be automatically operated on the balance tanks (i.e. spray over the unaffected tank). If design of spray system considers simultaneous spray on all the tanks (due to location in a common dyke or due to lesser distance between the tanks with respect to specified value in TAC rules), the additional cooling water spray as specified above is not required to be provided.

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- c) The spray system for the boiler burner front shall cover all the fuel oil and Lignite burner elevations, its adjacent piping structures, floors etc. At least 7 meters either side of burner elevations or as per NFPA recommendation whichever is stringent.
- d) Fuel oil tanks shall be protected by MVWS and Foam system
- e) In cable galleries, the water spray shall cover the exposed area of all the trays and racks. As far as possible, fire compartmentalization shall be done in case of cable galleries, cable spreader rooms, electrical equipment rooms etc.
- f) An isolation valve shall be provided at both upstream and downstream of each of the deluge valve. Bypass valve shall be provided for each deluge valve. The size of the valve shall be same as that of the deluge valve.
- g) The spray system for the Coal conveyor system shall cover the exposed area of both the forward and return conveyors and idlers. In transfer points, crusher house, track hopper, pent house etc., the water spray shall cover the drive equipments, pulleys, chutes, other equipments of the floor, complete floor area at various elevations.
- h) Water motor gong shall form part of accessories to be provided with deluge valve.
- i) A strainer ('y' type) shall be provided at upstream of deluge valve.
- j) Pressure gauges at both upstream and downstream of deluge valves, and in the detector pipe network shall be provided.
- k) Pressure switches shall be provided in spray and detector piping to exhibit "fire" and "spray on" annunciations and interlock for tripping of respective equipment wherever applicable.
- l) Wet type pipe detector network shall be provided for spray system using quartzoid bulb detectors. In case wet type pipe detection employed for Coal conveyers or any other equipment located above 20 meters elevation from deluge valve, additional pressure switch shall be provided to actuate the deluge valve.
- m) All spray pipe mains/ pipe lines shall be routed under-ground. Road, rail or pipe trench crossing be through RCC hume pipes of appropriate pressure class and the pipe lines shall be provided with coating and wrapping as per specification
- n) Facility for manual initiation of deluge valves, locally through a pushbutton or hand lever shall be provided
- o) Each outdoor deluge valve and its accessories shall be provided with housing with RCC roof.
- p) Deluge valve shall be of automatic resetting type.

7.4.4 Foam Protection System

Automatic fixed foam system is envisaged for main HFO and LDO storage tanks. In case of fire, the foam system for the respective tanks gets automatically activated on detection of fire by probe type heat detectors provided inside the fuel oil tanks resulting in pouring the foam water mixture on the oil surface inside the tank and foam blanketing the burning oil surface thereby cutting the oxygen supply and extinguishment of fire. The system consists of foam concentrate storage tanks, foam pumps, [(1w+1s)], balancing line with automatic controlling valves, foam makers, discharge outlets, interconnection piping, valves, fitting

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instrumentation and control system. In addition, semi-fixed system consisting of a separate foam solution ring main area around the tank farm area with foam hydrant valves at regular intervals is also provided.

- a) Complete system shall be designed as per NFPA-11 and TAC.
- b) Water for the foam system may be tapped off from the hydrant system.
- c) The operation of foam system shall be automatic with the aid of fire detection system provided for the fuel oil tank with a provision for manual operation. Auto/manual selection switch shall be provided at the local panel.
- d) Foam concentrate shall be of 100% AFFF type and shall be provided in [2x100%] capacity foam concentrate tanks. It shall be discharged to the foam pumps inductors through [2x100%] capacity foam pumps (one of motor driven and another of diesel engine driven) pumps through balancing line, with control valves, flow controllers etc.
- e) The minimum effective capacity of each foam concentrate tank and foam pumps shall be designed for simultaneous protection of one fuel oil tank of each type or size and as well as operation of two foam monitors/ hydrants at its design capacity for a minimum duration of 60 minutes or as minimum capacity if specified elsewhere.
- f) A design margin of at least 10% shall be considered over the calculated foam concentrate capacity, tank capacity and discharge capacity of the foam discharge pumps.
- g) Foam concentrate storage tank shall be provided with discharge pipe manifolds, individual isolation valves, tank inlet, drain, overflow connection, level indicators, level switches, etc. All the foam concentrate tanks, pumps, the local panel and other shall be located indoor in a building to be provided by the supplier/ Bidder.
- h) One number (1) foam proportioner (of 100% capacity) is provided for each type or capacity of fuel oil tank with a common standby foam proportioner. Separate isolation valves (manually operated) are provided for each proportioner for maintenance.
- i) Automatic solenoid valve shall be provided in foam supply line to each of the fuel oil tank at the upstream of foam proportioner. In the event of detection of fire, the signal shall start the foam pump, operate the deluge valve of water inlet valve to the designated foam proportioners of the tank, and as well as open the foam solution inlet valve to foam proportioner and thereby foam is injected to the tank under fire foam makers discharge outlets.
- j) Apart from feeding the individual tank, each set of foam inductors shall deliver foam solution to foam hydrant piping ring around the tank dyke whenever foam injection system is initiated so that spill fires if any may be extinguished by means of foam hydrants, hoses & portable (wheeled type) foam generator/ monitor.
- k) The minimum foam application rate of 3% foam solution shall be 12 lpm/ sqm of seal areas of floating roof type tanks and 5 lpm/sq.m (complete surface area) for fixed roof type tanks.
- l) The system shall incorporate features such as non-return valves to avoid mixing water with foam concentrate pipelines, strainers in water inlet and in foam

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concentrate lines, isolation valves of pumps/ flow control valves/ ratio proportioning devices etc.

- m) Manual operation facility shall be facilitated locally from the panel and operation of foam pump, opening of valves and injection of foam to any of the fuel oil tanks shall be achieved through selector switches, push button etc.

7.4.5 Inert Gas System

a) General

Total flooding system of Inert gas extinguishing system shall be provided for the following areas including false ceiling and false floor spaces as per NFPA 2001 (Latest Edition).

S.No	Details of Area to be Protected	Location	Approx. Sizes (m)		
			L	W	H
1.	[Electrical Equipment Room (EER) for unit .1]	[Main Control room at +17.00m level in TG building]	[...]	[...]	[...]
2.	[Electrical Equipment Room (EER) for unit .2]		[...]	[...]	[...]
3.	[Control room Including Computer room]		[...]	[...]	[...]
4.	[UPS room for unit .1(8.5 m level)]		[...]	[...]	[...]
5.	[UPS room for unit.2(8.5 m level)]		[...]	[...]	[...]

b) System Description

The Inergen gas total flooding system shall be an engineered system consisting of fixed nozzle and gas distributing network. The system shall be designed and installed in accordance with the NFPA 2001(Latest Edition).

The system shall consist of following major components:

- Bank of Clean agent cylinders with Gas each fixed with cylinder head valve and non-return valve
- Bank of standby cylinders with Gas fitted with - cylinder head valves and non return valves.
- Gas manifold and high-pressure hoses.
- Cylinder rack
- Pressure reducing devices.
- Pressure switches.
- Pilot cylinders if required
- Electric Actuator

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- ix) Manual push buttons
- x) Inhibitors
- xi) Directional valves
- xii) Flexible Hoses
- xiii) Discharge Nozzles
- xiv) Safety relief valves
- xv) Pipe and Fittings
- xvi) Bracket Supports and Hangers
- xvii) Caution hooters
- xviii) Caution boards & evacuation alarm
- xix) On line weighing system with digital display signal of loss of gas in the cylinder. Weight to be available at MFAP
- xx) Fire detection and alarm system including Gas release panel/ local control panels and interface unit/ monitor control module etc.
- xxi) Cylinder bank room (brick construction with RCC roof)
- xxii) Trolley to transport 2 numbers of cylinders at a time.

The quantity of gas required for the system shall be based on the gas required to blanket the volume of area protected including leakages.

In order to optimize the requirement of gas and considering the space for cylinder banks, it may be planned to club together requirements of two or more adjacent premises. The Bidder shall ensure that the appropriate logic is followed for discharge of gas in respective premises.

Bidder shall include provision for automatic actuation of the system in integration of FDA system in the premises concerned. Annunciation signal related to for system operation shall be provided in MFAP as well as locally on panel. Provision for time delay and evacuation alarm shall also be provided.

Bidder shall note that release of gas shall be possible directly from FDA panel as well as local GRP/ local Panel to operate the system from FDA panel and obtain signal/ control. Bidder shall also include all interface units viz. control and monitor module.

Pipe network shall be designed to achieve the design concentration of gas required for extinguishing the fire in the premises.

The concentration level shall not exceed the NOAEL and LOAEL level as per NFPA guidelines.

Manual pushbutton of each area shall be located near entry/ exit.

Bidder to develop logic for above and submit working scheme along with the tender. Any interface devices required to hook up this system with the Main Fire Alarm Panel shall be included by the Bidder as part of the scope as a whole.

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One no. wall mounted annunciation panel/ gas release panel near cylinder bank shall be provided for (duplicate) annunciation as well as operation of gas release system.

Each of the premises will have false floor and false ceiling. The room volume, volume above false ceiling and the volume below false floor of each premises/room shall be considered for protection and detection and for calculation of Gas quantity and other components of the system.

Each zone shall be equipped with fire detection system. On receiving the fire signal from the detection system agent gas shall be released automatically after a set time delay and gas shall be discharged into the enclosed space.

The system shall comprise of the following mode of operation and actuation and cancellation facility etc. with necessary control panel.

System operation shall be possible by the following means:

- Automatically due to fire detection in the protected area from main fire alarm panel.
- Operation of manual release push button located adjacent to protected area.
- By operating manual lever provided on electrical / manual control head on cylinder.
- By push button actuation at Clean Agent control panel in manual mode.

The clean agent shall be discharged / actuated automatically after an adjustable time delay based on the detection signal received. Pre-discharge alarm (audio + visual) shall be initiated before discharge of gas in main fire alarm panel & local control panel.

Hooter shall follow the alarm once the gas is discharged.

The release of gas shall be preceded by an audio visual alarm in the affected area for alerting and evacuating the personal and for this purpose, during time delay of about 60 seconds (which is settable from the panel) between the initiation of release and actual release of gas. The exact time delay to be incorporated in the system shall be decided during detailed engineering.

To avoid an inadvertent mal operation and release of gas, on either of the mode of gas release operation (auto or manual), provision of manual interruption (i.e.) gas discharge inhibition facility through a suitable device on local control panel, main fire alarm panel as well as each protected premises shall be provided so that the agent release can be stopped within the time delay.

Multi sensor type detectors (addressable type) shall be provided below false ceiling, above false ceiling and false floor. Cross zoning of detectors shall be incorporated in such a way that the fire is detected by at least one detector of each type to activate automatic inert gas release system. However, audiovisual alarm shall be annunciated even if any one of the type of detector has detected the fire.

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Refer electrical chapter of this Technical specification for details of detection system

Necessary provision shall be made in the fire alarm panel for switching off the air-conditioning system automatically as soon as the fire is detected.

c) Design Criteria

- i) Complete design, software used and all the system components/equipment shall be approved and listed by UL / FMRC/LPC/VDS.
- ii) Design, manufacture and installation of inert gas fire extinguishing system shall be strictly as per NFPA 2001 (latest edition). In case the system is as per LPC/VDS, then, Design concentration of the gas shall be as per ISO norms specified by of LPC/VDS.
- iii) 150/ 200 bar clean agent extinguishing system shall be designed and installed for below false floor, main room and above false ceiling of various risk areas.
- iv) The Physical properties and its discharge characteristic of clean agent shall meet the requirements of NFPA-2001 (Latest edition).
- v) The design calculation shall be supported by UL/FMRC/LPC/VDS listed software.
- vi) The system shall be designed for total flooding based on the single largest risk area of the control room to be protected. However grouping of cylinders shall be made in such a way that discharge takes place corresponding to the volume of the risk under fire. However, Bidder shall check the suitability of common cylinder bank to cover all the rooms/areas as per norms.
- vii) The system shall have 100 % Clean Agent filled standby cylinders along with manifold and automatic change over for each risk area from the fire alarm panel itself.
- viii) The complete volume of the single largest room including the above false ceiling and below false floor shall be considered for estimation of quantity of gas and containers.
- ix) When determining the gas quantity, the leakage losses from the enclosure shall be taken into account by the supplier. The exact amount of gas to compensate for leakage compensation shall be designed by the bidder taking into consideration the type and features of enclosure, enclosable openings if any and other considerations so that design concentration is achieved after discharge
- x) The discharge time period shall be such that the design concentration can be achieved within 60 seconds. The flow calculations shall establish these criteria.
- xi) The quality of gas shall conform to relevant design standard such as NFPA - 2001 or as specified by listing authorities:

d) System Requirements

i) Clean Agent gas

The quantity of clean agent gas provided shall be sufficient to protect the single largest risk area with 100 % standby. The every individual risk shall have its own distributing pipe, nozzles, alarm and actuation system etc.

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Both the main and standby cylinders shall be permanently connected to the distribution piping through manifold and auto change over. The clean agent discharge shall be substantially completed in a normal 60 seconds.

ii) Flow Calculation

System flow calculations shall be performed using software listed or approved by UL/FMRC/LPC/VDS. The system designed shall be within the manufacturers listed limitations. Bidder shall provide the sufficient measure facilities in the risk areas to overcome the situation of over pressurization due to release of clean agent and also provide calculation in support of same for each protected area.

The Bidder shall submit the approval certificate/ listing document from UL/FMRC/LPC/VDS for the of software used for flow calculation.

e) Clean Agent Quantity

Minimum design concentration of Clean Agent gas shall be as per NFPA-2001 (Latest Edition) norms and specified by the approving authority. Quantity of Clean Agent Gas shall be calculated for the total volume of the largest room to be protected.

f) Clean Agent Storage Cylinders

- i) All the storage containers shall be kept in an enclosed room.
- ii) The 150/ 200 bar Clean Agent storage cylinders shall be considered to hold Clean Agent at ambient temperatures.
- iii) Maximum pressure of storage cylinder shall be 150/ 200 bars.
- iv) Cylinders shall also have approval from CCE, Nagpur
- v) The cylinders shall be charged to a fill density or super pressurization within the range specified in the manufacturers listed manual.
- vi) Bidder shall select the capacity of cylinder based on the total quantity of gas required, storage space available and for better replacement and inter changeability. Preferably 80 liter capacity cylinders may be used
- vii) The cylinder shall be seamless, brand new never retested with month & year of manufacture shall be marked on the cylinders.
- viii) Each cylinder shall have a permanent name plate, specifying the agent, tare and gross weight in addition to the pressurization level, nominal agent volume.
- ix) Cylinder shall bear the mark of manufacturer, serial number. single test certificate issued by manufacturer and shall be duly approved by UL/FMRC/LPC/VDS.
- x) Cylinder shall conform to the requirement of NFPA 2001 (Latest Edition) and shall be compatible with the engineered system.
- xi) Each cylinder shall have pressure relief valve to protect the cylinders against excess pressure conditions. Pressure gauges and pressure switches with isolation valves on manifold shall be provided.
- xii) Automatic means such as check valve shall be provided to prevent agent loss if the system is operated when any of the cylinders is removed for maintenance.

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- xiii) The cylinder storage racks shall be provided for main as well as for reserve cylinders.
- xiv) The manifold and cylinders shall be securely mounted on the floor and suitably supported in a rack with provision for convenient taking out individual cylinder for servicing, according to the manufacturers installation manual. Such servicing shall be possible without shutting down the system.
- xv) The Bidder shall indicate the space provision for room required for the storage of Gas Cylinder s and Manifold Piping along with technical offer.
- xvi) The gas cylinders shall be provided with Base Plate, foundation bolts & nuts etc. so that, the entire load is evenly spread out over the entire plan area. No concentrated load shall be resulted from the mounting arrangement of the cylinder/containers.
- xvii) All the pressure, gauges/switches, manifold connections etc shall be easily removable for servicing / maintenance without any loss of gas.

g) Discharge Nozzles

Discharge nozzles shall be UL/FMRC/LPC/VDS listed. The material of construction shall be of Brass. The selection of nozzle orifice shall be such that 95% of the minimum design concentration of gas is discharged within 60 seconds, through the nozzles of the system.

Each nozzle shall be permanently marked to identify the manufacturer as well as type and size of the orifice along with tag / part number, orifice code, or other suitable marking as specified in relevant norms / codes.

h) Piping, Fittings

Pipes shall be of ASTM A-53 or A-106 type (Seamless Carbon Steel High Pressure Sch. 80 pipe) and pipe fittings shall be provided as per the requirements specified in NFPA-2001 (Latest Edition). Pipe thickness calculation shall be as per ASME B31.1 and fittings conforming to ANSI B1.20.1. All CS Studs, Bolts and Nuts shall be Hot Dip Galvanized as per ANSI A153 for corrosion resistance. The Pressure Reduction device shall be easily identifiable. All Valves shall be approved for intended use. The Gaskets, O-Rings and other Valve material shall be compatible to the Clean Agent.

The Clean Agent piping and nozzles shall be planned avoiding fouling with the following facilities, in the areas where protection is being envisaged:

- i) AC ducts.
- ii) Cabling in false flooring.
- iii) Light fittings, detectors etc.
- iv) Other miscellaneous equipment/ fittings

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i) Operating Devices

- i) Operating devices shall include Clean Agent releasing devices or valves, discharge controls and shut down equipment necessary for successful performance of the system.
- ii) The automatic Clean Agent system shall be of robust design and shall not be readily rendered inoperative. The Clean Agent system shall be designed to function properly for the temperature range specified in NFPA-2001.
- iii) The Clean Agent cylinders shall be mounted on front and firmly supported in brackets in a manner that they will not be easily subjected to mechanical, chemical or other damage, which would render the system inoperative.
- iv) In addition to Automatic actuation, there shall be a normal manual control for actuation, which shall be located so as to be conveniently and easily accessible at all times. This control shall cause the complete system to operate in its normal fashion.
- v) Manual controls shall not require a pull of more than 40 lb or a movement of more than 14 inches to secure operation. Each remote manual control for activation shall be located not more than 4 feet above the floor.

j) Local Control Panel

- i) Local control panel shall be free standing, floor mounted type and shall be suitable for both auto and manual operation. The panel shall be naturally ventilated, totally enclosed, dust and vermin proof, with IP-55 enclosure as a minimum. The Clean Agent system shall be actuated automatically from the fire alarm and detection panel. Fire alarm and detection panel, after detecting the fire in the protected area / zone, shall energize the solenoid valve/ electrically operated valve of cylinder to trigger the gas release operation in the respective protected area / zone. In addition to direct actuation of the cylinder valve from main fire alarm panel, those cylinders shall also get actuated through local control panel/ gas release panel. Necessary control / interlock cabling between Fire Alarm and Detection Panel and Clean Agent system panel, using multi-core 2.5 mm², Cu conductor PVC insulated flame retardant cable shall be provided by the Clean Agent Vendor. The main fire alarm and detection panel shall be located in pump house Control Room. The location of local control panel shall be decided during the detailed engineering.
- ii) The local control panel shall be equipped with adequate capacity of battery charger and Ni-Cod. Battery with 48 hour back up, for efficient operation of the system during mains power failure.
- iii) Local control panel shall be provided with all alarms, indicators, and caution/sign board and relays/ control switches meeting all the requirements of NFPA- 2001 and shall include but not be limited to the following:
 - Two alarms and one fault indicator lamp for each zone to be protected.
 - Combination of alarm silence and alarm off switch.
 - Combination of fault silence and trouble lamp switches.

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- Alarm test switch
 - Alarm re-set switch.
 - The system shall have a positive warning device by sounding alarm to alert personnel of the gas discharge and also a positive indication to show that the system has actuated.
 - Alarm indicating failure of supervised devices of equipment shall give prompt and positive indication of any failure and shall be distinctive from alarm indicating operation of hazardous conditions.
 - All indication lamps shall be LED type with minimum size of 10 mm.
- iv) Warning and instruction signs at entrance to and inside protection areas shall be provided.
- v) Potential free contacts shall be provided to shut off the fire dampers / louvers and Air Conditioning System.
- vi) Operating instructions shall be displayed on a name plate fitted permanently on the Clean Agent skid.
- vii) Clean Agent extinguishing system shall incorporate a pre-discharge alarm with a time delay, sufficient to allow personnel evacuation prior to discharge. The delay shall be minimum 30 seconds. However it shall be adjustable from 30 to 120 seconds.
- viii) Operating devices shall be by mechanical, electrical and pneumatic means conforming to NFPA2001. The power supply to electrical actuators shall be backed up with reliable battery supply. Such batteries shall be charged automatically by battery chargers. Power supply is taken from the Fire detection alarm system panels of the respective units. Required annunciations such as "Gas released", "Failure of automatic actuation", "Gas release aborted" etc shall be exhibited in the fire alarm panel.
- ix) Where pilot cylinders are employed for actuation of the cylinder banks, the number of pilot cylinders shall be as per the listed design manual.
- x) All manual operating devices shall be identified to the hazard they protect.
- xi) Manual abort switches for each of the area / zone shall be as per NFPA2001 or as specified by listing authorities.
- xii) The gas releasing devices at cylinder outlets shall be of reusable type after discharge at any instant.
- xiii) Supervision of automatic actuation devices, power supply, manual actuation circuits and complete wiring shall be provided through control system I panel and the healthiness shall be reported or indicated in the panel automatically.

k) Inspection and Testing

The complete system shall be tested to meet the requirement of NFPA 2001 norms. All equipments / devices shall be approved and listed by UL/FMRC/LPC/VDS except pipes, fittings & structural support.

Tests not limited to the following shall be performed:

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- i) A thorough visual inspection of the installed system and hazard area. The piping, operational equipment and discharge nozzles shall be inspected for proper size and location. The locations of alarms and manual emergency releases shall be confirmed. The hazard area shall be inspected closely for un-closable openings and sources of agent loss.
- ii) The Bidder shall furnish the composition certificate of Clean Agent from the manufacturer satisfying the requirements of the NFPA-2001.
- iii) Gas filling certificate shall be submitted from the manufacturer/ gas filling agency
- iv) A check of labeling of devices for proper designations and instructions. Name plate data on the storage cylinders shall be as per specifications.
- v) A test for mechanical tightness of the piping shall be conducted as per NFPA-2001
- vi) Storage containers shall meet the statutory requirement of approval / acceptance by CCE, Nagpur.
- vii) Design calculation shall be provided by the designer to prove that the area is not over pressurized and extinguishing capability is not affected due to existing ventilation of that area.
- viii) Complete system shall be installed, inspected, tested and commissioned as per recommendations of NFPA 2001. Bidder shall also consider Gas for one smallest room for system testing.
- ix) Prior to handing over of the system to Owner, the supplier shall provide operational training to Owner's operating personnel which shall consist of control system operation, trouble procedures, emergency procedures, safety requirements etc.
- x) The performance test of the system shall be carried out by releasing the agent gas in a selected area and all the design parameters shall be measured. All equipments, refilling of gas after test, instruments etc shall be provided by the contractor for the same.

I) Safety

- i) All the safety requirements recommended in NFPA2001 or as specified by listing authorities shall be incorporated in the installation by the bidder.
- ii) Appropriate warning signs shall be fixed outside of those areas protected by the system and also in areas where the gas may spread indicating clearly the hazard associated with the system such as Noise, turbulence, cold temperature, physiological effects on personnel etc.
- iii) Apart from written warning signs, audiovisual type warning signs (i.e.) hooters & strobe lights shall be provided; for pre-discharge and post-discharge activity. The sounder shall have selectable tone options.
- iv) The gas shall be discharged after a set time delay on receiving signal from the fire detection system. The duration of the timer shall be set at site after conducting test to find out the duration for evacuation of the personnel from the area.

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- v) To prevent the loss/release of gas automatically or manually during maintenance, the system shall have the facility of "LOCKOUT". The status of the system lockout condition shall be annunciated audio visually in the panel.
- m) **Materials of Construction**
- The material of construction shall be as per this specification for the items specified.
- For other items, the materials of construction used in the system shall be in accordance with NFPA-2001 or as specified by the equipment manufacturer for the intended use (if the same is not specified in NFPA-2001). However, all the items shall bear UL/FMRC/LPC/VDS listing
- Operating and maintenance manual.

7.4.6 Fire detection and alarm system

- a) General
- i) The annunciation panel at pump houses shall indicate the status of each pump, system pressure, operation of hydrant and/ or spray system, failure of starting of pumps, healthiness & failure of batteries/ chargers, main supply, low level of fuel oil tanks of diesel engines, tripping of pumps, low level / very low level of water level in the water supply system, selection status of batteries & chargers of panels and diesel engines etc. Alarms from these panels shall also be available to operator at fire station and at central monitoring station.
- ii) The addressable type panels at common control room shall receive signal from sensors from various areas/ equipments.
- iii) The Main Fire Alarm Panel to be located at common control room for two units shall cover the fire detection and protection system of the complete (all the areas) plant. This shall give audio -visual annunciations for fire in each of the risk area / equipment/ status of the fire protection system as well as system operator open /short circuit status of detector or control cabling etc. Further this shall activate a hooter/sounder in each of the area provided with fire/smoke detection system.
- iv) Number of Area Panels with alphanumeric mode and LED(cluster type) indication to be installed in control rooms of CHP, AHP, DM Plant, ESP Control Room, Switchyard control building, CW pump house and any other suitable area. In case of detection of fire, the fire signal (audio-visual) of particular area shall appear in the respective Area Panel and Main Fire Alarm Panel, Also it will be annunciated in the fire Station repeater panel.
- v) Area Panels shall have their own power supply unit and 24 V stand by battery in case of failure of normal AC supply. APs shall have facility to display all alarm and fault conditions, status of detectors of their respective area.
- vi) The Main Fire Alarm Panel, Repeater Panels and Area Panels shall be networked using RS 485 interface with fibre optic cable including all related accessories. Also, Main fire alarm panel and repeater alarm panel shall be connected through wireless network also. Distance between MFAP, AP, RP shall depend upon site conditions. The bidder shall provide all required hardware, software, cabling, interface cards, etc in this regard as per system requirement. A provision shall be

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kept to add/remove panels from the network. In network connection, bidder to provide two spare cores to be used in case of fault in working cores.

- vii) The addressable panel shall evaluate the signals received from the detectors, transmit the fire or trouble alarms (audio-visual) to prearranged points, supervise and monitor the complete fire detection & extinguishing circuits, initiate control functions like stoppage of Coal conveyers, closure of fire doors, shutdown of air-conditioning and ventilation plant/equipment, closure of fire dampers in a/c & ventilation system etc. Opening smoke extraction vents, switching on smoke extraction equipment, emergency lighting, tripping of transformer lockout relays etc. Details of such auxiliary functions shall be finalized as per Owner's requirement.
- viii) Bidder shall provide required electrical contacts relay (upon detection of fire) in their fire alarm panel to enable Owner to complete the output function for equipments/hydrants which are in the scope of Owner like tripping of conveyors etc.
- ix) All the circuits from the detectors to the panels and the circuits from the panels to the actuating devices (such as solenoid valves, deluge valves, push buttons etc.) Shall be closed loop type and shall be supervised for open and short-circuiting. The trouble signal shall also be annunciated in the respective panels.
- x) Facilities shall be provided on the fire alarm panel for simulating fire conditions, sensitivity adjustment, isolation of detectors etc. from the panel.
- xi) Complete fire detection, alarm monitoring and annunciation system from the panels shall be operated on DC supply, suitably converted by a dedicated rectifier bank taking supply from each of the panel. Further each panel shall be provided with 2x100% batteries and 2x100% battery chargers with provision for automatic change over from mains to batteries, automatic charging etc.
- xii) Each set of battery shall be of adequate capacity to supply fire detection and alarm system and as well actuating devices such as solenoid valves etc. for a period of 12 hours from the instant of charger/ ac failure.
- xiii) The batteries shall be of maintenance free sealed (NI - CD) type.
- xiv) The detector cable and other control cable shall be armored, screened and twisted FRLS type in external areas and shall be of unarmored FRLS type inside the buildings (in conduits). However, the cables associated with "Lignite conveyor-detection & protection system (within Lignite handling plant)" and unit control & control equipment room shall be of short term fire proof type conforming to category "s" as per BS: 6387.
- xv) The fire alarm system, of each unit shall be provided with necessary interface hardware and software for interconnection with LAN / WAN (respective unit as the case may be) of DCS for transfer of signals for the purpose of information to the unit control room. The plant information shall be made available through a serial link following mod bus or industry standard protocol to be decided during detailed engineering. All required plant data shall be transferred to/from DCS through a suitable gateway ensuring complete security. The exact number of points to be transferred through the communication link and the format of the data shall be finalized during the detailed engineering. The fire protection vendor shall provide all assistance to the DCS supplier including coordination and flow of required

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information etc to achieve the following:

- Display of all input points under alarm, connected to/or generated by fire alarm system on the main operator console of DDCMIS
 - To display diagnostic messages of fire alarm system.
 - Selection of suitable communication protocol between fire alarm system and DCS.
- xvi) The Bidder shall produce a design philosophy document stating the criteria for the fire detection and protection systems and in particular for zoning of the plant, selection of the control system, the detectors, their positioning, precautions against spurious signals, the interfaces between the fire detection and HVAC systems, the remote/local operation of fire dampers, smoke extraction fans and smoke vents, local indication of dampers, smoke extraction fans and vents and the operation of the fire protection systems etc. The Bidder shall ensure that, wherever possible, the zoning of the fire systems shall coincide with the zoning of the HVAC systems to simplify sequencing, interlocking and tripping of the HVAC and fire systems under operational, fire and emergency conditions. The bidder shall provide all necessary interfaces to other systems.
- b) Smoke Detection System
- i) In the areas where only smoke detectors are envisaged upon detection of fire, the same shall be annunciated in the respective panels and shall activate a local hooter/ sounder in the areas where fire is activated.
 - ii) Wherever both the Multi sensor type & photo - electric type smoke detection systems are provided, cross zoning of the signal shall be provided to initiate the fire extinguishing system of that area such as automatic MVW spray system of cable galleries etc.
 - iii) Two smoke detectors of both the types shall be provided for return air ducts of each room which shall consist of intake probe, detector housing, and exhaust pipe etc. The detector shall be mounted outside the duct.
 - iv) The design coverage area for smoke detectors (to be considered) shall not exceed 25 m².
- c) Detection System for Coal Conveyors
- i) The LHS cable detector for each conveyor shall be layed as per the standard practice of the manufacturer/ supplier. The arrangement shall be designed such a way that the same shall not hinder the normal operation and maintenance. LHSC shall be layed on pipe racks supplied by Bidder.
 - ii) The detection zone/loop divisions of LHSC system shall match with the MVW spray system.
 - iii) Upon detection of fire either by IR detector or LHSC detector, the running conveyors shall be stopped and the spray system shall be initiated. It shall also initiate spray system for the two adjacent zones after a time delay settable at site.
 - iv) The LHSC detector may be digital type/ analogue type and shall comply with latest TAC guidelines. In case of digital type suitable interface unit shall be provided which shall generate/ make the signal compatible with fire alarm panel.
 - v) The infra red type (IR) detectors shall be suitable for detecting moving fires in Lignite conveyors and at least one detector shall be provided for each of the

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conveyor if specified elsewhere.

- vi) The IR detector shall stop the conveyor upon detection of fire and give audiovisual annunciation locally and in fire alarm panel.
- vii) The IR detector shall be outdoor type weather proof and shall be able to function continuously in heavily coat-dust prone atmosphere without regular maintenance.
- viii) The IR detector shall be designed to reject deceptive phenomenon such as electric arc, heaters, artificial light sources (HPSV/ LPSV / incandescent lamps etc.) sunlight etc. While retaining the inherent detection characteristics.
- ix) Each of the IR detectors shall be provided with its own purging arrangement using blowers, hoses, etc and required power supply shall be derived from the fire alarm panel, or from nearby power supply system. Alternatively, supplier/ Bidder may offer separate blowers (2x100%) for purge air supply for all the detectors separately and the complete air piping air from the blowers to each of the IR detector shall be provided by the supplier/ Bidder.
- x) The performance of the proposed IR detector model for detecting moving fires shall be demonstrated to Owner as per test procedure acceptable to Owner before supply of the same at site. Such demonstration test shall be conducted in a typical Lignite conveyor test set up at works or in a plant.
- d) Detection System of Cable Galleries
 - i) In cable galleries, MVW spray system shall be actuated either by detection of fire by linear heat sensing cable detectors or by fire signal from smoke (after cross zoning) detection system. Apart from the automatic operation of spray system in the detected zone the adjacent two zones shall also be sprayed with water automatically after a set time delay simultaneously.
 - ii) LHSC detector shall run in a zigzag fashion (with an included angle of minimum 90°) at least in each of the top tray, bottom tray and in every alternate tray.
 - iii) The detection zone/loop divisions shall match with MVW spray zones.
- e) In the battery rooms, wherein electrical spot type detectors are to be provided,, alarm shall be provided whenever fire is detected. The coverage factor for the electrical type detector shall not exceed 25 sq. M per detector.
- f) The foam system of fuel oil tanks shall be operated by probe type heat detection system. In case fire is detected, the automatic Foam system shall be actuated for the detected tank and simultaneously MVWS cooling of the balance tanks shall be actuated as mentioned in CI 3.00.00 above.
- g) Analogue Addressable System
 - i) Complete system and all major/critical equipments such as detectors, panels etc shall be approved and listed by UL/FM/LPCB/VDS/TAC.
 - ii) All types of smoke & heat detectors shall be of analogue addressable type. Conventional detectors with interface modules are not acceptable. Each zone of LHSC detector and each IR detector shall be provided with interface module.
 - iii) All the fire detection systems, process actuated switch devices such as pressure/flow/temperature switches and relays of control functions shall be hooked up with the analogue addressable fire detection and alarm system.

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Required addressable interface units shall be provided for various switch devices by the supplier/ Bidder to make them addressable.

- iv) The wiring shall be of style 7 as per NFPA-72 with loop / short circuit isolators.
- v) Each of building / areas shall be considered as a zone and isolators shall be provided zone wise. In case of large building, isolators shall be provided for every 20 devices.
- vi) The complete system shall include, but not be limited to the following:
 - Master system CPU.
 - Analog addressable fire detection and alarm system panels including alarm modules, system supervisory control modules, auxiliary output control modules etc.
 - PC based monitoring station with colour graphic display terminal with programming and historical archiving facility along with laser printer.
 - Power supplies, batteries and battery chargers.
 - Analog addressable type heat detectors and analog addressable type smoke detectors.
 - Non addressable type conventional detectors (linear heat sensing cable detector/ infra red type heat detector) and switching devices each with its own addressable interface modules.
 - Software and hardware as required for complete operation of the system.
 - Complete wiring/cabling including its conduits/trays/fixtures etc.
- vii) The fire alarm control panel shall function as a communication interface between central processing unit and sensors. This panel shall have facility to process the input signal and to control all the input data received from initiating and indicating devices.
- viii) Fire alarm control panel shall have filters to ignore false alarm and increase sensitivity to real fire from sensors. The sensitivity of each detector should be automatically raised if detectors are gradually polluted due to dust and dirt entering inside the detector. If detectors are more polluted the control panel shall give a warning. The trouble report shall indicate the location of device requiring service.
- ix) The fire alarm control panel shall have separate LCD display to indicate the address of each device and clear text about the location of the alarm/ trouble. It shall record the event within the non-volatile system historical memory.
- x) Fire alarm control panel shall have printer to print out the alarm/ trouble occurrences.
- xi) The CPU shall serve as the systems central processor. Software shall be designed especially for fire alarm annunciation system applications and shall provide to monitor status of processing alarms according to priorities, controlling/processing communications and synchronizing all system activities.
- xii) The video display unit shall be the primary operator for data retrieval, alarm

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- annunciation, commands and programming functions.
- xiii) The system shall be able to recognize and indicate an alarm condition in a degrade mode of operation, in the event of processor failure or the loss of system communications to the circuit interface panels.
 - xiv) Field testing facility shall be provided by the system for either the complete system or specified area or a specified device while maintaining full function of areas not under test.
 - xv) All devices shall be individually identifiable for its type, its zone location, alarm set value, alarm and trouble indication by a unique alpha numerical label.
 - xvi) The software logic modules and system database shall be programmable using a ms - windows compatible program on pc at site and required hardware shall be included in scope of supply. The system software program shall be password protected and shall include full upload and download capability and during program upload or download through the pc, the capability of alarm reporting shall be retained. The software shall be downloaded to a pc for editing. The software shall enable Owner to add the spare loop provided in the fire alarm panels or addition of additional devices/detectors in any of the fire alarm panel.
 - xvii) The system shall support the use of color graphic display terminal for the display of information in an appropriate format.
 - xviii) The system shall include software for system data base, historical event log, logic, and operating system. The system shall require no manual input to initialize in the event of a complete power down condition. It shall return to an on line state as an operating system performing all programmed functions upon power restoration.
 - xix) Activation of any fire alarm initiating device shall display (LCD alpha numeric display) message in describing the device originating the alarm condition at the central monitoring station, at alarm panel, simultaneously at the repeater annunciation panel and shall initiate the associated protection systems & other related control functions. Similarly activation of any supervisory circuit, (supervised valve closure, air pressure abnormal, fire pump trouble, water pressure low, etc.) Or receipt of trouble report (primary power loss, open or grounded initiating or signaling circuit wiring, battery disconnect etc) shall display at the fire alarm control panel the origin of supervisory condition or origin of trouble condition as the case may be. It shall also record the occurrence of the event, the time of occurrence and the device initiating the same.
 - xx) System configuration shall be menu driven and capable of being operated by a person with no previous computer programming experience.
- h) Addressable System Hardware
- i) The detectors shall be self compensating for ambient temperature and humidity.
 - ii) The detectors shall display a steady led when in the alarm state. The led shall flash when in stand by or normal mode.
 - iii) The monitor system shall retain in local memory, minimum four pages of

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system activity, allowing scrolling of the data. It shall be capable of logging events to a hard disk drive for future retrieval. The number of events shall be limited only by the hard disk drive capacity.

- iv) At least one spare loop shall be provided in addressable type fire alarm panel located in unit control room and various area panels at specified locations. Further at least 20% of loop capacity shall be left free in each of the connected loop in all the panels, so that, additional devices may be connected to the system in any of the loop by Owner in future.
- v) Services
 - The Bidder's scope of services shall also include two inspections of the complete system including testing and repairs, if any, and system re-commissioning in full compliance with the requirements of NFPA during guarantee period of the contract.
 - The Bidder's scope of services shall also include imparting training in receipt, handling and acknowledgment of alarms, in the system operation including manual control of output functions from the system control panel. Training in the testing of the system including logging of detector sensitivity, field test of devices and response to troubles for number of employees of Owner at site on the installed system for sufficient duration
- vi) Telephone Auto Dialer
 - The main fire alarm panel shall include a telephone auto dialer in to it. It shall be possible to record a minimum of 6 (six) voice message into the auto dialer on field. It shall be possible to program / configure a minimum of 6 telephone numbers into the auto dialer on field. The auto dialer shall activate during the fire and convey a voice message to programmed numbers indicating the area under fire.

7.4.7 Piping and Valves

a) General

- i) Piping for all fire protection systems shall generally be laid under ground with proper wrapping and coating. At rail/road crossings, fire water pipes shall be laid inside hume pipes of suitable ratings.
- ii) For calculating friction loss in piping system: William & Hazen formula shall be used with c value as per TAC/NFPA norms.
- iii) Inserts/ embedment required for all pipe/ valve / equipment supports shall provided by the agency providing civil works. However the clamps, channels, bolts, nuts etc to support/mount piping/valves/equipments shall be supplied and erected by the Bidder.

b) Material of Construction

- i) Mild steel as per IS: 1239 (part-I) medium grade (up to 150 NB) & as per IS: 3589 Gr 410 (200 NB and above) or equivalent for pipes normally filled with water.
- ii) Mild steel as per IS: 1239 (part-I) medium grade (up to 150 NB) & as per IS: 3589 gr.410 (200 NB and above) or equivalent and galvanized as per IS: 4736 for pipes normally empty and periodically charged with water and foam system application.

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- iii) To prevent soil corrosion buried pipes shall be properly lagged with corrosion protective tapes of minimum thickness of 4 mm (in two layers) of Lignite tar type as per AWWA C 203 or coating and wrapping as per IS: 10221/IS: 15337..
- iv) Strainer wire shall be SS (AISI316). Strainer area shall be at least 4 times the pipe cross section at the pipe inlet.
- v) Minimum pipe thickness shall be 6 mm for 200 NB to 350 NB, 7 mm for 400 NB and 8 mm for beyond 400 to 600 mm.
- vi) All valves shall be as per applicable IS/BS codes & approved by tariff advisory committee (TAC)-INDIA/ LPA /TAC accredited professionals for specific fire protection system and shall be provided with locking arrangement (with locks) in open or close condition.
- vii) All the flanges and counter flanges shall conform to ANSI B 16.5 CI 150.
- viii) Strainer body as per IS: 2062.
- ix) Unless otherwise specified all elbows / bends shall be long radius type.
- x) For pipe fittings the material shall conform to ASTM A 234 Gr WPB or ASTM A 105 or equivalent and dimensional standard conforming to ANSI B16.9 (socket & threaded type), ANSI B 16.22 (for butt welded fittings) and ANSI B16.5 (for flanges and flanged fittings) as the case may be. Further galvanized malleable cast iron fittings as per IS 1879 or cast iron fittings as per BS-1641 are also acceptable.
- xi) The fittings shall be galvanized as per IS: 4736 for galvanized pipe application. In case of branching connections from GI mains for spray piping network, socket may be welded for more than two pipe reduction instead of standard tees.
- xii) Fabricated fittings shall not be acceptable up to pipe size of 300 NB. For sizes 350 NB and above, fittings may be fabricated as per BS: 2633 / BS: 534.
- xiii) Welding of galvanized iron pipes/fittings would be permitted provided the same is carried out by means of special electrodes suitable for the above application and the same shall be approved by Owner. After welding, welded portions shall be applied with three coats of zinc silicate treatment /rich paint over one coat of suitable primer. Further the Bidder shall provide proper zinc paint at the point of welding.

7.4.8 *[Fire Water Storage System]*

- a) *[Fire Water Tank of capacity [.....] m3 shall be designed to meet the requirements of TAC. The suction level of the fire water pumps is kept lower than the other make up water pumps so that always a fixed quantity of water is available for the fire protection system as per TAC norms.]*
- b) *[Required numbers of level transmitters / switches shall be provided so that required minimum fire water storage (as per TAC rules) is available for fire water service always and the whenever the water level is reduced to that extent, all the pumps located in service water pump house shall be tripped with prior audio-visual annunciation.]*

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7.5 Design Data Sheets

S.No	Detail	Elec. Motor Driven	Diesel Eng. Driven	Jockey Pumps
1	Service	a) Fire Hydrant System b) Fire spray water system		For pressurisation of fire water system
2	Duty	Continuous		
3	Location	Indoor		
4	Number of Pumps Required	a) Hydrant Pump - [2 Nos.]	Hydrant Pump - [2 Nos.]	Two
		b) Spray Water Pump - [2 Nos.]	Spray Water Pump - [1 No.]	
		Elec. Motor Driven	Diesel Eng. Driven	Jockey Pumps
7	Pump Performance Requirement			
	a) Performance standard	Hydraulic institute standard		
	b) Rated capacity (Cu.m/hr.)	[...]	[...]	[...]
	c) Total head, Kg/cm ² not less than	[...]		[...]
	Noise level at a distance of 1.5m from pump center line	85 dbA		85 dbA
	d) Rated speed (rpm) Max.	1500		3000
	e) Permissible tolerance in rated capacity (%)	As per IS : 5120		
	f) Permissible tolerance in efficiency at rated capacity (%)	(+ve) tolerance as per IS – 5120 but No negative tolerance		
	g) Range of operation	As per IS-1710		
8	Design standard	IS-5120		

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S.No	Detail	Elec. Motor Driven	Diesel Eng. Driven	Jockey Pumps
9	Pump type	Non-pull out type & above floor discharge		
10	Impeller type	Closed		
11	Type of gland lubrication and sealing	Self		
12	Shaft sealing arrangement	Mechanical seal/Stuffing box		
13	Axial thrust balancing device to be designed for pump shut-off operation	Yes		
14	Type of pump-motor connection	Direct	Direct through bevel gear box	Direct
15	Type of coupling	Flexible Coupling		
16	Mode of pump starting	As per manufacturer's recommendation		
17	Type of shaft bearing	Cut-less rubber backed by bronze, shore hardness 60-65 Deg.A		
18	Bearing lubrication	By self-water		
19	Material of Construction			
	a) Casing/bowl	2.5% NiCl as per IS:210 Gr. FG 260		
	b) Suction Bell	Do		
	c) Column pipe	Fabricated C. S. as per IS-2062		
	d) Impeller	ASTM A 351 Gr. CF8M		
	e) Wearing rings	Do		
	f) Shaft sleeve	AISI 410 (Hardened)		
	g) Shaft bearings	Cutless rubber backed by bronze shore hardness 60-65 Deg. A		
	h) Base plate	Carbon Steel as per IS-2062		
	i) Stuffing box	2.5% Ni C. I. As per IS-210 Gr. FG 260		
	j) Stuffing box packing	Graphited Asbestos		
	k) Line shaft	SS AISI Type 410		
	l) Pump shaft	Do		
	m) Shaft coupling	Forged/Cast Steel		
	n) Fastners	SS-316 which in contact with water and CS for others		
	o) Discharge head	Fabricated C. S. as per IS-2062		
	p) Companion flange	MS		

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Tender Document for R&M of Unit No.[.] of <i>[Name of the Power Plant]</i>	<i>[Logo of Utility]</i>
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S.No	Detail	Elec. Motor Driven	Diesel Eng. Driven	Jockey Pumps
20	Booster Pumps	←-----based on calculations, to be carried and submitted to Owner by Bidder-----→		

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8 COMPRESSED AIR SYSTEM

8.1 General

The compressed air system shall consist of Instrument Air compressors & their motor drives, Air Drying (ADPs) Plants, Service Air compressors & their motor drives, air receivers for each Air compressor, instrumentation and control, control panels, interconnecting compressed air piping in the compressor house, Instrument Air Piping network, service air piping network and Unit Instrument Air receivers (One for each SG/TG unit).

Air from Instrument air compressors shall be dried in respective Air Drying Plants in compressor house and delivered to the Air receivers. From the Compressed air piping header at the downstream of Air receivers, one instrument air piping header for each unit of main plant and one for balance of plant shall be provided.

Generally instrument air compressors are to be used for supplying instrument air application and service air compressors for service air duty. Valves & piping shall be arranged, so that interchange is possible during exigency. The instrument air header piping & valves at ADP outlet in compressor house shall be provided such that all the instrument air compressors may be interconnected and the entire system can be used as a station facility.

8.2 Codes and Standards

The equipment to be provided under this section shall specifically conform to the following codes, standards, specifications and regulations as applicable, including all its latest amendments subsequent to the year of publication as mentioned in table below.

S.No	Code	Description
1	IS-2825/1969	Code for unfired pressure vessels
2	IS-4503/1967	Shell and Tube Type Heat Exchanger
3	IS-5456/1985	Code of Practice for testing of positive displacement type air compressors and exhausters
4	IS-5727/1981	Glossary of terms relating to compressors and exhausters
5	IS-1239 part-1/1990	Mild Steel tubes, tubular and other wrought steel pipes
6	IS-1239 Part-2/1992 IS- 3589	Mild steel tubes, tubular and other wrought steel fittings
7	IS-6206/1985	Guide for selection, installation and maintenance of air compressors/plants with operating pressure up to 10 bars
8	ANSI-B16.5(1988)	Steel Pipes Flanges and Fittings
9	IS-7938/1976 IS-2002 ASME Sec.VIII Div.-1	Air Receivers for Compressed Air Installations

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S.No	Code	Description
10	IS-10431 Part-1/1983 IS- 5456	Measurement of Air Flow of Compressor and Exhausters by nozzles
11	ASME PTC-9	Performance Test Codes for Displacement Compressors, Vacuum Pumps and Blowers
12	ISO-7183	Compressed Air Dryers - Specification and Testing

In case of any contradiction with the aforesaid standards and the stipulations as per this Section and Attachments/Annexure of this section, the stipulations of this Section and its Annexure shall prevail.

8.3 Design Criteria

The Compressed Air System shall ensure a reliable supply of adequate quantity and quality of oil free air on continuous and intermittent basis for the $[(2 \times \dots)]$ MW units. It consists:

- Instrument Air (IA) for Instrumentation and Control purposes for the station.
- Service Air (SA) for usage in boiler, turbine, various BOP facilities and electrical equipment area general house cleaning and other miscellaneous usage.
- The normal pressure of Instrument Air supply at the outlet of Air Dryer shall be 8.0 Kg/Sq. cm(g) and shall not be lower than 7.5 kg/sq.cm(g) under any circumstances. Corresponding to the normal pressure at the outlet of dryer, the rated discharge pressure of IA compressor shall be worked out by the Bidder, allowing for pressure drops in system piping, equipment and all other accessories.
- The maximum expected pressure in the system shall be computed by considering 10% overpressure over and above the rated discharge pressure of each air compressor.
- Suitable interconnections shall be kept between SA and IA headers before Air Dryers for each unit with normally closed motorized isolation valves.
- The temperature of compressed air at the outlet of compressor house shall be limited to 45 °C. However instruments require air temperature less than 45 °C the same will be achieved by outlet header.
- Compressed air system equipment requiring clarified cooling water shall be capable of operation at design capacity with cooling water inlet temperature subject to a maximum of $[39 \text{ } ^\circ\text{C}]$. The above equipment shall also be capable to withstand a pressure not less than the shut off head of each clarified cooling water pump.
- The temperature of air at outlet from after cooler shall not exceed 10 °C above the cooling water inlet temperature.
- Air Compressors shall be identical and shall be designed for continuous operation with high efficiency to satisfy the performance requirements as specified in Annexure-A enclosed with this section.

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- j The power rating of the driver shall be selected such that a minimum margin of 15% is available over the power required to deliver rated capacity against rated discharge pressure. When the driver is not directly coupled to the compressor, due account should be made for losses in power transmission, in addition to the above margin.
- k Each Air Receiver shall be so sized that even in the event of total stoppage of air inflow to the same, the pressure in the Air Receiver shall not fall below 5.5 kg/cm² (g) within two (2) minutes of such stoppage, while maintaining an out flow of air at a rate equal to the rated capacity of a single compressor, during the aforesaid period. In no case, the size of each Air Receiver shall be less than that arrived from IS 7938.
The water filled volume of each Air Receiver shall be calculated in accordance with the guidelines specified above or 10 m³, whichever is higher.
- l The drying capacity of each Air Drying Plant (ADP) shall be provided to match the corresponding capacity of each compressor
- m The air drying plants receiving compressed air saturated with moisture shall be capable of operating continuously to provide reliable moisture free compressed air. Dew point of the outlet air measured at the stated operating pressure shall be -40 °C or lower throughout the operation.
- n Driers shall be suitable for part load operation while maintaining the outlet air dew point as specified above. Necessary instruments and controls shall be provided to ensure that the specified dew point is maintained irrespective of input variations.
- o The compressor and air dryer plant shall be designed for the following conditions:
 - i. Design Temperature- 50 Deg.C
 - ii. Design Relative Humidity- 100 %
- p The air drying plant shall be designed to deliver continuously air at dew point at atmospheric pressure and the quality of dry outlet air shall be conform to Instrument Society American Standard S 7.3 " Quality Standard for Instrument Air".
- q The temperature rise of cooling water in heat exchanger of compress air system shall be limited to 5 degree centigrade.
- r The after coolers and intercoolers shall be water cooled shell and tube type. The intercooler shall have air in shell side and water in tube side to add surge volume for reducing air pulsation before the second stage. Inter coolers and after coolers shall be designed in accordance with Sec.VIII, Div-I ASME code or equivalent.
- s Coolers shall be provided with removable tube bundle design in accordance with design code TEMA Class-C and shall be constructed with removable shell cover.
- t The coolers shall be designed for maximum heat load and atleast 10% design margin shall be provided in the number of tubes.
- u Noise level shall not exceeds 85 dBA when measured at distance of 1.5 m above the floor & from the equipment.
- v The IA & SA compressor shall be of same design parameter.

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8.4

Data Sheet

Sl. No.	Description	Parameter
1	AIR COMPRESSORS	
a	Type	Oil free, multistage screw type
b	No. of Compressors	IA- Working-[...], Standby-[...] and SA- (Working-[...], Standby-[...])
c	Nominal capacity	[35] nm ³ /min
d	Discharge pressure (min.)	At air receiver outlet [8.0] kg/cm ² (g). Discharge pressure to be decided accordingly.
e	Drive motor rating	At least 10% more than the maximum power demand of compressors.
1.1	Material of Construction	
a	Compressor chamber	Cast iron coated with corrosion resistant material
b	Rotors	Forged carbon steel coated with corrosion resistant material
c	Timing Gear	Low alloy steel
d	Shaft seals	High Alloy Steel.
e	Tube of Blow off cooler/ oil cooler	SS 304
f	Outer casing of coolers	Carbon Steel
2	INTAKE FILTER AND SILENCER	
a	Quantity	One per compressor
b	Dust concentration	30 mg/m ³
c	Particle size in microns	Up to 10 microns
3	INTER COOLER & AFTER COOLER	
a	Type	Shell and tube type water cooled
b	Design pressure on air side	[2 kg/cm ² more than air inlet pressure]
c	Design pressure of water side	Not less than shut off head of DMCW pump
3.1	Material of construction	
a	Tube	Admiralty brass or Aluminum brass or SS

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Sl. No.	Description	Parameter
		304
b	Shell	SA 285 Gr. C or equivalent
c	Tubesheet	SA 285 Gr. C or equivalent
d	Baffle	Carbon steel
e	Flanges	Steel IS 2862.
4	AIR RECEIVERS	
a	Quantity & Capacity	[... nos. (. nos of 10m ³ & no 2 m ³)]
b	Design pressure & temperature	[10 Kg/cm ² and 50 degree C.]
4.1	Material	
a	Shell End plates & flanges	IS: 2062 or Equivalent
5	AIR DRYING PLANTS	
a	Type	Heat of Compression
b	Nominal flow rate	To match the capacity of Instrument Air Compressor.
c	Dew point of outlet air at atmospheric pressure	(-) 40 degree C
d	Quantity	[..... Nos. (One for Each IA Compressor)]
e	Design drying cycle	8 hours.
f	Pre-filters and After filters	[2x100% for each dryer plant with automatic drain trap filter arrangement & with ceramic candle type elements]
g	Electric Heaters	[2x100% with thermostatic control for heater & facility for easy replacement of element]
h	Blowers	[2x100% capacity motor driven with individual dry type filters at air element.]
5.1	Material of Construction	
i	Adsorber vessels	Carbon Steel
	Adsorbers internals	SS 304
j	Relief valves	Brass or SS
k	Blower casing	Carbon steel
l	Blower blades & shaft	Stainless steel

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Sl. No.	Description	Parameter
m	Desiccant	Silica gel or activated alumina
n	Air piping	Galvanized steel
o	Valves in air line	CI or cast Steel or forged Steel body with stainless steel trim
p	Valves & water pipe line	SS/Bronze/Gun metal

8.5

System Description

a) Air compressors

- i) The design shall be such as to ensure trouble free operation with least vibration and noise. Suitable acoustical treatment will be provided to ensure the noise level within permissible limits as specified. Different parts of the compressor and accessories shall be arranged neatly in a compact manner. Due consideration shall be given for easy accessibility and maintenance of the compressors.
- ii) The compressors shall be oil free, multi-stage water cooled, electric motor driven screw type, heavy duty, rugged construction. Their speed shall be so selected as to result in low maintenance and trouble-free operation under specified conditions.
- iii) Compressor components shall be interchangeable as far as possible. Material of construction shall be suitable for the service.
- iv) Compression chamber wall thickness shall be such that to withstand maximum design pressure.
- v) Casing shall be cooled by means of water or oil as per manufacturer's standard practice.
- vi) During maintenance of compressor suitable arrangement for cleaning of the cooling water jackets shall be provided.
- vii) Dynamically balanced, one-piece Rotor construction with a symmetric profile to keep leakage loss to a minimum and ensure high efficiency.
- viii) Highly precise timing gears to maintain rotors in correct relative position shall be shaft mounted; oil lubricated & designed to counteract the axial forces incurred in compression.
- ix) Bearings shall be antifriction type, designed to suit radial & axial loads & minimum operating life of 40,000 running hours.
- x) Safety valves shall be provided on low pressure & high pressure stage. Inlet throttle
- xi) The rotor and shaft shall be of single piece construction, made of forged steel with suitable corrosion resistant coated material to minimize leakage and wear (AISI C1141 or equivalent). The stator (casing) shall be of Cast-Iron Construction with corrosion resistant material and with integral jacket cooling.
- xii) The seal rings and retainers shall be of stainless steel construction and shall be free for radial self adjustment on the rotor shaft. The seals shall prevent air and oil leakage along the shaft and shall be of floating restrictive ring type. Air vented

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from second stage discharge end seals shall provide buffer air to the other seals to prevent migration of oil towards the compression chamber under all operating conditions.

- xiii) The gaskets shall be of asbestos free material & Use of Oil lubricated anti friction type bearings to be at least 8000 running hours.
- xiv) The discharge blow off silencer shall be located at the downstream of discharge blow off valve.
- xv) Couplings shall be of non-lubricated flexible element spacer type & coupling guard shall be provided.

b) Lubrication system

- i) The compressor package shall include a lubricant management system which shall lubricate the bearings and seal. By the design, the compressor chamber (screw rotor housing) is totally separated from bearing/gear chamber.
- ii) The lubrication system shall consist of lube oil reservoir, lube oil pumps, suction strainers for pumps, supply & return system, oil cooler & twin full flow (2x100%) oil filters, required instruments etc.
- iii) Direct shaft driven positive displacement type oil pump having stainless steel rotors and steel casing shall be provided. An auxiliary motor driven pump shall be provided if required by the manufacturer to supply pre-start and shut down system. The pump discharge system will be protected by a relief valve.
- iv) The fouling factor shall be considered as per the recommendation of TEMA.
- v) Lube oil cooler shall be of water cooled & shell-&-tube type with water on the tube side.
- vi) Oil coolers shall be equipped with vent & drain connections on oil & water sides. Oil temperature control valve with manual override feature or bypass construction shall be provided to maintain constant temperature.
- vii) The lube oil cooler shall be designed for a heat duty corresponding to the peak power demand of the compressors.
- viii) The cooler shall be designed in accordance with the requirement of IS-2825.
- ix) Due consideration for the differential expansion of shell and tube shall be given in the design of the coolers.

c) Gear Box

Speed increasing gears between the motor and compressor stages shall consist of a common helical gear (alloy steel) driving the pinion of each stage. Helical timing gears shall be mounted on the rotor shafts to maintain accurate relative rotor position. Gears shall have a rating of AGMA-12 or equivalent.

d) Inter Cooler, After Cooler and Moisture Separator

- i) Inter-cooler shall be located between the low and high-pressure stages, if required, to reduce overall power consumption. Design performance shall be in accordance with Manufacturer's Standard and wall thickness of tubes and expansion joints shall ensure maximum trouble-free service for long period.

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- ii) It shall be located after compressor discharge to bring the outlet temperature of the compressed air within 10 °C, of the cooling water inlet temperature. Necessary safety valves shall be provided on inter coolers and after coolers.
- iii) Inter-cooler, After-cooler and Moisture Separator shall be provided with Auto trap stations including strainer, bypass and double isolating valves for the traps. Automatic traps shall be of reputed make and shall be of float type suitable for intended services. Y-strainer of 20 mesh screen of stainless steel shall be placed before each trap.
- iv) The moisture separator to be provided on after cooler air outlet shall have suitable internal baffling for removal of moisture and oil & shall be equipped with a level gauge with isolating cock.
- v) The design pressure of coolers shall be selected based on maximum air/oil/water pressure that may be encountered during operation. The shut off head of cooling water supply pumps shall be of the order of 8kg/cm²(g).
- vi) The shell, tubes, tube sheets and expansion joints with tube sheets particularly at flange portion etc. of the heat exchangers shall be designed to withstand the maximum working pressures encountered. Necessary allowance for corrosion shall be provided.
- vii) Intercoolers/After coolers shall be provided with supports, which are designed to avoid undue stress or deflection in support or body of the equipment.
- viii) Necessary drain and vent nozzles shall be provided for intercooler and after cooler.

e) Air Receiver

- i) There shall one air receiver for each compressor near compressor house, one receiver for DM plant & one instrument air receiver for each unit.
- ii) Air receiver(s) shall be in accordance with IS-2825 or ASME Volumes-VIII Div.I and IS-7938.
- iii) The air receiver shall be vertical self-supporting cylindrical vessel with dished ends and with supporting stand for resting on the civil foundation.
- iv) Design pressure & temperature shall be minimum 10 kg/cm² (g) and 50 °C
- v) Receivers shall be of welded construction with minimum number of joints. Longitudinal seams in adjacent sections of shell shall not be in the same line.
- vi) Each receiver shall be provided with drain connection with electrically operated automatic trap arrangement with isolation and bypass valves.
- vii) The material of construction of shell, dished ends, flanges etc. of the air receivers shall be of carbon steel as per IS: 2062 or equivalent.
- viii) All welding shall be performed in accordance with relevant codes. Filler material that will deposit weld metal with a composition and structure as near as that of the material being welded shall be used. The electrodes shall be dried in oven immediately before use to ensure freedom from porosity.
- ix) Receivers shall be provided with required number of nozzles, the orientations of which shall be subject to approval by the Owner. At least two gasketed inspection holes shall be provided for receivers up to 500 mm diameter. All

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openings shall be placed as far as possible from welded seams and in no instance shall pierce the seam.

- x) Receivers shall be provided with one or more safety relief valves of proper capacity so that the maximum working pressure of the system is not exceeded under any circumstance and set pressure of the same shall be atleast 10% above working pressure. Unless otherwise mentioned, each receiver shall be provided with at least one pressure gauge and one temperature gauge of proper range and required number of pressure switches for compressor control purposes.

- xi) Receiver shall be heat-treated in accordance with BS-5169.

f) Intake Air Filter and Silencer

- i) The intake air filter & silencer shall be of dry type with replaceable type filtering media, high efficiency suitable for outdoor duty.
- ii) Filters with multiple elements and quick removal type for easy cleaning to be provided at suction of each air compressor and shall also be of heavy-duty dry type. Oil bath type shall not be acceptable for non-lubricated compressors.
- iii) The filters shall be complete with integral silencers and all other accessories. The filtering elements shall be easily removable for cleaning or for replacement.
- iv) Minimum dust concentration of 30 mg / m³ may be considered.
- v) The silencer shall be provided to adequately dampen the operating noise as per the requirements.
- vi) Pulsation dampener of approved design shall be provided on the compressor suction and discharge manifold.
- vii) Maximum pressure drop across filter at design flow rate in any condition be 250 mm of water column.

g) Drive Unit

- i) The compressors shall be driven by constant speed squirrel cage induction motor unless otherwise specified.
- ii) The power rating of the driver shall be selected such that a minimum margin of 15% is available over the power required to deliver rated capacity against rated discharge pressure. When the driver is not directly coupled to the compressor, due account should be made for losses in power transmission, in addition to the above margin.
- iii) For other types of connection between drive unit and compressor, suitable flexible coupling shall be provided.
- iv) Necessary guard shall cover all exposed moving parts.
- v) Motor shall be suitable for eight (8) equally spreaded starts per hour.

h) Air Drying Plant

- i) Air-drying plant shall be of Heat of compression type.
- ii) Hot unsaturated compressed air shall be used for regeneration of exhausted desiccant in ADP.
- iii) In the rotary drum dryer, since the drum is continuously rotating, the regeneration and drying are continuously occurring cycles.

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- iv) Air dryer shall be Indoor located.
- v) The air dryer rotary drum motor should start automatically on compressor load command and stop the moment compressor unloads.
- vi) All hot vessels & pipelines to be insulated to restrict the outside temperature within 60 °C with mineral wool (or equivalent).
- vii) Quantity of desiccant to be calculated taking into account residual moisture content at the end of regeneration cycle.
- viii) Complete ADP equipments shall be preferably mounted on a skid.
- ix) Each ADP shall be provided with 2 Nos. of 100% capacity Pre-filters and 2 Nos. of 100% capacity after filters at the upstream and downstream of towers. The filtering media shall be of ceramic candle type elements design to withstand at least 50% of static pressure as differential pressure. The pre-filters shall be provided with automatic electrically operated drain trap arrangement with isolation with bypass valves.

i) Pressure Vessels

- i) All pressure vessels shall be designed as per IS : 2825 or approved equal
- ii) The vessels shall be of self supporting construction. All welding materials and procedures shall be as per IS: 2825 or approved equal.
- iii) All vessels shall be included with required manholes/hand holes.
- iv) Relief valves of adequate capacity shall be provided for each vessel. Relief valves shall be provided with hand lever. The valves shall be of stainless steel construction.
- v) Internal surfaces of all the vessels shall be suitably protected against corrosion and rusting. Corrosion allowance of 2.5 mm shall also be provided on shell and dished end thickness.
- vi) Draining trap station complete with Auto drain trap, isolation and by-pass valves and Y-strainer shall be provided for the moisture separator.

j) Solenoid Valves and Multi-way Valves

- i) The solenoid valve shall be of approved make. The solenoid valves shall have heavy duty, double impregnated tropicalised coils (Single or double solenoid as required) and shall be suitable for the operating temperature and for operation continuously energized, in a tropical climate.
- ii) The solenoid valves shall be of bronze body with stainless steel trim. The coil shall be of continuous duty and of epoxy moulded type, Class-F. The enclosure shall be watertight, dust tight, weather proof and shall conform to NEMA-4X standard. The valves shall be suitable for mounting in any position. Solenoid coils shall be Class-H high temperature construction and shall be suitable for continuous operation.

k) Interconnecting Piping, Valves and Fittings

- i) Pipelines shall be selected as per IS-6206/equivalent standard. Piping in airlines and cooling water lines up to 50 NB shall be socket welded and 65 NB and above shall be butt-welded and flanged type. All interconnected air piping and cooling water piping etc., as indicated in tender drawings shall be furnished by the Bidder, complete with valves, fittings, pipe supports as necessary.

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- ii) The air discharge piping shall be full size of compressor outlet or larger, short and direct with minimum number of fittings. Only long radius elbows shall be used where bends are unavoidable. The velocity of compressed air in pipe shall be limited to 6 to 10 m/sec for headers and 11 to 15 m/sec for piping network.
- iii) Long runs of vertical piping at compressor discharge shall not be acceptable.
- iv) The layout shall be such as to prevent resonance. Provision of thermal expansion of hot pipes shall be made.
- v) All pipe connections with equipment shall be flanged type. All pressure gauges/switches shall be complete with root valves and all temperature elements shall be mounted in a proper thermowell.
- vi) For water cooled compressors, cooling water shall normally be piped through the intercooler and after cooler in parallel. From the intercooler, the water shall be taken to cylinder jackets. A solenoid valve shall be provided on the water inlet line for interlocked starting of compressors. Where provision for automatic water flow regulation by thermostatic valve has been made, a suitable bypass arrangement to the valve shall be made so that flow to the cylinder is ensured under all circumstances.
- vii) The velocity in water pipes shall be limited to 2.0 m/s.
- viii) Sight flow indicators shall be provided on water discharge from each cylinder, intercooler and after cooler.
- ix) All traps shall be float operated. All traps shall be of auto drain type to drain out moisture at regular intervals. The body and cover shall be of cast iron/solid steel construction and internals shall be of SS. Isolating valves shall be of stainless steel.

I) Dew Point Indicator

Dew point indicator shall be digital type for spot measurement of dew point of air. The specification of the meter shall be as follows:

Range : (-) 40 °C to (+) 20 °C
Accuracy : ± 0.2 °C

Dew point monitoring facility shall also be provided in local Control Panel as well as in unit DCS operator work station

8.6 Performance Guarantee

a) Performance Guarantee Parameters

Following guarantee parameters to be demonstrated under Category-III

- i) Capacity and discharge pressure of each air compressor.
- ii) Parallel operation of Air Compressor.
- iii) Dew point of air at outlet of air dryer of Instrument Air Compressor.
- iv) NPSH across the whole range of the pump (if applicable).
- v) Pressure drop across the air dryer plant of the air compressor.
- vi) The Air drying plant shall be designed to deliver continuously air at dew point of minus (-) 40 deg C at atmospheric pressure and the Quality of dry outlet air to

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conform to Instrument Society of American Standard S7.3 "Quality Standard for Instrument Air".

- vii) Discharge pressure available at the outlet of Air drying Plant shall be minimum 8.0 Kg/cm² (g).

8.7 Inspection & Testing

- a) The Bidder shall carry out the following specific tests and inspections to ensure that the equipment furnished shall conform to the requirements of this section and in accordance with relevant codes and standards.
- b) Material identification of compression chambers, rotor, rotor shaft, suction and delivery valves constituting the compressors and all parts of intercoolers, after coolers, moisture separators, air receivers, strainers, filters, all interconnecting air and water piping with valves and all other parts and accessories that could not spelt out in this clause.
- c) Hydrostatic testing of compressor, intercoolers, after coolers, moisture separators, air receivers, strainers, filters, all interconnecting air and water piping with valves and all other applicable pressure parts that could not be spelt out in this clause will be carried out. Hydrostatic testing shall be carried out at 150% of the design pressure for at least one (1) hour, unless contradicted by the relevant test code.
- d) Specific tests to be carried out for each compressor.
- e) Non-destructive testing of rotors, rotor shaft and all other applicable parts.
- f) Type test/Routine tests for all the air compressors as per IS-5456. All performance tests for compressors shall be carried out with actual motor being furnished. Routine tests shall include the following tests and measurements:
 - i) Capacity (Free Air delivery)
 - ii) Speed
 - iii) Specific power consumption
 - iv) Volumetric and overall efficiency of machine
 - v) Test of loading and unloading mechanism
 - vi) Any other test deemed necessary for the system
- g) Dynamic balancing of all rotating components and assembly of each air compressor including all drive motors in the compressed air system.
- h) Tests for capacity, pressure drop and efficiency of each Intake Air Filter with silencer shall be as Manufacturer's standard. These tests shall be conducted along with performance testing of each compressor.
- i) Testing of all motor drives and control panels in the compressed air system.
- j) Dew Point tests to be carried out on each Air Drying Plant.
- k) Any other test deemed necessary for the system.

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9 FUEL OIL HANDLING SYSTEM

9.1 General

- i. This Specification is intended to cover HFO & LDO unloading system from railway wagons to fuel oil storage tank (HFO/LDO) using unloading pumps and other facilities like storage of HFO and LDO in the storage tanks, complete heating and transfer from storage tank to further handling by the pressurizing and heating system up to the boiler area and back.
- ii. The heating steam required for floor heater, suction heater in HFO storage tanks and all other areas as required shall be tapped off from a single point near the Fuel oil pump house (FOPH) Building at approximately 16 kg/cm²(g) at saturated condition. Steam pressure shall be reduced suitably by the Bidder as per the system requirement through a pressure reducing station equipped with a pressure relief valve, located near the FOPH. The bidder to calculate the steam requirement for the following heating applications:
 - HFO unloading header
 - HFO railway wagons
 - HFO unloading pumps, suction strainers and valves
 - HFO storage tank, floor heaters and suction heaters
 - HFO pipeline tracing & HFO equipment steam jacketing
 - HFO Oil heaters and valves
 - Oil water separator heating
 - Any other area as required.

Auxiliary steam piping from the steam generators to steam headers in unloading area and steam piping, tracer pipes for HFO heating and indicating type temperature control valves for suction heaters & temperature switches for control valves of floor coil heaters for HFO tanks shall be provided. Steam tracing with insulation shall be provided for HFO unloading headers up to unloading pump suction. All pumps, strainers and the HFO pipeline beyond unloading pumps shall be steam traced and insulated. Tanks, rail tankers, and heaters are also heated by steam

- iii. Condensate from various heat exchangers and floor coil heaters will be led to condensate flash tank. A portion of the hot condensate from the flash tank will be used for heating the oil water separator and rest will be sent to the effluent treatment plant. Flash tank vent will be vented out in atmosphere at a suitable and safe height. Necessary piping & accessories shall be provided for efficient operation of the condensate system.
- iv. Oil Water Separator System (OWS)
Oil handling area run off is the main source of oil in plant effluent. Oil spillage during unloading, washing of floors, leakage of pumps, etc. will be taken to oily water drain pit through trenches. From here mixture will be pumped to the oil water separator by oily water transfer pumps. For maintaining the oil viscosity and flow ability, hot condensate & steam will be used. The oil-water separator will

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be provided with a floor coil heater for heating by means of condensate from flash tank. In case of lesser quantity of available condensate for heating of OWS, steam shall be utilized for OWS heating. Heater shall be designed to handle both the heating media. The oil separator shall be a gravity separator (i.e., tank fitted with baffles and separation mechanism). The separated oil will be collected in barrel & disposed off suitably or can be pumped back to the HFO storage tanks by using the oil recovery pumps. The treated water from the separator shall be sent to the effluent treatment plant for further treatment

v. HFO Pipe Line Flushing

Provision shall be made for flushing all HFO pipelines by using LDO to avoid any blockage due to solidification. The flushed oil will be sent to HFO storage tanks.

vi. Fuel oil Drain System

The fuel oil drains from different equipment and piping etc. shall be brought by gravity to a drain oil tank. The oil collected in this tank shall be periodically pumped back to the Fuel Oil Storage Tanks.

vii. Fuel oil condensate system

Condensate from complete fuel oil plant shall be brought to a common condensate flash tank of [6 m³] capacity complete with all accessories in fuel oil area. Drains from this condensate tank shall be connected to station drains

9.2

Codes and Standards

Following codes and standards shall be followed by the bidder for fuel oil system:

- IS: 5120: Technical Requirements for Roto Dynamic Special Purpose Pumps.
- IS: 6536: Pumps for handling volatile liquids.
- IS: 11053: Process Pumps
- IS: 1593: Code for Furnace oil
- IS: 1460: Code for Light diesel oil
- IS: 803: Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded oil storage tank
- IS: 804: Rectangular pressed steel tank
- IS: 816: Code of practice for use of metal arc welding for general construction in mild steel.
- IS: 817: Code of practice for training and testing for metal arc welders.
- IS: 823: Code of procedure for manual metal arc welding of mild steel.
- IS: 5312: Swing check type reflux (non-return valves) (Part-I).
- IS: 620: Recommended rules for design and construction of large welded, low pressure storage tank.
- API: 650: Welded steel tank for oil storage.
- API-12 D: Large welded production tank.
- IS: 4503: Code for design & manufacture of heater.
- ANSI B31.1: Design of power piping system.
- API-600: Code for design & construction of gate valve for sizes

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- API-602: 50 NB or above.
Code for design & construction of gate valve for sizes below 50NB.
- API-598: Code for testing of gate valve.
- BS-1873: Code for design & testing of globe valve.
- BS-1863: Code for design & testing of check valve.
- BS-5351: Code for design & testing of ball valve.
- API-599: Code for design & testing of plug valve.
- IS: 1239: Mild steel tubes, tubular and other wrought steel Fittings (Part I & II)
- IS:554: Dimensions for pipe threads where pressure tight joints required on the threads.
- IS:4736: Hot dip line coating on steel tubes..
- IS:2712: Compressed asbestos fiber jointing.
- ANSI B16.5: Steel pipe flanges and flanged fittings.
- ANSI B16.9: Wrought steel butt-welding flanged.
- ANSI B16.11: Forged steel fittings, socket-welding and threaded.
- BS-2633: Class I arc welding of ferritic steel pipe work for carrying fluids
- OISD: Oil Industry Safety Directorate.
- Standards for Hydraulic Institute, USA
- ASME Boiler & Pressure Vessel Code: Section VIII, Division I, Pressure Vessel.
- ASME Boiler & Pressure Vessel Code: Section IX, Welding & Brazing qualification.

9.3 Design Criteria

i) General

Bidder shall adhere to the requirements stipulated in the data sheet and the technical specification. Bidder shall further note that the requirements/parameters indicated in the data sheet for various equipment/items/components shall be treated as indicative minimum and Bidder shall establish the final requirements of these parameters as per their system design but in no case these parameters shall be less than the indicative value specified.

ii) Unloading System for Heavy fuel oil (HFO) and LDO System

The unloading header shall be complete with minimum *[6 nos.]* for HFO & minimum *[3 nos.]* for LDO of unloading points and each point shall have *[6 meter]* long *[80 NB]* flexible metallic hose conforming to BS: 1435 with suitable flange and coupling to connect the road tanker with unloading header. One plug type isolating valve and a hose stand shall also be required for each unloading point. *[Three (3)]* nos. of HFO unloading pumps and *[two (2) nos.]* of LDO unloading pumps shall be envisaged.

LDO unloading pump (rotary positive displacement screw pump) shall be complete with isolating, drain and vent valves. Necessary supporting arrangements for unloading arrangement shall also be provided by the bidder.

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The unloading header for HFO service shall be steam heat traced and insulated. HFO unloading pump shall be horizontal rotary positive displacement screw pumps, steam jacketed with simplex filter in upstream of HFO unloading pumps.

iii) Tanks

Tanks shall be designed, fabricated, erected and tested in accordance with latest edition of IS: 803/API-650. Supports shall be as per IS: 800. Tanks shall be made of tested quality mild steel plates conforming to IS: 2062. The plates shall be rolled through plate bending machine by several numbers of passes to true curvature. The tanks shall be of welded construction.

Tank seams shall be positioned suitably so that they do not pass through tank connections. For cylindrical vessels consisting of more than two sections, longitudinal seams shall be offset. Reinforcement pads at tank connections shall be provided as per relevant codes. Flange faces of all nozzle connections shall be machined and square with the centre line of the tank. Where possible, inside seam weld shall be ground smooth, suitable for application of corrosion resistant primer.

Conical roof with a slope not less than 1 in 16 to ensure drainage of rain water shall be provided supported over the periphery; and the tank shall have single central column. The roof shall be designed for a live load of 200 kg/m². Structural support in the form of the rafter shall be provided when diameter of tank is greater than 4.75 m or when diameter of tank is less than 4.75 m and thickness less than 6 mm. Sufficient number of plugged holes shall be provided in the bottom plates of tanks for bottom testing as per IS-803.

Gaskets shall be suitable for specified service and shall be replaced after hydro test. No oil connection shall be made until the tank is ready for oil filling. After oil connection is made to the tank, no welding or hot work shall be done on the tank and associated pipelines.

Vent shall be designed as per API standards and shall have adequate venting area. Venting area shall be such that over pressure/ vacuum is not created during maximum filling/ draw-off rate. The open end of the vent line shall be covered with two layers of fine copper wire gauge of not less than 11 meshes/cm and fitted with hood.

Lightening protection system conforming to IS-2309 shall be provided for all tanks. System shall constitute suitable number of horizontal and vertical air terminals. All the air terminals shall be connected to an earthing ring conductor 300mm above the ground.

Design and construction features of Fuel Oil Storage Tanks:

S.No	Description	HFO Tank	LDO Tank
1.	Quantity	[...]	[...]
2.	Type of construction	Vertical cylindrical, fixed conical roof (supported roof), non-pressure type with vent & flame arrestor.	Vertical cylindrical, fixed conical roof (supported roof), non-pressure type with vent & flame arrestor.

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S.No	Description	HFO Tank	LDO Tank
3.	Codes and standards	IS-803	IS-803
4.	Design pressure(Internal/Vacuum)	[...]	[...]
5.	Design temp.	120	60
6.	Net Capacity between low level and high level (m3)	[...]	[...]
7.	Material of Construction		
8.	Shell, roof & bottom	IS-2062	IS-2062
9.	Structural	IS-2062	IS-2062
10.	Nozzles	ASTM A 106 Gr.B	ASTM A 106 Gr.B
11.	Flanges	ASTM A 105	ASTM A 105
12.	Corrosion allowance	1.8mm (min.)	1.8mm (min.)
13.	Floor Coil Heaters	Required	Not required

Design and construction features Drain oil tanks and condensate tank:

Description	Drain oil tank	Condensate Flash Tank
No. Of tanks	[...] nos. in Boiler area (One for Each SG) & 1 no. for Pressurization pump area	[...] No.
Tank capacity	[...] m ³ each in Boiler area & [...] m ³ for pump house area	[...] m ³
Design and construction code	IS:800	IS:2825 Class-II or equivalent
Design Temperature	[120 °C]	[215 °C]
Tank design pressure	As per applicable code	
MOC	As per IS:2062 plates	As per IS:2002 (grade 2A plates)
Type of Construction	Rectangular with vent and flame arrestor	Vertical cylindrical with dished ends.
Corrosion allowance in tank thickness	1.8 mm	1.8 mm

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Description	Drain oil tank	Condensate Flash Tank
Insulation	Required	Required

iv) Floor Coil Heater(For HFO & Drain Oil Tanks)

The coil heat transfer area shall be calculated based on saturated steam condition. The coils shall be laid at the bottom of the tank and shall be provided with steam inlet and condensate outlet flanges, outside the tank.

Steam floor coil heaters shall be designed suitably to initially raise the temperature of oil from minimum ambient temperature to the HFO handling/tank maintenance temperature of 60 °C in 72 hours time and maintaining the temperature at 60 °C during normal course of operation taking care of heat losses from the tank due to convection and radiation.

Steam flow to the floor coil heater shall be controlled by providing pneumatically operated control valve (On-Off Type) in the common header of segments of heater coils to maintain the desired level of temperature and the other three sections to be used during initial heating shall be provided only with isolation valves.

v) Suction Heater (for HFO Tanks)

Shell and tube type suction (outflow) heaters with “U” tubes shall be provided at the tank discharge of rated capacity [...] T/h and the same shall be designed to raise the temp of HFO from 55 °C to 65 °C. Seamless tubes, as per TEMA, class C of welded construction shall be used for tube bundle.

The heater shall have oil in shell side and steam in the tube side. Steam flow to suction heater shall be regulated through one pneumatically operated control valve on the steam supply line to the suction heater and the same shall be actuated from heater outlet temperature.

Each suction heater shall be mounted on the side wall of the storage tank and shall be suitably supported. Heating coil of suitable surface area shall be provided for heating the oil using steam. All other technical particulars shall be as per data sheet.

Design and construction features of HFO Heaters:

Type and no of heaters	[Three], shell and tube type, with oil through tubes (oil through shell is also acceptable)
Capacity of each heaters	To suit the rated capacity of each heavy fuel oil pressuring pump.
Heater design / construction	TEMA, ASME Boiler & pressure vessel code, HEI standards, USA pipe connections to heater as per TEMA class C BEV type.
Heater inlet fuel oil temperature	30 deg C

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Heater outlet temp	To suit the viscosity requirement at the fuel oil burner tips for the grade of oil used.
Metal temperature of HT surface	210 deg C
Heater Tubes	Seamless

vi) Pressure Reducing Station

One (1) no. pressure reducing station located near the fuel oil pump house for reducing auxiliary steam pressure from 16 kg/cm² to 4 kg/cm²(a).

vii) Oil Water Separator

The oil water separator shall be gravity type as per API and shall be provided with heating coils to maintain the flowability of oil.

Oil recovery pumps shall be provided for transferring the oil. The oil water separator arrangement shall be such that all the leakages, floor drains etc. of the complete fuel oil area is collected in to the same.

viii) Piping

Small pipes, below 50 mm NB shall be socket welded. Pipes 50 mm NB and above shall be butt welded. If any flow nozzles required, it shall be fixed in a pipe piece at shop.

All structural steel work and pipe supports shall be designed as per IS: 800. Insulation protection saddles shall be used at support points of all insulated piping. Hosepipes shall be supported with flexible connections to permit axial and lateral movements without restraint or binding at any supporting element.

All trap stations shall be complete with isolating valves, bypass arrangement and non-return valves. Steam traps shall be provided with integral or separate strainers.

All pipelines shall be given suitable slope towards drain point. All piping shall be provided with vents at the highest point and drain at the lowest point. Adequate supports, hangers, saddles, clamps, anchors shall be provided at regular intervals to keep pipe sag within permissible limits when the pipes are fully filled. Outdoor sliding supports material at the interface shall be such that no rust formation takes place. All steel sliding faces shall be covered with Teflon plates with counter sunk screws on top and bottom faces of sliding support. Hangers, trestles, saddle supports etc shall be fabricated from plates/sections conforming to ASTM-A-53/IS: 2062/equivalent and shall allow necessary pipeline movement. All piping shall be pickled, cleaned and capped before shipping and thoroughly cleaned before installation.

Steam & condensate headers with adequate number of outlet nozzles with isolation valves and flexible hoses shall be provided in the unloading area for heating the HFO road tankers.

Drain valves of required size and quality shall be provided on the pipe lines at drain points. Piping materials and requirement shall be as per data sheet.

The hot lines shall be supported with flexible connection to permit axial and lateral movements. Expansion joints shall be provided in order to restrain forces

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and movements for HFO and steam and condensate lines. Design of hangers, supports and auxiliary supporting steel members shall comply with the requirements of ASME B 31.1 as minimum

The layout of oil piping, valves, flanges, steam traps, fittings and supports etc. will be such as to facilitate maximum flexibility of interconnection of pumps, heaters, strainers. All HFO lines will be steam traced and properly lagged. All lines carrying steam and oil will be provided with adequate drain and vent connection. All fuel oil lines and filters will be provided with steam flushing points at suitable locations. All steam and condensate piping handling fluid of pressure below 20 kg/cm² (g) will conform to the latest edition of IS: 1239 (Heavy grade) or ASTM-A-106 Gr. B or other approved equivalent standards. Oil pipelines from discharge of pressurising pump to boilers will conform to IS: 1978 or other approved equivalent standard with latest amendments. Oil pipe lines in the unloading area will be of API-5L Gr B or ASTM A Gr 106 B. Double isolation valves will be provided from the discharge of the pressurizing pumps, for inline items that are to be removed for maintenance. This applies to flow meters, filters, isolation valves and the pressure maintaining valves etc. Larger lengths of piping that can be isolated will be provided with thermal relief valves.

Between the pressure oil line and the return oil line, an interconnecting line will be provided with automatic pressure control system to maintain the pressure of oil to the steam generator at a predetermined value. The interconnecting line will also serve to divert the fuel oil to the return line under conditions when oil supply to the burners is to be cut off or reduced. Suitable non-return valves will be provided on the return oil lines from the steam generators to prevent pressurized fuel oil from going back into the burners in the reverse direction when the quick acting valve closes. The fuel oil lines to individual boilers will be provided with pressure accumulators of adequate size (if warranted by design) to maintain the oil pressure at a constant value.

All flanges will conform to IS: 6392 or equivalent. The nominal pressure and temperature ratings of flanges will be such as to withstand the design condition of the respective pipe/equipment to which they are attached. Matching counter flanges with nuts, bolts and gaskets will be provided for all the system terminal points on oil, steam/condensate and air lines.

All high pressure pipe fitting will be of butt welded construction, wherever possible and will conform to ASTM-A-234 (carbon steel) or other approved equivalent.

All valves on oil, steam and condensate lines will have cast steel body. Valves for oil service will be fire safe ball valves type easy to operate, less maintenance prone, leak proof, and self-lubricating type. The valve internals will be chrome-steel for oil, steam / condensate lines. The drain valves will be located at the lowest points in the system to ensure complete draining of the system.

Suitable supports / hangers will be provided for all the piping covered under fuel oil facilities. Piping in the boiler area will be designed with laying up on trestle supports as far as possible. The pipes crossing roads/rails will also be trestle-supported. Dead zones in pipes will be avoided as much as possible. The high

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temperature piping / heat traced piping will be provided with expansion loops to take care of thermal expansion.

The steam traps will be of proven design and provided with integral/separate strainers. The trap body will be of carbon steel and the internals including strainer screen will be of stainless steel conforming to AISI-316.

Fuel oil system Piping, Valves, Fittings, Pipe Support, etc. shall be designed as Criteria and Requirements are given below:

Piping	Code/Material
Fuel oil piping	1) API-5L Gr.BERW or ASTM-106 Gr.B Sch.40 in the unloading area. 2) IS: 1978 or approved equivalent from discharge of pressurising pump to Boiler
Steam/condensate piping	ASTM A106 Gr.B Sch 40
Instrument air piping	IS 1239, Heavy class, Galvanised, Plain end.

ix) Valves

All manually operated valves shall be provided with gear mechanism, if the effort required to operate the valve exceeds 25 kgf. All valves shall be provided with hand wheels, extension spindles and floor stands, suitable operating platform/valve operation mechanism so that they can be easily operated by a single operator from the nearest operating floor. If required, locking devices shall be provided with valves for safety purpose. Chain operator shall be provided for valves, which are inaccessible from any nearest platforms. All flanged valves shall be supplied with its counter flange and associated hardware

Types of Valves:

- Gate Valve

Gate valves shall be used for isolation purpose for all sizes of steam and condensate lines and for sizes above 350 NB in fuel oil lines. Gate valve shall be provided with hand wheel, position indicator and draining arrangement.

Gate valves for sizes 50 mm NB and below shall be class 800, forged carbon steel valves with solid wedge, OS & Y rising stem, bolted bonnet with deep stuffing box and lantern ring with ends socket welded.

For sizes above 50 mm NB, cast carbon steel gate valves of 150/300 lbs class shall be provided. Face to face dimension shall be as per ANSI-B-16.10. Ends flanged shall conform to ANSI 150/300 lbs rating with raised face

- Globe Valve

Globe valves shall be used for regulation purpose for all sizes of steam, condensate and fuel oil lines. Globe valve shall be provided with hand wheel, position indicator and draining arrangement.

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For sizes 50 mm NB and below shall be class 800, forged carbon steel valves with plug type disc, OS&Y rising stem, bolted bonnet with deep stuffing box and lantern ring with ends socket welded.

For sizes above 50 NB, cast carbon steel globe valves of 150/300 lbs. class with plug or ball type disc shall be provided. Face to face dimension shall be as per ANSI-B-16.10. Ends flanged shall conform to ANSI 150/300 lbs. rating with raised face.

- Check Valve

Check valves shall be used for non-return purpose for all sizes of steam, condensate and fuel oil lines.

For sizes 50 mm NB and below shall be class 800, forged carbon steel horizontal lift type with bolted cover check valves with ends socket welded shall be used.

For sizes above 50 NB, cast carbon steel check valves of 150/300 lbs. class of swing check having bolted cover. Ends flanged shall conform to ANSI 150/300 lbs. rating with raised face.

- Oil Line Plug/Ball Valve

Ball/plug valves shall be used for isolation purpose in fuel oil lines for size 350 NB and below. Ball/plug valve shall be wrench or gear and hand wheel operated and shall have port position indicator with CLOSE/OPEN indications marked on valve body.

Ball valves for size 350 NB and below shall be of 150 lbs. class full bore type. Plug valves shall be self lubricated taper type.

- Steam Trap

The steam trap shall be of kinetic energy operated (e.g. thermodynamic, impulse type) or/and mechanical type (e.g. inverted bucket, float type) and shall be complete with integral strainer. The trap at the outlet of suction heaters shall preferably be of mechanical type. While selecting the trap, due consideration shall be given to back pressure on account of difference in elevation between trap discharge connections and condensate header

- Y-Strainer

The body of Y type strainers shall be bronze and perforated metal screen of type 316 stainless steel construction with less than 1mm opening/perforations. The strainer shall have a screwed blow off connection fitted with a removable plug. The ratio of free hole area to internal pipe area for the strainers shall be at least 10:1.

- Basket Strainer

Duplex strainers shall be provided at the suction side of all pumps. The strainers shall be designed for approved nozzle velocity and pressure drop.

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All the strainers in HFO service shall be steam traced and properly insulated with facility to accommodate heat tracers. The screen shall be of stainless steel construction with less than 1mm opening/perforations. The ratio of free hole area to internal pipe area for the strainers shall be at least 10:1.

The straining/filtering element shall be basket type suitable for easy removal and replacement. Oil drip plates shall be provided with all strainers for collecting oil. Strainers shall be provided with drain plug at the bottom to completely drain it when required. Differential pressure gauges & switches shall be provided across strainers.

x) Insulation and Cladding

The thickness of insulation shall be adequate to meet the heating system requirements and to limit the insulation outer temperature to 60 °C considering still air. Insulated surfaces of all equipment, piping, valves and fittings shall be covered with 24 SWG aluminum sheet held in place by self tapping nickel plated screws. Apart from the screws, joints shall be sealed with suitable sealing compound. All fastening material such as clips or wires for field weld to equipment, galvanized wire mesh, metal corner bead shall be furnished by the Bidder.

Separate insulation shall be provided for access doors bolted heads or manholes so that they may be readily removed without causing damage to the adjacent insulation. Edges and corners shall be protected by tight structural angles or metal strips.

Pipe clamps, supports of small piping, instrument take-off etc. protruding through the insulation shall be provided with same thickness insulation as the adjacent insulation except at hanger rods, which shall be sealed tightly.

Application of Insulation

a) General

Application of insulation shall be as per IS: 7413. Prior to the application of insulation the surface shall be made dry and clean by use of steel wire brushes. Where more than one layer of insulation is applied, the joints in adjacent layers should not coincide. At the joint of each layer of insulation, a uniform layer of joint filling mastic shall be provided over expansion joints so as to achieve uniform appearance as well as additional safety'

b) Piping

Arrangements for securing the metal finish over the insulation should ensure that direct metal contact between the insulated surface and outer metal cladding shall be reduced to minimum.

All joints shall be vapour tight and shall be able to accommodate thermal movements. Insulation shall be secured to the pipes by means of circumferential tie wires of 1.6 mm to 1.0 mm (16 SWG to 19 SWG), at not greater than 450 mm spacing and after tying, the ends shall be pressed into

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the insulation. Piping bend shall be insulated to the same specification as adjacent piping. Preformed material wherever used, it should be cut in lobster cut fashion and wired or strapped into position.

The final layer of insulation shall be secured by galvanized wire netting stitched with GI wire and this shall be anchored by means of wire ties and then covered by sheet metal to have a smooth surface finish. Vertical insulation shall be supported in position by means of metal rings at 3.6 m (max.) interval and suitable clamps.

A min. lapping of 75 mm shall be provided for longitudinal and circumferential joints of aluminum jacketing/cladding. No mitered 90° bend in aluminum shall be used. Expansion joints on insulation should be included in all pipe line to allow movement and expansion of pipe without producing random checking of the insulation. Bidder shall submit the details of expansion joint with the tender. The recommended intervals of Expansion joints are:

Pipe Temperature	Spacing of expansion joint
Below 200 deg C	5.5 Meters
Between 200 to 300 deg C	3.5 meters

c) Tanks

MS flats of 25 mm wide x 6 mm thick strip shall be provided at suitable pitch around the tank walls/roof (circumferential/vertical/floating/radial) over which the insulation shall be applied with wire netting on the outer side. Over the insulating material on roof, 15 mm thick hard setting cement layer as per IS: 5724 shall be built-up & trowelled smooth. Over this cement layer, 5 mm 5-mm thick water thick water proof compound shall be applied.

Aluminum sheet shall be provided over the insulating material so applied with 75 mm overlap and the joints shall be made water proof. Rainwater channel of 22-gauge aluminum sheet shall be provided around the periphery on top. The method of insulating all removable parts (e.g. access doors, man hole covers etc.) shall be such as to eliminate damage to the insulation on the removable part and on adjacent surfaces. Edges and corners shall be protected by tight structural angles or metal strips and shall be insulated to the same thickness to the adjacent surface. Dished ends of equipment shall be insulated by welding studs or cleats to the surface at approximately 300 mm intervals.

d) Valves and Flanges

For valves, pipe fittings, flanges, etc. clear space between ends or covering and flange of sufficient length shall be left to permit withdrawal of flange bolts

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without interface. Flanges, valve bonnets, end flanges and fittings shall be adequately insulated. End of the covering at these joints shall be leveled from the outside covering to the pipe and sealed. Flange insulation covers shall be made in two halves so that these may be removed readily without interference with the adjacent covering.

9.4 Inspection & Testing

- a) The Bidder shall carry out the following specific tests and inspections to ensure that the equipment furnished shall conform to the requirements of this section and in accordance with relevant codes and standards.
- b) Material identification of pumps rotor, rotor shaft, suction and discharge valves constituting the pumps and all parts of HFO coolers, tanks, heaters, strainers, oil separator etc. and all interconnecting fuel oil, auxiliary steam, and oily water piping with valves and all other parts and accessories that could not spelt out in this clause.
- c) Hydrostatic testing of Pumps, coolers, heaters, tanks, strainers, filters, all interconnecting fuel oil, auxiliary steam, and oily water piping piping with valves and all other applicable pressure parts that could not be spelt out in this clause will be carried out. Hydrostatic testing shall be carried out at 150% of the design pressure for at least one (1) hour, unless contradicted by the relevant test code.
- d) Specific tests to be carried out for each fuel oil Unloading & Pressurizing pumps.
- e) Non-destructive testing of rotors, rotor shaft and all other applicable parts.
- f) Type test/Routine tests for all the fuel oil pumps as per Indian of international standard. All performance tests for fuel oil pumps shall be carried out with actual motor being furnished. Routine tests shall include the following tests and measurements:
 - vii) Capacity (flow rate, TDH, NPSH)
 - viii) Speed
 - ix) Specific power consumption
 - x) Volumetric and overall efficiency of machine
 - xi) Test of loading and unloading mechanism
 - xii) Any other test deemed necessary for the system
- g) Dynamic balancing of all rotating components and assembly of each fuel oil pump including all drive motors in the Fuel oil system.
- h) Tests for capacity, pressure drop and efficiency of each Filter of Strainer as Manufacturer's standard. These tests shall be conducted along with performance testing of pumps.
- i) Testing of all motor drives and control panels in the Fuel Oil System.
- j) Any other test deemed necessary for the system.

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9.5 Technical Data Sheets

A. Unloading Pump

S. No	Particulars	HFO Unloading Pump	LDO Unloading Pump
1	Type of fluid handled	HFO	LDO
2	Temp of fuel oil	[70] °C	Ambient
3	Pump design construction code	HI Standard, IS: 5120, IS: 6536, IS: 11053	
4	No of pumps	[3]	[2]
5	Capacity of each pump	[.....] m ³ /h	[.....] m ³ /h
6	Pump discharge head	[.....] m/c	[.....] m/c
7	Pump suction head	[.....] m/c	[.....] m/c
8	Type of pump	Rotary, positive displacement, horizontal pump with relief valve (Sump pumps shall be vertical type)	
9	Type of drive	Constant speed squirrel cage, induction motor with flexible couplings	
10	Type of bearing	Antifriction Self lubricated ball/roller	Antifriction Self lubricated ball/roller
11	Material:		
	Casing	Closed Grain Cast Iron	Closed Grain Cast Iron
	Shaft	Stainless Steel	Stainless Steel

B. Pressurizing/Forwarding Pump

S. No	Particulars	HFO Pressurising Pump	LDO Pressurising Pump	Drain oil pump	Sump Pump
1	Type of fluid handled	HFO	LDO	Oil	Oil & Water
2	Temp of fuel oil	[70] °C	Amb.	[70] °C	[70] °C
3	Pump design construction code	HI Standard, IS: 5120, IS: 6536, IS: 11053			

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S. No	Particulars	HFO Pressurising Pump	LDO Pressurising Pump	Drain oil pump	Sump Pump
4	No of pumps	[4]	[4]	[2] for each Drain oil tank	[2] for each sump
5	Capacity of each pump	[.....] m ³ /h	[.....] m ³ /h	[.....] m ³ /h	[.....] m ³ /h
6	Pump discharge head	[.....] mlc	[.....] mlc	[.....] mlc	[.....] mlc
7	Pump suction head	[.....] mlc	[.....] mlc	[.....] mlc	[.....] mlc
8	Type of pump	Rotary, positive displacement, horizontal pump with relief valve (Sump pumps shall be vertical type)			
9	Type of drive	Constant speed squirrel cage, induction motor with flexible couplings			
10	Type of bearing	Antifriction Self lubricated ball/roller			
11	Material: Casing Shaft	Closed Grain Cast Iron Stainless Steel			

C. HFO/LDO Tanks

S. No.	Description/Particular	HFO tanks	LDO tanks
1	Quantity	[Two]	[Two]
2	Location	Outdoor	Outdoor
2.1	Design Ambient Temp	As per project information	As per project information
3	Type of construction	Vertical cylindrical, fixed conical roof (supported roof), non-pressure type with vent & flame arrestor	Vertical cylindrical, fixed conical roof (supported roof), non-pressure type with vent & flame arrestor
4	Codes and standards	IS-803	IS-803
5	Design pressure	IS-803	IS-803
6	Design temp(°C)	120	60
7	Net Capacity between low level and high level (m3)	[2000]	[600]

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S. No.	Description/Particular	HFO tanks	LDO tanks
8	Dimensions (approx)	As per IS:803	As per IS:803
9	Venting capacity	As per API-2000	As per API-2000
10	Insulation	Yes, On the shell	NA
11	Material of Construction		
11.1	Shell, roof & bottom	IS-2062	IS-2062
11.2	Structural	IS-2062	IS-2062
11.3	Nozzles	ASTM A 106 Gr.B	ASTM A 106 Gr.B
11.4	Flanges	ASTM-105	ASTM-105
11.5	Others	As per IS-803	As per IS-803
11.6	Corrosion allowance	Corrosion allowance 1.6 mm(min) Shell-10mm(min) Roof-6mm(min) (However, Bidder to indicate the final thickness based on the tank size selected and his design)	
12	Floor Coil heaters	required	Not required
12.1	Heating steam parameters at terminal point	Pressure – [16.0] kg/cm ² (a) & [210] Dec. C at terminal point near steam generator	
12.2	Code	TEMA, class C	
12.3	Initial temperature of oil (OC)	Avg. annual mean temp	
12.4	Final temperature of oil (OC)	60	
12.5	Time required for heating oil from minimum ambient temperature to storage temp	For [2000] m ³ in 72 hrs	
12.6	Ambient temperature for heat loss calculations	Avg. annual mean temp.	
12.7	Coil material	Seamless tube as per ASTM A-106 Gr. B	
12.9	Margin on calculated surface area of floor coil	10%	

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S. No.	Description/Particular	HFO tanks	LDO tanks
12.10	Number of heating coil	[6 sections]. Half the number of total sections shall be manually operated and the other half shall be through control valve	
13	Suction (outflow) heaters		
13.1	Type of heater	U tube, shall and tube type (oil in shell, steam in tube)	
13.2	Design Ambient temp.	As per Project information	
13.3	Codes & standards	TEMA, class C	
13.4	Flow	Corresponding to 30% BMCR heat input	
13.6	Fouling factor to be considered	0.005 hr deg. F sq. ft(Btu	
13.7	Design pressure & temp Shell side Tube side	[2.5 kg/cm ² (g), 120 °C] [4.0 kg/cm ² (g), 168 °C]	
13.8	Corrosion allowance	1.6 mm	
13.9	Coil material	Seamless tube as per ASTM A-106 Gr. B	
13.10	Overall steam to oil heat transfer co-efficient (including dirt factor)kcal/m2.hr. OC	98 (max) (Bidder to indicate)	
13.11	Insulation thickness	As required	
14	Tests & inspections (all inspection and testing shall be as per the QAP approved during detail engineering)		
14.1	Tanks		
a	Bottom testing, shall testing & fixed roof testing as per IS:803		
b	Dye penetration test on welds		
c	Hydraulic and other performance testing		
d	Spot radiography of welded joints as per IS:803/API 650		
14.2	Floor coil heater & suction heater		
a	Hydraulic testing at 1.5 times the design pressure on shell and tube side		
b	Thinning test on tubes shall be carried out on welds		

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S. No.	Description/Particular	HFO tanks	LDO tanks
c	Dye penetration test on welds		
d	Spot radiography on welds		
e	Other tests as per TEMA		
f	IBR approval for both floor coil heater and suction heater		

D. Oily waste pumps

S. No	Item	Oil recovery pumps	Oily water transfer pumps
1	Type	Vertical screw	Vertical screw
2	Quantity	[1 working + 1 stand by]	[1 working + 1 stand by]
3	Duty	Intermittent (suitable for parallel operation)	Intermittent (suitable for parallel operation)
4	Type of drive	Direct driven by AC electric motor	Direct driven by AC electric motor
5	Location	Outdoor	Outdoor
6	Fluid to be pumped	HFO/LDO	Mixture of HFO, LDO & water
7	Viscosity of oil, cst	As per Fuel Oil Analysis	As per Fuel Oil Analysis
8	Pump capacity, m ³ /hr	[.....] m ³ /h	[.....] m ³ /h
9	Pump suction head	[.....] mlc	[.....] mlc
10	Pump discharge head	[.....] mlc	[.....] mlc
11	Pump speed (RPM)	Max 1500	Max 1500
12	Material of construction		
12.1	Casing & rotor housing	Cl. As per IS:210, Gr. 260/CS as per ASTM A216 Gr. B	Cl. As per IS:210, Gr. 260/CS as per ASTM A216 Gr. B
12.2	Rotor	Stainless steel	Stainless steel
12.3	Shaft	Stainless steel	Stainless steel
12.4	Base Plate	As per IS:2062	As per IS:2062
12.5	Driving gear	Hardened & tempered alloy steel (13% Cr) with m/c cut teeth and ground finish	Hardened & tempered alloy steel (13% Cr) with m/c cut teeth and ground finish

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S. No	Item	Oil recovery pumps	Oily water transfer pumps
13	Motor		
13.1	Type of enclosure	TEFC flame proof as per IS:2148	TEFC flame proof as per IS:2148
13.2	Degree of protection	IP:54	IP:54
13.3	Type of suction	Flooded	Flooded
13.4	Operating temperature	For HFO 65 OC	Ambient
13.5	Sealing	Mechanical seal	Mechanical seal
13.6	Bearing	Self lubricated ball/roller	Self lubricated ball/roller
14	Special requirement	Tracing and insulation shall be provided	Not required
15	Painting	To be provided	To be provided
16	Accessories	All accessories as required and as specified including the relief valves	All accessories as required and as specified including the relief valves
17	Inspection & testing	As per approved QAP	As per approved QAP

E. Strainers

S. No.	Item	Oil recovery pumps
1	Type	Duplex
2	Quantity	One in the common suction header of pumps
3	Mesh size	40
4	Wire diameter	0.01 inch approx.
5	Free straining area of each strainer	Min. 4 times strainer inlet area
6	Operating flow rate, m3/hr	10 (The strainers shall be designed for 150% for the operating flow)
7	Viscosity of oil at operating temperatures	As indicated above
8	Allowable per drop (max) at 50% choked condition	10 mlc

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S. No.	Item	Oil recovery pumps
9	Design temp	90 <input type="checkbox"/> C
10	Steam heat tracing required	Yes
11	Material of construction	
11.1	Body	IS:2062/ERW pipe
11.2	Basket wire mesh	SS:316
11.3	Counter flange	IS:2062
11.4	Gasket	Wire inserted rubber gaskets suitable for application

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10 MILL REJECT HANDLING SYSTEM**10.1 General**

[Dense phase pneumatic conveying system shall to be employed for handling of the mill rejects]. Each mill reject discharge hopper shall be fitted with a positive pressure pneumatic conveying vessel which shall discharge the mill rejects through pipe lines in storage 'SILO'. Each unit shall be provided with and independent 'SILO' having a collection capacity of [16 hours]. The transmitting vessel shall operate on level probe mode with timer back-up.

100% standby capacity compressor/ air drying arrangement shall be provided by the bidder. The capacity of the compressors shall be selected considering all the mills of the units operating simultaneously.

10.2 Codes and Standards

The equipment to be provided under this section shall specifically conform to the following codes, standards, specifications and regulations as applicable, including all its latest amendments subsequent to the year of publication as mentioned in table below.

International standards like American/BS/DIN etc. equivalent or superior to below mentioned standards are acceptable. When IS specification is not available the equipment shall confirmed to one such international standard, which shall be indicated in the proposal. All codes and standards used/referred to shall be to their latest edition, version as on the date of the acceptance of the tender.

All equipments as may be necessary shall confirm to the provision of statutory and other regulations in force, such as Indian explosive Act, Indian factories Act, Indian petroleum Act and also those of State Government.

S.No	Code	Description
1	IS-2825/1969	Code for unfired pressure vessels
2	IS-4503/1967	Shell and Tube Type Heat Exchanger
3	IS-5456/1985	Code of Practice for testing of positive displacement type air compressors and exhausters
4	IS-5727/1981	Glossary of terms relating to compressors and exhausters
5	IS-1239 part-1/1990	Mild Steel tubes, tubular and other wrought steel pipes
6	IS-1239 Part-2/1992 IS- 3589	Mild steel tubes, tubular and other wrought steel fittings
7	IS-6206/1985	Guide for selection, installation and maintenance of air compressors/plants with operating pressure up to 10 bars
8	ANSI-B16.5(1988)	Steel Pipes Flanges and Fittings
9	IS-7938/1976 IS-2002 ASME Sec.VIII Div.-1	Air Receivers for Compressed Air Installations

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S.No	Code	Description
10	IS-10431 Part-1/1983 IS- 5456	Measurement of Air Flow of Compressor and Exhausters by nozzles
11	ASME PTC-9	Performance Test Codes for Displacement Compressors, Vacuum Pumps and Blowers

10.3**Design Criteria and System Description**

Mill Reject Handling System of Pneumatic type meeting the following requirement shall be provided:

- Mill reject system shall be provided for all [vertical type of mills].
- Pneumatic dense phase pressure conveying system shall be employed for transportation of mill rejects to silo.
- Design Datasheet is given in the table below:

S.No	System Parameter	Pneumatic Handling System
1	Duty	Continuous
2	Number of mill reject storage bins and capacity	One (1) no. for each unit to store mill reject for 16 effective running hours all the mills of the unit/units are operating simultaneously.
3	Number of mills working per boiler	[.....]
4	Design value of rejects	1% of the mill design capacity for the worst coal.
5	Maximum temperature of rejects	[.....]
6	Maximum size of mill reject to be handled	[(-) 40 mm]
7	Bulk density of mill rejects for volumetric computation	1600 kg/m ³
8	Bulk density of mill rejects for LOADS/STRENGTH computation	2400 kg/m ³
9	Inlet/outlet valves of mill reject discharge hopper	Pneumatically operated knife edge gate valve
10	Inlet valve of the	Plate valve/dome valve/butterfly

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S.No	System Parameter	Pneumatic Handling System
	vessel	valve/cone valve.
11	Sizing grid feed	Yes (To separate over size rejects/to give control to crushers, if proposed)
12	Emergency discharge chute with manually operated knife edge gate valves	Yes
13	Piping	MS IS: 3589
14	Bends/Fittings Laterals	Alloy CI to hardness 400 BHN

d) Mill Discharge Spout and Pyrite Hopper

Each coal mill has a discharge spout with an Air electric cylinder operated knife gate valve for discharging rejects into a pyrite hopper of adequate capacity. This hopper shall serve to store the mill rejects between each operating cycle of dense phase system. Minimum effective storage capacity shall be $[0.90 \text{ m}^3]$.

Each pyrite hopper shall be provided with an air electric air cylinder operated plate / dome type valve of approved design at the bottom, adequately sized manhole / inspection door, impingement deflector plate, sizing grid and emergency chute with manually operated flap gate. Any platform required to maintain the above equipment shall also be provided. One (1) no. manually operated gate valve shall also be provided before pneumatically operated plate / dome valve. Necessary explosion vent of proven design shall be provided in each pyrite hopper.

Each emergency chute shall be provided with a manually operated gate valve to transfer mill rejects from pyrite hopper to ground. The gates shall be of robust construction and suitable for trouble free operation. The lever / gear wheel arrangement for manual operation shall be designed such that minimum effort is required to operate the gate. Necessary access and platform shall be provided.

Each pyrite hopper shall be provided with two level switches - one to start the operating sequence and the other to indicate the failure of first level switch.

The sizing grid shall be provided inside the pyrite hopper to prevent oversized mill rejects, tramp iron etc., from entering the conveying vessel. The arrangement for collecting bigger pieces of coal rejects from the grid includes, among others, counter weight operated double flappers, chute work etc. Bigger pieces of coal rejects shall roll down from the grid and through counter weight operated flappers (to be provided preferably at the bottom of inspection door) be discharged to Owners trolley. The arrangement shall be finalized during detail engineering. The grid shall be made of minimum 10 mm dia. M.S. bars IS: 2062 with clear opening of 50 mm x 50 mm.

e) Mill Rejects Valves

Valves isolating pyrite hopper and mill rejects conveying vessel shall be of plate / dome type, pneumatically operated, quick opening and closing remote controlled design. The valve shall be of reliable and proven quality. It shall be possible to

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operate it cutting through the material flow. These shall be provided with proper sealing arrangement such that whenever the material is being conveyed from vessel to the bin, there shall not be any leakage of air from vessel to pyrite hopper / atmosphere. Solenoid valves and air piping shall be included in contractor's scope, 'Open' and 'close' limit switches shall be provided for panel indication of open/close status of valve. For isolating downstream equipment from pyrite hopper, a manually operated gate valve shall be provided above pneumatically operated plate / dome valve as explained.

Material of Construction

The valve components shall be suitable for trouble free operation while handling hot mill rejects.

S.No	Part	Material of Construction
1	Body	C.I IS: 210/ Grade 260 or BS: 1452
2	Dome/Plate	Alloy C.I/Hardened stainless steel (min. 350 BHN) with leak proof seat
3	Shaft	Stainless steel (AISI: 316)
	Control valves and pneumatic actuators details shall be as per clause no. 3.03.00	

f) Compressed Air Line Valves

- i) Remote actuated main valves on compressed air pipe lines shall be pilot operated solenoid pneumatic cylinder operated 100% leak proof valve.
- ii) Spring balanced two / three position control valve to actuate the pneumatic cylinder of main valves shall be either solenoid operated or pilot air pressure operated. In addition, mechanical lever for manual operation of valves shall be provided. Material of construction is subject to approval during detail engineering stage. Material of construction shall have minimum surface friction and be rust and weather proof.
- iii) Pneumatic actuators shall be completely enclosed type, double acting. The pneumatic cylinders for operation of valves shall be selected considering minimum 3 kg/cm²(g) inlet pressure. Material of construction shall be stainless steel. Integral micro limit switches for 'OPEN' or 'CLOSE' position shall be provided. External pointer for valve position and manual operation facility shall be provided.
- iv) Above valves shall meet the requirements of any international / Indian Standard Codes. Bidder shall clearly indicate in his offer the applicable standard / code.

g) Conveying System

From each surge pyrite hopper Mill Rejects shall be pneumatically conveyed along a pipe line in dense phase using a pressure vessel (conveying vessel) as discharge device. Conveying vessel shall be of bottom discharge type.

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Supply pressure of compressed air shall be in the range of [5-7 kg/cm²(g)] suitable pressure adjustment device shall be provided by the Bidder before each conveying vessel to obtain the required pressure in the conveying vessel.

Mill Rejects shall be conveyed in the pipe line in intermittent mode i.e. conveying vessel is filled up periodically and all the contents of conveying vessel are emptied at a time. Conveying system shall be idle till sufficient mill rejects are accumulated in surge hopper. This shall be repeated cyclically. Number of cycles of discharge per hour shall be optimized for minimum air consumption considering 0.8T/hr in flow of Mill Rejects into surge pyrite hopper.

Bulk mean velocity of material in the conveying pipe line shall be less than 10 m/s. Average velocity shall be computed from actual cycle time and length of piping (material travel path) during a number of conveying cycles.

Guaranteed Bulk mean solid / Air weight ratio shall not be less than 20 Average value shall be computed from actual air consumption and actual quantity of solids conveyed during a number of conveying cycles, for this purpose conveying cycle shall start from start of conveying vessel inlet valve open and terminate at the close of air supply line to conveying vessel.

Once optimum quantity of mill rejects are collected in the surge pyrites hopper, first level switch shall give cycle initiation signal to various valves. Sequential operation of various valves to complete the conveying cycle shall be effected by either pneumatic controls or solenoid valves with relay based controls or a combination of both. However, complete pneumatic controls shall be provided for the Mill Reject inlet valve to conveying vessel, to close with a time delay after opening. In case the first level switch fails to operate, another level switch provided slightly above the first one shall give an alarm to the operator indicating failure of the first level switch.

All the pneumatic and solenoid valves associated with each surge pyrite hopper conveying system shall be mounted locally in a water and dust tight enclosure. Degree of protection of enclosure shall confirm to IP-62. Manual operation of the system from local shall be possible from this valve enclosure in case of failure of remote operation system.

Pneumatic conveying system shall be designed to empty even the completely filled up surge pyrite hopper through conveying vessel in a number of automatic conveying cycles.

h) Conveying Vessel

Conveying vessel shall be designed and tested based on BS/ASTM standard for pressure vessels. Temperature of the Mill Rejects coming into the conveying vessel shall be considered at [200 degree centigrade] design pressure shall be the maximum pressure the vessel is subjected to during any operating condition. In any case it shall not be less than 10 Kg/cm² (g).

The conveying vessel shall be constructed with tested quality mild steel plates. They shall withstand the abrasive action and hot condition of mill rejects and the operating air pressure. The conveying vessel shall be supported independently on steel columns.

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The vessel shall have suitable located and adequately numbered air connections for supply of compressed air for conveying mill rejects through pipes to overhead bin.

The isolating valve at the top of vessel and the outlet bend piece at the bottom of the vessel shall be connected to vessel through air tight flanged joints. The material of construction for the outlet bend shall be alloy C.I. with minimum 400 BHN.

Conveying vessel shall be tested hydraulically for 1.5 times the design pressure.

i) Mill Rejects Conveying Piping, bends Fitting and Accessories

Minimum [115.0 mm OD. x 5.4 mm thick] ERW steel pipe as per IS:1239. Heavy class shall be supplied for mill rejects conveying piping.

The routing of the mill rejects conveying pipes is to be submitted by the Bidder, which shall be subject to approval by the Owner, during detailed engineering.

The pipe work shall be of such design as to enable quick dismantling repairs with flanged type joints. The flanges shall be slip on flat faced flanges as per ANSI B16.5 rating, fabricated out of carbon steel plates to IS:226/IS:2062/applicable International Standards. Gaskets shall be of compressed asbestos fiber with minimum 3 mm thickness.

All fittings (i.e. bends, specials etc.) used in the lines shall be as per good engineering practice, commensurate with the service conditions. The material of construction of fittings shall be alloy C.I. with minimum hardness of 400 BHN.

The specification includes the supply of all steel hangers supports and steel pipe bridge for routing of mill rejects piping. However mill rejects piping in the coal mill area shall be supported on Owners columns / floor.

j) Mill Rejects Storage Bin

- i) The proposed system envisages one no. storage bin for each unit having capacity [...] tonne effective storage for 16 effective running hours.
- ii) The reject bin shall be fabricated out of minimum 12 mm thick steel plates with adequate stiffeners. The minimum valley angle of Reject bin shall be 60°. The inside surfaces shall be provided with renewable 3.0 mm thick SS plate liner thickness. The 3 mm thick stainless steel liners (SS 316) covering whole surfaces conical portion and straight portion also above. Explosion diaphragm shall be provided to release the air from the Bin, in case the pressure exceeds 1.0 Kg/cm² (g).
- iii) The reject bin shall be sized at least to above mentioned capacities and shall be designed & located such that they can be emptied from bottom into Owner's trucks approximately [10T capacity] at regular intervals.
- iv) Access and platform shall be provided with 32 mm thick MS grating 32 NB GI pipe hand railing shall be provided wherever required.
- v) Manually operated undercut gate shall be provided at the mouth of each reject bin. Gate shall be double pivoted sector type. Suitable levers, pulleys / sheaves, ropes etc. shall be provided for operating the gate from the operating platform and ground level. The gear shall be made of cast steel and suitably hardened. The gate shall be designed for heavy duty application.

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- vi) Suitable vent with filters shall be provided at the top external to the silo. Vent filters shall have adequate number of bags made from synthetic fabric suitable for coal dust. Maximum air to cloth ratio ($\text{Nm}^3/\text{min}/\text{m}^2$) shall be considered as 1.5 with isolation of 10% bags. The material of filter bags shall be suitable for prolonged operation up to a temp of 200 °C without losing its collection efficiency and durability. Filter bags shall be suitably treated to minimize the chances of filter bags catching fire. It shall be possible to plug opening for the damaged bag filters, if any, to facilitate uninterrupted operation of the unit. The guaranteed particulate emission rate from the filter shall not be more than 50 mg/Nm^3 of air. Suitable explosion vents shall be provided for the bag filter unit. Sequential cleaning cycle shall be initiated with pressure drop signal across the bag filter once sufficient cleaning air pressure is available. Solenoid / pneumatic valves shall be provided for this purpose.
- vii) Bag cleaning mechanism shall be automatic, and shall comprise of solenoid valves, air nozzles, adjustable solid state timer, pressure switches, piping and fittings etc. Nozzles shall be placed just above the filter bags to facilitate individual cleaning of each bag.
- viii) The reject conveying pipes shall be terminated at the top of bins in individual terminal boxes. The terminal boxes shall be of steel construction with necessary deflector or impingement plate to take care of impact and wear due to high velocity reject particles discharging into the bin.
- ix) The bins, supporting structures etc. shall be suitable for storing hot reject particles at 200 °C. One (1) no. level switch shall be provided in the bin to indicate 'Bin Full' condition.

k) Air Line, Cooling Water and Drain Piping, Valves, Fittings and Accessories
Piping

- i) The scheme and scope of supply of the air, water and drain piping is to be submitted by the Bidder, which shall be subject to reviews and approval by Owner. The Bidders shall work out the sizes of air piping for the various services based on the system requirements (Design) and submit the final layout and pipe sizing data to the Owner for approval.
- ii) All pipes shall be tested hydraulically after installation to minimum 1.5 times the maximum pressure encountered.
- The air piping shall be galvanized and shall be as per IS:1239 Heavy Grade.
 - The water piping shall be as per ASTM-A-36/ASTMA-53 Type 'E' Gr. B/IS: 3589/IS: 1239.
- iii) For compressed air piping for instrument and control following standard shall be adopted.
- Size between 25NB & 50 NB :Seamless & Brass ASTM B 43 Sch. 40.
 - Size below 25 NB :Seamless copper to ASTM B75.
- iv) Following line velocities shall be assumed for estimating pipe sizes of compressed air lines :

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S.No	Pipe sizes	Velocity m/sec.		
		Below-50mm	50-150mm	200mm
1	Pressure below 2kg/cm ² (g)	15-20	20-30	25-35
2	Pressure above 2kg/cm ² (g)	20-30	25-40	35-45

- v) Screwed couplings shall be used.

Valves

- i) Code and Standards :

- IS: 778 - Gunmetal gate, globe and check valves for general purpose.
- IS : 780 - Sluice valve for water works purposes (50 to 300mm)
- Any other BS or equivalent international standard.

- ii) For valves of 40 mm size and above and up to a working pressure of 10 kg/cm²(g) :

- Type : Bolted bonnet, outside screw and yoke, rising stem, flat faced flanged eng.
- Material of Construction : Body - Cast iron (IS: 210 Gr. 25) with 0.30% of construction max. (P) and 0.12% max. (S) Trim & Stem - Gun metal

- iii) For valves below 40 mm size and up to a working pressure of 10 kg/cm² (g):

- Type : Union bonnet, rising stem, screwed end.
- Material of construction : Body -Gun metal, Trim & Stem - Gun metal

- iv) All valves will be tested hydraulically to minimum 2.0 times (for body) and 1.0 times (for seat) the maximum pressure encountered Air tests shall be conducted to detect seat leakage.

I) Air Receivers

- i) As far as possible, the design, manufacture and performance of air receivers shall be in accordance with the latest applicable Indian / British / American / DIN standards. The latest editions of the following shall be followed in particular :

- IS: 2825 - Code for unfired pressure vessels.
- ASME - Section - VIII, Division - 1.
- BS - 487 - Fusion welded steel air receivers.
- IS: 7938 - Air receivers for compressed air installation.

- ii) The materials of the various components shall conform to applicable IS/BS/ASTM/DIN standards.

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- iii) The air receivers shall be vertical self-supporting cylindrical vessels with supporting stands for resting on the civil foundation.
- iv) Other design parameters and design internal pressure of the receiver shall be as per the data specification sheet enclosed. The receiver shall be designed as per IS: 7938.
- v) Receivers shall be of welded construction with a minimum number of joints. Longitudinal seams in adjacent sections of shell shall not be in the same line.
- vi) Receivers shall be provided with gasket inspection openings.
- vii) Receivers below 500 mm diameter shall have at least two inspection holes. For receivers of larger diameter, manhole of minimum 450 mm diameter shall be provided. These openings shall be placed as far as possible from any welded seam and in no instance shall pierce any seam.
- viii) All welding shall be performed in accordance with relevant codes. Filler material that will deposit weld metal with a composition and structure as near as that of the material being welded shall be used. All welding electrodes shall be got approved by the Owner. The electrodes shall be dried in ovens immediately before use to ensure freedom from porosity. All the circumferential and longitudinal butt welds of the air receiver shall be subjected to 100% radiography in accordance with IS: 2825 (paragraph 8.7.2). Tee joints and dished welding shall be subjected to 100% radiography.
- ix) All other welding on the air receiver, including fillet weld and nozzle connection shall be DP tested as per IS: 2825.
- x) Each finished receiver complete with all welded attachments shall be hydraulically tested at 150% of the design pressure. The test pressure shall be maintained for at least 30 minutes. All joints shall be gentle hammered during the test.
- xi) Receivers shall be provided with relief valve of the capacity and set pressure as specified in the data specification sheet. The spring in the relief valve in service for pressure up to and including 250 psi shall not be reset for any pressure more than 10% above or below the design set pressure. For higher pressures, the spring shall not be reset for any pressure more or below 5% design set pressure.
- xii) Each air receiver shall be complete with drain connection of 25 NB with a trap station consisting of a trap, strainer, isolation and bypass valves.
- xiii) The receiver shall be provided with necessary number of nozzles. The orientation of the nozzles shall be subjected to the approval of the Owner.
- xiv) Local instruments like pressure gauge and thermometer of suitable range if asked for in the data specification sheet shall be supplied.
- xv) The Bidder will have all welding procedures & welders qualify in accordance with the relevant codes prior to commencing any welding at the works. These tests will be witnessed by Owner's representative.

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11 CRANES & HOIST**11.1 Electric Overhead Traveling (EOT) cranes**

This section deals with the specification of handling and hoisting facilities such as Electric overhead traveling (EOT) cranes, Single girder under slung cranes, Electric hoists, Manual travelling hoists, Passenger and Freight cum Passenger Elevator etc. required for erection & maintenance of the various plant, equipment and systems covered in this Bid document.

In general the specification covers the design, engineering, manufacture, packing, forwarding to site, insurance, unloading and storage, preservation and handling at site, supply erection, testing and commissioning and performance guarantee of the following handling and hoisting facilities for the equipment and system covered in this Bid document.

11.1.1 Codes & Standards

- a) The design, manufacture and testing of the crane(s) shall conform to the latest editions of the following codes and standards in general.

S. No	Code	Description
1	IS: 807	Code of Practice for Design, Manufacture, Erection and Testing (Structural Portion) of Cranes and Hoists.
2	IS: 3177	Code of Practice for Design of Overhead Travelling Cranes and Gantry Cranes other than Steel Works cranes
3	IS: 1835	Steel wires for Ropes
4	IS: 2266	Steel Wire Ropes for General Engineering Purposes
5	IS: 3443	Crane Rail Sections
6	IS: 3815	Point Hook with Shanks for General Engineering Purpose
7	IS: 5749	Forged Rams horn Hooks
8	IS: 816	Code of Practice for use of metal Arc Welding for General Construction in Mild Steel
9	IS: 9595	Code of practice for Use of Metal Arc Welding of Mild Steel
10	IS:7318 (P1)	Qualifying Tests for Metal Arc Welders (Engaged in Welding Structures other than pipes)
11	IS: 1323	Code of Practice for Oxy
12	NEC:	National Electrical Code

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S. No	Code	Description
	1985	
13	CMAA	Codes & Standards for design, manufacture, erection & testing of Cranes
14	IS: 325	Inductor Motor

- b) All electrical installation work shall comply with the provisions of Indian Electricity Act and Indian Electricity Rules as amended up to date.
- c) ANSI-B30.2.0- Safety codes for overhead and Gantry Cranes
- d) ANSI-B30.2.0 – Safety codes for overhead and Gantry Cranes

11.1.2**Design Criteria for Duty & Capacity for EOT Crane**

The EOT cranes shall be used for unloading, erection, maintenance and general station service of steam Turbine Generator and other associated auxiliary equipment to be installed in the TG Building.

The service duty is classified as 'Intermittent and standby service'

- a) Number of hours in service per annum : Above 2000
- b) Number of cycles for fatigue calculations : 2x105 in IS:3177/807
and relevant IS

[Two (2)] identical capacity EOT cranes shall be installed in A-B bay over operating floor of the Power house. These cranes shall work both independently and also in tandem operation. Crane capacity shall be designed for the single heaviest equipment to be handled in the TG hall with a 5% margin.

The performance of the EOT cranes shall be restricted to the following:

Main Hoist

- Safe working load (SWL) : [.....] T
- With a margin of 125 percent of SWL) : [.....] T
(Specified speeds need not be attained)

Above figure is tentative only and safe working load (X) for the EOT cranes shall be computed as:

$$X = 1.25 a$$

And safe working load (Y) for the EOT cranes with Lifting beam and sling shall be computed as:

$$Y = 1.25 \times (a+b)$$

Where a = Single heaviest equipment expected to be handled.

b = Weight of lifting beam and slings.

Normally the cranes are operated intermittently for one (1) shift only, however during overhaul and maintenance of the equipment, the EOT crane may be required to work for all three (3) shifts on intermittent duty and should therefore be capable of such operation.

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Data Sheet for EOT of TG Building

S.No	Parameters		
1	Capacity (Safe working load (SWL))	:	Main hoist - [....] tonnes
		:	Aux. Hoist - [....] tonnes
2	Rated speed (for any load from zero to SWL)	:	Main hoist - 1.6 m/min, Aux. Hoist – 7.5 m/min Trolley travel – 15 m/min. Crane travel – 30 m/min
3	Tolerance	:	± 10%
4	Creep speed	:	10% of rated speed for both main and auxiliary hoist
5	Deflection of main girder	:	Max. of 1/900 of crane span with SWL
6	DESIGN AND CONSTRUCTION		
a	Type	:	Double Girder
b	Duty class: Mechanism class	:	M5 as per IS-3177
c	Electrical service class	:	S4
d	Design ambient temperature for Motors	:	50 deg C
e	No. of starts per hour	:	150
f	No. of Trolleys	:	One
g	Span between runway rail centres	:	As per power house building floor drawings
h	Net runway length	:	As per Power House building floor drawings
i	Runway conductors -	:	Shrouded Copper Bus Bar along with spring loaded collectors
j	Maximum allowable current density at 40 deg. Ambient (suitable derating factor shall be considered for design ambient condition)	:	0.35 amps/sq.mm
k	Permissible tolerance	:	
	Difference in levels of crane rail top measured between two adjacent columns	:	2.0m
	Crane rail gauge	:	±3.0 mm
	Relative shift of ends of adjacent rails in plan and elevation after welding	:	1.0 mm
	Deviation of crane rail axis from centre line of web of supporting girder	:	±3.0 mm

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S.No	Parameters		
	Difference in levels of crane rail top (across the bay)	:	
	i) At supports of crane girder	:	15 mm
	ii) At mid span of crane girder	:	20 mm

11.1.3

System Description for EOT Crane Design & Constructional Features

a. General

Drives shall be designed with adequate margin to give best performance and efficiency. Safety arrangements shall be incorporated to prevent damage to motors on account of mechanical overload and electrical faults and to gearing, shafts, etc. due to over stressing and other detrimental conditions.

The crane shall be rigid in construction and all movements shall be smooth and non-jerky.

All materials shall be of tested quality and shall conform to the specification requirements and standards mentioned and shall be new and first class in all respects.

Casting and forgings shall be of testes quality and shall conform to their respective material specifications and shall be free from flaws and objectionable imperfections, machined true and in a workman like manner.

No wood or other combustible material shall be used unless specifically mentioned.

Proposals for repair or any similar operations involving plugging, welding, boring or addition of metal to the original castings or forgings shall be submitted to the Owner and his approval must be obtained before any such work is carried out. Drawing showing details and location of such repairs shall be submitted to the Owner.

All fabrication by welding shall be carried out by qualified and certified welders as per IS: 7318 (part 1).

Design shall provide for easy maintenance of all parts, particularly the wheel bearings on end trucks.

The Bidder / Supplier will ensure that the crane will be manufactured as per the tolerances specified below:

S. No	Particulars	Details
1	Span over LT wheels	± 6 mm upto 40 meters
2	Wheel base	

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S. No	Particulars	Details
3	LT	± 5 mm
4	CT	± 3 mm
5	Difference in diagonal	
6	LT	± 5 mm
7	CT	± 3 mm
8	Long travel wheel alignment	± 1 mm
9	Tilt of wheels or balancer axle	± 1 mm/ 1000 mm (Horizontal & Vertical)
10	Trolley wheel gauge	± 3 mm upto 7500 mm span ± 5 mm above 7500 mm span
11	Trolley track gauge	± 3 mm upto 7500 mm span ± 5 mm above 7500 mm span
12	'S' (mm)	'H' (mm)
13	Upto 2500	4
14	Above 2500 and upto 4500	6
15	Above 4500	10
16	Horizontal bend of girder in plan	Span/2000
17	Shift of the web plates of main & end girders from vertical over height 'H' measured near the mid span & close to the main diaphragm.	H / 200
18	Twist of the main girder	Span/1500
19	Axis of the flange plates from the axis of the beam	H /250
20	Tolerances on camber	
	Upto 4 mm	+ 4 - 0
	Above 4 mm and upto 8 mm	+ 5 - 0
	Above 8 mm and upto 16 mm	+ 6.3 - 0
	Above 16 mm and upto 31.5 mm	+ 8 - 0
	Above 31.5 and upto 63 mm	+10 - 0
	Over buffer length (Over buffer dimension on two sides will be same)	± 5 mm
	Height of centre of buffer (from the top of track rail)	+ 5mm

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b. Temperature Effects

Where any portion of the structure is not free to expand or contract under variation of temperature, allowance shall be kept for stress resulting from these conditions: the co-efficient of expansion for each degree centigrade variation of temperature above and below normal being taken as 0.000012 for mild steel.

Maximum use shall be of shop fabricated sub-assemblies.

Alternative design to those prescribed in specifications shall be considered only if found technically suitable and acceptable to the Owner in light of the requirements accompanied by substantial reduction in cost.

c. Material of Construction

The material of construction of the major components of the crane shall be as per Indian or international standard. Manufacturers are however free to use alternative material, which are superior for the intended service. But in all cases they are required to obtain prior concurrence of the Owner after furnishing chemical and physical properties of the offered material and any other information that may be asked for the Owner.

d. Load Indication

The crane bridge shall have permanent inscription in English on each side, readily legible from operating floor, stating manufacturer's name, serial no, the year of manufacture and the safe working load.

e. Structural Design Consideration**i) Minimum thickness of metal**

For load carrying members, the component plates, bars, angles and other rolled sections shall be minimum 8 mm thick. For tubes having both ends sealed the minimum thickness shall be 4.9 mm (6 SWG). For unsealed tubes the minimum thickness shall be 8mm. The chequered plates for platforms shall be minimum 6 mm thick over plane.

ii) Accessibility for maintenance

All structural parts shall be designed so that they are accessible for periodic cleaning, brushing and painting. All rivets/bolts shall also be accessible for periodic checking.

Foot walks shall be of sufficient width to give at least 500 mm clear passage on both sides of the girder except between railing and bridge drive Access stair case from the operating floor of the TG hall up to the crane girder level shall be provided.

The platforms along the bridge girders and over the crab shall allow convenient access for replacement, inspection, lubrication etc. for different mechanical and electrical components.

iii) Ruling dimensions and ratios

- For compression members, the slenderness ratio shall not exceed 120. In case of other load carrying members and subsidiary members the slenderness ratio shall not exceed 180.
- For girders, the following values of maximum span to depth ratio shall be governing as per IS: 807:

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Plate girders : Span/depth = 18

Lattice girders : Span/depth = 12

iv) Connections

- Unless otherwise specified, only riveted or welded joints shall be used.
- Where welding or riveting is not practicable, turned or fitted bolts shall be used with the approval of Owner.
- Minimum number of rivets or turned or fitted bolts in a connection shall not be less than two.
- Black bolts shall not be used in main structures and high tensile bolts shall not be used unless approved by the Owner. Bolts shall preferably be not used in tension.
- Where bolts pass through sections having tapered flanges, tapered flats shall be welded to inside of the flanges. Tapered washers shall not be used.
- Transverse fillet welds on load carrying members shall be avoided. If side fillets are used in end connections, the length of each side fillet should be not less than the edge distance between the fillets.
- Butt welds on structural members under tensile stress shall be checked by Radiographic examination as and when directed by the Owner.
- Splices shall be designed to resist one and half times the forces and moments to which it is subjected, but in no case it shall be less than $2/3^{\text{rd}}$ of the effective strength of the material spliced except that splices in the webs of the plate girders shall be designed for full strength of the web in shear as well as bending. For splicing tension members, the net section of the splice plate shall be ten percent more than that of the material spliced. Splices shall be proportioned and arranged, so that the gravity axes of the splices are in line with the gravity axis of the member to avoid eccentricity.

v) Deflections and Camber

- The total maximum vertical deflection of the girders for the live load plus trolley and not including impact or dead load of the girder shall not exceed limit of 1/800.
- The girders shall be cambered by an amount equal to the maximum deflection due to dead load plus one half the live load and trolley.

f. Mechanical Details

Material of Construction shall be selected for cranes operating in non hazardous area and relevant IS for each part. The capacity, the rail length, span mentioned are indicative. However the loads and the other dimensions shall be taken from the layouts and weights of the equipments to be lifted in A-B Bay of TG Hall.

i) Rope drums

Rope of drums shall be as per IS 3177. It shall be either Seamless pipe of cast steel or fabricated out of rolled steel plates. Fabricated drums shall be 100% radiographed and stress relieved before machining. The grooves of the drum shall be machine grooved and smooth finished. Rope drum shall be flanged at both ends. The cable reeling drums (wherever provided) shall be positively driven.

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ii) **Rope sheaves**

Rope sheaves shall be of cast steel or fabricated out of rolled steel plates.

iii) **Wire rope and Hook Block Assembly**

- The lifting main hook block assembly shall be ram's horn type or equivalent approved type for capacity greater than 40 Tonnes and auxiliary point hook with shank of capacity below 40 Tonnes and shall be of steel construction. Each hook shall be supported on ball or roller thrust bearing and shall rotate freely on its bearings. The hooks shall have locking arrangement.
- The sheaves of the hook block shall be encased in an oil tight casing permitting generous lubrication of wire ropes and sheaves and also preventing accidental tapping of hands.
- All sharp edges on the hooks shall be eliminated to prevent damage to the sling ropes. The hooks shall conform to the requirements of IS: 3177 and IS: 3815.
- The ropes shall be hemp cored for all cranes. Ropes shall be regular right hand lay as per IS: 2266-1989. The construction of the ropes shall be 6 x 37 up to 16 mm diameter and 6 x 36 above 16mm diameter. The rope length shall be sufficient so that 2 full lap shall remain on drum at the extreme low position of the hook. The braking loads for the hoist rope shall not be less than the load factor specified in IS 3177.

iv) **Gears & gear- boxes**

Straight and helical spur gearing shall be used for all motions. Worm & bevel gearing may be used in exceptional cases with the specifics approval of the Owner. All first reduction gears shall have helical teeth. All pinions shall be integral with the shaft.

All gears shall be hardened and tempered alloy steel, heat treated and confirming to IS: 4460 having metric module. Overhung gears shall not be used.

Surface hardness for pinion shall be 255 to 300 BHN and for gears it shall be 215 to 260 BHN. Difference in hardness of pinion and gear shall not be less than 20 BHN. All cast steel gear shall be tested by Gamma Ray. All gears shall be enclosed in oil tight gear boxes. Gear-boxes shall be of high Grade/cast steel or fabricated and split at each shaft centre lines. Fabricated gear boxes shall be stress relieved before machining. For cross travel and long travel motion, vertical gear-boxes with 'T' split may be used.

v) **Connection between rope drum & gear-box**

One of the following arrangements shall be adopted for connecting the rope drum with the gear- box.

- Flexible joint, incorporating flexible geared coupling housed within the drum.
- Fully flexible geared coupling between the drum & gearbox.

Drive of the drum by means of spring mounted on the drum shall be avoided as far as practicable.

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vi) **Wheels**

Crab/crane wheels shall be double flanged. Wheels shall be mounted in anti-friction roller bearing housed in 'L' shaped bearing brackets for easy removal during maintenance. Flangeless wheels with guide rollers are also acceptable.

Solid wheels shall be of forged rolled / cast steel. Wheels from 400 mm diameter and above may consist of hardened, rolled / forged steel tyre of not less than 60 mm thickness, shrunk on to cast iron center.

vii) **Coupling**

Motor shaft shall be connected to the gear-box input shaft through flexible shock absorbing coupling excepting pin bush type. Rotating parts shall be suitably covered by minimum 3.15 mm thick sheet steel hinged covers for safety. In case of single motor central drive for long travel motion, output shaft of the gear-box shall be connected to the line shaft through half geared couplings. Intermediate lengths of the line shaft may be connected through solid flange couplings. Half geared couplings with floating shaft shall be provided between the wheel and the line shaft.

viii) **Bearings & bearing housing**

Anti-friction bearings shall be used throughout except where required otherwise for technical reasons.

ix) **Buffers**

Spring loaded/hydraulic type rubber buffers shall be provided on all the 4 corners of the bridge girders and the end carriages for cross and long travel motions respectively based on the duty class of the crane whereas rubber buffer may be used for class M3 and M5 duty cranes. Amount of impact forces shall be decided depending upon the type of buffers selected.

x) **Bridge Girder and End Carriage**

- The crane shall have double girder.
- The bridge girder shall be box section type or braced I - beam type as per standard design practice. The exterior surface shall be smooth and as free as possible from projections etc. to minimize dust collection on it.
- The crane bridge shall be carried on end trucks of suitable design. Each end truck shall be built up from steel plates welded together to form a closed box section with opening at each end to receive the wheels. Welded to the trucks shall be steel sections to form bearings for the wheel axles and the driving shaft. End trucks shall be provided with rail sweep and bumper. They shall also be provided with suitable jacking pads for maintenance of the wheel and bearings. The location of the jacking pads shall be such that it shall not interfere with the maintenance of the wheels and its bearing.
- Driving wheels shall be of the double flange and taper tread type and shall be ground to equal diameter in pairs. Wheel axles may be either of the stationary or rotating type as per standard practice. If stationary type, they shall be prevented from turning in the truck by means of a key plate fitting

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into a slot in the end of the axle and if rotating type, wheels shall be keyed to them.

- Where more than two bridge wheels are used per end truck, the end truck shall be split into two sections, each carrying one bridge independent of other. Two sections of the end truck shall be joined by suitable joining device that shall ensure uniform wheel loading. Steel pads shall be welded on the tops of end trucks where the girder rests and shall be machined to receive the girder ends.
- Trolley travel rail ends shall be curved upwards to stop the trolley smoothly and prevent it from leaving the rails in case of over travel at its maximum speed.
- End trucks shall be equipped with spring/rubber buffers and rail sweep for bridge travel. The rail sweep shall be such that it can push away any object that may fall on the runway. The buffers shall be of substantial design and suitable for engaging the stops at the end of runway.
- Breathing holes shall be provided in completely enclosed welded box type girders. Drain holes shall be provided in all places where water or oil is likely to collect where practicable, means of access shall be provided for inside inspection of completely enclosed box girders.
- In bridge girder strength calculations, the trolley rails and chequered plates shall not be considered as load carrying members.

xi) **Wheel Stops**

Bridge and trolley wheel stops shall be provided before the end stops. These shall match to wheel radius. Wheel stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails. Wheel stops shall be welded to the girder.

Sweeps shall be attached to the end carriages and to the trolley, to remove foreign material from the rails.

xii) **Brakes**

All brakes shall be of 'fail-safe' design and shall operate automatically in case of power failure. Two brakes shall be provided for all motions (One Electro hydraulic Thrustor brake and One DC Electromagnetic brake). Out of the two (2) brakes provided for hoisting motion, one shall be provided at the gear box input shaft and other on motor side. Hoisting brakes shall be designed to hold 1.5 times full load torque while cross travel and long travel brakes shall be designed to hold 1.25 times full load torque.

xiii) **Lubrication**

Grouped lubrication system shall be used for the cranes. Lubrication of the gears and pinions in the gear-boxes shall be splash fed from the sump. In case of three reduction, vertical mounted gear-box (having limited motion), are used, an oil pump shall be fitted to ensure lubrication of all gears.

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xiv) **Trolley Frame**

- The trolley frame shall be built up from heavy steel plates, angles and channels adequately braced to resist vertical, lateral and torsional strains, welded to form a rigid one piece frame. Alternatively, it may be of cast steel construction and should be covered by flooring as far as possible.
- On bottom of trolley frame, on each side a double spring bumper shall be provided to engage stops at each end of the bridge.
- Equalizer sheaves shall be mounted on the trolley frame in such a manner that deflection resulting from the force on the sheaves is not directly transmitted to the hoisting mechanism.
- Sheaves shall be so arranged on the trolley that rope reeling arrangement resulting there from shall ensure a lifting of the load in almost a vertical line with minimum of swing or side-movement.

xv) **Platforms and Ladders**

- Maintenance platform of 1m width at the crane girder level connecting A-B bay for maintenance purpose
- Safe means of access shall be provided at every place where any person engaged in the examination or maintenance of the crane has to work adequate handholds and footholds shall be provided as necessary.
- One meter high double tier handrail and suitable toe-boards shall be provided along the entire length of platform (on the bridge), which shall not be less than 930 mm wide.
- Access ladders one (1) each for access (a) on either side from gantry girder level walkway to crane bridges walkway (b) from crane bridge walkway to Operator's cabin (c) from crane bridge walkway to suspended cradle.
- Every platform shall be provided with steel chequered plate top and shall be securely fenced with one meter high double tier hand rails and toe boards. Platforms shall be of sufficient width to enable undertake of normal maintenance work.
- In case lattice riveted construction is offered for the bridge girder, full length chequered plate platform with adequate headroom shall also be provided at bottom chord level for periodic checking of all rivets/bolts and other items.
- Access to operator's cabin from bridge girder platform shall be by staircase having adequate width and proper sloping.
- Handrails shall be of galvanized steel PVC coated pipe of flush welded construction, ground smooth using 32 mm nominal bore medium class pipe to IS: 1239. Hand-railing construction shall be with double horizontal pipe runs, with top run about one (1) meter above walkway level. Toe plates of 100x6 mm thick or approved equal flat shall be provided. Pipe posts shall not be spaced more than 1.75 meters apart.
- All ladders shall have 450 mm clear width and provided with 20 mm diameter steel rod rungs spaced at 300 mm apart Safety cage in steel welded construction shall be provided for ladders higher than 2.5 meters in height.

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xvi) Runway Rails

- Crane runway rails with bolts and nuts and complete with shims, taper flats, anchor bolts, inserts and other fixtures for fixing the rails to crane girders shall lie under the scope of supply of the present specification. Erection of LT rails & fixing of the same is included in the scope of the Bidder.
- The length of the rail supplied shall be sufficient to cover the whole of runway length. Crane-runway rails of the sections shall be joined by welding to make it continuous and there should not be any gap between the successive rails. End rails shall be provided with stoppers to prevent longitudinal shifting.
- The rail section shall be as per IS: 3443.
- The Bidder shall quote the unit rate for Runway Rail with holding fixtures, etc. for adjustment of contract price corresponding to changes, if any, in the length of runway rails to be actually required under this specification, compared to what has been specified herein.

xvii) Trolley Rail

- The specification includes the supply of trolley travel rails complete with fixtures for fixing the rails to the body of crane.
- The length of the rail supplied shall be adequate for maximum permissible trolley travel. Gap between successive rails shall not exceed 2 mm and end rails shall be provided with stoppers to prevent longitudinal shifting.

xviii) Rail Joints and Fixing

- Rail joints shall be properly located and shall be joined through flanged bolting/welding. All rail-to-rail joints should be butt welded except the building expansion joint. The rails shall be butt jointed by either Thermit welding or Fusion welding process. The Crane vendor shall get his proposal for edge preparation of rails, welding procedures and sequence approved in advance by the Owner.
- The schemes of securing the rails to the Gantry girder/bridge structure with dampers, bolts and nuts, their alignment etc. shall be subjected to the approval of the Owner. Rail fixing arrangement shall be such that the profiles of damp match the rail flange.

xix) Tolerances

The limits of tolerance as specified in the Data Specification Sheet shall be observed.

xx) Rail End Stops

Rail End Stops of adequate design shall be provided on both ends of the runway. The end stop location and arrangement shall be such that the unavailable length of runway (for crane operation) on any end is a minimum.

xxi) Drive Mechanism

- Equal driving effort shall be applied at each drive wheel of bridge and trolley to prevent one end from travelling faster than the other.
- For bridge, the torsional deflection in the cross shaft shall be limited to safe value.

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- For bridge drive if twin motors are used, these motors shall be equidistantly located at each wheel end. Suitable interlock shall be provided to prevent single motor operation at any time.
- Trolley drive shall be achieved by single motor in which the motor shall drive a common output shaft through proper gearbox and traction power shall be transmitted to the geared wheels by means of pinions mounted on both ends of the output shaft.
- All machineries for the drive unit shall be properly aligned. Self-aligning type gear couplings shall be used between connection shafts to take care of transverse as well as axial movement wherever necessary. Wherever components of considerable amount of inertia is directly mounted on the high speed shaft (e.g. brake drum, couplings, etc.) they shall be balanced statically to minimize vibration.
- Motor rating shall be calculated keeping margin of at least 15% over the maximum power requirement in the duty condition specified. Further, the hoist motors shall be rated to lift 125% of the design load on the hook at the rated speed.
- Along with the drive mechanisms adequate brakes shall be provided as detailed elsewhere in this specification. Selection and design of brakes shall be the complete responsibility of the manufacturer. The brakes shall be of accurate rating to stop each motion within a very short distance and in a safe and smooth manner.

g. Electrical Details

Power supply to the crane will be from the 415V station PDB/ACDB meant for Crane/Hoist etc., as shown in the Electrical SLD.

Power supply and standard voltage levels

The following standardized voltage levels will be adopted:

S. No	PARTICULARS	DETAILS
1	LTAC	415V, 3 phase, 50 Hz, 4 wire solidly earthed system. Power supply be made available at this voltage only. Other voltages will be obtained by providing transformer/ transformer – rectifier unit with MCBs on both primary and secondary side and $\pm 5\%$ and $\pm 10\%$ taps on transformers secondary.
2	AC control and signaling voltage	240 V, 110 V AC
	Socket outlets for	
3	Hand lamps	24 V, single phase, 50 Hz, AC obtained through suitable transformers

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S. No	PARTICULARS	DETAILS	
4	Hand tools	240 V, 15A, 2 pin plus earth with plug interlocked switch	
5	Electro-magnetic brakes	220 V, DC obtained through individual brake control panels.	
6	Monitoring and signaling in electronic installations, mimic panels	24/ 48 V. DC	
7	Illumination/ lighting	240 V, AC	
	The three phase symmetrical short-circuit ratings of the switch gear at 415 V will be 50 kA for 1 second. The system/ unit/ equipment will be designed so as to be suitable for the following variations in voltage and frequency :		
		Voltage	Frequency
8	Permissible variations with rated performance, rated current and control effectiveness maintained	$\pm 10\%$ For LT system	+5% & -5%
9	Permissible variations for control and regulation equipment with rated performance and control quality maintained	$\pm 10\%$	+3% & - 6%

Voltage dip on the starting of largest LT motor will be limited to 15% of the nominal voltage at the motor terminals. Total voltage dips on starting of large motors on crane will be limited to 3% on crane and 6% in DSL system.

i) Following will be included on the pendant unit:

Push button for	Hoist slow, hoist fast, lower slow, lower fast, left cross traverse, right cross traverse, forward long travel, backward long travel, emergency stop conditions.
Switch for	Lights and bells
Lamps for	Power 'ON' indication and emergency corner switch operation.

The Pendant Push Button station will be supported independently, earthed separately independent of suspension.

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- **Cabin operated cranes:**

The operator's cabin will contain the following:

- Master controllers for all the motions and magnet (wherever applicable).
- Emergency stop push button.
- Foot switch for alarm or bell.
- Switches for all lighting equipment on crane.
- Switches for exhaust fan and for cabin fan.
- A fire extinguisher.
- Insulating mat and operator's chair.
- Cabin light and fan.

Annunciation panel with indication lamps for power 'ON' control 'ON' emergency corner switch operated, ammeter and voltmeter with selector switches.

- **Radio remote control:-**

- In this mode of control system, all the 3 motions Hoist.
- Main/creep for main hoist &aux hoist separately.
- Cross travel.
- Long travel can be controlled.

The system will have capability to provide range of 1.5 times the long travel distance of the crane.

In the case of signal failure, all motion will come to a safe stop.

The system will have facility of controlling speed in two steps:

- Slow speed on the first step of the breaker contact / pushbutton of the radio remote control representing the first or second notch of the master controller.
- Full speed on the second step of the breaker contact / pushbutton of the radio remote control representing the final notch of the master controller.

ii) Transmitter

Transmitter will have following features:-

- Constructed with sophisticated microprocessor technology and surface mounted electronics.
- Transmission type: - FM FSK
- Transmission speed: - 9.6 Kbps.
- Built in self-test for all functions.
- Transmitter will consist of switching breaker, dial switch and push buttons.
- Switching breaker will be non locking to zero position or maintained function.
- Indications:-
- Operation status
- Battery status

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- Indicators that display information from crane.
- PIN -code (Personal Identification Number)
- Internal antenna.
- Rechargeable battery.
- Battery 7.2 V NiCd
- Operating time: - About 8 hours.
- Different operating frequencies (minimum 16 nos.)
- Two hand upstart.
- Stop push button.
- Operating conditions: - Areas having large temperature variations, dusty, more vibrations, oil and humidity.
- Operating temperature range: - Min. 10 deg C to Max. 60 deg C
- Protection class: IP - 54
- Casing material: Polycarbonate / ABS Plastic

iii) Receiver

Receiver will have following features

- Upto20 functions exclusive safety relays (for transmitting preset reference values to VFD in the crane).
- 2 safety relays (for control of main contactor)
- Power supply suitable for 240 V AC, 6 A.
- Minimum 16 different operating frequencies.
- Two redundant microprocessors for monitoring each others.
- Cyclically redundancy checks check for high security of transmitted radio messages.
- Frequency scanning in the receiver.
- Memories last 10 users.
- Interlocking of the relays.
- Momentary or latched relay functions.
- Two hand up start (to avoid unintentional start).
- Protection class: IP - 65.
- Casing material: Aluminum profile for fast mounting on DIN rail -
Operating temperature range: - Min. 10°C to Max. 60°C

iv) Enclosure Class

- For indoor operations
 - Resistance boxes : IP : 11
 - Motors : IP : 54
 - All other electric equipment : IP : 54
- For outdoor operations

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- Resistance boxes : IP : 33 with canopy
- Motors & panel : IP : 55 with canopy
- All other electrical equipment : IP : 65 with canopy

v) Cables

For details refer Part-B, Section-II, Volume-II.

vi) Earthing

A ring earthing system will be provided on the crane. Each and every electrical equipment will be connected to this earthing at least at two points. However the electronic circuit insulated earth wire will run in panel and terminate at main earth connection only at one point. The earthing will be connected to the fourth trolley line in DSL system through 2 no's of current collector. Additionally current collectors will also be provided on crane rails for earthing on crane . All these collectors will be connected to earthing ring.

An earth core will be provided in trolley feed cable and the magnet. The cable reeling drum will have a separate slip ring for earthing purpose.

It will conform to general specification for earthing.

Rubber matting's will be provided in front of the protective and control panels.

All bonds between earth conductors and crane parts will be welded if possible, or riveted and soldered. Where screwed bonds are made, care will be taken that there is satisfactory contact surface and nuts will be locked to prevent their loosening? Earth connections to equipment will be made by means of multi strand flexible conductor to adequate section.

The earth ring on the crane/ machine will be connected to the plant earthing system through to gantry rails. Each end of each gantry rail will be bonded to the plant earthing system.

In addition, intermediate earthing bond will also be provided on the rails at every 60 m in case of longer tracks.

Flexible copper bonds will be provided across any gap in the running gantry rail. For mobile equipment with flexible cables, one separate copper conductor of adequate size will be provided for earthing.

h. Operation

The crane shall be operated either from cabin in the crane bridge and from a pendant control station and through remote control unit.

i. Operator's Cabin

The operator's cabin shall be steel fabricated open type, suitable for indoor service, and air conditioned, fire proof construction and complete with light, fan and seat. The cabin shall be located on one end of the crane bridge and on the opposite side of Down Shop Lead (DSL) and under one of the bridge girders, so that it is offset to one side. The cabin shall be provided with guarding handrails

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and the floor shall be covered with electric insulating carpet. Clear headroom of 2300 mm shall be ensured within the cabin. The cabin shall be well braced in order to provide adequate strength and rigidity. The outside surfaces of the cabin and floor beams shall present smooth and pleasing appearance.

A foot operated type-warning gong shall be provided within the cabin. The cabin shall be compact and adequately sized to accommodate controllers, protective panel, distribution board and other accessories required for operating the crane. Arrangement shall be such as to provide unrestricted view of load at any position to the operator.

Dead man's Handle/Control for each of the crane motions shall be provided in the cabin.

Cabin's platform shall be provided with 10 mm thick rubber sheet on the floor to comply with I.E. Rules. No wooden paneling shall be permitted. The sides of the cabin shall be covered with plate steel to a height of one (1) meter. The floor shall be designed for a load of 300 kg per meter square of floor area exclusive of the weight of any equipment mounted on or attached to the cab. An access ladder shall be provided from the bridge girder to the Operator's cabin.

In addition to above, accessories not limited to the following shall be adequately arranged/ mounted in the cabin:

- Manually operated master control switches, main line disconnecting switches and other necessary controls and wiring with fittings.
- A swing way operator's chair.
- Complete concise instructions covering the crane operation, maintenance and periodical lubrication etc typed in English and neatly framed in a permanent frame for each reference.
- A non-oscillating-ventilating fan having 350 mm swing (240V AC, single phase) with suitable guard, and separate regulator.
- Adequate fluorescent illumination with switch inside the cabin.
- An electric alarm gong and an additional 300 mm dia. hand operated metal gong.
- Portable carbon dioxide fire extinguisher and sand bucket.

Location of the cabin shall be on one side of the crane so as to permit maximum visibility of all operations of the crane. Location of cabin and/or access ladder shall be such as to prevent personnel from making accidental contact with crane and/or trolley runway conductors.

Enclosure protection class of all Electrical equipment shall be at least IP 54 or better except that for motor which shall have IP-55 protection & Resistance boxes, which may have IP-23 protection.

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j. Pendent Station

The pendent station shall locate the push buttons for controlling the various motions of the crane and shall be hung from the crane trolley to a height of approximately 1 meter above the operating floor.

With pendent operation, foot operated travel brake and the drum controllers need not be provided.

k. Repair Cage

- i. A repair cage shall be provided on the inside of the end carriage for attending the main current collectors. In case, the trolley current collectors are located below trolley rail level on the inside webs of the bridge girders, guards shall be provided on the trolley to prevent the hoisting ropes from coming in contact with conductors as well as a repair cage shall be provided on the trolley to attend to these conductors.
- ii. Repair cages shall also be provided at the corners of the crane, if required, to facilitate removal and replacement of long travel wheels.
- iii. The repair cages shall be adequately sized, guarded for safety and correctly located for the intended service. Suitable access to the cages shall be provided.

l. Guarding

- i. Guards of an approved design, which shall push forward or off the rail track any object placed across it, such as person's foot or arm, shall be attached to each end of the end carriage.
- ii. Protection guards to live electrical wirings/conductors shall be provided.
- iii. Suitable guards to revolving shafts and coupling, long travel cross shafts and gears, shall be provided.
- iv. The sheaves of the hook block fitted with two sheaves or fewer shall be guarded to prevent trapping of a hand between a sheave and the in running rope.
- v. Effective means of guiding the wire ropes over the sheaves shall be provided so as to prevent dismounting of rope from the sheave grooves even when a slack rope condition is developed.
- vi. All openings in foot walk flooring, for access to bottom chord platform, if any, and to other inspection platforms, shall be provided with covers having suitable locking means to avoid any accidental opening.
- vii. All electrical panels, resistance boxes and crane trolley wires shall have suitable rain/dust hoods over them to prevent water and building construction material falling on them, as it is apprehended that erection and commissioning of the crane might have to be taken up before the completion of the building roof.

11.1.4 Quality assurance and Test & Inspection

The crane shall be offered for inspection and testing during different stages of its manufacture, starting from raw materials till the completion of the crane, by the Owner/his authorized representative at the Supplier's or his sub-supplier's works as per the inspection procedure mutually agreed between the Owner or his authorized representative and the Supplier. Inspection shall be regarded as a check up and shall be in no way binding on the Owner.

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Documents for all electrical and mechanical equipment supplied with the crane shall be put up for inspection along with the equipment.

After inspection, an endorsement would be made in the inspection certificate about the availability of the documents.

The crane shall be completely assembled and tested in the Supplier's works for full load and 25% over load on hoisting and cross traverse motion, in presence of Owner in addition to other tests as specified in the latest revision of IS:3177 as applicable.

The following test shall be carried out at manufacturer's works during inspection.

High voltage test of panels.

Contact sequence test for all motions.

Necessary clearance from statutory authorities (if any) shall be obtained by the Bidder on behalf of the Owner before the cranes are put under operation immediately after the cranes are commissioned. The crane after erection shall be tested as follows:

- a) Insulation tests and other tests mentioned shall be carried out as per the latest edition of IS: 3177 (as applicable).
- b) Deflection Test
- c) The deflection test of the bridge girders shall be carried out as per latest edition of IS: 3177. After the deflection test with safe working load, the crane shall be tested for deflection with 25% over load and there shall not be any permanent set after the removal of the load.
- d) Speed Tests
 - i) All motion of the crane shall be tested with rated load on all notches at the time of commissioning of the crane at site and the speeds shall be attained within the tolerance limit.
 - ii) All motions of the crane shall be tested with 25% over load in which case the specified speeds need not be attained but the crane shall show itself capable of dealing with the over load without difficulty.
 - iii) Note for point (i) and (ii) above:
Necessary test loads for testing at both shop floor and site shall be arranged by Bidder.
- e) Brake Tests
 - i) The hoist brakes shall be capable of braking the movement with rated as well as over load. (150% for hoisting and 125% for traveling. However, the braking path with rated load shall not exceed hoisting speed/ 150 for class 1 & 2 duty cranes, speed/ 120 for class 3 duty cranes, speed/100 for class 4 duty cranes.
 - ii) The long travel and cross travel brakes shall be capable of arresting the motion within a distance in meters equal to 10% of the speed in meter / min and the retardation due to braking shall not exceed the values as given in the table below :

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Working condition of the crane	Retardation, according to percentage number of driving wheels, in m/sec ²		
	100	50	25
Indoor (When $\mu = 0.2$)	1.5	0.75	0.40

Legend μ = Friction Factor

11.2

Single Girder Under slung Crane (EOT/HOT)

a) Codes and standards:

The design, manufacture and performance of EOT/HOT U/S crane along with manual hoist and Geared trolley shall comply with all currently applicable status, regulations and safety codes and shall also confirm to the latest applicable Indian or International standards.

i) The crane structures shall be designed Manufactured and tested in accordance with IS: 807-2006. The Crane shall be designed with a margin of 25%.

- Black bolts shall not be used in the load bearing structures of the crane. Also high tensile friction grip bolts shall not be used unless approved by Owner.
- Traverse fillet welding on the load carrying members shall be avoided.
- All butt welds on the structural members, subject to tensile stress, shall be X-rayed.
- Maximum deflection of the bridge girder of U/S crane with safe working load on the travelling hoist shall not exceed 1/900 of the span of crane with travelling hoist stationed at mid span and excluding deflection due to dead load.
- U/S crane shall be supplied complete with buffer & buffer stops.
- The u/s crane after installation at site shall be load tested as per IS: 807-2006.

ii) Technical specification of Manual Hoists & Geared Trolleys to be used in HOT U/S crane

- Ball and roller anti frictional bearing only shall be used. Swiveling type standard shank hook mounted on grease lubricated anti-friction thrust bearing shall be used. The Chain Pulley Block shall conform to class-I duty as per IS: 3832-2005.
- Load chain & operating chain shall be of calibrated type.
- Pulley used for the operating mechanism shall have suitable guards to prevent the operating chain from coming out.
- All the open gearings shall have suitable cover.
- No-load testing shall be done at works after full assembly in presence of Owner. The Chain Pulley Block shall be load tested at site after erection.
- No wooden parts shall be used in the Chain Pulley Block.

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- Travelling speeds, tractive effort & bill of materials shall be indicated by the Bidder during approval of drawing & shall be subjected to Owner's approval.

b) Technical specification of EOT U/S crane

Please refer Electrical details furnished for electrically operated (EOT) Crane above. The Under slung electrically operated crane is excluded from the following.

- Operator cabin & Cabin operation
- Remote control operation

c) Inspection & Testing

The manufacturer shall conduct all tests required to ensure that the equipment furnished shall conform to the requirements of the specification and in compliance with the requirements of the latest edition of IS: 3832-2005 or equal standards for manually operated hoists and IS3177.

All the monorail hoists shall be tested at site as per the stipulations of relevant Indian Standards.

d) Painting

The exposed surface of all items of equipment shall be thoroughly cleaned and painted. Refer chapter on painting given elsewhere in the specification.

11.3

Electric Hoist

a) Technical Specification

- The hoist shall be designed in accordance with IS: 3938-983.
- For outdoor hoists, motors, brakes & other equipment shall be covered to suit to outdoor operations.
- All Electric hoists shall be pendent operated.
- Power supply shall be through flexible trailing cables, which shall be clamped with PVC or non-metallic clamps.
- Power isolator shall be provided at operating height.
- Defects in the materials like fractures, cracks, blowholes, or laminations are not allowed.
- No cast iron parts shall be used except for electrical equipments and no wood or combustible material shall be used unless specifically mentioned otherwise.
- All working parts requiring replacements or inspection or lubrication shall be easily accessible without the need for dismantling of other equipment or structure.
- All parts of the hoist shall be thoroughly cleaned of all loose mill scales, rust or foreign matter & then painted as specified. All parts inaccessible after assembly shall be painted before assembly & assembled while paint is still wet.
- All Elec. hoists shall be provided with maintenance / repair platforms with handrails and staircase at one end.

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- xi) All parts except motors, resistors, thrustors, solenoids, etc. shall be de-rusted manually & painted before assembly& assembled while paint is still wet.

b) Construction Features

Electrically operated hoist shall be a complete unit with travelling trolley, hoisting motor, travel motor, rope drum, wire rope, necessary gearing, sheaves, brakes, hook, pendent push button station, contactor panel, all wiring, conductor for travel motion, limit switches, end stops, buffers, earthing terminals and other accessories to make the equipment complete in all respects. Electrically operated hoist shall have minimum factor of safety as five (5).

i) Mechanical Details

• Travelling Trolley

The travelling trolley shall be motor driven. Trolley frames shall be fabricated from rolled structural steel sections. The side plates of the trolley shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalizing pin.

• Wheel & drive

The electric hoist shall run on two pairs of wheels, a pair of which shall be driven by motor through reduction gear. The wheels shall be of cast steel/forged steel, single flanged with taper / parallel treads to suit to monorail. The wheels shall be machined on their treads to match the profile of the monorail. The wheels shall be mounted on anti-friction bearings & shall be easily removable for repair & replacement. The wheel diameter shall be selected such that skidding does not take place even under unloaded condition.

• Hoist mechanism

The hoist mechanism shall consist of a bottom block fitted with a standard forged swivel hook of the specified capacity, supported on 2 or 4 falls of wire rope. However, non-spinning type of wire rope shall be used for 2 falls rope arrangement. The wire rope shall be wound on a grooved drum which shall be sufficiently long to accommodate in one layer the length of rope requisite for the specified lift & in addition not fewer than two turns at each anchored end & one spare groove at the opposite end. The hoist drum shall be motor driven through gears enclosed in oil filled reduction gearbox.

• Rope Drum

Rope drum shall be as per IS 3938. Rope drum shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drum shall be machine grooved right and left with grooves of a proper shape for the rope used. Grooving shall be of proper length to handle entire rope required to make the specified lift plus the two dead laps at each anchor point, without overlapping.

• Wire Ropes

Wire ropes shall be of Right Hand Ordinary (RHO) lay construction. The rope shall be fastened to the drum with an attachment having strength equal to that of the rope. The rope fastening at the swinging end shall be aligned so as to prevent rope coming off its reeling. Rope shall be of sufficient length so that two (2) full laps shall remain on the drum at extreme low position of the hook.

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Reverse bends or cross bends and bird caging shall be avoided. The breaking loads for the hoist ropes shall not be less than the factor specified in IS 3938. The load shall include rated load on hooks, weight of the bottom block and the weight of rope. Wire rope for hoists shall conform to IS: 2266-2002

- **Gearing.**

Straight & helical spur gearing shall be used for all motions. Worm & bevel gears shall not be used without specific permission from Owner. Preferably all first reduction gears shall have single helical teeth. All gears shall be hardened & tempered alloy or carbon steel with machine cut teeth. Surface hardening of teeth is not acceptable. All gears shall be enclosed in oil filled gear box except when not possible.

- **Couplings**

Each motor shall be connected to its gear drive by a flexible coupling.

- **Lubrication**

All gears & bearings shall be lubricated either by splash lubrication or by grease. If possible, all the lubricating points shall be grouped together in easily accessible positions.

- **Bearings**

Ball & roller antifriction bearings of reputed make shall only be used, with minimum bearing life as per IS: 3938.

- **Brakes**

D.C. Electromagnetic brake shall be provided for each motion, however in case of conical rotor motors manufacturer's standard brake can be used. Bidder to indicate the type of brake offered.

- **Shafts and Axles**

Shafts and axles shall be of forged steel and shall have ample strength, rigidity and adequate bearing surface for intended duties. Shafts and axles shall be accurately machined and properly supported. Shafts shall, as far as possible, be furnished straight. If shouldered, these shall be provided with fillets of ample radius or shall be tapered to avoid loss of strength and stress concentration. These shall be designed considering allowances for keys and splines.

- **Lifting Hook**

The lifting hook shall be single hook type, solid, forged, heat treated, of rugged construction and provided with a standard depress type safety latch. Lifting hook shall have swivels and operate on ball or roller thrust bearings with hardened races. Lock to prevent hook from swiveling shall be provided. Lifting hook shall conform to IS 15560:2005 as applicable.

- **Buffers, Stops and Sweeps**

Spring or rubber buffers shall be provided on the trolley. Suitable end stops shall be provided which shall be welded on the ends of monorail to contact the buffers mounted on the trolley.

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Trolley wheel stops shall be provided before the end stops. These shall match to wheel radius. Stops to prevent trolley from running off the monorail shall be abutted against ends of monorail. Stops shall be welded to the monorail.

Sweeps shall be attached to the trolley to remove foreign material from the rails.

- **Guards**

All exposed couplings, shafts, gear wheels, pinions, drives etc. shall be safely encased and guarded.

The sheaves of hook blocks shall be guarded to prevent trapping of hand between a sheave and the in-running rope

ii) **Electrical Details**

- **Standards**

The equipment shall be selected as per the guide lines provided in the latest edition of the relevant Indian Standards. The equipment shall also conform to the latest Indian Electricity Rules & other statutory Regulations prevalent at the place of installation as regards to safety requirements, earthing & other essential provisions specified therein.

Following shall be followed:

Indian Standards, relevant international standards such as IEC, VDE, BS, JIS, NFPA etc. Indian Factory Act 1948

Indian Electricity Act 1910

Indian Electricity rules-1956, State's regulations.

All electrical equipment including cables shall be selected for an ambient temperature of [50 deg C] and relative humidity of [88 %].

- **Power supply condition**

Power supply to the hoist shall be 415V +/- 10%, 3 phase, 50Hz +/- 5% AC 4 wire with solidly earthed neutral to be tapped from Station PDB/ACDB shown in SLD..

The following voltages shall be used in the hoist:

415 volts, 3 phase, 50 HZ - for motors 110 volts, single phase, 50 Hz -for electrical circuit of pendant control / control posts. 220 volts, DC for DC electromagnetic brakes.

The different voltages mentioned above, other than 415 V, 3 phases, 50 Hz shall be obtained through individual separate transformers & transformer rectifier units connected to 415 V.

Each transformer shall be provided with tapplings at +5% & + 10% on the primary.

Electrical system shall be designed for a fault level of 50 kA. Earthing system adopted shall be type TN-CS.

- **Power supply collection & distribution**

Incoming power supply to the hoist shall be terminated at the line side terminal of sheet steel, dust proof cable junction box installed near hoist gantry in an accessible position. Bidder shall provide proper flexible festoon cable system to

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deliver the power supply to the electrical control panel of the hoist. Electrical control panel of hoist shall contain following equipment/devices:

- A three pole isolator with suitably rated fuses to take care of the system fault. The rating of the isolator shall be sufficient to carry the combined full load currents of the hoist & travel motor.
- A three pole main line magnetic contactor suitable to carry the combined full load currents of hoist & travel motor.
- Fuse & over load relays in the individual motor power circuit. The over load relays shall be self reset type.
- Reversing contactors for individual motor. The rating of the contactors shall be at least 50% higher than the respective motor full load current at the specified duty cycle. The minimum rating of the power contactor shall be 30 amps. It shall be heavy duty & of class AC-4 as per IS: 2959-1985.
- Transformer & transformer rectifier set for control voltage supply & for supply to DC electromagnetic brakes respectively.
- Speed control equipment as necessary. Plugging of motors shall be avoided by suitable control.

Suitable arrangement shall be provided to intimate control room during emergency in the form of audio-visual alarm. Necessary contacts/auxiliary relays shall be provided.

The electrical panel shall be sheet metal clad (16 gauge), totally enclosed (IP-54) with hinged & gasketed front door. Cable entry/exit shall be through compression type cable glands.

● **Pendant control station**

All drive motors shall be controlled with individual magnetic reversing type contactors operated through momentary contact push buttons (mounted on pendant unit/ control posts. The push button shall return to the 'off' position as soon as the pressure is released. The release of the push button shall immediately & automatically cause the brake to clamp. In addition to the start up 'ON' push button, which shall energise the main Bidder, one lockable 'OFF' push button shall be provided in the push button station & shall be connected in the main contactor coil circuit. The push buttons shall be clearly marked as per the recommendations of IS: 3938-1983 to indicate the function of each button.

The pendant unit shall be fixed either to the hoist unit or to the monorail as specified. It shall be capable of withstanding rough handling without damage. The weight of the pendant shall be supported independent of cable by means of PVC sleeved chain or wire rope. The pendant shall be effectively earthed. A chain or rope does not provide an effective earth connection & shall not be relied upon for that purpose.

The reversing contactors for individual motors shall be electrically interlocked. The control scheme adopted shall ensure smooth normal speed lowering, hoisting & travel as specified.

The pendant shall comprise of following push buttons and indicating lamps.

- Start & stop

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- Trolley travel to & fro
- Hoist & lower
- Red lamp for supply ON

- **Limit switches**

Hoist & travel motion shall be provided with limit switches to limit the ultimate positions of the hook & the hoist block.

The limit switches shall conform to the requirements specified in IS: 3938-1983/ International Standards.

- **Motors**

All motors shall be totally enclosed fan cooled, crane duty, squirrel cage induction motors. It shall be ensured that these are special motors suitable for crane duty with pull out torque of not less than 150% of the rated torque. Motors shall conform to IS:325-1996 . All motors shall be suitable for 60starts/hour.

The motors shall be selected for the duty class of hoist unit. The duty cycle factor for each motor shall not be less than 40%.

The motor selected shall be suitable for frequent reversal, braking & acceleration. Motors shall have class 'F' insulation with max. utilization to within class 'B' admissible temperature rise corresponding to ambient air temperature as per clearance diagram. All windings shall be impregnated for service in the tropics having ambient temperature as stated in the clearance diagram of the hoist.

Each motor shall have a robust terminal box accurately fixed to the frame. Each terminal box shall have ample room for termination of the aluminium conductor cables.

- **Brakes**

Separate electromagnetic brakes, operated through direct current shall be provided for each motor driven mechanism. Brakes shall be of approved make & shall be connected so as to apply automatically when power supply fails or when the push button is released or with adjustable delayed time lag preceded by electrical braking when the push button is released.

Brakes shall be designed as per the latest edition of IS: 3938-1983/ International Standards.

Disc brake may be provided for CT motion and shoe brakes may be provided for hoist motion.

- **Enclosure class**

The equipment in the hoist shall be suitably protected against direct radiant heat and rain. It shall be rendered proof against ingress of dust and vermin.

All electrical equipments like motors, junction boxes, electrical panel, limit switches, brakes etc. shall be provided with enclosure class IP-54 for non-dusty or indoor environment and IP-55 for outdoor application.

Canopy shall also be provided for outdoor hoist.

- **Power collection system**

Power supply to the hoist unit shall be through flexible festoon cable system. The festoon cable shall be mounted on a retracting roller supports for the full length of

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the working zone parallel to the I-beam carrying the hoist unit. The retracting trolleys shall run on a separate supporting beam. Vendors shall specify the supporting beam according to the retracting rollers offered by him to enable provide such beam in the building structure.

One end of the festoon cable shall terminate in main cable junction box at the extreme end of the monorail beam. The other end shall terminate on to the main power disconnecting switch located in the control panel. The flexible trailing cable shall have ample length to cover full track length & shall be supported at suitable intervals by means of properly selected movable trolleys. These retracting rollers shall be prevented from bumping through suitable spacers so that undue stress is avoided on the cable. Similarly the trolleys shall be inter-connected through metallic drag chains to avoid pull on cables. Suspension of flexible cable system below the support rail shall be restricted to avoid mechanical damage & interference with operation.

- **Earthing**

TN-CS type of earthing shall be provided. This would require a separate earth conductor in the power cables, both for fixed wiring as well as for flexible festoon cables. Earth bus shall be formed on the hoist and each equipment shall be earthed through this earth bus.

c) Inspection & Testing

The manufacturer shall conduct all tests required to ensure that the equipment furnished shall conform to the requirements of the specification and in compliance with the requirements of the latest edition of IS: 3938-1983 or equal standards for electrically operated hoists.

All the monorail hoists shall be tested at site as per the stipulations of relevant Indian Standards.

11.4

Manual Hoist

a) Technical Specification

- i) Ball and roller anti frictional bearing only shall be used. Suitable greasing points shall be provided.
- ii) Swiveling type standard shank hook mounted on grease lubricated anti-friction thrust bearing shall be used. Lifting hook shall be solid, forged, heat treated alloy or carbon steel of rugged construction and provided with a standard depress type safety latch. Lock to prevent the hook from swiveling shall be provided.
- iii) The Chain Pulley Block shall conform to class-I duty as per IS: 3832-2005.
- iv) Load chain & operating chain shall be of calibrated type as per relevant IS. The total length of the load chain shall exceed the minimum length required to give the prescribed range of lift by not less than three links per fall to ensure that the slack end anchorage is not loaded. The load chain wheel shall be of adequate strength and shall be suitably designed to ensure effective operation of the chain and shall be properly secured with shaft, preferably with splines.
- v) Pulley used for the operating mechanism shall have suitable guards to prevent the operating chain from coming out. The length of the hand chain shall be such that the lowest point of the suspended loop shall hang 400 mm above the

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operating level. Hand chain wheels shall be provided with flanges and designed to ensure effective operation with hand chain. Minimum diameter of pulling chains shall be 6 mm.

- vi) Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section. All open gearing shall be suitably covered.
- vii) The hoist shall also conform to various safety codes as applicable at the place of installation.
- viii) Shafts and axles shall have ample strength and rigidity and adequate bearing surface for the intended duties.
- ix) Pulleys used for operation mechanism shall have suitable guards to prevent the operating chain from covering off.
- x) Brakes shall be of automatic type that shall stop and hold the load when hand-chain pull is released and shall permit controlled lowering of the load when hand-chain pull is applied in the lowering direction.
- xi) Pawls shall be of sufficient strength to arrest the full load from lowering due to gravity. The pawl and ratchet wheel shall be of steel, hardened and tempered so as to attain required wear resistance and toughness.
- xii) All hoists shall be provided with maintenance / repair platforms with handrails and staircase at one end.

b) Inspection & Testing

The manufacturer shall conduct all tests required to ensure that the equipment furnished shall conform to the requirements of the specification and in compliance with the requirements of the latest edition of IS: 3832-2005 or equal standards for manually operated hoists.

All the monorail hoists shall be tested at site as per the stipulations of relevant Indian Standards.

c) Painting

The exposed surface of all items of equipment shall be thoroughly cleaned and painted. Refer Chapter on painting given elsewhere in the specification.

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12

QUALITY ASSURANCE, INSPECTION & TESTING

The Bidder shall adopt Quality Assurance Programmes as per relevant standards subject to Owner's approval, to ensure that the equipment and services under the scope of work, whether manufactured or performed within the Bidder's works or at his sub-vendor's premises or at the Owner's site or at any other place of work, are in accordance with the specifications. Such programmes shall be outlined by the Bidder and shall be finally accepted by the Owner after discussions before the award of the contract. The QA programme shall be generally in line with IS/ISO-9001. The Quality Assurance Programme of the Bidder shall generally cover the following:

- a) Organization structure for the management and implementation of the proposed Quality Assurance Programme.
- b) Quality System Manual.
- c) Design Control System.
- d) Documentation and Data Control System.
- e) Qualification data for Bidder's key personnel.
- f) The procedure for purchase of materials, parts, components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
- g) System for shop manufacturing and site erection controls including process, fabrication and assembly.
- h) Control of non-conforming items and system for corrective actions and resolution of deviations.
- i) Inspection and test procedure both for manufacture and field activities.
- j) Control of calibration and testing of measuring testing equipment.
- k) System for Quality Audits.
- l) System for identification and appraisal of inspection status.
- m) System for authorizing release of manufactured product to the Owner.
- n) System for handling, storage and delivery.
- o) System for maintenance of records, and
- p) Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

12.1**General Requirements - Quality Assurance**

- a) All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. A programme of inspection/tests to be carried out by the Bidder for some of the major items is given in the respective technical specification. This is, however, not intended to form a comprehensive programme as it is the Bidder's responsibility to draw up

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and implement such programme duly approved by the Owner. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Bidder and will be submitted to Owner for approval.

- b) Manufacturing Quality Plan (MQP) will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Bidder's/ Sub-vendor's Quality Control Organization, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted to the Owner for review and approval. The format for MQP shall be submitted by the Bidder for the approval of the Owner before the award of Contract.
- c) Field Quality Plans (FQP) will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Bidder's "Site Quality Control Organization", during various stages of site activities starting from receipt of materials/equipment at site. The format for FQP shall be submitted by the Bidder for the approval of the Owner before the award of Contract.
- d) The Bidder indicate in the QP the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., These Quality Plans and reference documents/standards etc. will be subject to Owner's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Owner shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Owner or his authorized representative and beyond which the work will not proceed without consent of Owner in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to the Owner along with technical justification for approval and dispositioning.
- e) The material shall be dispatched from the manufacturer's works after the same is accepted by the Owner.
- f) All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.
- g) All welding and brazing shall be carried out as per procedures drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Owner.
The welding/brazing procedures shall be followed as per Indian/International Standards.
- h) All brazers, welders and welding operators employed on any part of the contract either in Bidder's/sub-vendor works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Owner.

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- i) Welding procedure qualification & Welder qualification shall be as per Indian/International Standards. However, where required by the Owner, tests shall be conducted in presence of Owner for the site erection. Any other statutory requirements for the equipment/systems shall be complied with.
- j) On all back-gauged welds MPI/LPI shall be carried before seal welding.
- k) Unless otherwise proven and specifically agreed with the Owner, welding of dissimilar materials and high alloy materials shall be carried out at shop only.
- l) No welding shall be carried out on cast iron components for fabrication or repair.
- m) All non-destructive examination shall be performed in accordance with written procedures as per International Standards but qualified operator. NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.
- n) All plates of thickness above 40 mm and all bars stock/Forging above 40 mm diameter shall be ultrasonically tested.
- o) The Bidder shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-vendors.
- p) For components/equipment procured by the Bidders for the purpose of the contract, after obtaining the written approval of the Owner, the Bidder's purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-vendor shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the vendor's quality control organization, the relevant reference documents/ standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful vendors shall be finalized with the Owner.
- q) If required, the Owner shall carry out quality audit and quality surveillance of the system and procedures of the Bidder's or their sub-vendor's quality management and control activities. The Bidder shall provide all necessary assistance to enable the Owner carry out such audit and surveillance. The Bidder shall also take requisite corrective measures for restoring/ improving the system in line with the outcome of such quality surveillance and audits.
- r) The Bidder shall carry out an inspection and testing programme during manufacture in his work and that of his sub-vendor's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identity and acceptability of all materials, parts and equipment. Bidder shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.
- s) Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Bidder in ensuring complete conformance of the

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materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.

- t) For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.
- u) Rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Owner.
- v) In case any deviation is observed with respect to relevant document or good engineering practices, and the same is considered by the Bidder to be acceptable, as it is or with certain rectifications/ modifications, based on his detailed technical analysis, then the Bidder shall refer the same to Owner along with reason for deviation, proposed corrective action, technical justification for suitability of the proposal and preventive measures for avoiding recurrence of similar deviations. Based on his evaluation, the Owner may accept the proposal as it is or with modifications or may reject the same. Such proposals shall be raised in suitable Non-conformity report format (NCR). The NCR can be raised irrespective of the CHP stages in the QP.
- w) Burn in and Elevated Temperature Test Requirement for Electronics Solid State Equipment:
- x) All solid state electronic systems/equipment shall be tested as a complete system/equipment with all devices connected for a minimum of 168 hours (7 Days) continuously under energized conditions prior to shipment from manufacturing works, as per the following cycle.

Elevated Temperature Test Cycle

During the elevated temperature test which shall be for 48 hours of the total 168 hours of testing, the ambient temperature shall be maintained at 50 °C. The equipment shall be interconnected with devices which will cause it to repeatedly perform all operations it is expected to perform in actual service with load on various components being equal to those which will be experienced in actual service.

During the elevated temperature test the cubicle doors shall be closed (or shall be in the position same as they are supposed to be in the field) and inside temperature in the zone of highest heat dissipating components/modules shall be monitored. The temperature rise inside the cubicle should not exceed 10°C above the ambient temp at 50 °C.

Burn in Test Cycle

The 48 hours elevated temperature test shall be followed by 120 hours of burn in test as above except that the temperature shall be reduced to the ambient temperature prevalent at that time.

During the above tests, the process I/O and other load on the system shall be simulated by simulated inputs and in the case of control systems; the process which is to be controlled shall also be simulated. Testing of individual components or modules alone shall not be acceptable.

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In case the Bidder/ sub-vendor is having any alternate established procedure of eliminating infant mortality of components, the detail procedures followed by the Bidder/ sub- vendor along with the statistical figures to validate the alternate procedure may be submitted to the Owner for his consideration.

The Bidder/Sub-vendor shall carry out routine test on 100% item at Bidder/sub-vendor's works. The quantum of check/test for routine and acceptance test by Owner shall be generally as per criteria/sampling plan defined in referred standards. Wherever standards have not been mentioned quantum of check/test for routine / acceptance test shall be as agreed during detailed engineering stage.

12.2 QA Documentation Package

The Bidder shall submit the QA Documentation in *[two hard copies and two CD ROMs]*, as identified in respective quality plan with tick (✓) mark.

Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Bidder/ sub-vendor and the same shall be submitted to the Owner in *[2 hard copies and 2 CD-ROMs]*, within two weeks of dispatch of the equipment.

11.2.1 Typical contents of QA Documentation is as below:-

- a) Approved Quality Plan.
- b) Material mill test reports on components as specified by the specification and approved Quality Plans.
- c) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
- d) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
- e) Heat Treatment Certificate/Record, if applicable (Time- temperature Chart).
- f) All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).
- g) Inspection reports duly signed by the Inspector of the Owner and Bidder for the agreed Customer Hold Points.
- h) Certificate of Conformance (COC) wherever applicable.

Similarly, the Bidder shall be required to submit two sets *[(two hard copies and two CD ROMs)]*, containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.

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12.3 Inspection, Testing and Inspection Certificates

- a) The word 'Inspector' shall mean the Owner's Inspection engineer and/or agency acting on behalf of the Owner to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- b) The Owner's Inspection Engineer and/or agency acting on behalf of the Owner shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Bidder shall obtain for the Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, permission to inspect as if the works were manufactured or assembled on the Bidder's own premises or works.
- c) The Bidder shall give the Owner [fifteen (15)] days written notice of any material being ready for inspection/testing. Such tests shall be to the Bidder's account except for the expenses of the Inspector's. The Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within [fifteen (15)] days of the date on which the equipment is noticed as being ready for test/inspection failing which the Bidder may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the Owner duly certified copies of test reports in [two (2) copies] for his review and approval.
- d) The Owner's Inspection Engineer and/or Owner's inspection agency acting on behalf of the Owner shall within fifteen [(15) days] from the date of inspection as defined herein give notice in writing to the Bidder, on any objection to any drawings and all or any equipment and workmanship which is in his opinion is not in accordance with the contract. The Bidder shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Owner's Inspection Engineer and/or agency acting on behalf of the Owner, giving reasons therein, that no modifications are necessary to comply with the contract. After due consideration, the Owner may accept or reject the same.
- e) When the factory tests have been completed satisfactorily at the Bidder's or sub-vendor's works, the Owner shall issue a certificate to this effect within [fifteen (15) days] of completion of tests. The completion of these tests or the issue of the certificates shall not bind the Owner to accept the equipment should it, on further tests after erection be found not to comply with the contract.
- f) In all cases where the contract provides for tests whether at the premises or works of the Bidder or any sub-vendor, the Bidder, except where otherwise specified, shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Owner's Inspection Engineer agency acting on behalf of the Owner, to carry out effectively such tests on the equipment in accordance with the Contract and shall provide the facilities to accomplish testing.
- g) The inspection by the Owner's Inspection Engineer agency acting on behalf of the Owner and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Bidder in respect of the contract.

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- h) To facilitate advance planning of inspection in addition to giving inspection notice, the Bidder shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.
- i) All inspection, measuring and test equipment used by Bidder shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Bidder shall maintain all the relevant records of periodic calibration and instrument identification. Wherever asked specifically, the Bidder shall re-calibrate the measuring/test equipment in the presence of Owner's Inspection Engineer agency.

12.4 Shop and Site Tests

- a) Shop tests will include all tests to be carried out at Bidder's works, at works of his sub-vendor and at works where raw material supplied for manufacture of equipment is manufactured.
- b) All materials will be of tested quality supported with correlated test certificates. Whenever tested quality material is specified and wherever called upon by Indian Boilers Regulations or by design code, the test pieces are to be prepared and tested to Owner's satisfaction. The results of the tests will be certified.
- c) Shop and Site tests will include electrical, mechanical, performance and hydraulic tests in accordance with relevant IS or any other approved standard or any other tests called for by the Owner under these specifications to ensure that the plant being supplied fulfills the requirements of the specifications. For equipment not covered by any IS or other approved standards, the tests to be carried out will be in accordance with the quality plan to be agreed to between the Bidder and the Owner.

General Notes

- a) For IBR items, if applicable, stamping on the components, inspection and certification will be carried out by the IBR as per the IBR procedures. However the Bidder will also be identified the same to which project they are meant by stamping/ stenciling.
- b) For non IBR items inspection will be as per mutually agreed QAP. The QAP will be submitted for major items and will be finalized during detail engineering. Joint protocol and dispatch clearance will be based on the agreed QAP.
- c) Major items for which the QAP are to be furnished will be mutually discussed and agreed during detail engineering.
- d) For items/ components not covered in the QAP, Bidder will furnish the certificate of compliance.

12.5 Site Tests

The successful Bidder will prepare and submit detailed quality plans in the format prescribed by Owner setting out the quality practice and procedures to be adopted by him for assuring quality for each equipment under this specification from the receipt of material at site, during storage, erection, pre-commissioning to final commissioning of the plant. These procedures will necessarily include all

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checks/tests conducted at site for preservation, assembly, alignment, positioning of the equipment, foundation preparation, welding/bolting, heat treatment, non-destructive examination, hydraulic test, running test, performance test etc. The above will be discussed and finalized by the Bidder with the Owner.

The Bidder will also furnish detailed quality procedure proposed by him for storage, preservation, painting, acid cleaning, alkali boil out, steam blowing, hydraulic test, air/gas tightness test etc. to the Owner. The same will be discussed and finalized by the Bidder with the Owner.

12.6 System Checking / Reliability Trials:

- a) Successful Bidder will carry out tests at site to prove to the Owner that each equipment of the supply complies with requirements stipulated and is erected in accordance with requirements specified. Before the plant is put into trial operation the Successful Bidder will be required to conduct tests to demonstrate to the Owner that each item of the plant is capable of correctly performing the functions for which it was specified and its performance, parameters etc. are as per the specified/approved values. These tests may be conducted concurrently with those required under commissioning sequence.
- b) The tests required will specifically include the following :
 - Checks on operation of all fans to ascertain level of noise and vibration.
 - Test running of pumps
 - Calibration test of orifice, flow nozzles, instruments and control equipment to the extent included in these specifications.
 - Tests on C & I Equipment - The Bidder will demonstrate the performance of all C&I equipment.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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**MODEL TENDER DOCUMENT FOR SELECTION OF
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**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)**

**VOLUME-II,
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION- ELECTRICAL**

**RENOVATION & MODERNISATION
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1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of Balance of Plant complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 List of Attachments

The following List of attachments is enclosed along with this specification.

[Note: List of attachments is depends on specific project scope of work. R & M consultant may attach the attachments as per project specific scope of work. For reference all attachments are considered in this package as per scope of work considered]

Legend: O: USE, X: NOT USE

Sl.No	Attachment Number	Description	Rev No	Application
1	E1	Motor	R1	O
2	E2	Motorized Actuators	R1	O
3	E3	LV Transformers(Dry type/Oil type)	R1	O
4	E4	415V Switchgear, MCC and DBs	R1	O
5	E5	415V Non Segregated Bus Duct	R1	O
6	E6	220V DC system	R1	O
7	E7	HV Cables	R1	O
8	E8	LV Cables	R1	O
9	E9	Illumination system	R1	O
10	E10	Cable Carrier System	R1	O

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11	E11	Earthing and Lightning Protection system	R1	O
12	E12	6.6kV Switchgear	R1	O
13	E13	Variable Frequency Drives	R1	O
14	E14	6.6kV Segregated Phase Bus Duct	R1	X
15	E15	Emergency Diesel Generator	R1	O

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E1
TECHNICAL SPECIFICATION FOR MOTORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E1

1.0 MOTOR

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Electric Motor complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS : 325	:	Specification for three phase induction motor.
IS : 900	:	Code of Practice for installation and maintenance of induction motors
IS : 996	:	Single phase AC motors
IS : 1231	:	Dimensions of three-phase foot-mounted induction motors
IS : 1271	:	Thermal evaluation and classification of electrical insulation.
IS : 2223	:	Dimensions of flange mounted ac induction motors.
IS : 2254	:	Dimensions of vertical shaft motors for pumps
IS : 3177	:	Crane duty motors
IS : 4029	:	Guide for testing three phase induction motors.
IS : 4691	:	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	:	Specification for rotating electrical machinery.

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IS : 4728	:	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	:	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	:	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	:	Designation of Method of Cooling of Rotating electrical machines.
IS : 8223	:	Dimensions and output ratings for foot mounted rotating electrical machines with frame numbers 355 to 1000.
IS : 8789	:	Values of performance characteristics for three phase induction motors.
IS : 12065	:	Noise level of motors.
IS : 12075	:	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	:	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	:	Temperature rise measurement of rotating electrical machines
IS : 12824	:	Type of duty and classes of rating assigned.
IS : 14222	:	Requirements and method of Impulse withstand test
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IEC: 60034	:	Rotating electrical machines.
NEMA, MG-1	:	Motors and Generators
ISO : 1940-1	:	Mechanical vibration – Determination of permissible residual unbalance

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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All motors shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment.
- b. AC Motors shall be of [constant speed, squirrel cage, three/ single phase, induction type.] Motors shall be rated for [continuous duty/intermittent duty]. They shall also be suitable for long period of inactivity. They shall also be suitable for direct online starting (DOL starting).
- c. DC motors provided for emergency service shall be shunt / compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.
- d. Power supply for AC motors shall be as follows:

Table: 2.0

1.	[Below 0.22 kW]	:	240V, 1 Phase, 50Hz
2.	[From 0.22 kW up to & including 160 kW]	:	415V, 3 Phase, 50Hz
3.	[Above 160 kW]	:	6.6kV, 3 Phase, 50Hz

- e. All AC motors shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- f. DC motors shall be rated for 220V DC supply with voltage variation of -15% to +10%.
- g. The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, break down and full load torques are available for the intended service.

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- h. Moreover, motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
- i. Motors shall be capable of developing the rated full load torque even if the supply drops to 70% of the rated voltage.
- j. For 6.6kV motors, locked rotor current not to exceed [600%] of full load current, including positive tolerance, except for BFP. For BFP the starting current shall be [450%] of FLC. For 415 V motors Locked rotor current not to exceed [600%] of full load current with IS tolerance.]
- k. For DC motors, the starters shall be provided to limit the starting current to [2] times of the full load current.
- l. Maximum continuous motor ratings shall be at least [10%] above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.
- m. Accelerating torque at any speed with the lowest permissible starting voltage shall be at least [10%] motor full load torque. Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.
- n. The motors shall be suitable for bus transfer schemes provided on the 6.6kV and 415V systems without any injurious effect on its life. If motors are connected to an automatic bus transfer system, they may be subjected to 150% of the nominal voltage during changeover of buses due to the phase difference between the incoming voltage and motor residual voltage. In such cases, motors shall be capable of restarting under full load after momentary loss of voltage.
- o. Motors shall be of [energy efficient of type Eff-2] as per IS: 12615/equivalent IEC/ International Standards.
- p. Motor shall be designed to keep torsional and rotational natural frequencies of vibration of the motor and driven equipment at least 25% above the motor operating speed range.

1.3.1 System Grounding

Table: 3.0

(a)	6.6 kV	:	Low Resistance Grounded to limit the earth fault current to [300 Amps]
(b)	415 V	:	Solidly Grounded
(c)	220V DC	:	Ungrounded

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1.3.2 Fault Level

Table: 4.0

(a)	6.6 kV	:	[40 kA for 1 second]
(b)	415 V	:	[50 kA for 1 second]
(c)	220V DC	:	[25 kA for 1 second]

1.3.3 Degree of Protection

Table: 5.0

(a)	Indoor Motors	:	[IP 54]
(b)	Outdoor Motors	:	[IPW 55]
(c)	Cable Box located in Indoor Area	:	[IP 54]
(d)	Cable Box located in Outdoor Area	:	[IPW 55]

1.3.4 Winding Insulation

Table: 6.0

(a)	For 6.6 kV AC Motors	:	[Class – F]
(b)	For 415V AC Motors	:	[Class – B]
(c)	For 220V DC Motors	:	[Class – B]

1.3.5 Winding Conductor Material

Table: 7.0

(a)	For 6.6 kV AC Motors	:	Copper
(b)	For 415V AC Motors	:	Copper
(c)	For 220V DC Motors	:	Copper

1.3.6 Bearing

Table: 8.0

(a)	For Drive End	:	[Roller]
(b)	For Non Drive End	:	[Roller / Ball]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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1.3.7 Temperature Rise

Table: 9.0

(a)	For Air Cooled Motors	:	[70 °C] over ambient temperature [Class B]
(b)	For Water Cooled Motors	:	[80 °C] over inlet cooling water temperature [Class B]

1.3.8 Motor Earthing

Table: 10.0

(a)	Motors above 90 kW	:	[50 x 6 mm GI Flat]
(b)	Motors above 30 kW and up to 90 kW	:	[25 x 6 mm GI Flat]
(c)	Motors above 5 kW and up to 30 kW	:	[25 x 3 mm GI Flat]
(d)	Motors up to 5 kW	:	[8 SWG GI Wire]
(e)	Terminal Box	:	[8 SWG GI Wire]

1.3.9 Space Heater

Table: 11

(a)	For Motors 30 kW rating and above	:	Space heater suitable for 1Phase, 240V AC, 50 Hz supply
(b)	For Motors below 30 kW rating	:	No Space heater provided.

1.3.10 Painting

Table: 12

a)	Paint Type	:	Epoxy based with approved class
b)	Paint Thickness	:	[Within 100 to 150 micron.]
c)	Paint Shade	:	[RAL5012 BLUE]

1.4 Specific Requirements

1.4.1 Locked Rotor Withstand Time

- The starting time of the motor shall be at the minimum permissible voltage.
- For motors with starting time up to 20 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot

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condition at highest voltage limit shall be at least 2.5 second more than starting time.

- c) For motors with starting time more than 20 second and up to 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 second more than starting time.
- d) For motors with starting time more than 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- e) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.

1.4.2 Starting Voltage Requirement

I.	All motors (except mill motors):
a)	[85% of rated voltage for motors up to 4000 kW]
b)	[75% of voltage for motors above 4000 kW]

II.	For mill motors:
a)	[85% of rated voltage for motors above 1000 kW]
b)	[90% of rated voltage for motors below 1000 kW]

The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at [125%] rated speed in reverse direction.

The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

1.4.3 Winding and Insulation

a)	6.6 kV AC motors	:	Winding material shall be of copper. Insulation shall be of [Class F with winding temperature rise limited to Class B]. They shall withstand 1.2/50 microsecond switching surges of "4U + 5 KV" (U = Line voltage in KV). The coil inter-turn insulation shall be suitable for 0.3/3 micro second surge of 32 / 12 KV followed by 1 min
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			power frequency high voltage test of appropriate voltage on inter turn insulation.
b)	415V AC & 220V DC motors	:	Winding material shall be of copper. Insulation shall be of [Class B with temperature rise limited to Class B.]
c)	Conveyor motors		Short circuit rings of conveyor motors shall be either joint less or welded type. Brazed joint is not acceptable.

1.4.4 Motor Control

a) For HV Motors

- i. Motors of rating above [160 kW] shall be suitable for 6.6 KV voltage
- ii. Frequent starting motors of rating above [160 kW] shall be suitable to be controlled by vacuum contactors

(b) For LV Motors

- i. Motors of rating less than [132 kW] shall be operated by Contactor from respective MCCs. Motors of rating up to [18.5 kW] shall be provided with MPCBs and Electronic overload relays. Motors of rating above [18.5 kW] and below [45 kW] shall be provided with MCCBs and Electronic overload relays. Motors of rating [45 kW] and above but less than [132 kW] shall be provided with MCCBs and CT operated Electronic over load relays.
- ii. Motors of rating [132 kW] and up to [160 kW] shall be suitable to be controlled by Air circuit breakers from switchgear, PMCCs and shall be provided with comprehensive numerical motor protection relays.
- iii. Only for firefighting system, motor rated [upto 200kW] shall be fed from 415V switch board.

1.4.5 Starting duty

Motors shall be suitable for [3 nos. consecutive Cold starts ups and 2 nos. consecutive Hot starts ups.] Motors shall be suitable for three equally spread starts per hour when the motor is under normal service condition.

1.4.6 Bearings

- a) Anti-friction type radial and thrust bearings (ball, roller) and sleeve bearing shall be rated for minimum standard life of 40,000 hours taking bearing and driven equipment loads (in case the drive is not having

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separate thrust bearing) into account. If bearings are lubricated, loss of grease shall be scarce and it shall not creep along shaft into motor housing. Facility of removal of excess grease shall also be provided for grease lubricated bearings.

- b) Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if Anti-friction bearings can take vertical thrust, thrust & guide bearings are not required.
- c) Bearing shall be effectively sealed against dust ingress and shall be pressure grease gun lubricated. The bearing and housing shall be so designed that greasing shall be possible while the motor is running, without removal of covers.
- d) Where bearing supports are attached to the motor casing, adequate bracing shall be provided on these supports to reduce vibrations and ensure life of bearings.
- e) If the bearings are oil lubricated, a drain plug shall be provided for draining residual oil and oil level gauge shall be provided to show precisely oil level required under standstill and running conditions.
- f) Unless otherwise approved, bearing lubricating system shall be such that no external forced oil or water is necessary to maintain required oil supply to keep bearing temperature within design limits.
- g) Lubricants shall be selected for prolonged storage and normal use of motors in tropical climate and shall contain corrosion and oxidation inhibitors. Greases shall have suitable bleeding characteristics to minimize setting. The selected lubricants shall be indigenously available.
- h) Motors rated above 1000 kW shall have insulated bearings to prevent flow of shaft currents.

1.4.7 Temperature Rise

- a) For Air Cooled Motors, temperature rise of insulation should be limited to [70 °C] over ambient temperature by resistance method.
- b) For Water Cooled Motors, temperature rise of insulation should be limited to [80 °C] over inlet cooling water temperature mentioned elsewhere, by resistance method.

1.4.8 Cooling

[All motors shall be either Totally Enclosed Fan Cooled (TEFC) or Totally Enclosed Tube Ventilated (TETV) or Closed Air Circuit Air Cooled (CACA) type. However, motors rated 3000 kW or above can be Closed Air Circuit Water Cooled (CACW)]

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1.4.9 Enclosure

- a) All motor enclosures shall conform to the degree of protection of [IP54] for indoor and IPW-55 for outdoor installation unless otherwise specified. Motor for outdoor or semi outdoor service shall be of weather proof construction. Motors of large output rating located indoor could have screen protected drip proof (SPDP) enclosure conforming to [IP-23.]
- b) For motors located in outdoor & corrosive locations, FRP canopy shall be provided. In case steel canopy is provided, the same shall be epoxy painted to meet the surrounding atmosphere. Motors located in hazardous areas such as Hydrogen plant shall have flame proof enclosures of Group – IIB conforming to IS: 2148.
- c) For hazardous locations such as fuel oil facilities area, the enclosure of motor shall have flame proof construction conforming to IS 2148.

1.4.10 Noise Level and Vibration

Noise level shall be limited to 85 dB (A) at 1.5 meters from the motor. However the same shall be as per IS: 12065 unless otherwise specified. The peak amplitude of vibration shall be within the specified limits laid down in IS: 12075. Motors shall withstand vibrations produced by driven equipment. HV motor bearing housings shall have flats in both X and Y directions suitable for mounting 80mmX80mm vibration pads. Vibration pads with screwed holes for mounting vibration probes shall be provided at both DE and NDE.

1.4.11 Temperature Monitoring

[In HV motors, at least four numbers simplex/ two numbers duplex platinum resistance type temperature detectors shall be provided for each phase of stator winding]. Each bearing shall be provided with dial type thermometer with adjustable alarm contact and two numbers duplex Platinum resistance type temperature detector (3 wire, 100 ohm at zero °C). In case of CACA and CACW motors dial type temperature indicator shall be provided (one each for hot and cold air temperature monitoring for CACA and CACW and one each for inlet and outlet water temperature monitoring for CACW). If alarm and trip are required for cooling air temperature, temperature switch shall be provided. The contact rating shall be minimum 0.5A at 220V DC and 5A at 240V AC. Flow switches shall be provided for monitoring cooling water flow of CACW motor and oil flow of forced lubrication bearing. Low voltage motors rated 100 kW and above shall be provided with two PT100 RTDs per phase of winding.

1.4.12 Earthing

Motor body shall have two earthing points on opposite sides. Motor terminal boxes shall also have separate grounding terminals.

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1.4.13 Termination

- a) HV motors can be offered with either Elastimold termination or dust tight phase segregated double walled (metallic as well as with insulated barrier) cable boxes. In case Elastimold terminations are offered, then protective cover and trifurcating sleeves shall also be provided. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided in case of cable boxes. The main cable box / terminal box shall withstand *[a fault current up to 40 kA for 0.25 seconds for HV motors and 50 kA for 0.25 seconds for LV motors]*. Separate terminal boxes shall be provided for space heaters and RTDs and NCT (if applicable).
- b) *[All terminal boxes shall be capable of being turned through 360 degrees in steps of 90 degrees unless otherwise specified.]*
- c) For HV motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

1.4.14 Differential Protection

For motors rated 6.6kV, *[2000 KW & above,]* neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box for differential protection.

1.4.15 Tropical Protection

- (a) All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- (b) All fittings and hardware shall be corrosion resistant.
- (c) Space Heater
- (d) Suitable single phase space heaters operated at 240V, 50Hz, 1Phase AC supply shall be provided on motors rated for 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided.
- (e) The space heater shall be sized to maintain the motor internal temperature above dew point when the motor is in idle condition.

1.4.16 Rating Plate

Motor shall have Stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / NEMA-MG-1 and following additional information:

- (a) Type of bearing and recommended lubricants along with location of insulated bearing.
- (b) Temperature rise under normal/abnormal conditions.

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(c) In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.

(d) Year of Manufacture

1.4.17 Drain Plug

Motor shall have drain plugs so located that they shall drain the water, resulting from the condensation or other causes from all pockets of the motor casing.

1.4.18 Dowel Pins

Motor shall be designed to permit easy access for drilling holes through motor feet or mounting flange for installation of dowel pins after assembling the motor and driven equipment.

1.4.19 Painting

The complete motor assembly including fan shall be painted with corrosion proof paints of approved class.

1.4.20 Lifting provision

Motor weighing 25 Kg or more shall be provided with eyebolt or other adequate provision of lifting.

1.4.21 Local Push Button Station (LPBS)

- a) Each motor shall be provided with push button station as per process requirement i.e. Start/Stop or Emergency Stop.
- b) The degree of protection of LPBs shall be IPW 55 for outdoor and IP 54 for indoor applications.
- c) All Push Buttons shall be push to actuate type and stop Push Button shall be lockable in off position as per the scheme requirement.
- d) The Emergency local stop push button of Stay put type shall be provided with Press to lock & turn to release keyless mechanism.
- e) All PBs shall be provided with 2 numbers NO and 2 numbers NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to switchgear module for direct tripping and another contact to control system.
- f) Terminals to be suitable for 2 cores of 2.5 Sq.mm. cable with 20% spare terminals.
- g) All LPBS shall be of Poly Carbonate /FRP / Die Cast Aluminium material.

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I) TestsType Test

For each type & rating of HV and LV motors of rating above [50 kW], the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last[five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- (a) Visual and dimensional check
- (b) Winding resistance measurement
- (c) No load test
- (d) Mechanical vibration
- (e) Direction of rotation versus phase sequence
- (f) Insulation resistance measurement
- (g) High potential test
- (h) Locked rotor test
- (i) Speed/torque test
- (j) Over speed test
- (k) Temperature rise test
- (l) Determination of characteristic
- (m) Degree of protection test for the enclosure.
- (n) Noise level
- (o) Shaft current and bearing insulation test (Applicable for HV motors)

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

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IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.5 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

Dimensional General Arrangement drawing

- a) [Motor sizing calculation
- b) Foundation Plan & Loading
- c) Cable end box details
- d) Space requirement for rotor removal
- e) Thermal withstand curves hot & cold
- f) Starting and speed torque characteristics at 80% & 100% voltage
- g) Complete motor data
- h) Erection & Maintenance Manual
- i) Test reports
- j) QAP]

1.6 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	Technical Particulars	Unit	Parameters	Remarks
1	Motor application		[As per requirement]	
2	Rated Output, kW	kW	[As per requirement]	
3	Maximum continuous kW obtainable without exceeding specified temperature rise	kW	[By Bidder]	
4	Motor type		Squirrel cage induction motor	
5	Duty Cycle (IEC 60034-1)		[S1]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
6	Rated voltage	kV	6.6 kV for HV motors 415 V for LV motors 220V DC for DC motors	
7	Phase/frequency	Hz	50	
8	Allowable variation in supply conditions			
a)	Voltage		6.6 kV	
b)	Frequency		50	
c)	Combined			
9	Method of starting		DOL	
10	CT details for differential protection	Yes/No	For motors of rating > 2000kW	
11	Full load amperes	A	[By Bidder]	
12	Locked rotor current amperes	A	HV(Except BFP): 6 times without tolerance BFP: 4.5 times without tolerance LV: 6 times with IS specified tolerance DC : 2 times with no positive tolerance at rated terminal voltage.	
13	Method of Cooling (IC code)		[As per requirement]	
14	Enclosure (IP Code)		Indoor : IP54 Outdoor : IPW55	
15	Construction (horizontal or vertical)		[As per requirement]	
16	Max. temperature, by resistance method	Deg C	120 deg (Class B)	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
17	Insulation class		HV: Class F LV: Class B	
18	Motor insulation system (describe material used)		[By Bidder]	
19	Bearings		[By Bidder]	
a)	Type			
b)	Quantity			
c)	Lubrication system pressure and flow			
20	Temperature detector (type & quantity)			
a)	Winding		[As per requirement]	
b)	Bearing		[As per requirement]	
21	Space heaters		30 kW and above	
a	Watts (Rating/Operating)	W	[By Bidder]	
b	Volts (Rating/Operating)	V	[By Bidder]	
22	GD ² of motor		[By Bidder]	
23	Power factor		[By Bidder]	
a)	Full load	p.u		
b)	3/4 load	p.u		
c)	1/2 load	p.u		
d)	No load	p.u		
24	Efficiency		[By Bidder]	
a)	Full load	%		
b)	3/4 load	%		
c)	1/2 load	%		
25	Impedance data		[By Bidder]	
a)	locked rotor reactance per phase	Ohm		
b)	Rotor resistance per phase	Ohm		

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S. No.	Technical Particulars	Unit	Parameters	Remarks
c)	stator resistance per phase	Ohm		
26	Net motor weight	Kg	[By Bidder]	
27	Terminal box dimensions H/W/D	Mm	[By Bidder]	
28	Rotor removal clearance	mm	[By Bidder]	
29	Winding connection (star or delta)		HV: Star LV: Delta	
30	Noise Level	dB(A)	[As per requirement]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E2
TECHNICAL SPECIFICATION FOR MOTORIZED
ACTUATORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E2

1.0 MOTORIZED ACTUATORS

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Motor Operated Actuator complete with all accessories for efficient and trouble-free operation of valves, dampers and gates for R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS : 325	Specification for three phase induction motor.
IS : 900	Code of Practice for installation and maintenance of induction motors
IS : 996	Single phase AC motors
IS : 1271	Thermal evaluation and classification of electrical insulation.
IS : 2223	Dimensions of flange mounted ac induction motors.
IS : 4029	Guide for testing three phase induction motors.
IS : 4691	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	Specification for rotating electrical machinery.
IS : 4728	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	Designation of Method of Cooling of Rotating electrical machines.

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IS : 8789	Values of performance characteristics for three phase induction motors.
IS : 9334	Electrical Motor Operated Actuators.
IS : 12065	Noise level of motors.
IS : 12075	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	Temperature rise measurement of rotating electrical machines
IS : 12824	Type of duty and classes of rating assigned.
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package
IEC: 60034-1	Rotating electrical machines.
NEMA, MG-1	Motors and Generators

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All motor operated actuators shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.
- Depending on the required type of services, the rating of motor operated actuators shall be selected. For isolating service, the actuator shall be [rated for three successive open-close operations of the valve/ damper or 15 minutes continuous operation whichever is higher.] Whereas for regulating service, the actuator shall be suitably [time rated for required number of duty cycle or 150 start per hour whichever is higher].
- The actuator shall be accompanied with constant speed, squirrel cage, three/ single phase, induction motor. The motor shall be designed for high

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torque and reversing service. They shall also be suitable for direct online starting (DOL starting).

- d. Motors of actuators shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- e. The motor operated actuator shall be sized for performing open / close operation at rated speed against designed differential pressure at [90%] of rated voltage. The motor shall have [10%] design margin on the shaft design power.

The actuator shall meet the following performance requirements:

- i. Open & Close the valve completely and make leak tight valve closure without jamming.
- ii. Attain full speed of operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- iii. The motor reduction gearing shall be sufficient to lock the shaft when the motor gets de energized and prevent drift from torque switch spring pressure.
- iv. The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.
- v. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

1.4 Specific Requirements

1.4.1 Construction

- a) The actuator shall essentially comprise of drive motor, limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, space heater and internal wiring.
- b) The actuator enclosure shall be totally enclosed, dust tight, weather proof with [IPW 55] degree of protection.
- c) All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

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- d) Gear train shall be made of metal (fiber gears are not acceptable). Self locking feature shall be provided to prevent drift under torque switch (wherever applicable) spring pressure when motor is de energized.
- e) Manual wheel shall disengage automatically during motor operation.

1.4.2 Type

- a) The actuators shall have integral starters along with overload relays with built-in single phase preventer.
- b) A 415 V, 3 phase, 3 wire, 50 Hz power supply will be provided from power plant 415 V switchgear through MCCB. Control voltage of the starter circuit shall be 110 V AC or depending on manufacturer's practice. But the same shall be derived from incoming 415 V, 3 phase, 3 wire supply.

1.4.3 Motors

- a) Type: The drive motor shall be three phase, squirrel cage induction motor suitable for direct on line starting with starting current limited to six times the rated current
- b) Enclosure: The motor shall be totally enclosed, self ventilated with [IPW 65] degree of protection.
- c) Insulation: The motor winding shall be insulated with [Class – B] insulation having temperature rise limited to [Class – B].
- d) Bearing: The motor bearing shall be [double shielded, grease lubricated and antifriction type].
- e) Earthing: At least two earthing terminals shall be provided for the motor body. Separate earthing terminal should be provided for terminal box.
- f) Protection: The following electrical protections should be provided for the motor:
 - i. Single Phasing Protection
 - ii. Overload Protection
 - iii. Overheating Protection through thermostat
 - iv. Wrong Phase Sequence Protection
- g) Limit Switches: Each actuator shall be accompanied with following switches:
 - i. Four nos. positional limit switches (2 for open & 2 for close), each adjustable at any position from fully open to fully closed positions of the valve / damper.
 - ii. Two torque limit switches, one for each direction of travel, self blocking & adjustable torque type.

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- iii. Four nos. end travel limit switches, two for each direction of travel.
 - iv. A single shaft shall actuate all contacts of limit switches at each position.
- h) Interface: Open/close command termination logic with position and torque limit switches, positioned circuit shall be suitably built in the PCB inside the actuator.
 - i. For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided. Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the DCS shall be energized to initiate opening and closing, by 24V DC signal from the external control system. Potential free contact provided by the IPR shall be utilized in the control circuit of the contactor of motorized actuators.
 - ii. For modulating drive, the command to actuator shall be in form of 4- 20mA signal. The necessary positioning circuit and motor protection shall be provided.
 - iii. Open/close command termination logic shall be suitably built inside actuator.
- i) Hand Wheel: Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall disengage automatically when the motor is energized.
- j) Position Indicator / Transmitter: The actuator shall have
 - i. One built in local position indicator for 0 – 100% travel.
 - ii. One position transmitter of modulating / inching type for remote indication suitable to stabilize 4-20mA signal and operated with [24V DC].
- k) Space Heater: Space heater of suitable rating shall be provided. The power supply shall be derived from main power supply available in the actuator.

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- l) Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be done with [2.5 sqmm] copper wires. All wiring shall be well identified at both ends with ferrules.
- m) Terminal Box:
- i. The terminal box shall be weather proof with removable front cover and cable glands suitable for cable connection. The terminals shall be suitable for connection of [2.5 sq.mm copper] conductor.
 - ii. Necessary double compression cable glands with nickel coating and tinned copper lugs for cables shall be provided.
 - iii. The terminal block shall be suitable for 650V grade power cable.
- .
- n) Rating Plate : Motor and actuator shall have Stainless steel nameplate(s) showing all particulars as per relevant IS/ IEC and following additional information:
- i. Type of bearing and recommended lubricants.
 - ii. Temperature rise under normal/abnormal conditions.
 - iii. Degree of Protection
 - iv. In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.
 - v. Year of Manufacture

1.5 Tests

The actuator and all components thereof shall be subject to routine factory tests as per relevant IS standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

1.5.1 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum [7] days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc.]

1.5.2 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished with requisite no. of copies for approval of the Owner.

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- b) The equipment shall be dispatched from works only after receipt of owner's written approval of shop test reports.

1.6 Drawings Data and Manuals

The drawings, data & manuals for the motorized actuators shall be submitted as indicated below:

1. [Actuator Data Sheet]
2. General arrangement drawing
3. Internal wiring Diagram and Control Schematic.
4. Torque switch and Limit switch contacts development.
5. QAP for Test Reports
6. Manufacturer's Catalogue.
7. Instruction manuals on Installation methods.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		Integral
2.	Application		[As per project specific]
3.	Motor type		Squirrel Cage
4.	Supply voltage	V	415 V, 3 ph, 3 wire.
5.	Phase, frequency	Hz	3ph, 50 Hz
6.	Motor rated voltage	V	415V/230 V
7.	Control Voltage	V	[110 V AC]
8.	Voltage and its variation	V	± 10%
9.	Frequency and its variation	Hz	+ 3 to -5%
10.	Combined V & f variation	%	10%

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S. NO.	DESCRIPTION	UNIT	DATA
11.	Degree of Protection		IPW 65
12.	Winding Insulation		Class B
13.	Temperature Rise (over ambient temperature)	°C	Class B
14.	Painting		[RAL 5012]
15.	Motor Starting		
a)	Method		DOL
b)	Starting Current		6 times

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E3

TECHNICAL SPECIFICATION FOR LV TRANSFORMERS

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E3

1.0 LV TRANSFORMER (DRY TYPE/OIL TYPE)

1.1 General

This specification is intended to cover [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV Transformers (Dry type/Oil type) complete with all accessories for efficient and trouble free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

CODE	NAME OF STANDARD
IS:334	Dimensions for porcelain Transformer bushing
IS:335	New insulating oil for transformers and switchgears
IS:1271	Classification of insulating materials for Electrical Machinery and apparatus in relation to their stability in service.
IS 2026	Specification for power Transformer (all parts)
IS:2071	Method of high voltage testing
IS:2099	High voltage porcelain bushings
IS:2147	Degree of protection.
IS:2705	Current transformers
IS:3202	Code of practice for Climate proofing of electrical equipment
IS:3637	Gas operated relays
IS:3639	Fittings and accessories for power Transformers
IS:5561	Electric Power connectors
IS:6600	Guide for loading of oil immersed transformers

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CODE	NAME OF STANDARD
IS: 11171	Dry type transformers
IS:10028	Code of practice for selection, Installation and maintenance of transformers Part I, II and III
CBIP	Manual on transformers
IEC60076	Power Transformer
IEC 60214	Tappings
IEC 60726	Dry-type power transformers
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
ANSI C57.12.51	Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160 Volts
ANSI C57.12.55	Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard
ANSI/IEEE C57.98	Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
ANSI/NFPA 70	National Electrical Code
IEEE C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.94	Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers

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CODE	NAME OF STANDARD
NEMA ST 20	Dry Type Transformers for General Applications
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The transformers shall be dry type (AN) for indoor location and shall be oil type (ONAN) for outdoor location.
- b) The oil type transformer shall be installed in hot, humid and tropical atmosphere with ambient temperature equal to 50°C. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- c) The transformer shall be capable of continuous operation at specified rating under the following condition:
 - i) Voltage variation - $\pm 10\%$
 - ii) Frequency variation - $[+3\%, -5\%]$
 - iii) Combined voltage and frequency variation (absolute sum) - $[10\%]$
- d) The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.
- e) The noise level shall be limited to the value specified by NEMA Standard Publication No. TR-1-1993 when measured in accordance with conditions outlines in ANSI/IEEE C57.12.90-1999/IS13964/CBIP publication.
- f) The design shall be such as not to cause any undesirable interference with radio or communication circuits.
- g) Transformers shall accept without injurious heating, combined voltage and frequency variation which produce an over fluxing condition of 120% for one (1) minute.

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- h) Each transformer shall be sized based on actual load with 10% margin and considering voltage regulation factor. It shall be sized by considering 100% load connected on the bus considering other transformer outage. An appropriate load factor of 0.9 for continuous and 0.2 for intermittent shall be considered.
- i) The impedance of the transformers shall be chosen such that the fault level on the LV switchgear does not exceed 50kA including the motor contributions and also voltage dip while starting the motor does not exceed 15% at motor terminal.

1.4 Specific Requirements of Transformers

1.4.1 Enclosure (for dry type)

- a) The encapsulated cast resin transformer shall be housed in naturally ventilated floor mounted cold rolled sheet steel cubicle with louvers backed by fine brass wire mesh. The enclosure shall be of bolted type fabrication and degree of protection shall be at least IP32. The minimum sheet steel thickness shall be 2 mm.
- b) Enclosure shall be provided with lifting lugs and grounding terminals at both ends. Further the enclosure door shall have pad locking provision.
- c) The enclosure door shall be interlocked with service transformer incoming breaker such that.
 - The door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position.
 - [6.6] kV side circuit breaker can be closed only when the doors are closed.
- d) Necessary illumination with controls shall be provided in the enclosure.
- e) Thermostatically controlled space heater inside the enclosure of suitable rating shall be provided if necessary.

1.4.2 Tank (for oil type)

- a) For LV transformers, the tank shall be of conventional type.
- b) Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.
- c) Tank shall be designed to permit lifting, by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.
- d) Tank together with radiators, coolers, conservator, bushings vessel and other fittings, shall be designed to withstand full vacuum without permanent distortion.
- e) The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

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- f) The material used for gaskets shall be cork-neoprene or approved equivalent. Gasketed joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather. Spare gaskets shall be provided for all openings as shipping gaskets will not be reused.
- g) Tank shall be provided with all necessary valves.
- h) Tank shall be provided with a pressure release device which shall operate at a pressure below the test pressure for the tank and radiators. This device shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall be rain proof after blowing and shall be provided with a device visible from ground to indicate operation. An equaliser pipe connecting the pressure relief device to the conservator shall be supplied. This device shall be provided for all transformers. Pressure relief device shall be equipped with remote monitoring/alarm contacts

1.4.3 Core

- a) The transformers shall be three phase core type. The core shall be built up with high grade, non-ageing, low loss, high permeability grain oriented cold rolled silicon steel laminations especially suitable for core material. Laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.
- b) CRGO sheets shall be coated with insulation varnish. Insulation shall be able to withstand the curing temperature and shall reduce eddy current to minimum. The core shall be protected from corrosion with a rust-resistant coating.
- c) The core clamping brackets shall be designed to provide an even distribution of clamping forces to the core, yokes and legs and shall be rigidly braced to reduce sound levels and losses.

1.4.4 Winding

- a) The coils shall be manufactured from electrolytic copper conductor with sufficient number of radial supports and fully insulated for rated voltage.
- b) The insulating material shall conform to Class F. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and shall withstand even the severest of temperature fluctuations.
- c) Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. The windings shall be arranged to ensure a free circulation of the air and to reduce the hot spots in the winding.

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- d) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.
- e) The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer, under short circuit stresses, switching or other transients.
- f) All coils rated 1200V or higher shall be subjected to partial discharge tests to ensure a properly cured and void free casting.

1.4.5 Encapsulation (for dry type)

- a) HV and LV coils shall be separately cast under vacuum in fibre glass reinforced epoxy resin compound. The insulation shall be fire resistant, non-inflammable, non-hygroscopic and resistant to temperature fluctuations.
- b) The epoxy shall contain filler material providing characteristics superior to unfilled epoxy including higher temperature rating, better heat conductivity, better arc resistance and adhesion to the conductor, plus a coefficient of expansion closer to that of the conductor material. The epoxy resin shall be self extinguishing.
- c) Encapsulated winding shall be free of internal voids, surface irregularities, etc. No surface finishing of encapsulated winding shall be undertaken after the process of encapsulation.

1.4.6 Insulating Oil (for oil type)

- a) The transformer shall be filled with mineral insulating oil suitably inhibited to prevent sludging.
- b) The quality of oil to be supplied for the transformer shall conform to the parameter specified in IS: 335 with latest amendments. No inhibitors shall be used in oil. Prior to filling oil shall be tested as per IS: 335 for tan delta, specific resistivity, breakdown voltage, moisture content etc.
- c) Transformer shall be dispatched oil filled. 10% excess oil for topping up shall be supplied in non-returnable container suitable for outdoor storage.
- d) Oil preservation shall be by means of conservator tank complete with silica gel breather and oil seal.
- e) Oil preservation shall be by means of bellows/ diaphragm sealed conservator tank with silica gel breather to avoid direct connection between atmosphere and transformer oil. It shall be complete with level gauges, pipes , drain valve etc. The level gauges shall be so placed that same can be readable standing from ground.
- f) Necessary device shall be kept to provide annunciation in the event of rupturing of bellow.

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1.4.7 Tappings (OCTC)

- a) Off-circuit taps as specified shall be provided on the high voltage winding.
- b) The transformer shall be capable of operation at its rated KVA on any tap provided the voltage does not vary by more than $\pm 10\%$ of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be provided.
- e) Off circuit tap changer switch where provided shall be 3 phase, hand operated, by an external handle with position markings and pad locking facility and mechanical stops to prevent over cranking beyond extreme positions.
- f) Arrangement shall be such that switch can be operated at standing height from ground level.
- g) The operating handle can be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator with pad locking facility.

1.4.8 Fittings and Accessories:

The following fittings and accessories shall be provided :

- a) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the purchaser's earthing conductors. Suitable earthing terminals on cable boxes shall also be provided.
- b) Terminal marking and rating plates shall be as per the specified standard.
- c) In case of oil type, the conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of -5°C up to an oil temperature of 100°C , with oil level varying within the minimum and maximum visible levels with necessary accessories.
- d) In case of oil filled type, Valves shall be supplied on the transformer tank and radiators.
- e) Pressure relief device: Pressure relief device shall be provided for transformers rated 2 MVA and above which shall be of sufficient size for rapid release of any pressure that may be generated within the tank and which may result in damage of the equipment
- f) Gas and Oil Actuated Relay (Magnetic Reed Type Gas & Oil Relay):

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A double float type magnetic reed type gas and oil relay as per applicable standard shall be provided for all oil filled transformers. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. These contacts shall be wired up to the transformer marshalling box. The relay shall be provided with shut off valves on the conservator side as well as the tank side.

g) Temperature Indicators

i Oil temperature indicator (OTI)

All oil type transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device. The contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC.

ii Winding Temperature Indicator (WTI):

A device for measuring the hot spot temperature of the winding shall be provided. The accuracy class of winding temperature indicator shall be $\pm 20^{\circ}\text{C}$ or better.

iii Oil Level Indicator:

A magnetic type oil level indicator shall be provided to indicate oil level in the tank.

iv RTD/transducers for remote annunciation:

In addition to the above mentioned indicators, the Oil and winding temperature measurement, RTDs / transducers shall be provided for remote indication in the DCS. RTDs shall be duplex platinum type with nominal resistance of 100 ohms at zero degree centigrade.

h) Bushing Current Transformers for stand by earth fault protection shall be provided in the neutral bushing and lead shall be brought to Marshalling box.

i) Radiator (oil filled type): Tank mounted radiators banks shall have bolted flanged connections and pipe extensions to permit withdrawal of

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transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes (unless otherwise approved) to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. The interconnecting pipes shall be provided with drain plug and air release vents.

- j) Conservator (For oil filled type): The transformers rated below 7.5MVA shall be provided with conventional single compartment conservator with dry air filling the space above the oil.

1.4.9 Bushings

- a) The bushing shall conform to the requirements of IS:2099 and IS:3347.
- b) All transformer bushings shall be of porcelain (for oil filled)/ epoxy (for dry type).
- c) The neutral terminal of 433V winding shall be brought out on a bushing along with the 433V phase terminal to form a 4 wire system for the 433V. Neutral CTs shall be located in the lead coming out of the winding and location of these CTs shall not be inside the tank.
- d) The neutral terminal of secondary shall be brought out through an outdoor. Further this neutral terminal shall be connected by a copper flat of size [50 mm x 6] mm, which shall be brought down upto 100 mm above ground. The copper flat shall be insulated and supported from the tank body.

1.4.10 Terminal arrangement

- a) Cable boxes
- Wherever cable connections are specified, suitable cable boxes shall be provided and shall be air insulated.
 - Cable boxes shall have drilled gland plate of adequate size to receive cables and to allow easy termination.
 - Removable drilled gland planes shall be provided in the cable boxes.
 - The additional supports for the cable boxes shall be galvanised iron.
 - The contractor shall provide earthing terminals on the cable box, to suit [50mmx6] mm GI flat.
- b) Bus duct
- Wherever Bus duct termination is specified a flanged throat or equivalent connection shall be provided for termination of bus duct enclosure. The winding termination shall be outdoor type bushing. The material of the bus duct termination arrangement of the transformer shall be nonmagnetic. The bus duct may be either phase-segregated or non-segregated.

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- ii. Tolerance permissible for the height of terminals and bus duct flange location specified for bus duct termination over ground level is $\pm 5\text{mm}$. Contractor has to ensure that radiator, conservator and explosion vent do not obstruct the path of the bus-ducts.

1.4.11 Marshalling box

- a) A sheet steel weather, vermin and dust proof marshalling box shall be furnished. The sheet steel used shall be at least 2.0 mm (CRCA) thick. The box shall be free standing floor mounted/tank mounted type and have a sloping roof. The degree of protection shall be IP-55 in accordance with IS:2147.
- b) The marshalling box shall have a glazed door of suitable size for convenience of temperature indicators reading.
- c) All incoming cables shall enter the marshalling box from the bottom.

1.4.12 Wiring

- a) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- b) Wiring shall be done with 650V PVC wires in conduit or PVC armored cable. *[Minimum wire size shall be 1.5 sq.mm stranded copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.]*
- c) Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. *[Terminals shall be stud type, suitable for terminating 2 nos. 2.5 mm2 stranded copper conductor and provided with acrylic insulating cover.]*
- d) All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- e) Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

1.4.13 Painting

- a) All steel surfaces shall be thoroughly cleaned by sand blasting and / or by chemical agents, as required to produce a smooth surface free of scales, grease and rust.
- b) The external surfaces, after cleaning, shall be given a coat of high quality red oxide or yellow chromate primer followed by filler coats.
- c) The transformer finished with two coats of epoxy based powder coated paint. The paints shall be carefully selected to withstand tropical heat,

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rain etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

- d) Painting shade shall be subject to owner's approval.
- e) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.14 Name Plate

Nameplates of approved design shall be furnished at each cubicle (one no. each at front as well as at backside of cubicle) and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black background. Self-tapping screws shall hold the nameplate. *[Nameplate size shall be minimum 20 x 75mm for instrument/device and 40 x 150mm for panels. Caution notice on suitable metal plate shall be affixed at the back of terminal Box.]*

1.5 Tests

1.5.1 Type Tests

For each type & rating of LV Transformers, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within *[last five]* years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within *[last five]* years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- a) Temperature rise test
- b) Dielectric test

1.5.2 Routine Tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The following tests shall be performed on each transformer as a minimum:

- a) After assembly, each core shall be pressure tested for one minute at 2KV (r.m.s.) A.C. between all bolts, side plates, structural steel works and the core.

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- b) The wiring for auxiliary power and control circuitry shall be subjected to withstand one minute power frequency test with 2.0KV (r.m.s.) to earth
- c) Measurement of winding resistance
- d) Measurement of voltage ratio and check of phase displacement
- e) Measurement of short circuit impedance and load loss
- f) Measurement of no load loss and current
- g) Dielectric routine tests
- h) Excitation loss and current measurements shall be made at 90%, 100% and 110% of the rated voltage as routine test.
- i) Partial discharge test
- j) Tan delta test

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings/ Data and Manuals

Drawings, data, and manuals for the transformers shall be submitted as indicated below:

- a) *[General Arrangement Drawing]*
- b) *Dimensioned general arrangement drawing showing enclosure, core coil assembly, terminal arrangement, marshalling box and various fittings.*
- c) *Transport/shipping dimensions with weights, wheel base detail etc.*
- d) *Foundation plan & loading.*
- e) *Bus duct/cable termination arrangement.*
- f) *Control schematics and wiring diagrams.*
- g) *Test reports and QAP*
- h) *Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.*
- i) *Instruction manuals on Transformer and its various fittings The manual shall clearly indicate method of installation, checkups and tests to be carried out before commissioning of the equipment.]*

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Note: The drawings, data and manuals listed are minimum requirement only. The Bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted.

1.7 Ratings and Requirements

Table 2.0

6.6/0.420 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Application	[As per project requirement]	[As per project requirement]
2.	Location	Indoor	Outdoor
3.	Type	[Dry Type: epoxy cast resin transformer]	[Oil type transformer]
4.	Reference standard	IS 11171	IS 2026
5.	Rated power (indicative)	[As per project requirement]	[As per project requirement]
6.	Rated winding voltage ratio (line to line)	6.6/0.433 kV	6.6/0.433 kV
7.	Number of phases	3	3
8.	Winding	2	2
9.	Rated frequency	50 Hz	50 Hz
10.	Type of cooling	AN	ONAN
11.	Insulation Class	Class F or Better	Class F or Better
12.	Temperature rise Over ambient temperature of 50°C		
a.	For Winding by	90°C or lower as permissible for class	55°C

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	resistance method	of insulation offered	
b.	For Oil by Thermometer method	Not Applicable	50 °C
13.	Insulation level (LI/AC)		
a.	HV- (LI/AC)	60 KVp/20 kVrms	60 KVp/20 kVrms
b.	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
14.	Vector group	[Dyn11]	[Dyn11]
15.	Short-circuit impedance on principal tap	[As per project requirement]	[As per project requirement]
16.	Parallel operation of transformer	Momentarily	Momentarily
17.	Type of taps provided	OCTC, full capacity	OCTC, full capacity
18.	Taps provided on	H.V. winding	H.V. winding
19.	Range of taps	[+/- 5 % in steps of 2.5%]	[+/- 5 % in steps of 2.5%]
20.	Method of Tap charge control-		
a.	Manual local	Yes	Yes
b.	Electrical local	No	No
c.	Electrical remote	No	No
d.	Automatic	No	No
21.	System earthing		

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a.	H.V.	Non-effectively earthed			Non-effectively earthed
b.	L.V.	Effectively earthed			Effectively earthed
22.	Terminal arrangement				
a.	H.V.	6.6kV(UE) Cable/ busduct			6.6kV(UE) Cable/ busduct
b.	L.V.	Non-segregated phase bus duct			Non-segregated phase bus duct
23.	Neutral for earthing	GS flat connector			GS flat connector
24.	Transformer bushing	HV	LV	LV - N	Same as Dry type transformer
25.	Voltage class KV(r.m.s.)	7.2	1.1	1.1	
26.	Creepage distance mm	[As 25mm/kV]			[As 25mm/kV]
27.	Min. Ph-Ph/ Ph-E clearance mm	As per Standard			As per standard
28.	System fault Level				
a.	HV Side	40 KA (r.m.s.)			40 KA (r.m.s.)
b.	LV Side	50KA (r.m.s.)			50KA (r.m.s.)
29.	Max. Noise level	As per NEMA std. TR-1			As per NEMA std. TR-1
30.	Auxiliary supply	415 V, 3 ph, 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)			415 V, 3 ph 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)
31.	LV neutral side	[As per project]			[As per project]

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	current transformer for standby earth fault protection	requirement]	requirement]
32.	Guaranteed no load loss (kW)	[By Bidder]	[By Bidder]
33.	Guaranteed load loss (kW)	[By Bidder]	[By Bidder]
34.	Efficiency		
a	At full load	[By Bidder]	[By Bidder]
b	At 75% load	[By Bidder]	[By Bidder]
c	At 50% load	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II**

**SECTION-II, PART-B, ANNEXURE-E4
TECHNICAL SPECIFICATION FOR 415V SWITCHGEAR,
MCC & DBs**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E4**1.0 415V SWITCHGEAR, MCC AND DB****1.1 General**

This specification is intended to cover the *[design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning]* of 415V Switchgear MCC and DBs, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2551	Danger notice plates
IS :2705	Current transformers-specification
IS :3156	Voltage transformer specification
IS :3231	Specification for electrical relays for power system protection
IS: 8084	Specification for interconnection busbars for AC voltages above 1kV up to and including 36kV.
IS :8623	Specification for low-voltage switchgear and control gear assemblies
IS :8686	Specification for static protective relays
IS :10118	Code-of practice for selection installation and maintenance of switchgear and control gear
IS :12021	Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 v ac
IS : 13947 (Part 1)	Specification for low-voltage switchgear and control gear
IS : 13947 (Part 2)	Specification for low-voltage switchgear and control gear –part 2: circuit breakers
IS : 13947 (Part 4)	Specification for low-voltage switchgear and control gear -part 4 : contactors and motor feeders

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Codes	Name of Standard
IS : 13947 (Part 5)	Low-voltage switchgear and control gear specification Part 5 : control circuit devices and switching elements
IEC 61439	Low voltage switchgear and control gear assemblies.
CEA	CEA regulations for installation and operation of meters 2006.
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All 415V Switchgear, MCC and DB shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- All 415V Switchgear, MCC and DB shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-) 5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC system	:	-15% to +10%

- 415 V switchgear & MCCs shall be of indoor /outdoor, double front/single front [Preferably single front] and fully draw out type. ACB feeder may be of single tier/two tier configuration depending upon rating. DBs (ACDB / DCDB) shall be of single / double front [Preferably single front] and fixed type. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration shall be provided.
- All AC motor starters shall be suitable for Direct on Line (DOL) starting. Motors rated below [132]kW shall be provided with combination starters consists of MCCB/MPCB, contactors and electronic over load relay and

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the motor starter shall comply with Type – 2 coordination conforming to relevant code and standards. Motors rated [132] kW and above shall be breaker controlled and shall be provided with comprehensive motor protection relay. Motors rated above [160]kW shall be fed from MV Switchgear [Only for firefighting system Motor rated up to 200kW shall be fed from 415V switch board].

- e) For 415 V switchgear & MCCs Feeders rated [630A] and above shall be equipped with Air Circuit Breaker (ACB). Outgoing/Incoming feeders rating below [630] A shall be MCCBs.
- f) For DBs Incomer rated 630A and above shall be ACB. Incomer below 630A shall be MCCB. Outgoing feeder may be MCCB/MCB depending upon the bus fault level.
- g) All ACB shall be draw out type & should have Service, test and disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- h) Local/remote selection shall be provided for all incoming/Outgoing ACB module. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local(Switchgear).
- i) Two out of three breaker logic shall be considered for switchgear/MCC. However mechanical interlock shall be considered for income of MCCB operated DBs.
- j) Also, Local/remote selection switch shall be provided for all motor modules for control from Remote(DCS). Also for breaker operated motor, breaker shall be closed in Test position from local(Switchgear).
- k) All motors shall be provided with Emergency stop push button.
- l) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary MCCB/MCB shall be provided for each MCC, 2 x 100% per section. However breaker shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from bus bars. This control supplies shall be monitored.
- m) All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 415V switchgear, MCC and DBs shall have following minimum features.

- a) All 415V switchgear, MCC and DBs shall be metal enclosed, indoor, floor mounted and free standing type. The panels shall be suitable for cable entry at bottom and busduct connection at top.

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- b) Between 415V Switchgear and dry type transformers, non segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with busduct manufacturer in this regards is covered in this specification.
- c) All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d) Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels
- e) Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f) The switchgear enclosure shall confirm to the degree of protection IP-54 (for outdoor). For indoor, enclosure shall confirm to IP52, however for Busbar chamber of switchboards rated above 1600A, degree of protection shall be IP-42.
- g) Paint shade for complete panels excluding end covers shall be [RAL 9002] and [RAL 5012] for extreme end covers for all board.
- h) The switchgear assembly shall comprise a continuous, line-up of single / multi tier cubicles. The installations of circuit breakers however shall be limited to the bottom two tiers only. Working height shall be limited to [250 mm to 1800 mm] from the floor level.
- i) Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc
- j) A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgears having more than one bus section.
- k) Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable

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terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.

- l) For MCC/DB a full height vertical cable chamber with cable supports shall be provided in each section to facilitate unit wiring.
- m) 2x100%, 415V/110V AC control transformer shall be provided for control, Indication and annunciation supply for contactor operated motor feeder. All the necessary auxiliary and main contactor shall be provided suitable for this control supply.
- n) Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module.
- o) Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- p) Supplier shall provide total 20% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- q) Motors of rating 30 kW and above shall be provided with anti-condensation heaters. Necessary provision for supply of motor space heating shall be considered in the switchgear.
- r) The incoming connection to transformer of more than 1000kVA and inter-connecting sections between switchboards shall preferably be of bus ducts.
- s) It should be possible to carryout maintenance on a feeder with adjacent feeders alive.

1.4.2

Bus and Bus taps

- a) The main buses and connections shall be of high [conductivity Aluminum / Copper] alloy sized for specified current ratings with temperature rise limited [to 40°C over ambient temperature of 50°C].
- b) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminum contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance. Adequate contact pressure shall be ensured by means of two bolts connection with plain & spring washers and locknuts. Temperature rise shall not exceed 105 degree for silver plated joints over an ambient temperature of 50 degree.
- c) Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- d) Bus insulators shall be flame-retardant, track resistant type with high creepage surface. All buses and connections shall be supported and braced to withstand the stresses due to maximum short-circuit current and also to take care of thermal expansion.

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- e) Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f) Power shall be distributed to each module or compartment by a set of vertical bus bars. The vertical bus bars shall run behind the modules. Necessary tee off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.
- g) The clearance between the individual bare phase power bus bars and between the phase and earth bus bars in air shall be not less than [25.4] mm.
- h) Three phase, neutral (with at least [50] % rating of main Bus bar and continuous earth bus shall be provided. Bus bar and tapping shall be provided with color coded PVC sleeves.

1.4.3

Air Circuit Breaker

- a) All Circuit Breakers for incoming feeders and Bus couplers shall be [four] poles; single throw, motor operated and air break type. Circuit breaker for outgoing feeders shall be triple pole, single throw and air break type. However for supply feeders it shall be [four] pole.
- b) Circuit Breakers shall be [draw out type] having Service, Test & Disconnected positions with positive indication for each position.
- c) Circuit breakers of identical rating shall be physically and electrically interchangeable.
- d) Bolted disconnected links shall be provided for all outgoing feeders for isolation of neutral, if necessary.
- e) For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open – close – open operation of the circuit breaker shall be possible after failure of power supply to the motor when the spring is charged after a closing operation.
- f) Mechanical safety interlock shall be provided to prevent the circuit breaker from being racked in or out of the service position when the breaker is closed.
- g) Automatic safety shutters shall be provided to fully cover the female primary disconnects when the breaker is withdrawn.
- h) Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indicator, an operational counter and mechanism to indicate spring charge / discharge condition.
- i) In addition to the auxiliary contacts required for normal breaker operation and indication, each breaker shall be provided with followings for interlocking purpose:-
 - i. Position / cell switch with 4 No + 4 NC contacts.

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- ii. Limit / auxiliary switches shall be convertible type that is facility for changing N.O. contact to N.C. and vice-versa.
- iii. Mechanical stopper to prevent accidental falling while withdrawing.
- j) Breaker cannot be racked in from 'isolated' to 'test' position with the door open together with provision for defeat of this interlocking, however, the door can be closed only when the breaker is brought back to 'isolated' position. Insertion of breaker into 'Service' position not possible if the shutters are not free.
- k) Door can be opened only when breaker is OFF and is in 'Isolated' position. Remote closing of breaker not permitted with door open.
- l) Anti pumping relay / device to ensure that there can be only one closing operation for each closing command.
- m) Suitable trolley arrangement shall be provided for breaker/starter modules. Two trolleys per switchgear room shall be provided so that top most breaker module of all types, sizes and rating can be withdrawn on trolley and lowered for maintenance purpose.
- n) Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage.

1.4.4 Contactors, MCCB and MPCB

- a) Incomers for MCCs and DBs rated below 630A shall be MCCB.
- b) Incomer and bus coupler rated below 630A shall be mechanically Interlocked.
- c) Motor starter contactors shall be of air break, electromagnetic type. Suitable for DOL starting of motor, and shall be of utilization category AC-3 for ordinary and AC-4 for reversing starters. DC contactor shall be of DC-3 utilization category.
- d) The contactors shall be three pole, air break type designed for [duty class III category A.C. –3 with non-bouncing silver / silver alloy.]
- e) Each contactor shall be provided with two (2) normally open and two (2) normally closed auxiliary contacts unless otherwise specifically stated. Rating shall be decided by the bidder.
- f) Reversing contacts shall be electrically and mechanically interlocked.
- g) Contactors with delayed dropout feature shall be provided for some essential auxiliaries. These contactors shall not dropout on power failure if the voltage is restored within 3 seconds.

1.4.5 Electronic over load relays

- a) Electronic overload relays shall conform to IEC:292-1 and shall be triple pole, ambient temperature compensated with adjustable setting, inverse time lag, built in single phase preventer and hand/auto reset type

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provided as per requirement along with necessary command, feedback cable, coupling relays etc.

- b) Provided with 1 NO and 1NC contact of rating same as the auxiliary contact of the contactors.
- c) The relay shall be able to withstand prospective short circuit current without damage or injurious heating till the motor protection MCCB/MPCB clears the fault.
- d) Relays may be direct acting or CT operated, depending on current rating. CTs shall be included in the scope of supply.

1.4.6 Bus Transfer scheme:

Each switchgear of two incomer and bus coupler shall be provided with the following provisions.

- i) Dead bus closing.
- ii) Manual live change over (Momentary paralleling)
- iii) Automatic bus transfer scheme.

1.4.7 Current Transformer

- a) Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made.
- b) CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c) CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d) All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e) CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Voltage Transformer

- a) Voltage transformers(VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b) VTs shall be of the single-phase type. VTs shall be protected on their primary side by MCCBs with interrupting ratings corresponding to breaker rating and by MCB (with auxiliary contacts) on the secondary sides.

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- c) VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d) It shall be possible to replace VTs without having to de-energise the main busbars.
- e) VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.9 Transducer

For all the incoming and the outgoing of 415V Switchgear / MCC/ DB Feeders requiring remote metering and/or current monitoring shall be provided with multi-functional transducers. The output shall be 4-20 mA DC which shall correspond to the normal range.

1.4.10 Secondary Wiring

- a) The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b) Fuse /MCB and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c) Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d) Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with [stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring.]
- e) Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.11 Terminal Blocks

- a) Terminal blocks shall be 660V grade box-clamp type with marking strips, similar to 10 mm² or equal. Terminals for C.T. secondary leads shall have provision for shorting.
- b) Not more than two wires shall be connected to any terminal. If more than two wires at one terminal are required, separate terminals with function wise shorting links shall be provided. [Spare terminal equal in number to 20% of active terminals shall be furnished.]
- c) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged so that individual wires of an external cable can be connected to consecutive terminals.

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1.4.12 Ground bus

- a) A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b) Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c) C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.13 Space Heater

- a) Each vertical section shall be provided with thermostat controlled space heater 5A, 3 pin socket plug.
- b) In addition, motor feeders rated [30 KW and above] shall be wired up for feeding the motor space heater through suitably rated breaker auxiliary NC contact and/or contactor.
- c) Cubicle heater, Motor heater, and Plug socket circuit shall have individual switch fuse units/MCB.

1.4.14 AC Distribution Boards (ACDBs)

- a) AC Distribution Boards shall have MCCB/MCB at incomer depending upon the short circuit rating. Distribution Boards may be fed from switchgear and shall have two incomers. AC distribution Boards shall be of two types - one with 415V, 4-wire, triple pole and neutral (TPN) outgoing feeders and the other with 240V, 2-wire, single pole and neutral (SPN) outgoing feeders.
- b) For small loads, MCB boards with TPN MCB as incomer and TPN/SP MCBs for outgoing may be considered. The feeder rating and quantity shall be as per requirement.
- c) Board shall be single/double front [preferably single front], metal clad, front matched, dust and vermin proof, fixed type, compartmentalized and extensible on both sides.
- d) Bus bars shall have same cross section throughout the length. Rating of the neutral bus bar shall be 50% of the main bus bar. Earth bus bar shall run in bottom chamber throughout the length of the Board.

1.4.15 DC Distribution Boards

DCDBs shall have two incomers and a bus coupler. Incomers and outgoing feeders of DCDBs shall be MCB/MCCB modules. They shall be fixed type and floor mounted. Other constructional features shall be similar to ACDB.

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The feeder rating and quantity shall be as per requirement.

1.4.16 Control & Indication

The circuit breaker shall be wired up for local & remote operation. Each breaker cubicle shall be equipped with following:

- a) Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In switchgear position, the breaker shall be operated from switchgear only in test position with only protection (no interlock).
- b) Two (2) heavy duty, oil-tight, push buttons for Trip & Close.
- c) Circuit breaker shall be indicated electrically. The following indication colour shall be used.

Breaker open - GREEN

Breaker closed - RED

Spring Charged - WHITE

Breaker Auto Trip- AMBER

- d) However, any other indication shall be provided as per owner's requirement.
- e) Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.
- f) For all MCCB feeders, trip indication lamp shall be provided on front of the compartment.
- g) For all starters, ON, OFF and trip indication lamps shall be provided on front of the compartment.

1.4.17 Relays, Protection & Metering

- a) The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- b) All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner.
- c) All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.

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- d) All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- e) Energy meters shall be provided for incomer of 415V Switchgear and MCC and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than 1.0S.
- f) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- g) All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- h) The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- i) All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- j) Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- k) D.C supply shall be supervised by DC supervision relays.
- l) Trip circuit shall be supervised by Trip circuit supervision.
- m) Tripping shall be done through high speed lock out relays.
- n) All meters/ instrument shall be flush mounted on front panel, at least 96mm² size with 90° linear scales and accuracy class of 2.0.
- o) Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- p) For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- q) Metering and protection shall be as per below table

a)	Incomers	
	Protections	Metering
i	Time graded short circuit protection	Local Current (single phase) indication and remote indication through transducer.

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ii	Over current protection	Voltage Measurement for all three phases and remote indication through transducer.
iii	Earth fault protection	KW, Kwhr
b)	Bus coupler	
	Protections	Metering
i	Over current protection(51)	Local Current (single phase) indication.
ii	IDMT Earth fault protection(51N)	
c)	Contactor controlled motor feeders [90kW and above motor only]	
	Protections	Metering
i	Time graded short circuit protection	Local Current indication and remote indication through transducer.
ii	Over current protection	
c)	[Motor Feeders [of 132KW and above only]]	
	Protections	Metering
	Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload etc.	Local Current indication and remote indication through transducer.
[Other feeders]		
a)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection	[Voltage – phase to phase,]
	Fuse failure protection	
b)	Motor feeders (MPCB/MCCB with Contractors)	
	Protections	Metering
	Electronic Overload relay (with single phase preventor), short circuit protection (through fuse/MCCB/MPCB as specified)	
c)	Incoming feeders for ACDB/DCDB	
	Protections	Metering

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	Short circuit protection (if MCCB)	[Voltage (single phase and, Phase Current (1 Phase))] Local indication only.
d)	Outgoing feeders of ACDB/DCDB	
	Protections	Metering
	Short circuit protection (through fuse/MCCB)	

1.5

Tests

I) Type Test

For each type & rating of 415V Switchgear, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted are as follows:

- Measurement of insulation resistance of Circuit Breaker in closed and open positions.
- Measurement of milli-volt drop across Circuit Breaker main contacts and other joints.
- Measurement of Circuit Breaker/Contactor operating time for close & open at nominal voltage and 80% of rated voltage.
- Measurement of resistance, IR value and drop-off/pick-up voltage of close and trip coils.
- Healthiness of limit switch contacts.
- Spring charging motor functional checks.
- Verification of phase sequence and checking of clearances of busbars between phase to phase and phase to earth.
- Measurement of milli-volt drop across busbar joints

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- i) Torque tightness test.
- j) High voltage test on busbar.
- k) Measurement of CT/PT polarity, ratio and knee point voltage.
- l) Electrical and mechanical interlock checks.
- m) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- n) Secondary injection of all metering circuits.
- o) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below

- a) [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening.
- b) Bill of Materials.
- c) Technical Data sheet and Catalogue.
- d) Foundation drawing details with bottom view of switchgear.
- e) Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f) Control Schematics & Wiring diagram.
- g) Inspection and Test Plan (ITP).
- h) Suggestive list of protective relays.
- i) Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

415V switchgears, MCC and DB shall comply with the particulars indicated in the following tables.

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Table- 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		415 Volts, 3 Phase, 4 wire 50 Hz.
2.2	System neutral earthing		Solidly earthed
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		a) 2.5kV b) 1.5kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		90°C for busbars having non-silver plated joints 105°C for busbars having silver plated joints
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	50
b	Dynamic Rating	kA (peak)	105
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		Cu/Al
2.14	Fully draw out (FD)/ Fixed (F)		FD for Switchgear/MCC; F for DBs.
2.15	Entry –Top (T)/Bottom (B)		Top for busduct, bottom for cables
2.16	Degree of protection		IP 52
2.17	Colour finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	GS
2.19	Minimum clearances in air of live parts	mm	As per standard
3.0	Starters		
3.1	Type	DOL	DOL
3.2	Contactor rated duty		AC3 for DOL
3.3	Single phasing preventer required.	Yes / no	Yes
3.4	Thermal overload relay reset	Manual / Auto	Settable for either to Manual or Auto
4.0	Circuit breakers		
4.1	Maker's name		[By bidder]
4.2	Voltage, frequency & no.of phases , poles		415 V, 50 Hz, 3 Ph, 4 Pole
4.3	Rated operating duty		O-3min-CO- 3min -CO
4.4	Circuit breakers type		ACB
4.5	Short circuit withstand current for 1 sec. Duration	kA	50
4.6	Rated making current	kAp	105
4.7	Rated current at site reference ambient temp	A °C	[By bidder]

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S. No.	DESCRIPTION	UNIT	DATA
4.8	Type of operating mechanism		Spring charged motor and manual
4.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
4.10	Control voltage		
a	Spring charging motor	V AC/DC	[220V DC/240V AC]
b	For closing/tripping	V AC/DC	220V DC
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	As per IS
b	Closing at normal voltage	%	As per IS
c	Trip coil	%	As per IS
4.12	Power required for closing at normal voltage	W	[By bidder]
4.13	Power required for tripping at normal voltage	W	[By bidder]
4.14	Spring charging motor details:		
a	Rating	kW	[By bidder]
b	Rated voltage	V, AC/DC	[By bidder]
c	Spring charging	Sec.	[By bidder]
	Electrical and mechanical anti-pumping features been provided	Yes/No	Required
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		415 V, 50 Hz & 3 P for outgoing, 4P for incoming and supply feeders
5.2	Rated operating duty		As per IS
5.3	Rated breaking capacity	kA (rms)	50

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S. No.	DESCRIPTION	UNIT	DATA
5.4	Rated making current	kA (Peak)	105
5.5	On/off operation		
5.6	Manual	Yes/No	Yes
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	Yes
5.8	Auxiliary contacts required	Yes/No	[As per project specific]
6.0	Contactors		
6.1	Make		[By Bidder]
6.2	Rated duty	AC3/A C4	AC3 for DOL AC4 for RDOL
6.3	No of poles		3
6.4	Utilization category		[By Bidder]
6.5	Rated voltage of auxiliary contacts	V	[By Bidder]
6.6	Rated voltage of coil	V	[By Bidder]
6.7	Rated breaking capacity	Factor of rated current	[By Bidder]
6.8	Rated making capacity	Factor of rated current	[By Bidder]
6.9	Limits of operation		As per IS/IEC
a	Supply voltage variation		[By Bidder]
b	Supply frequency variation for closing		[By Bidder]
c	Drop out voltage		[By Bidder]
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		

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S. No.	DESCRIPTION	UNIT	DATA
7.1	Voltage Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
7.2	CT Ratio		Primary current/1A or 5A
7.3	Measuring CTs		CI - 1.0 instrument safety factor 5.0
7.4	Protection CTs		CI 5P20
7.5	Measuring VTs		(min)/phase CI1.0
7.6	Protection VTs		CI 3P
8.0	Control transformers		
8.1	Make		[By Bidder]
8.2	Type		Dry Type
8.3	Applicable standards		As specified in the specification
8.4	Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
8.5	Class of insulation		Class-B or Better
8.6	Rated output	VA	[As per project specific]
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		[By Bidder]
10.2	Make		[By Bidder]
10.3	Type designation		[By Bidder]
10.4	Setting range		[By Bidder]
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		[By Bidder]
11.2	Make		[By Bidder]
11.3	Type		[By Bidder]
11.4	Current setting range		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	[By Bidder]
12.0	Under voltage relay		
12.1	Make		[By Bidder]
12.2	Type		[By Bidder]
12.3	Voltage rating	V	[By Bidder]
12.4	Setting range	V	[By Bidder]
13.0	Auxiliary relays and timers		
13.1	Make		[By Bidder]
13.2	Type		[By Bidder]
13.3	Coil voltage	V	[By Bidder]
14.0	Control/selector switch		
14.1	Make		[By Bidder]
14.2	Type designation		[By Bidder]
15.0	Meters		
15.1	Applicable Standards		As specified in the specification.
15.3	Accuracy Class		Class 1.0 or Better
15.4	Make		[By Bidder]
15.5	Type		Multi function with RS 485 connectivity
16.0	Voltmeter		
16.1	Make		*[By Bidder]
16.2	Type		Moving coil
16.3	Applicable standards		As specified in the specification.
16.4	Accuracy class		Class 1.0
17.0	Ammeter		

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S. No.	DESCRIPTION	UNIT	DATA
17.1	Make		As specified in the specification.
17.2	Type		Moving coil
17.3	Applicable standards		As specified in the specification.
17.4	Accuracy class		Class 1.0
18.0	Indicating lamps		
18.1	Make		As specified in the specification.
18.2	Type		Clustered Led
18.3	Voltage	V	As specified in the specification.
18.4	Wattage of lamp	W	As specified in the specification.
19.0	Push buttons		
19.1	Make		As specified in the specification.
19.2	Type designation		As specified in the specification.
19.3	Contact rating	A	As specified in the specification.
20.0	Space heater		
20.1	Make		As specified in the specification.
20.2	Type		As specified in the specification.
20.3	Rated voltage	V	As specified in the specification.
21.0	Wiring and terminal blocks		
21.1	Voltage grade		1.1 kV
21.2	Insulation		[By Bidder]
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	2.5 for CT & PT 1.5 for Others
b	Control wiring	Sq.mm	1.5 for Others

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S. No.	DESCRIPTION	UNIT	DATA
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		Sliding type
	II) For Fixed Type		Stud & nut type
21.5	Minimum current rating of terminal blocks	A	10

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E5
TECHNICAL SPECIFICATION FOR 415V NON
SEGREGATED PHASE BUS DUCTS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E5**1.0 415V NON SEGREGATED PHASE BUS DUCT****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Non Segregated Phase Busduct, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS 8084	Interconnecting Bus bar for AC Voltage above 1KV up to and Including 36kV
IEC 60947	Low Voltage Switchgear and Control gear
ANSI/IEEE C37.20	Metal-Clad and Station-Type Cubicle Switchgear
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear
IEC 60439	Low-voltage switchgear and control gear assemblies.
BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) The 415V Non-segregated phase bus duct shall serve as an interconnection between the 415V Switchgear and 11/0.433kV LV Transformer. The Non-segregated phase bus duct shall be installed

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indoor/Outdoor in a hot, humid and tropical atmosphere. All panels associated with Non-segregated phase bus duct shall be located indoors/Outdoors.

- b) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- c) For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be as specified in Clause 1.7 Rating and requirements.
- d) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the required short-circuit currents.
- e) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- f) The bus ducts shall be self cooled and shall not be equipped with blower or any other type of forced ventilation.
- g) The equipment rating shall be based on an ambient temperature. Same phase disposition shall be maintained throughout the run of the bus duct. Phase crossover units, if required, shall also be provided inside the Busduct itself.
- h) Bus ducts shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current.

1.4 Specific Requirements

1.4.1 General

- a) 415V Non Segregated Phase Busduct is provided for connection between low voltage side of 11/0.433kV cast resin dry type /oil type transformers and associated 415V Switchgears shall be of TPN (3 phase and neutral) along with necessary bends, flexible at both transformer & switchgear ends, flanges, phase crossover chambers (if required), support structures & accessories including terminations at the equipment ends.
- b) The 415V bus duct shall be metal enclosed, non-phase segregated enclosure type, self cooled and insulated for 1.1kV voltage. The cooling medium inside the duct shall be air.

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- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) The 415V non-segregated phase bus duct will be installed indoor or partially indoor & outdoor depending upon the location of equipment being interconnected in a hot, humid and tropical atmosphere. All panels associated with LV non-segregated phase bus duct will be located indoors.
- e) The continuous current rating and momentary peak withstand current rating of the Busduct between transformers & their associated switchgears shall be same as that of the associated switchgears and as indicated in the specification.
- f) All supporting steel structures shall be hot dip galvanized.
- g) The bus ducts shall be provided with space heaters to control moisture. Slicagel breather if required same shall be provided.

1.4.2 Enclosures

- a) The enclosure shall be rectangular and shall be made of [aluminium alloy/Mild steel] of grade [19000H2] as per IS-5082. The entire bus duct shall be designed with dust, weather and vermin-proof construction. The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- b) *[Phases shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminum alloy) of 3mm for bus rating including and above 3000A whereas enclosures for normal bus current rating (<3000 A) shall be sheet steel fabricated type of 2.5mm thick].*
- c) Enclosures shall be provided with flange ends with drilled dimensions to suit the flanges at the switchgear and transformer ends.
- d) Circumferential neoprene rubber gaskets shall be provided for dust tight joints with adjacent enclosure section.
- h) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion / contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.

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- i) All outdoor bus-enclosures shall be so designed & constructed as to prevent accumulation of rain water on top sheet. Similarly all Gasketed flanged joints shall be suitably protected against direct splashing of rain water in case of outdoor runs. The connection flanges shall be sufficiently stiffened so as not to bend while tightening the bolts.
- j) Outdoor portions of the bus duct, if any, shall have continuous rain hood of non magnetic material or with suitable arrangement for rainwater prevention.
- k) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, switch gear terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets.
- l) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between indoor and outdoor portions of the bus duct.
- m) In case, the bus duct penetrates the firewall, the wall frame assembly and the seal shall be designed for the same fire rating as the firewall.
- n) Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct. Space Heaters shall be provided in the bus duct.
- o) Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- p) Shipping length of the Busduct shall be not more than three (3) meters in length.
- q) Minimum Degree of protection of Busduct enclosure shall be IP-52 for indoor and IPW-55 for outdoor section of the Busduct.

1.4.3 Bus Conductor

- a) The bus conductor shall be of high conductivity, [Aluminium alloy / Aluminium].
- b) The bus conductors shall be given a coat of matt black paint to facilitate heat dissipation. However the sizing of the bus conductor shall consider the conductor as bare.
- c) The bus conductor shall be designed for bolted connections throughout the run.
- d) Flexible connection shall ensure an efficient and trouble-free connection.

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- e) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminium contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- f) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.
- g) The bus bar shall be sleeved with FRLS heat shrinkable, colour coded PVC sleeves at intermittent points for phase identification.
- h) The material of the conductor shall be aluminium alloy of grade [63401WP] as per IS: 5082. The temperature rise of conductor shall be 40 degree over design ambient temperature of 50 degree. Also, the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.

1.4.4 Disconnect Link

- a) Removable bolted disconnected link shall be provided in the bus for the purpose of isolation.
- b) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- c) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- d) A minimum clearance of [300 mm. (12")] shall be provided between the disconnected bus sections with the link removed.

1.4.5 Insulators

- a) The bus conductor supporting insulators shall be flame retardant, non-hygroscopic, high impact and high dielectric strength material with an anti tracking contour.
- b) Material of insulator shall be [Epoxy SMC moulded /FRP].
- c) Spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the short circuit current assigned to the bus duct.
- d) Bus support insulators shall be interchangeable, high creepage, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.

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- e) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- f) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator.
- g) Space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus duct.

1.4.6 Connections & Terminations

- a) All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the switchgear, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the switchgear and auxiliary transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.

1.4.7 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- c) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- d) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.
- e) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.

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- f) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

1.4.8 Ground bus

- a) The ground bus of two numbers of separately run [50x10 mm] minimum GS flat shall be provided along the run of the bus duct. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.
- b) Ground bus shall be finally to connected to power plant earth grid at one end.

1.4.9 Wiring

All wiring for space heaters shall be done with insulated stranded copper conductor of not less than [2.5 mm² cross-section]. Each wire shall be identified at both ends with wire designation as per bidder's wiring diagram and shall be brought out to a terminal box outside the bus duct.

Terminal blocks shall be box-clamp type minimum 10 mm² with marking strips.

At [least 20% spare terminals] shall be furnished in the terminal block.

1.4.10 Name Plate

Suitable name plate shall be furnished with each piece of equipment.

[Materials for name plate shall be plastic / lamicaid, 3 mm thick, using white letters on black background.]

1.4.11 Space Heater

Thermostatically controlled Space heaters shall be provided in the bus ducts, wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation. At least one number space heater with thermostat shall be provided at each transformer and switchgear end.

The space heaters shall be suitable for continuous operation on single phase supply, and shall be automatically controlled by thermostats. Necessary wiring up to junction boxes mounted on bus duct and from junction boxes to switchboards shall be provided.

1.4.12 Painting and Finish

- a) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as

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possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint

- b) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- c) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- d) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].
- e) The interior surface finish shall be as per manufacturer's standard.
- f) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- g) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.
- h) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- i) The paint shade shall be subject to owner's approval.

1.5 Tests

l) Type Test

For each type & rating of 415V Non segregated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test

1.6 Drawings and Documents

Drawings, data & manuals for the 415V Non segregated phase bus duct shall be submitted as indicated below:

- a) [Dimensional GA drawing
- b) Data sheets
- c) Typical calculation for arriving at the size of conductor and the insulator spacing.
- d) Type test report (short circuit, temperature rise test) for similar bus duct manufactured by the proposed manufacturer.
- e) Foundation layout and requirements
- f) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

1.7 Ratings and Requirements

Major technical parameters of 415V non segregated Bus Duct are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table: 2.0

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.	Type of bus duct		Non segregated phase bus duct	
2.	Rated voltage and No. of phase	V	415V, Triple Pole , Neutral(3Phase & 4 Wire)	
3.	Applicable standard		IS 8084	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
4.	System Frequency	Hz	50	
5.	Design ambient temperature	Degree	50	
6.	Rated Current	A	[As per project Requirement]	
7.	Designation (from & to)		[As per project Requirement]	
8.	Type of cooling (NSPBD)		Natural air	
9.	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
10.	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
11.	One minute power frequency voltage withstand	KV (RMS)	2.5	
12.	Continuous current rating at 50°C design ambient air temperature	A	[As per project Requirement]	
13.	Material a) Bus bar b) Enclosure		a) [Aluminum] b) [Aluminum alloy/MS]	
14.	One second short circuit withstand rating	KA (RMS)	50	
15.	Momentary short circuit withstand current	KA (Peak)	105	
16.	Bus bar Support		[FRP/ SMC]	
17.	Degree of protection		IP 52 for indoor IP W55 for outdoor	
18.	Earthing Conductor Material		GS	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
19.	Heating		Thermostat controlled space heater	
20.	Fittings of silica gel breather and drain plug		Required	
21.	Finish of Bus Enclosure		a) Inside: Matt Black b) Outside [RAL 5012]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E6

TECHNICAL SPECIFICATION FOR 220V DC SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E6

1.0 220 V DC SYSTEM

1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of 220V DC system with its all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS- 266	:	Specification for Sulfuric Acid
IS- 1069	:	Specification for Water for Storage battery
IS- 1146	:	Specification for rubber and Plastic Containers for Lead Acid Storage Batteries
IS-1652-1991	:	Stationary Cells and Batteries, lead acid type (with Plante positive plates) – Specification
IS- 3116	:	Specification for Sealing Compound For Lead Acid Batteries
IS- 8320	:	General requirements and methods of tests for lead acid storage batteries.
IS- 6071	:	Specification for synthetic separators of lead acid storage batteries.
IS-10918-1984	:	Specification For Vented Type Nickel-Cadmium Batteries.
IS-14782-2000	:	Code of Practice for maintenance and testing of large Lead Acid Batteries in Generating Station and Substation.
ANSI-C-	:	Guide for surge withstand capability test.

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37.90a		
IEC - 60623	:	Secondary Cells and Batteries Containing Other Non-Acid Electrolytes – Vented Nickel- Cadmium Prismatic Rechargeable Single Cells.
IEEE-1115-2000	:	Recommended Practice For Sizing Nickel-Cadmium Battery For Stationary Application.
IEEE-485-1997	:	Recommended Practice For Lead Acid Battery For Stationary Application.
IEEE-946-1992	:	Recommended Practice For The Design Of DC Auxiliary Power Systems For Generating Station.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IS:5	:	Colours for ready mix paints.
IS : 694	:	PVC Insulated Cable for working voltages upto and including 1100V
IS : 1248	:	Specification for Direct acting indicating analogue electrical measuring instruments.
IS:13947 Pt-1	:	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS : 13947	:	Specification for low voltage switch gear and control gear
IS : 3231	:	Electrical relays for power system protection.
IS : 3842	:	Application guide for Electrical relays for AC System
IS : 3895	:	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	:	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	:	Code of practice for phosphating of Iron and Steel
IS:6619	:	Safety Code for Semi-conductor Rectifier Equipment.
IS:6875	:	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 VAC or 1200VDC

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IS : 9000	:	Basic environmental testing procedures for electronic and electrical items.
IS:13703	:	Low voltage fuses for voltages not exceeding 1000 V AC, 1500VDC.
EEUA-45D	:	Performance requirements for electrical Alarm Annunciation system

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity (IE) Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- 220 V DC Systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The system shall be suitable for operation in a highly polluted environment.
- The permissible voltage variation for 220V battery shall be from -15% to +10%.
- The battery shall be of storage type [Lead Acid Plante Positive Plate/Ni-Cd] Type. The Battery shall be of high discharge performance type. The plates shall be designed for maximum durability during all service conditions including high rate of discharge & rapid fluctuation of load.
- While estimating the battery size, temperature correction factor [based on lowest expected temperature 5 Deg C], margin on capacity [10%] and aging factor [1.0 for Lead Acid Plante and 1.2 for Ni-Cd] shall be considered.
- Cell Voltages for Lead Acid batteries:

i.	Nominal Discharge Voltage/cell	2.0 V
ii.	Float Voltage/cell	2.2 V
iii.	Boost Voltage/cell	2.7 V
iv.	Capacity for ten(10) hour rate at 27°C any time during the entire duty	1.85 V/Cell

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	cycle	
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f) Cell Voltages for Ni-Cd Batteries

i.	Nominal Discharge Voltage/cell	1.2 V
ii.	Float Voltage/cell	1.42 V
iii.	Boost Voltage/cell	1.7 V
iv.	Capacity for five(5) hour rate at 27°C any time during the entire duty cycle	1.14 V/ Cell

- g) 2x100% sets, 220V of either Lead-Acid Plante Type or Nickel-Cadmium battery banks with 2 x100% float cum boost charger catering to 100% of unit as well as station loads shall be provided.
- h) Permissible voltage variation for 220V battery shall be from 190V to 240V.
- i) The Ampere-Hour capacity of DC Storage Battery shall be based on [Three] hours' continuous DC supply at rated voltage to essential auxiliaries.
- j) Batteries shall be suitable for being boost charged to fully charged condition from fully discharged condition within 10 hours.
- k) Lead acid batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.2V/cell.
- l) Ni-Cd batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42V/cell.
- m) The float-cum-boost charger shall be rated to cater to the following:
- Trickle charging current of the battery
 - Equalizing charging of the Battery
 - Boost charging of the Battery
 - Continuous load on the DC system
 - 25% spare capacity over above loads.

1.4 Specific Requirements

1.4.1 Constructional requirements of battery

a) Containers

Container shall be made of transparent glass for lead acid and polypropylene for Ni-Cd batteries. It shall be robust, heat resistance, leak

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proof, non-absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container. The marking for the electrolyte level should be for the upper and lower limits. Container shall be closed / sealed lid type.

The pole sealing arrangement should be such that no acid particle gets entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

b) Vent Plugs

Vent plug shall be provided in each cell. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the spring type hydrometer can be inserted into the vent to take electrolyte sample.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuation of load. The construction of plates shall conform to latest revisions of standards as applicable for type of battery.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative posts shall be clearly marked.

The plante positive plates shall be supported from the ledges of the SAN container. They should not be supported at the bottom of container. Sufficient space shall allowed to allow the creepage of the plates.

d) Sediment Space

Sufficient sediment space shall be provided so that the cells shall not have to be cleaned out during normal life and prevent shorts within the cells.

e) Cell Insulators

Each cell shall be separately supported on PVC / Porcelain / Hard rubber insulators fixed on the racks with adequate clearances between adjacent cells. Minimum distance between adjacent cell shall be more than the bulge allowed for two cells in accordance with relevant IS standard.

f) Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS: 266 and distilled water conforming to IS: 1069 for lead

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acid batteries and battery grade potassium hydroxide for Ni-Cd batteries. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately in a separate non-returnable container. 10% extra electrolyte shall be furnished to cover spillage in transit or during erection.

g) Connectors and Fasteners

Lead or Lead coated copper connectors (For Lead acid Plante Type batteries) and Nickel coated copper connectors (for Ni-Cd batteries) shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated/Nickel coated to prevent corrosion. The thickness of lead coating of connectors should not be less than 0.025 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulated shrouds. End take-off connections from positive and negative poles of battery shall be made by single core cables having stranded aluminum conductors and XLPE insulation. Necessary supports and lugs for termination of these cables on battery shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 30 minutes discharge current of the respective battery and through fault short circuit current which the battery can produce and withstand for the period declared. Suitable number of inter rack connectors shall be supplied by the bidder to suit the battery room layout during the detail engineering.

h) Battery Racks

Steel racks with anti-corrosive epoxy paint for all the battery shall be provided. They shall be free standing type mounted on porcelain / hard rubber / PVC pads insulators. Battery shall be located in the single tier arrangement. However battery having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The battery rack and support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

i) Manufacturer's Identification Systems

The following information shall be indelibly marked on outside of each cell:

- i. Manufacturer's name and trade marks
- ii. Country and year of manufacture
- iii. Manufacturer type of designation
- iv. AH capacity at 10 hour discharge rate
- v. Serial number

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1.4.2 Constructional Requirements of battery charger

- a) The Charger shall be indoor, floor mounted, self supporting sheet metal enclosed cubicle type. All necessary base frames, anchor bolts and hardware shall be supplied. The charger shall be fabricated using cold rolled sheet steel shall not less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied. The lugs for cables shall be made of electrolytic copper with tin coat. The chargers shall be tropicalised and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The chargers shall have hinged double leaf doors provided on front / or backside for adequate access to the charger internals. All the charger cubicle doors shall be properly earthed. The degree of protection of charger enclosure shall be at least IP-42.
- b) All indicating instruments, control and selector switches and indicating lamps shall be mounted on the front side of the charger.
- c) Electronic equipments shall be of modular design consisting of plug in modules in standard 19 inches metallic racks with metallic card guides. The cards should be provided with proper handles. Card to card wiring should be preferably through a motherboard. Unplanned jumpering and track modifications are not permitted and track modifications are not permitted. Mechanical interlocks to prevent wrong insertion of cards should be provided. Each card shall have its junction and test points identified. Maintenance aids such as extension printed wiring boards and jumper leads shall be provided.
- d) The layout of charger equipment shall be such that their heat losses do not give rise to excessive temperature within the charger panel surface. Location of the electronic modules shall be such that temperature rises of the location, in no case, shall exceed 10°C over ambient air temperature outside the charger.
- e) Printed Circuit Boards (PCB)
PCB shall be made of glass epoxy of 1.6 mm thick, fire resistant, bonded with 99.8% pure copper foil, free of wrinkles, blisters, scratches and pinholes. The contact surface of the edge connectors of the PCBs shall be plated with hard gold to a minimum thickness of 5 microns. Component identification shall be printed on PCB by silk screen method. All PCBs shall be tropicalised and masked.
- f) Contactors

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All battery chargers shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. The operating coil shall be rated for 415 Volts AC.

g) Thermal Overload Relay

A thermal overload relay incorporating a distinct single phase protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

h) Rectifier-Transformer and Chokes

The rectifier-transformer and chokes shall be dry and air cooled (AN) type. The rating of the rectifier transformers and chokes shall correspond to the rating of the associated rectifier assembly. The rectifier-transformers and chokes shall have class-B insulation with temperature rise limited to class A insulation value.

i) Rectifier Assembly

The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective charger. The rectifier cells shall be provided with their own heat dissipation arrangement with natural air cooling. The rectifier shall utilize diodes / thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink shall not be permitted to exceed 85 °C absolute duly considering the maximum charger panel inside temperature. Calculations to show what maximum junction temperature shall be and what the heat sink temperature shall be when operating at 200% and 100% load current continuously duly considering the maximum surrounding air temperature of 50°C outside the panel have to be submitted. Necessary surge protection devices and rectifier type fast acting fuses shall be provided in each arm of the rectifier connections.

1.4.3 System Concept for 220 V DC system

- a) First float cum boost charger shall be normally ON in float mode, supplying the D.C. load and at the same time trickle charging the battery and shall (a) provide occasional equalizing charge (b) boost charge the battery up to 2.7/1.7 Volts per cell as required.
- b) The characteristics shall be such that if load is high and exceeds the charger capacity, the excess load shall be supplied by the battery.
- c) The second float-cum-boost charger shall be normally in stand-by (auto float/charge) mode and shall come into the circuit automatically (a) to take over the functions of first float cum boost charger in case of its failure (b) to provide occasional equalizing charge as required, (c) boosting charge the battery up to 2.7/1.7 Volts per cell.

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- d) The float-cum-boost charger shall also have provision for float, equalizing, and boost charging the battery through manual selection. On failure of station A.C. supply, float-cum-boost charger shall go out of service and battery shall take over to supply emergency loads.

1.4.4 Operational requirements of charger

- a) The float-cum-boost charger shall be sized to restore the fully discharged battery to full charge condition in ten (10) hours with 10% margin over maximum charging rate and also to operate as a float charger.
- b) The batteries & chargers shall be so designed that the maximum fault level on DC DB is limited to 15KA (Indicative only; the actual value shall be decided by the contractor after substantiating the same by calculation.)
- c) The battery shall be trickle charged at 2.15 to 2.25 V per cell and 1.4 to 1.42V per cell for lead acid and Ni-Cd battery respectively. All chargers shall also be capable of boost charging the associated battery at 2.0 to 2.7 V per cell for lead acid and 1.53 to 1.7V for Ni Cd at the desired rate. The chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50 °C.
- d) Necessary interlocks shall also be provided to avoid accidental boost mode operation when loads are connected to the bus.
- e) The battery chargers as well as their automatic regulators shall be of static type. Battery chargers shall be capable of continuous operation at the respective rated load in trickle mode i.e. trickle charging the associated lead acid battery/Ni-Cd battery while supplying the DC loads.
- f) Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle / float or Boost charging.
- g) All battery chargers shall be provided with facility both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage / current control, whether automatic or manual. Means shall be provided to avoid current / voltage surges of harmful magnitude/ nature which may arise during changeover from Auto to Manual mode or vice versa under normal operating condition.
- h) Soft start feature shall be provided to build up the voltage to the set value slowly within fifteen (15) seconds. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the charger nor shall it cause blowing of

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any of the charger fuses. The charger shall not trip on overload or external short circuit. After clearance of fault, the charger voltage shall build up automatically when working in automatic mode.

- i) When on automatic control mode, during trickle / float charging, the charger output voltage shall remain within (\pm) 1% of the set value for AC input voltage variation of (\pm) 10%, frequency variation of (+) 3 / (-) 5%, a combined voltage and frequency variation of 10% (absolute sum) and a continuous DC load variation from zero to full load. Uniform and step less adjustment of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire trickle / float charging output range specified. Step less adjustment of the load limiter setting shall be possible from 80% to 100% of the rated output current for trickle / float charging mode.
- j) During boost charging, the battery chargers shall operate on constant current mode (when automatic voltage regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50% to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be vernier type.
- k) Energizing the chargers with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere shall be less than fifteen (15) seconds.
- l) Momentary output voltage of the charger, with the battery connected shall be within 94% to 106% of the voltage setting during sudden load change from 100% to 20% of full load or vice versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above mentioned change.
- m) The charger manufacturer may offer an arrangement in which the voltage setting device for trickle/ float charging mode is also used as output voltage limit setting device for Boost charging mode, and the load limiter of the trickle / float charging mode is also used as Boost charging current setting device.
- n) Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.

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1.4.5 Auxiliary Equipment

- a) DC Voltmeter, DC ammeter and AC voltmeter in 96 mm square shall be provided for each charger. The instruments shall be 240 scale, antiglare glass, flush mounted type, dust proof and moisture resistant. The instrument shall have easily accessible means from zero adjustments. The instruments shall be of 1.5 accuracy class.
- b) In addition to above, following metering provision shall be given for remote metering / recording at PLC/DCS
 - i. Battery Voltage
 - ii. DC voltage of float & Boost charger
 - iii. DC current of float & Boost charger
 - iv. DC load voltage
 - v. DC load current
 - vi. DC Voltage and Current at FCBC
 - vii. Centre Zero Ammeter with Shunt to read Discharge/Charge current
 - viii. Ammeter for Battery Trickle Charge current
 - ix. DC Bus Voltmeter indicating - +ve to Earth, -ve to Earth and +ve to -ve with Selector switch.

The following indications shall be provided

- i. AC Supply – R,Y,B Healthy
- ii. DC supply – Available
- iii. Charger in Float Mode
- iv. Charger in Equalising mode
- v. Charger in Boost mode
- vi. Charger tripped on fault
- vii. D.C Earth fault sensing & alarm

Suitable soft link to be provided for interfacing with DDCMIS.

c) Air Break Switches

All chargers shall have AC input and DC output switches of air break, single throw, load break and fault make type. The contacts of the switches shall open and close with a snap action. Switches shall be rated for 120% of maximum continuous load. 'ON' and 'OFF' position of the switch shall be clearly indicated.

d) Control and Selector Switches

Control and selector switches shall be rotary, stay put type with escutcheon plates showing the functions and positions. The switches shall be of sturdy construction and suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred. The contact ratings shall be at least the following:

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- i. Make and carry continuously - 10 Amps
- ii. Breaking current at 220V DC - 0.5 Amp (inductive)
- iii. Breaking current at 240V AC - 5 Amp. at 0.3 p.f.

e) Fuses

Fuses shall be of HRC cartridge fuse link type. Fuses shall be mounted on fuse carriers which are mounted on fuse bases. Wherever it is not possible to mount fuses on fuse carriers, fuses shall be directly mounted on plug in type bases. In such cases one insulated fuse pulling handle shall be supplied for each charger. Kick-off fuses (trip fuses) with alarm contacts shall be provided for all DC fuses.

f) Indicating Lamps

Three (3) indicating lamps shall be provided to indicate AC supply availability. The indicating lamp shall be of panel mounting, LEDs and capable of clear status indication under the normal room illumination. The lamps shall be replaceable from front. The lamp covers shall be preferably screwed type, unbreakable and moulded from heat resistant material.

g) Blocking Diode

Blocking diode shall be provided in the output circuit of each charger to prevent current flow from the Battery into the charger.

h) Annunciation System

Following annunciation shall be provided for local and remote indications in all chargers(List is indicative only)

- i. AC supply failure
- ii. Rectifier fuse failure
- iii. Surge circuit fuse failure
- iv. Filter capacitor fuse failure
- v. Load limiter operated
- vi. Charger fail / trip
- vii. Battery on Boost
- viii. Battery on Trickle
- ix. DC output fuse failure
- x. Positive grounded
- xi. Negative grounded
- xii. Battery fully discharged
- xiii. AC input under voltage
- xiv. DC voltage low
- xv. DC voltage high
- xvi. DC system earth fault

The annunciation system shall have audio-visual arrangement and shall incorporate acknowledge, reset and test push buttons. On occurrence of fault, the corresponding window lights up and shall stay in lighted

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condition till the fault is cleared and the reset push button is pressed. At least 20% spare annunciation windows with accessories shall be provided.

i) Lamp / Space Heaters / Receptacles

The charger panels shall be provided with:

- i. Internal illumination lamp with door switch.
- ii. Space heater with thermostat control.
- iii. 3-pin 5A receptacle with plug.
- iv. Lamp, heater and receptacle circuits shall have individual switch fuse units/MCB.

1.4.6 Battery Accessories

Each battery shall be furnished complete with following:

- a) First charge of electrolyte plus 10% extra.
- b) Teak wood racks with 3 coats of anti-acid paints.
- c) Stand insulators 5% extra.
- d) Cell inter-connectors 5% extra and one extra end take-off.
- e) Lead-coated connection hardware 5% extra
- f) Cell numbering tag with fixing arrangements
- g) Insulated cable clamps with hardware
- h) Six (6) extra cell with all accessories but without acid
- i) In addition to the above each battery shall be furnished with a set of following accessories.
- j) One (1) Interconnector bolt wrench
- k) One (1) Hydrometer syringe
- l) One (1) Thermometer with specific gravity correction scale.
- m) One (1) Cell testing voltmeter with leads.
- n) One (1) Pocket thermometer
- o) One (1) set of Acid resisting funnels
- p) One (1) set of Acid resisting jugs of adequate capacity
- q) One (1) set of Rubber aprons
- r) One (1) set of Rubber gloves
- s) PVC spill trays under the battery cells
- t) Spanner for cells

Catalogues and Instruction manuals of battery and battery charger to be furnished.

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1.4.7 Painting

- a) All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.
- b) After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality lead oxide primer and stoved after each coat.
- c) The equipment shall be finished in Siemens Gray RAL: 9002 color with two coats of epoxy based powder coated paint except end covers and RAL 5012 for end covers. The coating shall be done electro statically followed by stoving.
- d) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.8 Installation

- a) The battery room floor shall be acid resistant type and walls shall have acid resistant tiles up to a suitable height. Alternatively acid resistant paints are also acceptable. Adequate ventilation shall be provided in the battery room for the removal of hydrogen.
- b) The Battery charger along with D.C. distribution board shall be located in separate rooms.
- c) After erection and connection of the Battery Charger, the contractor shall complete the charging discharging cycles recommended by the manufacturer. The contractor shall rig up a suitable discharge resistor for this purpose.
- d) Connection from Battery terminals shall be made by means of cables. Lead coated terminal connector shall be furnished for this purpose.

1.5 Tests

1) Type Test

For each type of Battery and battery charger, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

All Battery, Battery chargers, Inverters and its components thereof shall be subject to shop tests as per relevant IS/IEC standards. The tests on Battery chargers shall include but not limited to the following:

- a) Voltage regulation check from 0 to 100% loads with $\pm 10\%$ input voltage variation.
- b) Ripple content measurement.
- c) D.C short circuit test to prove ability of current limit.
- d) Measurements of transient overshoot/undershoot during switching ON/load throw-off.
- e) Current limiter operation.
- f) Special tests for electrical equipment, when specified in relevant Indian / International standard shall be carried out on at least one item of each rating.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports. Drawings, Data & Manuals:

1.6

Drawings, Data & Manuals

1. Following drawings/ data and Manuals to be submitted for approval:

- a) [Dimensional battery layout diagram and plan & section.
- b) Connection details of take-off terminals.
- c) Dimensional general arrangement drawings of battery charger clearly showing device dispositions, cable entry, space requirement, etc.

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- d) Sectional views of battery charger.
- e) Charger foundation plan and loading.
- f) Charger schematics and wiring diagrams.
- g) Test reports
- h) Detailed bill of materials
- i) Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.
- j) Instruction manuals of battery and battery Charger. The manual shall clearly indicate method of installation, check-ups, and tests to be carried out before commissioning of the equipment.
- k) Bidders shall note that the drawings, data and manuals listed herein are minimum requirements only. The Bidders shall ensure that other necessary write-ups, curves and information required to fully describe the equipment are submitted with their bids].

1.7 Rating and Requirement

S.No	Technical Particulars	Unit	Parameters	Remarks
1.0	General			
1.1	Bidder's Name			
1.2	Make			
1.3	Application		[For Main plant/BOP]	
2.0	Battery			
2.1	Make and country	:	[By bidder]	
2.2	Type	:	Lead acid(Plante)/Ni Cd	
2.3	Reference standard		As specified in specification	
2.4	Rated system voltage	: (Volts)	220V DC	
2.5	Rated capacity for one hour discharge at 27°C	: (Ah)	[As per project specific]	
2.6	Rated capacity for 10 hour discharge rate at 27°C	: (Ah)	[As per project specific]	
2.7	Nominal voltage per cell	: (V)	2.2V /1.42V	
2.8	End cell voltage	: (V)	1.85/1.14V	
2.9	Number of cells per battery	:	Based on type of battery.	
2.10	Short circuit current	: (kA)	[By bidder]	
2.11	Mounting type	:	[By bidder]	

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S.No	Technical Particulars	Unit	Parameters	Remarks
2.12	AH efficiency at rated load	: (%)	[By bidder]	
2.13	Watt hour efficiency	: (%)	[By bidder]	
3.0	Constructional details		[By bidder]	
3.1	Container			
a	Material			
b	Thickness	Mm		
3.2	Separator			
a	Type			
b	Material			
c	Thickness	Mm		
3.3	Electrolyte			
3.4	Quantity for first filling plus 10% extra			
3.5	Specific gravity at twenty seven (27) degree Centigrade			
a	With all cells fully charged			
b	At the end of discharge			
3.6	Method of supporting elements		[By bidder]	
a	Edges of plates and Inner surfaces of container	Mm		
b	Bottom of negative plates	Mm		
c	Top of plates	Mm		
d	Sediment space	Mm		
3.7	Weather explosion-proof cent plugs are provided		[By bidder]	
3.8	Distance between centre's of cells when erected	mm	[By bidder]	
3.9	Expected life span of battery	Year	[By bidder]	
3.10	Proposed Layout (attach layout)		[By bidder]	
4.0	Battery Charger			
4.1	Number of rectifiers	:	[By bidder]	
4.2	Reference standard	:		
4.3	Make and country			
4.4	Type	:		

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S.No	Technical Particulars	Unit	Parameters	Remarks
4.5	Rectifiers with thyristors Y/N	:	[By bidder]	
4.6	Rated input AC voltage	: (V)	415V, 3ph, 4 wire	
4.7	Frequency	: (Hz)	50	
4.8	Output DC current	: (A)	[By bidder]	
4.9	Rectifier efficiency	: (%)	[By bidder]	
4.10	DC voltage setting adjustment of AVR for float charging		[By bidder]	
4.11	Boost mode:		[By bidder]	
a	Starting rate	: (V)		
b	Finishing rate	: (V)		
4.12	Protection class of cubicles	:		
4.13	Residual ripple	: (%)	[By bidder]	
4.14	Current limiting feather provided	: (Yes/No)	[By bidder]	
4.15	Soft starting feather provided	: (Yes/No)	[By bidder]	
4.17	Voltage and current setter in different mode provided	: (Yes/No)	[By bidder]	
4.18	Type of cooling	:	Natural	
4.19	Paint shade: Indoor and outdoor		[RAL 5012]	
5.0	Constructional details		[By bidder]	
5.1	List of major accessories			
5.2	Diode			
a	Make			
b	Type			
c	Rating			
d	Voltage	V		
e	Current	A		
5.3	Rectifier Transformer			
a	Make			
b	Rating	kVA		
c	Connection			
	Primary Winding			
	Secondary Winding			

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S.No	Technical Particulars	Unit	Parameters	Remarks
d	Voltage			
	Primary Winding	V		
	Secondary Winding	V		
e	Percentage of tap provided			
	Primary Winding	%		
	Secondary Winding	%		
5.4	Control/ Selector switch			
a	Make			
b	Type designation			
c	Voltage Grade	V		
d	Current rating	A		
e	Make and carry			
f	Brake			
g	Spring return or stay out			
h	Type of handle			
i	No. of positions			
j	No. of poles/ ways			
k	Angular Movement			
m	Special features if any			
5.5	Indicating Lamp			
a	Make			
b	Type			
c	Voltage	V		
d	Series resistor value	Ohm		
6	Thickness of battery charger panel sheet steel;	Mm		
5.6	Weight & dimensions		[By bidder]	
a	Length	Mm		
b	Depth	Mm		
c	Height	Mm		
d	Weight	Kg		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E7
TECHNICAL SPECIFICATION FOR HV CABLES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E7

1.0 HV CABLEs

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of HV cables complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part II)	:	XLPE insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques
IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the

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		cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All HV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The HV power cables shall be 6600V unearthed grade, single/multi core stranded Aluminum conductor, extruded XLPE insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-2). These cables shall conform to IS 7098 (Part II).
- d) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- e) HV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- f) HV cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)
 - v. Installation conditions.
 - vi. Voltage drop under normal running and starting condition
 - vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
 - viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
 - ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.

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1.4 Specific Requirements

1.4.1 Type of Cable

a) HV cables shall be 6600V unearthed grade, heavy duty, stranded aluminium conductor, XLPE insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-2) cables conforming to IS: 7098 part II.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum to form compact conductor having a resistance within the limits specified.

1.4.3 Conductor Shield

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be provided over the conductor by applying non metallic semi conducting tape or by extrusion of semi conducting tape or by extrusion of semi-conducting compound or a combination of the two. The semi conducting polymer shall be cross linked for XLPE cables.

1.4.4 Insulation

The insulation of the HV cables shall be XLPE type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

1.4.5 Insulation Shield

A non magnetic semi conducting shield shall be put over the insulation to confine electrical field to the insulation. The XLPE cable insulation shield shall be strippable.

The metallic layer of the insulation shield shall be grounded at least at one location in the cable's run. In the case of single conductor cable, care should be taken with regard to ampacity when grounding at more than one point.

For all the cables having insulation shield, it shall have some form of stress relief measure at every splice at termination. This can be stress cones, moulded devices, heat shrink or cold shrink kits. All kits must be suitable for the voltage class and cable size.

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1.4.6 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.7 Armour

HV cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.8 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.9 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than 500m or as per required length.

1.4.10 Identification of cores:

HV power cables shall be identified by color code.

1.4.11 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers

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shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.

b) Workmanship shall be neat, clean and of the highest grade.

c) Special Properties:

All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:

- i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
- ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
- iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
- iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
- v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
- vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
- vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.12 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.13 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]
- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.

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- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.4.14 Fire Proof sealing system

- i) General
 - a) Fire proof sealing system shall consist of Fire-stops/fire-seals for sealing of cable/cable tray and conduit/pipe penetrations, both horizontal and vertical, through brick or RCC walls/floors, to prevent the spread of fire from one area, which is separated from others by fire-resistant barriers.
 - b) 'Fire-breaks' provided on long runs of cable racks/trays to prevent the propagation of fire along the cable rack, within a single fire-area or fire- zone.
 - c) The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop/fire-break.
 - d) The FPS system shall comply in all respects with the requirements of the codes and standards listed below

IEEE-634 ASTM-E-814

ANSI-IEEE-383 IEC-331 IEC-332

ii) Fire stop/ seal

The FPS system adopted for cables or cable trays penetrating through walls and floor constitute a openings, or cables passing through embedded conduits / pipes / pipe- sleeves, fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

iii) Fire Break

The fire proofing system, other than fire-stops, adopted to retard flame propagation long runs of horizontal or vertical cable trays in the same fire zone or area, in an event of a fire, shall constitute a 'fire-break' and shall be provided by applying a suitable fire –resistance coating on cables and cable trays for the required length, with or without a fire resistant panel, at the point of the fire break to obtain the fire-rating specified.

iv) Application of fire proof sealing system

Fire stops shall be provided for cable penetration openings listed below

The passage of cables/cable trays pipe sleeves/embedded conduits through walls / floors.

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Vertical raceways, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

Cable entry through openings in floor slabs below HT/LT switchgear, MCCs, various Control and relay panels and other bottom entry panels, shall be effectively sealed by fire stop

Location of fire breaks

Firebreaks shall be provided on both cable rack and trenches at all cable tray Intersections and tee-offs.

On linear runs of cable trays between fire stops or fire breaks, fire breaks shall be provided at intervals of 15 metres on horizontal cable runs and 5 m on vertical cable runs.

Fire breaks in linear runs of cable trenches between intersections and tee-offs shall be provided at intervals of 30 metres.

Bidder shall furnish the test certificates for the fire stops and fire breaks after award of contract for Owner/Owner's Representative review. If the certificates are not satisfactory all the tests shall be conducted free of cost. The offered system i.e. fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Owner / Owner's Representative.

v) Test on fire stops

The fire stops shall be subjected to the following type tests:

- a. Fire Rating Test
- b. Hose Stream Test

Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

Preconditioning of fire stop test specimens before conducting the fire rating and hose stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the fire rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable

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penetration fire stop, with a maximum temperature limit on the unexposed surface of 200°C.

Tests on fire breaks

Firebreaks shall undergo the following tests as per ANSI-IEEE-383:

- Ampacity test
- Flame test

1.5 Tests

1.5.1 Type Test

For each type & rating of HV cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 H.V. Power cable, 6600V unearthed grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		6.6 V	
2.	Voltage Grade		6.6/6.6kV Unearthed	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE cables		90°C	
5.	Maximum conductor temperature for		250°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE cables			
6.	Conductor		Aluminum	
7.	Insulation		XLPE	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		Armoured	
11.	System Grounding		Resistance Grounded	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		40 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E8
TECHNICAL SPECIFICATION FOR LV CABLES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E8

1.0 LV CABLES

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV cables for power & control applications complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS:1554(Part I)	:	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100V
IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part I)	:	XLPE insulated PVC sheathed cables for working voltage up to 1.1kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques

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IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All LV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The LV power cables shall be 1100V grade, single/multi core stranded Aluminum conductor, extruded XLPE/PVC insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1). These cables shall conform to IS 7098 (Part I) for XLPE and 1554(part 1) for PVC insulation.
- d) The control cables shall be 1100 V grade, multi core, stranded annealed high conductivity copper with extruded PVC insulated inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1).
- e) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- f) The continuous and short time current carrying capacity of PVC insulated cables shall be based on maximum operating temperature of 70°C and 160°C respectively.
- g) LV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- h) Power cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)

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- v. Installation conditions.
- vi. Voltage drop under normal running and starting condition
- vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
- viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
- ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.
- x. The minimum size of cables to be used shall be as follow :
 - Aluminium conductor : 6 Sq. mm.
 - Copper conductor : 2.5 Sq. mm

1.4 Specific Requirements

1.4.1 Type of Cable

- a) LV power cables shall be 1100V grade, heavy duty, stranded aluminium conductor, XLPE/ PVC insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS: 1554(Part 1) for PVC insulation and IS 7098(Part 1) for XLPE insulation.
- b) Control Cables shall be 1100 V grade, heavy duty with annealed high conductivity stranded copper conductor, PVC insulated, FRLS PVC inner sheathed, armoured and FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS : 1554.
- c) LV power cables of size above 35 sq. mm may be provided with XLPE insulation. Bidder shall clearly indicate the type of insulation provided in the technical bid.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum for LV Power cables and Copper for control cables to form compact conductor having a resistance within the limits specified. All the cables of size 25mm² and above shall have sector shaped conductors.

1.4.3 Insulation

The insulation of the LV power and control cables shall be [XLPE/PVC] type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

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1.4.4 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.5 Armour

LV power and control cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.6 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.7 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than the following:

- a) Power cables: 500m
- b) Control cables: 1000m

1.4.8 Identification of cores and spares:

LV power cables shall be identified by color code. However LV control cables shall be identified by the number of its cores.

[Multi-core control cables shall have 20% spare core, minimum one spare.]

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1.4.9 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.
- b) Workmanship shall be neat, clean and of the highest grade.
- c) Special Properties:
All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:
 - i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
 - ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
 - iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
 - iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
 - v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
 - vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
 - vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.10 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.11 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]

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- b. Voltage grade*
- c. Year of manufacture*
- d. Type of insulation.*
- e. Type of outer sheath e.g. "FRLS" etc.*
- f. ISI marks*
- g. Nominal cross sectional area of the conductor & no of cores*
- h. Sequential marking*
- i. Owner's identification mark]*

1.5 Tests

1.5.1 Type Test

For each type & rating of LV power and control cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 L.V. Power and control cables, 1100 V grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		415 V	
2.	Voltage Grade		1.1 kV	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE/PVC cables		For XLPE: 90°C For PVC: 70°C	
5.	Maximum conductor temperature for		For XLPE: 250°C For PVC: 160°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE/PVC cables			
6.	Conductor		For power cable: Aluminum	
			For Control Cable: Copper	
7.	Insulation		For power cable: XLPE/PVC	
			For Control Cable: PVC	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		For power cable: Armoured	
			For Control Cable: Armoured	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
11.	System Grounding		415 V system is solidly grounded.	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		50 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E9

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E9

1.0 ILLUMINATION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Illumination System complete with luminaries and all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS 1913	:	Electrical lighting fittings- General and safety requirements
IS 2418 - Part I	:	Tubular fluorescent Lamp
IS 3480	:	Flexible steel conduits for electrical wiring
IS 3646 (Part I to III)	:	Code of Practice For Interior Illumination
IS 4012	:	Dust proof electric lighting fittings
IS4013	:	Flame proof enclosure
IS 6665	:	Code of practice for industrial lighting
IS 5077	:	Decorative light fittings
IS 9537 - Part II	:	Rigid steel conduits for electrical installations

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IS 9583	:	Emergency lighting units
IS 9900	:	High pressure mercury vapor lamp
IS 9974	:	High pressure sodium vapor lamp
IS 10322	:	Luminaries for street lighting
CBIP Manual	:	Substation Equipment, Illumination and Layouts
IES (Illuminating Engineering Society of North America)	:	Application and Reference Volume
IEC 60598	:	Luminaries
CEA	:	CEA regulations and standard technical specification.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All illumination systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The illumination systems shall be suitable for operation in a highly polluted environment.
- b. Lighting fixtures shall be suited for the following range of frequency and voltage variations:
 - i. Voltage Variation : $\pm 10\%$
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

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- c. All emergency DC lighting systems shall be suited for voltage variation from -15% to + 10% of rated voltage.
- d. The design of the lighting systems shall be such that it shall ensure average lux levels specified for different areas.
- e. The illumination system shall comprise of the following:
 - i. Normal AC lighting
 - ii. Normal cum emergency lighting system
 - iii. 220V DC Emergency lighting system
 - iv. Maintenance 24V AC lighting system
 - v. Portable emergency lights with self contained battery packs.

1.4 Specific Requirements

1.4.1 Scope of work

The scope of work shall include design, preparation of Lighting design and manufacture, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with Lighting system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Switchgear room and cable gallery.
- iv) All roads within battery limit.
- v) Perimeter and boundary illumination of the above premises.
- vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room and cable gallery.
- v) FOPH area.
- vi) Transfer towers & Conveyor galleries.
- vii) All roads within battery limit.
- viii) Perimeter and boundary illumination of the above premises.

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- ix) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- c) Balance of plant Area:
 - i) Lighting system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- e) AHP Area:
 - i) Switchgear rooms.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard control room
 - ii) GIS building (if applicable)
 - iii) Transformer area
 - iv) All roads within battery limit.
 - v) Perimeter and boundary illumination of the above premises.
 - vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

1.4.2 Illumination System Description

The plant illumination system shall comprise of the following categories:

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a. Normal AC lighting

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply from the normal lighting distribution boards (LDB). All the lighting fixtures connected to this system shall be available as long as the 415V station / unit auxiliary service supply is available.

b. Normal cum emergency lighting system

Certain lighting fixtures considered essential shall be connected to this system. In this system the lighting circuits shall be fed from lighting distribution board connected to 415V Normal cum Emergency Switchgear. The lighting fixtures connected to this system shall be available whenever normal supply is available in the plant and also whenever DG set supplies the power to 415V Normal emergency switchgear.

These lighting fixtures will go off for a few seconds when normal supply fails but will be automatically restored when the emergency AC bus is re-energized by automatic transfer to standby DG supply.

[20% of the total fittings shall be fed from Emergency lighting for areas such as Switchgear room and control rooms etc.]

c. Emergency 220 V D.C. Lighting

The Emergency DC Lighting System shall be located strategically in critical operating areas and at emergency exits. Emergency DC lighting shall also be provided in the Control rooms, Switchgear/ MCC rooms and other strategically important areas. These fixtures shall be fed from respective Emergency DC Lighting Panels. The Emergency DC Lighting Panels (DC ELLP) shall be fed from 220V DC Distribution Boards (DCDB).

These lights shall remain normally OFF but on failure of AC supply these lights shall be automatically ON. Tube lights with Electronic choke suitable for 230 V, AC / DC operation or other Energy Efficient Lamps may be used for DC emergency lighting.

d. Maintenance 24 V AC Lighting System

For lighting facilities comprising portable hand lamps and/or connection of portable hand tools etc., required during the routine maintenance work, 24V single phase 3 pin sockets with switches shall be provided at selected points in the areas listed below. Such sockets for routine maintenance shall be clearly identified by colour coding in order to distinguish them from the normal 240V power outlets. Necessary outlets shall be made on the inside walls of the building near equipments.

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- i. Boiler area: Near inspection manholes on the boiler platforms and near boiler drum at different levels on all four sides.
- ii. TG building: Near HP & LP heaters, turbine flash tank, blow down tank, near condenser water box and near bus duct termination of generator end.
- iii. ESP columns: Near inspection manholes
- iv. Near de-aerator.
- v. Cable galleries.

Any other areas considered necessary identified during detailed engineering.

e. Portable Emergency Lights

This system shall be provided by portable self-contained battery / automatic charger / inverter fed compact fluorescent lamps in isolated buildings / areas where station D.C. supply is not available. These portable emergency light units shall be switched on automatically on loss of normal AC supply. *[Battery packs for portable emergency lights shall be rated for minimum 3 hours duty and the battery shall be of Ni-Cd.]*

f. Exit lights

Emergency escape signs shall be provided at the exit doors, escape routes, intersection corridors, at different floor levels/directions, windowless rooms, toilets, firefighting equipment, lifts, control rooms, switchgear rooms and the areas considered necessary by bidder. *[9W CFL]* lamp shall be used for exit lamps.

The contractor shall design emergency exit lighting system based on plant layouts and install escape lights at suitable locations considering the various escape routes. Emergency exit lights will be fed from normal-cum-emergency lighting panel, wherever available, *[and will be with in-built battery (Ni-Cd) back up of 3 hours operation.]*

1.4.3

Illumination Calculation

- a. Standard Lumen method shall be adopted for interior and exterior lighting in order to determine the number of lighting fixtures for obtaining the desired average level of illumination.
- b. The coefficient of utilization shall be considered to take care of Lumen loss due to:

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- i. Effect of room dimensions.
 - ii. Absorption of light in luminaries.
 - iii. Absorption of light at various room surfaces i.e. ceiling wall etc.
 - iv. Floor cavity, ceiling cavity.
 - v. Mounting height.
- c. Moreover a maintenance factor shall also be considered to account for the fall of illumination due to aging, pollution like dust deposits etc.
 - d. Voltage drop at the fixture terminals from the MLDB shall [not exceed 3%]. Circuit loading of each lighting Panel shall be done in such a way that almost balanced loading in all the phases i.e. R, Y and B is achieved. At least two sub circuits shall be used for illumination of a particular area. Sub circuit loading of each lighting panel shall be restricted to 2000 Watts.
 - e. Design of lighting system shall be such that the average lux level as specified is achieved. The Bidder shall submit illumination calculation/layout for the purchaser's review.

1.4.4 Lighting Distribution System

- a. Separate lighting transformers shall be provided inside the lighting distribution boards located at required location. Lighting distribution system shall be distinct and separate from the LV main distribution. Lighting transformers shall be encapsulated cast resin dry type.
- b. AC lighting panels shall have 240V single-phase, 2 wire incomer controlled by earth leakage circuit breaker and number of single phase outgoing circuits controlled by MCBs. The lights connected to a circuit or few circuits shall be 'ON' automatically through photocell for outdoor lighting. Provision shall be made for switching 'ON' the rest of the lights. Lighting fixtures in indoor areas shall be controlled from the respective lighting panels
- c. Normal 240 V AC Lighting System
For this system, lighting points shall be supplied at 240 V AC through 415 V, 3-phase, 4-wire, 50 Hz, LDB. The supply shall be derived from 415 V, 3-phase, 4-wire, 50 Hz switchgear through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant. Different circuits shall be used from different source. The whole lighting network shall be balanced as far as possible.
- d. Normal/Emergency 240V AC System
For these systems, the distribution shall be by 415V, 3-phase, 4-wire, 50 Hz supply. This supply shall be derived from 415 V, 3-phase, 4-wire, 50

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Hz normal emergency switchgear for NE & lighting through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant.

e. Emergency 220 V DC Lighting System

The power supply shall be obtained from the nearest 220 V DC switchboard. DC lighting panel will have one (1) incomer controlled by double pole MCB, Outgoing circuits will be controlled by DP MCB. Upon failure of the normal-cum-emergency AC supply, emergency DC lighting fixtures will be made automatically ON. The change over in the reverse direction shall also be automatic.

f. Maintenance 24V AC Lighting System

24 V AC supply for maintenance purposes (for hand lamps and/or hand operated tools) shall be supplied from 24 V AC distribution panel, which receives 240 V power supply from 415 V/240V transformer modules of N/E switchgear. 24 V AC distribution panel consists of one incomer controlled by MCB, one 240/26.5 V dry type transformer of adequate rating and number of outgoing circuits controlled by MCB.

1.4.5 Illumination levels and choice of lighting fixtures

The area-wise distribution of average illumination levels and type of luminaries shall be as indicated below:

[Note: These are indicative only. However as per specific Existing project, Bidder may refer section I of this specification for exact details of type of fixtures.]

Table 2.0

Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
A - TURBINE GENERATOR BUILDING				
1.1	General (auxiliary equipment areas)	200	Industrial well glass fixture, dust & jet proof, die cast aluminium body, stove enamel finish, vitreous enamel reflector integral mounted control gear/industrial bulk head with integral mounted control gear.	1x70 W/ 1x150 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.2	Cable vault	100	Industrial type FTL with vitreous enamel reflector	Energy Efficient FTL
1.3	All switchgear room area (including off-site building control room)	250	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.4	TG Building operating floor	250	Industrial high bay with anodized aluminium reflector with all accessories including control gear	1x400 W Metal Halide lamp
1.5	Unit control room and Switchyard control room	400	Decorative recessed with wide angle mirror optic antiglare type	Energy Efficient FTL
1.6	Battery rooms	150	Corrosion-proof	Energy Efficient FTL
1.7	TG building ground, mezzanine floor and misc. floors	200	Industrial well glass with integral control gear	1x150 W/ 1x250W Metal Halide lamp
1.8	Air washer room and A/C plant room	200	Totally enclosed vapor proof with clear acrylic cover	Energy Efficient FTL
1.9	Unloading and maintenance bay	300	Industrial high bay with anodised aluminium reflector	250 W HPSV lamp (for mounting height > 9m)

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.10	Electrical laboratory, chemical laboratory etc. (air-conditioned)	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
B -	BOILER AREA			
1.1	Boiler area and platforms, ESP area and platforms	100	Dust proof / dust tight well glass fixture	70 W Metal Halide lamp
1.2	Feeder floor areas	150	Dust proof / dust tight increased safety well glass	70 W Metal Halide lamp
1.3	ESP control room	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
C -	VARIOUS OFF-SITE BUILDING			
1.1	Equipment room (pump house)	200	Industrial type with vitreous enamel reflector upto mounting height of 8 M	150 / 250 W HPSV lamp
1.2	Switchgear room	250	Industrial high bay for mounting heights above 8M	Energy Efficient FTL
1.3	Outside working areas	70	Flood light medium beam	250 W HPSV lamp
1.4	Stores	100	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.5	Fuel Oil Tank Farm	50	General Purpose flood light with weatherproof fixture	250 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.6	Fuel oil decanting pump house, Hydrogen storage area, Coal conveyor areas	150	Flame-proof well glass	1 x 70 W HPMV lamp
D -	GENERAL			
1.1	Corridors, walkways, staircase, etc.	100	Industrial type with vitreous enamel reflectors/channel mounted box type	Energy Efficient FTL/1 x 70 W HPMV lamp
1.2	Lockers, toilets, wash rooms, etc.	100	Channel mounted box type	Energy Efficient FTL
1.3	Elevator well	50	Industrial bulk head	1 x 100 W incandescent lamp
1.4	Building periphery lighting	50	Industrial well glass with integral mounted control gear/industrial bulk head with integral mounted control gear/flood light fittings with timer control	70 W HPSV lamp / 400 W HPSV lamp
1.5	Office Rooms	300	Decorative recessed type FTL	Energy Efficient FTL
1.6	Transformer yard and Switchyard	50 on equipment, 20 general	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
1.7	Street lighting	20	Street weatherproof fixture with timer control	150 / 250 W HPSV lamp
1.8	Parking area	70	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
E	DC LIGHT FITTINGS			

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.1	Control room	400	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp
1.2	Other areas	250	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp

1.4.6 Area wise distribution of Lighting system in plant

Area wise lighting distribution shall be as below:

Table: 3.0

Area/building	Percentage Distribution of Lighting		
	Normal	Normal & Emergency	220V DC
Turbine Generator Building (all the bays)	80%	20%	10%
Control rooms	80%	20%	10%
Boiler Area (Grade level & Platforms)	80%	20%	5%
Service building	90%	10%	5%
Various pump houses and electrical switchgear rooms such as AHP, CHP, FOPH switchgear room, etc.	90%	10%	5%
Electro static precipitator	90%	10%	5%
Switchyard and Transformer yard	80%	20%	5%

1.4.7 Lighting System Design

The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of

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lighting specified in following paragraph. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

a. Indoor Lighting

The recommended values of illumination level for various areas in the plant are indicated in the table above. Lighting layouts shall be designed such that the ratio of minimum to average illumination shall not be less than [0.6]. Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/buildings in the plant.

i. Maintenance Factor:

- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Industrial areas with normal interiors such as workshops, stores : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors such a crusher house and junction towers : 0.5

ii. Reflection factor for wall/ceiling

- White and very light colors : 0.7
- Light colors : 0.5
- Middle tints : 0.3
- Dark colors : 0.1

iii. The working plane shall be considered at 0.85 m from the floor level.

iv. The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1 meter.

b. Outdoor Lighting

- i) The recommended illumination levels for outdoor areas are indicated in the above table.
- ii) Mounting height, spacing of flood lights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.05.

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- iii) Maintenance factor shall be generally 0.6 under average conditions.
- iv) Flood lights for area lighting shall be mounted on building structures. For outdoor lighting i.e. around the power plant building and transformer yard provision to be made with 400W outdoor type lamps mounted on wall/structures.
- v) Automatic switching ON/OFF shall be shall be provided through timers/photo cells.
- vi) For road illumination inside the boundary limit lighting poles shall be provided and the distance between the poles shall not exceed 30m.
- vii) Aviation obstruction lights shall be provided on tall installations (Chimney, Cooling Towers etc) as per Airports Authority and international standards. Aviation warning lights shall be high intensity type-A flashing LED type with varying intensity for day and night.
- viii) In an area, the lighting fixtures shall be arranged in different phase / LPs such that even in case one lighting panel is faulty complete lighting is not affected. In any location the lighting shall be arranged from two phases.
- c. The circuit loading on each circuit shall be restricted to 80% of the MCB rating.
- d. The voltage drop from LDB and any fixture shall not exceed 3%.
- e. All lighting design calculations, layouts, conduit wiring diagrams, LDBs and LPs drawings and technical data sheets etc shall be furnished for Owner/ Owner's consultant's approval.

1.4.8 Lighting system equipment

- a. Lighting Distribution Boards (LDB) & Lighting Panels (LP)
 - i. The Lighting Distribution board shall be fed through 415V/433V lighting transformers with off circuit taps $\pm 5\%$ in steps of 2.5%. The lighting transformer shall be cast resin dry type , vector group of [Dy1], class F insulation with temperature rise limited to class F and shall be housed in a suitable enclosure. In general, the transformers shall conform to the specification covered under 'Service transformers. The lighting distribution boards shall consist of MCCB incomer and required number of double pole MCB controlled out going feeders to LPs. The LDB shall be designed for the required short circuit level of [20] kA. All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-52. Outdoor panels shall be weather proof type with IPW-55 protection. The

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thickness of sheet steel enclosures shall be CRCA, 2 mm minimum for load bearing and 1.6 mm for other members.

- ii. Number of outgoing feeders in each LDB shall be provided as per requirement including the minimum 3 nos spare feeders for "Purchaser use". Each outgoing MCB in LDB's shall be of 15 A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB
- iii. Individual control in office buildings shall be through single pole flush type switches/MCBs. In those areas where group controls are required, rotary switches shall be provided
- iv. External area lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers/photo cell.
- v. In high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder / platform / approach shall be provided for maintaining / replacement of light fittings.
- vi. Each of the LDBs shall be provided with voltmeter and ammeter along with selector switches, "SUPPLY ON" indicating lamps, etc. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.
- vii. Two ground pads with bolts and nuts shall be provided on each board for connection to 50x6/25x3 mm GS flat.

b. Lighting Fixtures and Lamps

- i) Fluorescent fixtures with electronic ballast shall be generally provided for a room height upto 5m. Type of fixture shall be industrial type with gasket, clear acrylic cover and enamelled reflector or decorative type to suit the aesthetics. For areas with false ceiling, recessed mounted decorative fixtures with mirror optic louvres shall be used. In control room / computer rooms, decorative mirror optic fluorescent light fittings with antiglare features shall be provided. The surface finish shall be smooth, unobtrusive and scratch resistant.
- ii) Reflector shall be of sheet steel or aluminium, minimum 20 SWG thick and securely fixed by fastening device of captive type.
- iii) Fixture shall be suitable for 19 mm conduit entry and 16 SWG GI earth wire connection.
- iv) Fixture shall be furnished complete with lamps and integrally mounted accessories. These shall include holders, ballast, capacitor, starter, ignitors (separate type) etc.

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- v) For corrosive areas, corrosion proof lighting fixture shall be provided. For hazardous areas, light fittings, conduits, junction boxes etc. shall have to meet the corresponding area classification requirement.
- vi) Medium bay or high bay type of lighting fixtures with HPMV/HPSV lamps shall be used depending on the mounting heights for indoor areas having room height more than 5m. Medium/ High bay fixtures shall be provided with vibration damper wherever required.
- vii) For areas like boiler and outdoor areas such as roads, street, transformer areas and open yards, weatherproof HPSV flood/ street lighting fixtures shall be used. For areas like boiler platforms, weatherproof well glass type HPSV fixtures with wire guards shall be used.
- viii) All type of fluorescent lamps including Compact Fluorescent Lamp (CFL) shall be bi-pin rotary type and either cool daylight or white.
- ix) Mercury / Sodium vapour lamp shall be colour corrected type with screwed cap.
- x) Lamps shall be suitable for use in position and capable of withstanding small vibrations.
- xi) Ballasts shall be of heavy duty, low loss and polyester-filled type with copper winding.
- xii) Ballasts for Mercury / Sodium vapour lamps shall be provided with suitable tappings to set the voltage within range specified.
- xiii) Ballasts shall be free from hum. Ballasts which produce humming sound shall be replaced, free of cost.
- xiv) In multi-lamp fixture, each lamp shall be provided with individual ballast.

c. Switches, Receptacles

- i. In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms, etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided
- ii. 240V, 50 Hz, 3 pin Power Receptacles (5A, 15A) shall be provided in all building/areas of the plant. Inside a building, receptacles shall be provided at interval of 30m or part thereof for hand tools, water coolers, exhaust fans etc. Inside each cabins at

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least two receptacles shall be provided and the same shall be indoor/outdoor/flameproof as per the location. Minimum 2 nos of 5A and 1 no 15A receptacles shall be provided in each room. Receptacles shall be heavy duty, complete with individual plug and switch as described below:

Table: 4.0

S.No.	Type	Description
1	RA	5A, 240V, 2 Pole, 3 Pin with third pin earthed - Suitable for flush mounting in office areas and control room. The switch shall also be flush mounting piano type.
2	RB	15A, 240V, 2 Pole, 3 Pin with third pin earthed - Wall/column mounted, metal clad gasketed construction, suitable for 19 mm conduit entry, screwed metal cover tied with metal chain, weatherproof construction suitable for indoor/outdoor installation. This shall be provided at an interval of 30m, or minimum one in each room.
3	RC	63A, 415V, 3 Phase, 5 pin interlocked plug and switch with fifth pin earthed. Wall/column mounted, metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 4 Core 35 sq.mm AYWY cable. These receptacles shall be provided at an interval of 50m throughout the Plant Area.
4	RD	100A, 415V, 3 phase, 5 Pin interlocked plug and switch with fifth pin earthed Wall/column mounted metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 3.5 Core, 95 sq.mm AYWY cable.

d. Cables and Wiring

- i. Wiring from lighting DBs/panels to individual fixtures, plug points, fans, etc. shall be of single core, 2.5sq.mm, 1100 V grade PVC stranded copper conductors through surface mounted or concealed medium duty GI conduits confirming to IS 1239 with earth wire. The wires in the conduits shall not exceed 60% of the conduit area.
- ii. 1100V grade stranded copper conductor, PVC insulated, colour coded, wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, outdoor areas like transformer yard and road lighting, cabling shall be adopted. The

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specification of cable shall conform to the details indicated in "Cabling System" section.

- iii. Minimum size of wires in case of conduit wiring shall be 2.5sq.mm copper in case of lighting and 4sq.mm copper in case of receptacle wiring
- iv. Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits. Wires of AC and DC lighting system shall be carried out in separate conduits
- v. For outdoor lighting, the cable shall be buried at a minimum depth of 750 mm from ground level or run in cable trays. The buried cables shall have suitable bedding, protective covers and markers
- vi. Material used for saddles, clamps, JBs, etc. shall be galvanized
- vii. Office buildings, laboratory buildings shall have concealed wiring with 2.5sq.mm wires using PVC conduits. In heat zones, i.e. in the areas where ambient temperature is 600 C and above, heat resistant control cables shall be used in hot dip galvanised rigid steel surface mounted conduits

e. Fans and Regulators

- i. The fans shall have three well balanced blades, double ball bearings and shall be reasonably free from noise. Fan motor shall be totally enclosed type with copper winding and class-E insulation. Sweep shall be given as 1200 /1400 mm.
- ii. Regulators shall have minimum five steps. Electronic Regulators with smooth control shall be provided.

f. Flame-Proof Equipment

- i. The enclosure of all flameproof equipment for use in hazardous areas where gases/vapors of Group I, IIA, IIB are present, shall be of cast iron/cast aluminum, stove enamel finished. Chemical corrosion resistant epoxy finish shall be provided in corrosive areas. The construction shall comply with relevant applicable standards
- ii. If the enclosures are additionally required to be weather proof, neoprene gaskets shall be provided to make the enclosure dust and weather proof providing a degree of protection of IPW 55.
- iii. All ferrous parts, exposed to atmosphere shall be suitably plated/galvanized

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- iv. All internal wiring shall be connected to terminal blocks provided in terminal enclosure on incoming side.
- v. Flameproof cable gland entries shall be provided suitable for the cable sizes. The number of required cable entries for junction/terminal boxes as required for branching, terminating of cables for lighting distribution shall be provided. All unused cable entries shall be closed by flameproof plugs.
- vi. Flameproof receptacle unit (socket with associated switch/MCB and plug) shall have interlocking feature such that plug cannot be inserted or taken out with switch/MCB in "ON" position.
- vii. Adequate mounting lugs with necessary hardware shall be provided for mounting the equipment on wall/structure.
- viii. These enclosures shall have inscription warning against opening the enclosure unless the circuit is isolated. Equipment rating and ON/OFF positions of switches/MCBs shall also be designated.
- ix. The BIDDER shall indicate that the enclosures have been tested and certified by relevant statutory authorities for use in hazardous areas.

g. Lighting poles and towers

- i. Lighting poles for street lights and flood lights shall be of swaged and welded steel, pole of height 9M/11M and shall conform to relevant standard. Poles shall be hot dip galvanized internally and externally after fabrication as per IS 2629 / IS 2633 / IS 4759 standards. The Poles shall be designed to withstand the maximum wind speed as per IS 875. The steel sheet used to manufacture steel poles shall be of minimum thickness of 3 mm and shall conform to relevant standard . Junction boxes shall be provided with weather proof flush doors and locking facility. Bidder shall design and furnish the foundation drawings for the poles to withstand basic wind speed of minimum [50]meter/sec.
- ii. The supply of poles/Towers shall be complete with base plate, foundation bolts, hot dip galvanized brackets / necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
- iii. Towers for mounting flood lights shall be e of continuously tapered poly gonal cross section and shall be supplied with all acesssories. Steel structure for towers shall be made of hot dip galvanized steel. A steel ladder and platform at the top shall be provided. The length of each step of the ladder shall be at least

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300 mm and spacing between two adjacent steps not more than 300 mm. The structure shall be suitable for mounting the required number of flood lights, weights of maintenance crew and specified wind pressure. The factor of safety shall be [2] for each part and section. The Contractor's structural design drawings shall be approved by the Purchaser before fabrication.

1.4.9 Name Plate

Name plates shall be furnished for identification of devices and circuits. All switches, controls and indications shall be permanently and legibly marked in English regarding the functions.

1.4.10 Painting

All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.

After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoved after each coat.

The equipment shall be finished in approved color shade by owner with two coats of epoxy based powder coated paint. The coating shall be done electro statically followed by stoving.

Sufficient quantity of touch-up paint shall be furnished for application at site.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

Tests on Lighting Distribution Boards / Panels shall include:

a. Wiring continuity tests.

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- b. High voltage and insulation tests.
- c. Operational tests.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *Lighting panels & distribution boards.*
- b) *Receptacles & Junction boxes.*
- c) *Street light poles & towers.*
- d) *Lighting fixture complete with lamps and accessories.*
- e) *Non-integral/separate type control gear box for lighting fixtures, as applicable.*
- f) *Lux level calculations for each area.*
- g) *Data sheets for lighting fixture, lamps, accessories with light distribution curves, co-efficient of utilization charts etc. Type and routine test certificates of transformer and cables.*
- h) *Control schematic and wiring diagram of 415V AC/220V DC lighting panel with automatic changeover from AC to DC and vice-versa, 415V normal AC Street/area lighting panel with automatic ON/OFF feature.*
- i) *Technical leaflets and data sheet on each piece of equipment/ device such as MCB, switch, fuse, receptacle etc. Type and routine test certificates of transformer and cables.*
- j) *QAP and relevant test certificates*

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- k) Lighting layouts showing the disposition of fixtures, lighting panels/boards, circuit distributions, conduit & wire routing.
- l) Key Single Line Diagram for lighting distribution, board wise single line diagram with feeder loading, cable schedule and interconnection chart, design calculation for lighting.]

1.7

Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC DC	240V, 1Ph, 50Hz 220V DC
1.2	Variation in Supply		
	a) Voltage	%	±10
	b) Frequency	%	±5
	c) Combined voltage & frequency	%	10
1.3	Design Ambient Air Temperature	°C	50
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	50KA for 1 sec
	b) At 220V DC (For DC LP)	kA(DC)	[10] kA for 1 sec
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		G.I
b	Conductor size	SWG	12
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		[By bidder]
2.2	Rated Voltage, phase and Frequency	AC	415V, 3phase, 4 wire, 50Hz
2.3	One Minute Withstand Voltage	V	2500
2.4	Mounting Type		

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S. No.	DESCRIPTION	UNIT	DATA
	a) LDBs		Floor Mounted
	b) Single Phase LP		Wall/Structure mounted
2.5	Type and no of circuits & feeder rating		[As per project requirement]
2.6	Colour shade		[RAL 5012]
2.7	Lighting Transformer		
	a) Type		Epoxy cast resin dry type
	b) Voltage Ratio	V	415/415V
	c) Taps	%	+/-5%
	d) Vector Group		[Dyn1]
	e) Impedance	%	[5%]
	f) Rating	KVA	[As per project requirement]
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		[By Bidder]
3.2	Luminaries		[By Bidder]
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		[By bidder]
	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		[By bidder]
	a) Luminaires		
	b) Accessories		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Schedule of fitting and Accessories		[As per project requirement]
5.0	Technical details of luminaries		[By bidder]
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumen s	
	ii) After 1000 burning hours	Lumen s	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		[By bidder]
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		[By bidder]
a	Power factor		
5.4	Luminaries		[By bidder]
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		G.I
	ii) Suitable upto conductor size	SWG	12
c	Internal wiring size	Sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		[By bidder]
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		[By bidder]
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		CTs VTs
8.1	Make		[By bidder]
8.2	Type		[By bidder]
8.3	Output	VA	[By bidder]
8.4	Accuracy Class		[By bidder]
8.5	Literature enclosed	Yes/No	[By bidder]
9.0	Meters		VOLTMETER AMMETER WATTMETER
9.1	Make		[By bidder]
9.2	Type		[By bidder]
9.3	Accuracy Class		[By bidder]
9.4	Literature enclosed	Yes/No	[By bidder]
10.0	Relays (if any provided)		[By bidder]
10.1	Make		

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S. No.	DESCRIPTION	UNIT	DATA
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a)Normally open		
	b)Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		[By bidder]
11.2	Suitable for use in hazardous area		
	a)Area classification		[Fuel oil pump house, Main oil tank area]
	b)Gases/Vapor group		[By bidder]
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	[By bidder]
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	[By bidder]
12.0	Lighting Control Switches		[By Bidder]
12.1	Make		
12.2	Decorative		
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		[By Bidder]
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	

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S. No.	DESCRIPTION	UNIT	DATA
14.0	Lighting wires		[By Bidder]
14.1	Make		[Point wiring with respect to different length shall be furnished]
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	Conduits		[By bidder]
15.1	Make		
15.2	Rigid Steel		Galvanized
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		[By bidder]
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		Yes
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		[By bidder]
17.1	Make		
17.2	Type of Poles/Towers		

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S. No.	DESCRIPTION	UNIT	DATA
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		[By bidder]
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E10
TECHNICAL SPECIFICATION FOR CABLE CARRIER
SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E10

1.0 CABLE CARRIER SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Cable Carrier system complete with all accessories for efficient and trouble free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS 800	Code of Practice for structural Steel
IS 1646	Code of Practice for Fire Safety of buildings
IS2667	Fittings for Rigid steel Conduits
IS 3419	Fittings for Rigid Non – Metallic Conduits
IS 3837	Accessories for Rigid Steel Conduits
IS 4649	Adaptors for Flexible Steel Conduits
IS 5216	Guide for Safety Procedures and Practices in electrical Work

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Cable and cable trays shall be installed in an ambient temperature of 50 °C and relative humidity of 95%.
- b) The cable carrier system shall be designed considering the following:
 1. Facility for easy laying of cables.
 2. Access to maintenance.
 3. Neat and aesthetic appearance.
 4. Safety of equipment & personnel.
 5. Ground water seepage.
- c) Cables shall be laid in prefabricated ladder/perforated type trays and in conduits. Direct burial of cable shall be mostly avoided.
- d) Upper cable trays and all vertical cable trays shall be provided with tray covers.
- e) Cable filling in the trays or racks shall not exceed 80%. Conduits if used, the wires in the conduits shall not exceed 40% of the conduit area.
- f) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V cables shall be laid in top trays and cables of subsequent voltage grade in lower tier of trays. Instrumentation cables shall be laid at bottom most tray.
- g) At least 300mm clearance shall be provided between HV and LV cables & LV and control/Instrumentation cables.
- h) Support system for cables shall be prefabricated type.
- i) Single core cables shall be laid in trefoil touching formation. Trefoil clamp shall be provided in a staggered manner.
- j) 1100V grade power cables of [120] mm² size and above shall normally be laid in single layer in trays/on racks.
- k) 1100V grade power cables below [120] mm² may be run in double layers in case of space restrictions.
- l) Control and instrumentation cables can be laid up to a maximum of three layers in each tray/rack.

1.4 Specific Requirements

1.4.1 Scope of work:

The scope of work shall include Design, Preparation of Cable Tray, Trench/Duct bank/Conduit Layout, supply of Cable tray and its Accessories, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the Cable Carrier System

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for following package. The below list indicates area where cable carrier system to be provided but not limited to:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- iv) Laying and Termination of power & control cables for all the equipments of TG package.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room.
- v) FOPH area.
- vi) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- vii) Laying and Termination of power & control cables for all the equipments of Boiler package.

c) Balance of Plant Area:

- i) Cable Carrier System for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
- ii) Laying and Termination of power & control cables for all the equipments of BOP package.

d) CHP Area:

- i) CHP Switchgear room
- ii) Conveyor.
- iii) Crusher House
- iv) Stacker and Reclaimer
- v) Any other area covered in this package.
- vi) Laying and Termination of power & control cables for all the equipments of CHP package.

e) AHP Area:

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- i) AHP Switchgear room.
- ii) Silo Area.
- iii) Any other area covered in this package.
- iv) Laying and Termination of power & control cables for all the equipments of AHP package.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard
 - ii) Transformer yard
 - iii) Inter plant cabling.
 - iv) Any other area covered in this package.
 - v) Laying and Termination of power & control cables for all the equipments of eBOP package.
- g) All civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification. Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Bidder.
- h) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work.
- i) For Terminal Points and Exclusions of Cable Carrier system and Specific scope of work Bidder may refer section I of this specification.

1.4.2 General Installation Requirements:

- a) Cable trays shall be fabricated from 14 gauge mild steel sheets. Cable trays shall be of hot dip galvanized Steel of ladder/perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings to be submitted by Bidder. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanized.
- b) Constructional details, supporting arrangement and installation details for cable trays shall be furnished by Bidder.
- c) Each 2.5 meter section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.
- d) Cable tray covers shall be fabricated from 16 gauge MS sheets. Cable tray covers shall be hot dip galvanized and same shall be provided for all outdoor cable trays and vertical raceways/trays. Covers for vertical raceways shall be in individual, easily removable sections to facilitate cable maintenance.

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- e) Cable Tray of Standard width of 600mm shall be followed. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.
- f) Cable trays shall be ladder type with maximum rung spacing 250 mm depth 100 mm and rung width not less than 50 mm.
- g) Cable trays in areas subjected to excessive coal dust, or mechanical damage shall have hot-dip galvanized sheet metal tray cover installed on front tray in vertical run and inverted 'V' type on upper tray in horizontal run. Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.
- h) Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal / vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.
- i) Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/termination kits, lugs, glands, ferrules, tapes etc. and other accessories, grounding of cable armor. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.
- j) Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.

1.4.3 Cable Routing/Laying

- a) Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some

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cases cables may have to be laid underground and for short runs in conduits for protection while crossing roads and other facilities.

- b) For interplant connections, the cables may be routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.
- c) For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.
- d) In boiler area, trench shall be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.
- e) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.
- f) Cables for redundant equipment/system shall be run in separate trays in separate route.
- g) Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.
- h) Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).
- i) The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall and fire proof doors.
- j) The floor of the cable spreader rooms shall have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably planned to avoid water entry through this place.
- k) Cables shall generally be laid on cable trays either in concrete trenches or overhead supported from building steel/structures. Cables shall be run in concrete trenches in those electrical rooms at ground level, which are without any spreader room below. In mechanical equipment areas (Indoor), overhead cable trays shall generally be used.

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- l) For inter plant connections, the cables shall be routed through an overhead cable bridge pipe cum Cable Bridge. For isolated but long outdoor cable route with very few cables of 3/4 nos., the cables may be directly buried with prior permission from the purchaser.

1.4.4 Installation of Cables

- a) The Bidder shall install, terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.
- b) The HV power cables of 6.6kV shall be laid in trays or racks as follows:
- In single layer only.
 - 3 core cables to be laid in touching formation.
 - Cables in trefoil groups of the same circuit shall be laid as indicated below so as to ensure balanced current distribution:

Y Y Y Y

R B B R R B B R and so on.

- c) 1100V grade power cables shall be laid in single layer in trays depends on size of cables. Cable of up to 120 sqmm shall be laid in two layers. Beyond this size single layer will be followed.
- d) Control and Instrumentation cables can be laid up to a maximum of three layers in each tray.
- e) The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.
- f) Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there shall not be more than 2 nos. 90 Deg. Bends between pull points.
- g) Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension, minimum bending radius and no. of bends.

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- h) All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :
- Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.
 - Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.
 - For all HV, LV, Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.
- i) All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.
- j) The portion of galvanized steel, which, if required, undergoes any welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.

1.4.5 Cable Termination and Joints (if applicable and not covered in cable specification)

- a) The Bidder shall supply cable termination and jointing kits in requisite quantity for HV. Power Cables, LV. Power, Control Cables, etc. along with all accessories & consumables required for making termination and joints complete . All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/joints are intended.
- b) The straight through joints of HV. cables shall be heat shrinkable and pre moulded push on type. The end termination kits for HV. cables shall be of {Raychem/3M/Elastimold} type. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.
- c) Glands and lugs required for termination of HV, LV. shall be supplied by the Bidder in required quantity.
- d) Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer etc. Cable glands shall match with the sizes of different HV/LV/Control cables.

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- e) Cable lugs shall be suitable for termination of different cross-sections of L.V./Control cables and shall be of following types:
 - i. Aluminium tubular terminal end for solderless crimping to aluminium conductors.
 - ii. Copper tubular terminal end for solderless crimping to copper conductors.
 - iii. Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.
 - iv. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.
 - v. The terminations shall with tinned copper only.
 - vi. For mill area, the cable shall be routed through GI pipes embedded in Ground.
 - vii. In heat zone areas as far as possible the cables shall be taken away from the area to avoid heat. If cabling in the heat zones can not be avoided, the cables shall be terminated in junction box of IP 67 protection class away from the heat zones and small length of cables may be laid from junction box to the respective equipment to facilitate easier replacement in case of fire. Bunching of cables in the heat zones and boiler areas shall be avoided and laid in separate groups.

1.4.6 Identification

- a) The complete cabling system shall be properly identified. Methods for identification of cabling system will be furnished to the Bidder and the Bidder shall strictly adhere to the said methods.
- b) Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- c) Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate, projected above ground level.
- d) Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) meters in cable tray/trench runs. Cable tags shall also be provided

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inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant / purchaser or his representative.

- a) Checking of continuity / phasing and IR values for all the cables before and after HV test
- b) Checking of continuity / phasing and IR values for all the cables before and after HV test.
- c) HV test and measurement of leakage current after termination of cable kits (for HT cables).
- d) Checking of earth continuity for armour.
- e) Check for mechanical protection of cables.
- f) Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
- g) Check earthing of cable structures.
- h) Check safe head room in gallery area
- i) Check clearance from ventilation duct and light fittings for cable structures.
- j) Check proper fixing of cable structures.
- k) Check for proper drainage and removal of water (if any).

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall

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obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[General arrangement drawing Cable Tray]*
- b) *[Cable Tray Accessories like Tee, Cross, Bends, Coupler, Reducer etc]*
- c) *[Cable Tray support materials]*
- d) *[Technical Data sheets for cable carrier system].*

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		[By bidder]
2.	Size of Tray	mm	[600/450/300/150]
3.	Material		Galvanised Steel
4.	Application		[As per project requirement]
5.	Type of Tray		[Ladder/Prerforated]
6.	Thickness of Tray	mm	2mm
7.	Thickness of Galvanization		[100 microns]
8.	Tray Cover Size	mm	[As per project requirement]
9.	Cable Tray Accessories		[By bidder]

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SL NO.	DESCRIPTION	UNIT	DATA
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	a) [100] b) [50x 50 x 6]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E11

**TECHNICAL SPECIFICATION FOR EARTHING AND
LIGHTNING SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E11

1.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Earthing and Lightning Protection System complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanizing of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:9537	Conduits for electrical installation.
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
CEA	CEA Regulations and standard technical specification for main plant package.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Earthing system design shall consist of earth grids and electrodes buried in soil in the whole plant area, embedded in concrete inside all the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.
- b) The main objectives of earthing system is to:
 1. Provide safety to personnel from contact of dangerous potential caused by ground fault.
 2. Ensure sufficient grounding current for effective relaying.
 3. Stabilize circuit potential with respect to ground.
- c) The earthing conductor shall be designed for fault current of [50 kA] for duration of 1 second.
- d) It is the responsibility of the Bidder to undertake the soil resistivity measurements at site and select suitable size of conductor based on the soil resistivity.
- e) Ground conductor shall be of galvanized steel for above ground and mild steel for embedded and below ground earthing.
- f) Main earth grid conductor shall be mild steel (MS) of [40] mm dia.
- g) Suitable corrosion allowance shall be considered over ground conductor size depends upon soil resistivity.
- h) The main purposes of lightning protection system are to :
 1. Provide protection to structures from lightning strokes.
 2. Provide a low resistance-conducting path to lightning discharge.
 3. Lightning protection shall be provided as per IS: 2309 for Boiler area and other tall structures within the battery limit.

1.4 Specific requirements

1.4.1 Scope of Work

The scope of work shall include Design, Preparation of Earthing and Lightning Layout, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the safety earthing and Lightning Protection system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

- a) TG Area:
 - i) TG Platforms.

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- ii) TG area Grade Levels Maintenance area.
- iii) All equipments, structures etc of TG package.
- iv) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- b) Boiler Area:
 - i) Boiler Platforms
 - ii) Boiler Grade Levels covering coal mill and Maintenance area.
 - iii) ESP Platforms
 - iv) ESP/FOPH switchgear room.
 - v) FOPH area.
 - vi) All equipments, structures etc of Boiler package.
 - vii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- c) Balance of plant Area:
 - i) Earthing and lightning protection system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- e) AHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard, Transformer yard and BTG area are provided with earth mat of [40] mm dia MS Rod conductor buried below 600mm from ground level. Areas like AHP, CHP, Boiler and TG, and all other

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BOP area below grounding system are covered in this eBOP package and above ground earthing for AHP, CHP, Boiler, TG and Mechanical BOP are covered in respective package itself. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system for above ground are covered in respective packages and below ground is covered in this eBOP package in same way as earthing system.

1.4.2 Earthing system

- a) Earthing system shall be designed in accordance with IS 3043 and Indian Electricity Rules and Acts.
- b) Fault current for the earthing system shall be designed for [50] KA for duration of 1 sec.
- c) All electrical equipment, non-current carrying metal parts, structures, building steel, lightning protection system, transformer neutrals shall be connected to station ground grid.
- d) Treated earth pits including riser shall be provided for transformer neutral earthing.
- e) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- f) Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.
- g) All off site area of AHP , CHP etc shall be provide with peripheral earthing with at least two connection to main station earth grid through treated earth pit.

1.4.3 Ground Grid Conductor

- a) Ground grid conductor of mild steel rod shall be used.
- b) *[The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.12 mm (on diameter of conductor) per year over the design life of 40 years.]*
- c) However bidder shall consider as per CBIP norms “ Manual on Earth mat design” the corrosion allowance as below:
 - For soil resistivity greater than 100 ohm-meter: No allowance.

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- For soil resistivity greater than 25- 100 ohm-meter: 15% allowance.
- For soil resistivity less than 25 ohm-meter: 30% allowance.

1.4.4 Underground Grid

- The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80.
- [The ground grid conductors shall be buried in earth at a depth of 600 mm]. The length of ground conductors below earth shall be sufficient to ensure a ground resistance less than one (1) ohm.
- The ground grid conductor shall be so laid as to provide short and direct connection to building steel and major electrical equipment.
- Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.
- All ground grid conductor connections shall be welded type.
- Ground grid shall be interconnected with the ground grid of neighboring areas at least at two (2) points for further reducing the ground grid resistance.
- Suitable pigtails shall be provided and shown in the [layout drawing] for connection with ground grid of neighboring areas.
- A minimum earth coverage of [300] mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.
- In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.
- Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.
- Grounding conductor around the building shall be buried in earth at a minimum distance of [1200] mm from the outer boundary of the building.
- The Bidder shall carryout the grounding of all electrical equipments and connection to main earth grid.

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1.4.5 Ground Electrode

Ground electrodes shall be [40] mm dia. and [3] metre long M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductors. All connections to the conductors shall be done by arc welding process.

1.4.6 Above Ground Connections

- Galvanized steel flats shall be used for all connections above earth.
- Inside building, ground conductors shall be run for each floor supported on building steel and/or cable trays. These ground conductors in turn shall be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.
- Two separate and distinct ground connections shall be provided for each electrical equipment in compliance with I.E. Rules.
- All steel columns and structures shall be connected to the earth mat through earth leads.

All connections above ground shall be welded type except connection to equipment/structures which shall be bolted type.

1.4.7 Risers

Risers are required for connecting the equipment and structures with the ground mat. Risers are to be provided from underground mat to above ground levels where the ends shall be left free for connecting to the equipment. Each riser shall be 1 No. [40] mm dia. M.S. rod and shall project above grade level/concrete floor level by minimum 300 mm. They are to be clamped or supported along the outer edge of the concrete foundation. Connection to the ground mat shall be done by arc welding.

1.4.8 Equipment Ground Lead

- Equipment ground connections shall be sized to carry the ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.
- The minimum ground conductor sizes for various equipment and structures are given in below.

Table 2.0

DESCRIPTION	SIZE	MATERIAL
a) Main Grounding Grid Conductor	[40] mm dia Rod	Mild Steel
b) Riser/Pigtail From Grounding Grid/Mat	[40] 40 mm dia Rod	- Do -

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DESCRIPTION	SIZE	MATERIAL
c) Electrode	[40] mm dia, [3000] mm long Rod	- Do -
d) Conductor used for connection of various equipment/structures as listed below		
HV motors, Earthing ring, Earthing lead to earth pits etc.	[50 x 10] mm	Galvanised steel
Structures, Control Panels, Cable Trays etc.	[50 x 10] mm Flat	- Do -
415V Power Control Centres, Motor Control Centres, Distribution Boards etc.	[50 x 10] mm Flat	- Do -
Local Panels, Lighting Panels	[25 x 6] mm Flat	- Do -
Motors :		
Above 90 kW	[50 x 10] mm Flat	Galvanised steel
Above 30 kW Upto 90 kW	[25 x 6] mm Flat	- Do -
Above 5 kW Upto 30 kW	[25 x 3] mm Flat	- Do -
Upto 5 kW	[8] SWG	- Do -
Miscellaneous Items, viz. Push Button Station, Junction Boxes etc	[8] SWG	- Do -

{The Above size of Earth flat is indicative only. Bidder shall refer Volume II Section I for size of earth flat used for existing plant or as per design.}

1.4.9

Jointing and Connection

- All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.
- The bending of the large diameter ground conductor where necessary shall be done by gas heating.
- The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- The connections between the riser/pigtail and earthing conductors

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(galvanized steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.
- g) Equipment/structures ground connections shall be coated with weather resistant paints/cold galvanizing paints after proper checking / testing.
- h) Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

1.4.10 Earthing system installation

- a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
- b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750 mm.
- c) The earthing conductor crossing the road / track shall be laid in hume pipe or laid at a greater depth to avoid damage.
- d) When earth conductor passes through floors, walls, etc suitable pipe sleeves shall be provided and the same shall be sealed after installation.
- e) The connection between earthing pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
- f) Metallic conduits and pipes shall not be used as earth continuity conductor.
- g) Street lighting poles, flood light poles & towers, their junction boxes shall be connected to the earthing conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.
- h) The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.
- i) Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten [10] metres. Fence gate shall be separately grounded with flexible connection to permit movement.

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- j) [50 x 10] mm galvanized steel flats(minimum size) shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing. These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground. Earthing conductors can be embedded in concrete floor of the building wherever necessary without having direct contact with the reinforcement rods. At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- k) All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.
- l) Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.
- m) Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.
- n) A continuous [50 x 10] mm (minimum size) G.S. flat earthing conductor shall run along the cable trays and supporting structure of all cable routes. This earthing conductor shall be attached to each section of cable tray/trays through [50 x 10] mm G.S. flats. The earthing conductor shall be securely connected to the earth mat at both ends.
- o) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
- p) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.
- q) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- r) The cable sheaths, screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.
- s) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- t) Main plant earth grid and switchyard earth grid shall be interconnected each other by minimum two numbers of leads.

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1.4.11 Lightning Protection System Design

- a) Lightning protection design and installation work shall be provided on the basis of IS 2309 Code of Practice.
- b) Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down conductors and pipe electrodes.
- c) The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than value specified in IS shall be provided with lightning protection. However, Boiler areas, station building, switchyard building shall be provided with lightning protection irrespective of the arrived risk index.
- d) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.
- e) Down conductors shall run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.
- f) A Lightning electrode shall be provided at the connection point of the down conductor with the station ground.
- g) Galvanized steel rods and flats shall be generally used for air termination and connections. All connections shall be welded type.

1.4.12 Air Terminations

- a) The vertical air terminal rods shall be installed at the roof of Turbo generator building, Boiler and chimney etc to protect these objects from lightning strokes.
- b) The projected length of the Air termination rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.
- c) The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building, the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.
- d) All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size [50 x 6] mm galvanized steel flats.
- e) For chimney air termination, rods interconnected by circumferential conductors will be provided at the apex of flue and also upon outer shell of the chimney. The air termination system will be formed by lead coated copper conductors to prevent melting and corrosion of conductors due to flue gas.
- f) For cooling towers, air termination system will comprise of horizontal

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circumferential conductors at the top

1.4.13 Down Conductors

- a) Galvanized steel down conductors of suitable size [25 x 6] shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.
- b) Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.
- c) The connection between each down conductor and rod electrode (by means of 40 mm mild steel rod riser) shall be made by others. However Bringing down comer with test link at a level of 1500mm approximately from above ground level shall be boiler contractor scope of work.
- d) The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleared on outside of the building wall and column/structure at about 750 mm intervals unless stated otherwise in the drawing.
- e) At all supports for down conductor along the column/wall of the buildings etc. the portion embedded inside the building concrete should not touch the reinforcement bars.
- f) All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.
- g) The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

1.4.14 Switchyard Lightning protection

- a) For switchyard lightning protection shall be provided by lightning masts and/or shield wires.
- b) In case of lightning protection by shield wire, the shield wires provided shall be of GS wire strung across the pinnacles of the gantry tower structures. The size of shield wire shall be based on the lightning impulse current expected and the time duration for which it is likely to flow. Allowance shall be given in the final size to account for corrosion of the shield wire during service at rate of [0.03] mm per annum. However, minimum size of the shield wire shall not be less than [70]sq.mm. The zone of coverage for the shield wire shall be considered as 60 deg between the two shield wires and 45 deg for end shield wires. The down conductors from shield wires shall be run along the towers and

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connected to rod/pipe electrodes.

- c) In case of lightning protection by lightning protection masts, the down conductors from the masts/peaks/shield wires shall be run along the tower and connected to the test links mounted on the towers at 1500m from the ground level. Conductors from the test links shall be connected to the rod/pipe electrodes which in turn are connected to the main earth grid in the switchyard. Calculations for sizing and determining topography and number of lightning masts shall be furnished for approval.

1.4.15 Electrodes (for Lightning Protection)

The electrodes shall be [40 mm] diameter [3000 mm] long mild steel rod. These shall be driven into the ground.

All the electrodes shall be interconnected by means of one (1) [40 mm] dia mild steel rod which shall be laid under ground at a minimum depth of [600 mm] below finished grade level unless stated otherwise. This ground mats/electrode in turn shall be connected to main grounding grid.

1.4.16 Riser (for Lightning Protection)

All risers connected to grounding mat shall be [40 mm] mild steel rods and shall be projected 300 mm above grade level unless stated otherwise.

1.4.17 Jointing & Connection

- a) All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.
- b) The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- c) The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.
- d) All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.
- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- g) The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- h) The steel to copper connection shall be brazed type.

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- i) The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.
- j) The sizes and materials of earthing conductors to be used in lightning protection system are listed below :
- k) Note: The above sizes are indicative only. Actual size shall be as per Bidder design or as per existing plant details as provided in Section I in case of replacement work as called for.

Table 3.0

DESCRIPTION	SIZE	MATERIAL
a) Vertical Air Termination	[20] mm dia Rod	Galvanised steel
b) Horizontal Conductor	[50 x 6] mm flat [25 x 6] mm Flat	-----do-----
c) Down Conductors	[25 x 6] mm Flat	-----do-----
d) Ground electrode / riser	[40] mm dia Rod	Mild Steel
e) Interconnection with earth mat	[40] mm dia Rod	Mild Steel

1.5

Tests

l) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the

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Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

The following test shall be conducted:

- a) Measurement of earth resistance for each electrode.
- b) Measurement of total earth resistance.
- c) Measurement of earth loop resistance for E/F path of biggest LV drive.
- d) Check tightness of all earth connections
- e) Check earthing of all metallic equipments, cable trays, bus bar supporting structures, building column (if steel all elect equipments, pipe lines etc. as per the drawing / specification)

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[Earthing Material like conductor , flat , welding description etc]*
- b) *[Air termination rod and its accessories etc]*
- c) *[Technical Data sheets for Earthing and Lightning system].*

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1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II**

**SECTION-II, PART-B, ANNEXURE-E12
TECHNICAL SPECIFICATION FOR 6.6kV SWITCHGEAR**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E12

1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of 6.6 Switchgear, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 226	Structural steel (standard quality)
IS : 375	Switchgear bus bars, main connections and auxiliary wiring, marking and arrangement
IS : 722	AC electricity meters
IS : 728	Galvanized steel structures
IS : 2099	Specification for bushings for alternating voltages above 1 000 volts
IS : 2147	Degree of protection
IS : 2516	Alternating current circuit breakers
IS : 2544	Specification for porcelain post insulators for systems with nominab l voltages greater than 1 000 volts
IS : 2705	Current transformer specification
IS : 3043	Code of practice for earthing
IS : 3156	voltage transformers specification
IS : 3231	specification for electrical relays for power system protection
IS : 3427	A.C. metal enclosed switchgear and control gear for rated voltages above 1 kV and upto to and including 52 kV.
IS : 4710	Switches and switch isolators above 1000 V but not exceeding 11000 v.
IS : 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
IS : 6875	Control switches push buttons

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Codes	Name of Standard
IS : 8084	Specification for interconnecting bus-bars for ac voltage above 1 kV up to and including 36 kV
IS : 8686	Specification for static protective relays
IS : 9046	Specification for ac contactors for voltages above 1000 v up to and including 11 000 v
IS : 9224	Low voltage fuses
IS : 9385	HV fuses
IS : 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
IS : 9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 v
IS : 10601	Dimensions of terminals of high voltage switchgear and control gear
IS : 11353	Guide for uniform system of marking and identification of Conductors and apparatus terminals.
IS : 13118	Specification for high voltage ac circuit breakers
IEC 6044-1	Current transformer
IEC 6044-2	Voltage transformer
IEC 6056	High voltage alternating current circuit breakers
IEC-60099-1	Non-linear resistor type gapped arrestor for AC systems
IEC-60099-4	Metal oxide surge arrestor without gap for AC system
IEC 60129	A.C disconnectors and earthing switches
IEC 60255	Electrical Relays
IEC-60298	High voltage metal enclosed switchgear and control gear.
IEC 60529	Degrees of protection provided by enclosures
IEC-62271-100	High voltage alternating current circuit breakers.
CEA	CEA regulations
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All 6.6kV Switchgear shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- b. All 6.6kV Switchgear shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-)5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC System	:	(+)10% to (-)15%

- c. All motors rated above 160kW shall be feed from 6.6kV switchgear.
- d. Motor rated [160-600kW] shall be provided with [vacuum contactor/vacuum circuit breaker] and motor rated above [600kW] shall be provided shall be provided with vacuum circuit breakers.
- e. 6.6kV switchgear shall be Indoor, metal clad, floor mounted, Single front and fully draw out type. Design and construction shall be such as to allow extension at either end. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels
- f. All 6.6 kV Circuit breaker shall be draw out type & should have Service, Test and Disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- g. Local/remote selection shall be provided for all incoming/Outgoing Circuit Breaker modules. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local (Switchgear).
- h. Two out of three Incomer logic for 6.6kV Switchgear shall be provided. For Unit and station board one Incomer shall be there from Unit Transformer and Station Transformer respectively. Tie feeder shall be provided between Unit and station switchgear such that in case of loss of supplies to unit switchgear from UAT, the same shall be restored from respective station switchgear. In order to achieve the same, fast bus transfer shall be provided at Unit switchgear.
- i. All motors shall be provided with Emergency Stop Push buttons.
- j. Control and Indication voltage level shall be 220V DC.

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- k. Maximum system fault level at 6.6kV bus including initial motor contribution shall be 40kA for 1 sec.
- l. 6.6kV System shall be earthed through resistance to limit fault current to 300A.
- m. Surge arrestor shall be provided for each motor feeder/Transformer feeder.
- n. The switchgear will be located in a clean but hot humid and tropical atmosphere.
- o. Duty involves direct-on-line starting of large induction motors with motor starting current varying 6 times the full load current. For BFP starting current varying 4.5 times of full load current.
- p. For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and this specification.
- q. The switchgear and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current without any damage or deterioration of material.
- r. All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 6.6 kV switchgear shall have following minimum features.

- a. 6.6 kV switchgear shall be of indoor, metal clad, single front, single tier, floor mounted, horizontal drawout type with vacuum circuit breaker and free standing type. The Panels shall be suitable for cable entry at bottom and bus duct connection at top.
- b. Between 6.6kV Switchgear Incomer and transformer, segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with bus duct manufacturer in this regards is covered in this specification.
- c. All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d. Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and Covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels.

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- e. Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f. The switchgear enclosure shall confirm to the degree of Protection of the [IP4X] for indoor installation. However degree of protection of LV chamber shall be [IP-52]. No louvers/Opening shall be provided on the top of panel. All the other louvers if provided shall have very fine brash or GI mesh screen.
- g. Paint shade for complete panels shall be [RAL 5012] for extreme end covers for all board.
- h. The working zone shall be restricted to [750mm to 1800mm] from floor level. Total height of the switchgear panels shall not exceed [2600 mm].
- i. Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc.
- j. A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgear having more than one bus section.
- k. Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.
- l. Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module at any one cubicle. Further distribution to all verticals shall be in the scope of bidder.
- m. Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- n. Supplier shall provide total 10% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- o. Switchgear shall have provision to receive 415V, 3ph, 4wire supply. Single phase 240V balanced supply shall be derived from 415V, 3ph, 4 wire supply. Each cubicle shall be provided with thermostat controlled space heaters suitable for operation from 240 V \pm 10%, single phase, 50 Hz, + 3% - 5% supply and 5A, 240V AC, 3 pin plug socket and cubicle lamp. The space heaters shall be located at the bottom of the switchboards. Cubicle heater, plug/socket/lamp circuits shall have individual switch fuse units. Motors shall

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be provided with anti- condensation heaters at 240V.Necessary provision for supply of motor space heating shall be considered in the switchgear.

- p. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.
- q. Controls and interlocks as required for the safe switching, operation and maintenance of the switchgear shall be provided. Mechanical interlocks shall be provided in addition to electrical wherever possible.
- r. It should be possible to carryout maintenance on a feeder with adjacent feeders alive.
- s. The Fast Bus Transfer (FBT) panel shall be totally enclosed, floor mounted panel conforming to degree of protection IP-42. The minimum thickness of cold rolled sheet steel used shall be 2.0 mm. The ABT panel shall consist of a lineup of control boards, with cable entry provisions from bottom of panel. The height of FBT panel inclusive of mounting channel, anti-vibration pads etc. shall be restricted to [2400 mm].
- t. The switchgear shall be [natural cooled].
- u. The circuit breakers, contactors, bus VTs shall be mounted on withdrawable truck which shall roll out horizontally from service position to isolated position.

1.4.2

Bus and Bus Taps

- a. The main buses and connections shall be of high conductivity [aluminum / aluminum alloy].Control and auxiliary buses shall be of electrolytic copper/copper wires.
- b. Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- c. Bus insulator shall be flame-retardant, non-hygroscopic, track resistant type with high creepage surface. This shall be of non-carbonizing material such as epoxy bonded fiberglass. Bus bars shall be color coded for easy identification.
- d. The bus bar supports shall be able to withstand stresses due to maximum short circuit and also take care of any thermal expansion.
- e. Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f. The continuous rating of the main bus bars shall be same as that of the incomer circuit breaker and shall carry this continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].

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- g. The busbar chamber shall be provided with inter panel barrier with epoxy cast seal off bushings through which the buses will pass through so as to prevent fire from one panel to another.

1.4.3

Circuit Breaker

- a. The circuit breaker shall be of vacuum type.
- b. The circuit breakers shall be fully draw-out type, having service, test and disconnected positions with positive indicators for service & test positions.
- c. The breakers shall have motor operated spring charged mechanism. It shall be possible to charge the springs manually, if, required. Breakers shall be trip free and shall have an anti-pumping device. The operating duty cycle shall be 0 -3 min.-CO-3 min.-CO.
- d. For motor, spring charging shall take place automatically after each breaker closing operation. One 'open-close-open' operation of the circuit breaker shall be possible after failure of power supply to the motor.
- e. Automatic safety shutters shall be provided to ensure the inaccessibility of live parts after the breaker is drawn out. There shall be distinct overall door for the breaker compartment and shall be lockable.
- f. Truck shall have distinct service, Test and Isolated positions. It shall be possible to close the breaker compartment door in isolated position also. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions.
- g. Outgoing breakers shall be suitable for switching transformers and motors at any load. Motor feeders shall be suitable for frequent direct on-line starting of motor.
- h. Mechanical safety interlocks shall be provided to prevent
 - i. The circuit breaker from being racked in or out of the service position when the breaker is closed.
 - ii. Racking in the circuit breaker unless the control plug is fully engaged
- i. Breakers shall be adequately de-rated to account for design ambient temperature and temperature inside the cubicle.
- j. Equipment and component rating and quantities shall be suitably selected according to the requirements with adequate margin.
- k. Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage

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1.4.4 Contactor

High voltage contactor shall be of AC-3 utilization category and shall be of vacuum type. Fuse and contactor shall be mounted on withdrawable truck. The contactor shall be latched type and shall be complete with mechanical trip indicator, anti pumping relay, surge suppresser, single phasing preventor etc.

1.4.5 Bus Transfer scheme:

The 6.6kV Unit Switchgear shall be connected to their respective unit auxiliary transformer through bus duct. These buses of unit switchgear shall also be connected to 6.6kV buses of station switchgear through tie feeders and breakers located at the unit and station end. Automatic Fast bus transfer scheme shall be provided between 6.6kV unit and station switchgear such that in case of loss of supplies to unit switchgear from UT, the same shall be restored from respective station switchgear. The automatic bus transfer system shall consist of fast, slow etc. transfer in Auto/ Manual mode.

In addition to above, each switchgear shall be provided with the following provisions-

- Dead bus closing
- Manual live change over (Momentary paralleling)
- Automatic slow bus transfer.

1.4.6 Current Transformers

- a. Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made. They shall have sufficient thermal and mechanical capacity to withstand the maximum momentary current rating of the breakers.
- b. CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c. CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d. All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e. CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.
- f. Accuracy class of CT shall be 5P20 for protection, PX for differential protection and 0.5 for metering.

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1.4.7 Voltage Transformer

- a. Voltage transformers (VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b. VTs shall be of the single-phase type. VTs shall be protected on their primary side by fuse and by MCB (with auxiliary contacts) on the secondary sides.
- c. VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d. It shall be possible to replace VTs without having to de-energise the main busbars.
- e. VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Transducer

For Incoming and outgoing feeders remote metering transducer shall be provided. The output shall be 4-20 mA DC which shall correspond to the normal range. All the transducer shall be dual output type.

1.4.9 Secondary wiring

- a. The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c. Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d. Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with *[stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring (applicable for internal panel wiring).]*
- e. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.10 Terminal blocks

- a. Terminal blocks shall be of 1100 V grade, stud type with marking strips. Terminals for CT secondary leads shall have provision for easy shorting, earthing and shall be suitable for connecting 2 cables of 2.5 mm² copper.
- b. Sufficient terminals shall be provided on each terminal block to ensure that

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not more than two outgoing wires are connected per terminal. All spare contacts of auxiliary relays, timers etc. shall be wired up to the terminals. [20%] spare terminals shall be provided on each terminal block.

- c. Terminal blocks shall be located to allow easy access. Wiring shall be grouped such that the individual wires of a cable can be connected to consecutive terminals.

1.4.11 Ground bus

- a. A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b. Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c. C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.12 Control & Indication

- a. The circuit breaker shall be wired up for local & remote operation. Each breaker shall be equipped with following:
- b. Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In Local position, the breaker shall be operated from switchgear only in test position.
- c. Each cubicle shall be provided with Auto/ Manual Switch. Trip selection switch and Trip-Neutral- Close (TNC) switch.
- d. Circuit breaker shall be indicated electrically. The following indication color shall be used.
Breaker closed – Red
Breaker opened – Green
Spring Charged – White
Breaker Auto trip – Amber
- e. However any other indication shall be provided as per owner's requirements.
- f. Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.

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- g. Breakers shall be controlled locally and/or remotely as per plant operational requirement. Necessary Interposing relays & feedback signal shall be provided based on the DCS IO list.
- h. Breaker control supply shall be of 220 V DC. Breaker spring charging motor shall be suitable for 220 V DC.

1.4.13 Cable termination

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection.

1.4.14 Bus duct connection

Bus duct connection shall be generally from top of the switchgear.

All connection bus work shall have the same continuous rating as associated switchgear bus and shall be fully braced for the short circuit current mentioned in specification.

All provision such as matching flange and other accessories shall be furnished for connection to bus duct.

1.4.15 Painting

All sheet steel surfaces shall be chemically cleaned, degreased and pickled in acid to produce a smooth, clean surface free of scale, grease and rust. After cleaning, the surface shall be given a phosphate coating followed by a coat of high quality primer and baking in the oven.

The paint shade shall be subject to owner's approval. Sufficient quantity of touch up paint shall be furnished for application at site.

1.4.16 Relays, Protection & Metering

- a. The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/ diagnostic facilities shall be provided.
- b. All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner. All numerical relays shall be compatible with IEC 61850.
- c. All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.
- d. All AC operated relays shall be suitable for operation at 50 Hz. AC voltage

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operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

- e. Energy meters shall be provided for incomer of 6.6kV Switchgear and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than [0.2S]. The accuracy class of CT and VT for energy metering shall have accuracy class of [0.5]
 - f. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
 - g. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
 - h. The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
 - i. All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
 - j. Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
 - k. D.C supply shall be supervised by DC supervision relays.
 - l. Trip circuit shall be supervised by Trip circuit supervision.
 - m. Tripping shall be done through high speed lock out relays.
 - n. All meters/ instrument shall be flush mounted on front panel, at least 96 mm² size with 90 degree linear scales and accuracy class of [2.0.]
 - o. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
 - p. For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
 - q. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- r. Metering and protection shall be as per below table

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	Protections	Metering
a)	Incomers, Tie Feeders and all Outgoing Feeders except Motor and Transformer Feeders	
	<ul style="list-style-type: none"> IDMT Over current relay (51) Instantaneous O/C relay(50) Inverse time over current relay residually connected for Earth Fault detection (51N). Inverse time over current relay (51NS) connected to transformer neutral for stand-by earth fault. (Applicable for 6.6 kV Unit and Station Incomer only) 	<ul style="list-style-type: none"> Current in all the three phases (Metering at Switchgear end) Voltage of all three phases (Metering at Switchgear end) kWH meter (Metering at Switchgear end) kVARH meter (Metering at Switchgear end) Current in all the three phases (Remote metering through dual output type transducers) Voltage in all the three phases (Remote metering through dual output type transducers) Watt transducer (Remote metering through dual output type transducers) VAR transducer (Remote metering through dual output type transducers)
b)	Bus Couplers	
	<ul style="list-style-type: none"> IDMT Over current relay (51) IDMT Earth fault relay (51N) 	Current on all the 3 phases
c)	[Motor Feeders]	
	<ul style="list-style-type: none"> Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload with unbalance current features etc. Differential Motor Protection for Motor rating above & equal to 	<ul style="list-style-type: none"> Current on all the 3 phases from Local & Remote. KW meter shall be provided.

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	<p>2000kW.</p> <ul style="list-style-type: none"> Winding and Bearing temperature protection by means of RTDs connecting the same to DCS. The motor protection relay shall check the actual no. of repeated starts and compare the same with the manufacturer's permitted number of starts and prevent further starting attempts once the same is exceeded. Under voltage relay. CBCT for sensitive Earth fault (if required) 	
d)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection (Fuse failure protection No Voltage protection)	Voltage on all the 3 phases from Local & Remote.
e)	Transformer Feeder (6.6/ 0.433kV)	
	Protections	Metering
	<ul style="list-style-type: none"> IDMT Over current relay (51) Instantaneous O/C relay (50) Residual Earth fault protection (51N) CBCT for sensitive Earth fault (if required) Transformer Mechanical Protection (Buchholz protection for oil type transformer/WTI high alarm and trip/ OTI high alarm & trip (for oil type) Stand By Earth fault protection (51N) Connected to transformer Neutral 	Current on all the 3 phases from Local & Remote.

1.5 Tests

I. Type Test:

For each type & rating of 6.6kV Switchgear, the Bidder shall submit the reports

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of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening for Owner's approval. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II. Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative. However the following minimum routine tests shall be conduct.

- Power-frequency voltage tests on the main circuit
- Dielectric tests on auxiliary and control circuits
- Measurement of the resistance of the main circuit
- Partial discharge measurement
- Mechanical operation tests
- Heat Run test
- Pressure tests of gas-filled compartments
- Tests of auxiliary electrical, pneumatic and hydraulic devices
- Verification of correct wiring

III. Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV. Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

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1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below.

- a. [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening]
- b. Bill of Materials.
- c. Technical Data sheet and Catalogue.
- d. Foundation drawing details with bottom view of switchgear.
- e. Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f. Control Schematics & Wiring diagram.
- g. Inspection and Test Plan (ITP).
- h. Suggestive list of protective relays.
- i. Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

6.6kV Switchgear shall comply with the particulars indicated in the following tables.

Table 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		[By Bidder]
1.2	Place & Country of manufacture		[By Bidder]
1.3	Specifications and Standards		As per Table 1.0
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		6.6 kV/7.2 kV, 3 Phase, 3 wire, 50 Hz.
2.2	System neutral earthing		Non Effectively earthed (Fault current Limited to 300A by neutral grounding resistor)
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz

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S. No.	DESCRIPTION	UNIT	DATA
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		20kV 60kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		Continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	40 kA for 1 Sec
b	Dynamic Rating	kA (peak)	100 kA
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		[Cu/Al]
2.14	Fully draw out (FD)/ Fixed (F)		FD / Single front
2.15	Entry –Top (T)/Bottom (B)		Top for bus duct, bottom for cables.
2.16	Degree of protection		[IP4X] and for LV chamber shall be [IP-52].
2.17	Color finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	[Aluminum]
2.19	Minimum clearances in air of live	mm	As per standard

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S. No.	DESCRIPTION	UNIT	DATA
	parts		
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		6.6kV,50hz,3 phase,3 pole
3.3	Rated operating duty		O-3min-CO- 3min -CO
3.4	Circuit breakers type		VCB
3.5	Short circuit withstand current for 1 sec. Duration	kA	40
3.6	Rated making current	kAp	100
3.7	Rated current at site reference ambient temp	A	[By bidder]
3.8	Type of operating mechanism		Spring charged motor and manual
3.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
3.10	Control voltage		
	Spring charging motor	V AC/DC	[220V DC]
3.11	Closing Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.12	Opening Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.13	Operating time		
	Opening time	ms	< 65
	Breaking time	ms	< 15
	Total tripping time	ms	< 80 (total break time)
	Total Closing time	ms	< 80 ms

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S. No.	DESCRIPTION	UNIT	DATA
3.14	Number of breaks per pole		One
4.0	Contactor		
	Voltage class	kV	7.2
	Short time Rating		[By bidder]
	Duty		AC3
5.0	Fuse		
	Voltage class	kV	6.6
	Rupturing capacity	kAp	100
6.0	Current Transformer		
a	Make		[By bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]
e	Basic Insulation level	kV	7.2/20/60
6.1	CT for differential protection		
	Class		PS class
	Secondary resistance at 75 ° C		[By bidder]
	Knee Point Voltage		[As per purchaser requirement]
	Excitation Current		< 30mA
6.2	CT for Metering		
	Class		[0.5]
	Secondary resistance at 75 ° C		[By Bidder]
6.3	CT for Protection		
	Class		[5P20]
7.0	Voltage Transformer		
a	Make		[By Bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]

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S. No.	DESCRIPTION	UNIT	DATA
e	Voltage ration		[By Bidder]
8.0	Meters		
a	Make		[By Bidder]
b	Type		[By Bidder]
8.1	Voltmeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
8.2	Ammeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
9.0	Indicating lamps		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Voltage	V	As specified in the specification.
d	Wattage of lamp	W	[By Bidder]
10.0	Push buttons		
a	Make		
b	Type		As specified in the specification.
c	Contact rating	A	[By Bidder]
11.0	Space heater		
a	Make		
b	Type		As specified in the specification.
c	Rated voltage	V	As specified in the specification.

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S. No.	DESCRIPTION	UNIT	DATA
d	Power rating	W	[By Bidder]
12.0	Wiring and terminal blocks		
a	Voltage grade		1.1 kV
b	Insulation		[By Bidder]
c	Minimum size of conductor for:		
	• Power wiring	Sq.mm	2.5 for CT & PT for internal panel wiring only and 4 for external wiring
	• Control wiring	Sq.mm	1.5 (for internal panel wiring only)
f	Type of terminal blocks:		
g	I) For Withdraw able Type		Sliding type
h	II) For Fixed Type		Stud & nut type
i	Minimum current rating of terminal blocks	A	10
13.0	ABT Panel		
a	Make		
b	Type		[By bidder]
c	Panel thickness	mm	2
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		Catalogue shall be furnished by the bidder.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E13

**TECHNICAL SPECIFICATION FOR VARIABLE FREQUENCY
DRIVES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E13

1.0 VARIABLE FREQUENCY DRIVE

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Variable Frequency Drives complete with all accessories for efficient and trouble-free operation of of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS-3700	:	Essential ratings and characteristic of semi-conductor devices
IS-3715	:	Letter symbols for semi-conducting devices
IS-4411	:	Code of designation of semi-conducting devices
IS-5001	:	Guide for preparation of drawings for semi-conductor devices
IS-5469	:	Code of practice for the use of semi-conductor junction devices
IS-5621	:	Hollow Insulators for use in electrical equipment
IS-6209	:	Methods for partial discharge measurement.
IS-6297	:	Transformers and indicators for electronic equipment
IS-8789	:	Performance parameters for motors
IS-12729	:	Switchgear and control gear for voltages exceeding

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		1000V- General requirements
IS-13408	:	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IEC 146	:	Semi Conductor converters
IEC 168	:	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V
IEC 270	:	Partial discharge measurement
IEC 297	:	Dimension of panels and racks
IEC 326	:	General requirements and measuring methods for printed wiring boards
IEC 352	:	Solder less wrapped connection
IEC-61800-3,4&5	:	EMC requirements and specific test methods
IEC-60664-1	:	Insulation coordination for equipment within low-voltage systems
IEC/EN-60204-1	:	Safety of machinery-electrical equipment of machines
IEC/EN-60529	:	Degrees of Protection Provided by Enclosures (IP Code)
IEC/EN-61000-3-12	:	Electromagnetic compatibility
IEEE 444	:	Protection standards for converters
IEEE 519	:	Harmonic control & reactive compensation of static power converters

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DIN 41488	:	Electrical engineering dimensions
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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) All VFDs shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The VFDs shall be suitable for operation in a highly polluted environment.
- b) All VFDs shall be suited for uninterrupted operation under the following variations in bus voltage and frequency:
 - i. Voltage Variation : +/-10%
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency
- c) The VFD shall be of modern design for similar applications in power plants. The system shall be commutated inverter type with minimum [six] pulse design, [IGBT based] and PWM controlled or better control system.
- d) VFD shall consist of Input section (rectifier and filter), control section and output section (PWM module, base drive circuits).
- e) VFD shall include an input filter for limitation of the harmonic current. General requirements of VFD shall conform to IEC 61800-2 and IEEE-519.
- f) VFD shall follow EMC directives as specified in IEC-61000.
- g) VFD model shall be suitably selected based on actual cable length from VFD to motor terminals. Shielded cables suitable for VFD applications shall be provided by the bidder.
- h) For [12 pulse] VFD, required 3 winding transformer and necessary cabling shall be provided by the bidder.
- i) Bidder shall provide inverter duty motor to withstand voltage stresses produced by PWM action

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1.3.1 Performance requirements:

- a) The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise.
- b) The system shall be suitable for the load characteristics and the operational duty of the driven equipment.
- c) The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment:
 - i. Variable torque changing as a function of speed i.e. speed squared.
 - ii. Constant torque over a specific speed range.
 - iii. Constant power over a specific speed range where the torque decreases when speed increases.
- d) The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The system shall be designed for linear continuous speed control from [10% to 100%] of driven equipment's rated speed and shall be of a modern proven design.
- e) The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800-4 and it shall be considered in the design of the motor.
- f) Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 115% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than one minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- g) During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit up to 60 seconds.
- h) The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- i) The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95 % of the minimum operational speed for more than 10 seconds.
- j) Maximum noise level of motor shall be measured as per relevant IS standard.

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- k) Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and troubleshooting/ maintenance.
- l) Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

The drive system shall ensure following:

- i. VFD induced torque pulsation are limited to maximum 1% (even at low speed) so there is minimal stress to the equipment
- ii. Motor is protected from dv/dt stresses.
- iii. No appreciable increase in motor audible noise.

1.3.2 Control requirement:

- a) The VFD and motor characteristics shall be suitable for load specific torque-speed characteristics.
- b) Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.
- c) The system shall also be equipped with a facility which shall restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart the converter shall be capable of synchronizing on to a rotating motor and develop full acceleration torque within 10 seconds.
- d) The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.
- e) The drive motor shall be speed controlled corresponding to 4-20 mA reference input signal unless otherwise specified upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed at the last speed reference available prior to the loss of signal.
- f) It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/manual selection shall be from VFD panel unless otherwise specified.
 - i. With the selector switch in "manual" mode, the operator shall be able to set the speed through keypad, mounted on front of the drive panel or from speed increase/decrease push buttons from the field. Motor operated potentiometer shall be provided as a speed set point device.
 - ii. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's DCS (Process Control) system. Necessary equipment required for interfacing with DCS shall also be provided in the drive panel.

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- g) The required provision for the interface with remote I/O (*as per requirement*) shall be through hardwired connection (with potential free contacts and transducers)
- h) Drive system shall have provision for interface with upper level automation such as electrical control system.
- i) The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.
- j) Bypass Feature
 - i. Bypass breaker / contactor-HRC fuse complete with protection, annunciation and metering shall be provided.
 - ii. All Variable frequency drives (VFD) having bypass feature shall have motor protection relay along with necessary control and metering etc. Switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended by opening its isolation devices.
 - iii. Safety interlock between inverter and bypass breaker/contactors shall be provided such that closing of healthy device is inhibited in case of external fault.

1.4 Specific Requirements

1.4.1 Constructional Requirements

- a) Panel Construction
 - i. The panel shall include suitable semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors (if required), filters (if required), control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of integrated standards.
 - ii. Upstream breaker include suitable semi conducting power devices (Diodes / IGBT) modules will be provided on the front door.
 - iii. Safety Interlock shall be provided so that power cabinet cannot be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.
 - iv. The drive shall be suitably housed in sheet steel panels fabricated with 2 mm thick cold rolled sheet steel. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. The maximum and minimum operating height shall be 1800 mm and 400 mm respectively.

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- v. Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600 mm clear from bottom of the cable gland plate.
- vi. Bus bars shall be of electrolytic copper, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.
- vii. All the switches component and accessories which are essential for normal and emergency operation shall be mounted on the door and shall be operable externally. Digital meters shall be preferred. Analogue instruments, where provided, shall be switchboard type, back connected, 72x72mm. Scale shall have red mark indicating maximum permissible operating rating.
- viii. All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- ix. All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with PVC insulated, fire retardant, copper conductor wire. 1.5 mm² size wire shall be used for control circuits, 2.5 sq.mm for CT/PT circuits and 0.75 mm² for electronic circuits. The control fuse rating is 10 Amps or less and 2.5mm² size for control fuse rating above 16A for electrical circuits and 0.7 mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered. Minimum 20% spare terminals shall be provided.
- x. All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipment and power electronic equipments shall be used.
- xi. All low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.
- xii. DC link capacitor and pre charging and discharging circuit shall be preferably mounted in the rear of the panel. Suitable removable type hooks shall be provided for lifting the panel.
- xiii. Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- xiv. All equipment shall be complete with double compression glands, lugs etc.

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b) Cooling

- i. The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Bidder shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N + 1) shall be provided.
- ii. Necessary starters shall be provided within the VFD panels for the ventilation fans, any other auxiliary motor etc.
- iii. The system provided shall be interfaced with drive starting and shut down such that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., shall be incorporated in the overall sequence logic.
- iv. MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easily accessible location.

1.4.2 Motor

The motor shall be designed, constructed and tested in accordance with the Specification for high Voltage Induction / Synchronous Motor, in addition to the following requirements:

- a) The motor shall be suitable for VFD control.
- b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- c) The motor shall be designed to operate continuously at any speed in the operating range for the driven equipment (ie; ID fan / Coal feeder).
- d) The permitted voltage variation shall take into account the voltage drop across the AC drive and all other system components upstream the motor.
- e) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications.
- f) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- g) The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4.

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- h) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

1.4.3 Static Power Converter

- a) The static power converter shall consist of a line side converter for operation as a rectifier and a load side power converter for operation as a fully controller inverter. Power converter shall be fast switching, most efficient and low loss type.
- b) The converter shall be co-ordinated with the transformers. The converter shall be able to withstand a three phase short circuit current until interrupted by normal breaker operation.
- c) Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- d) All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- e) The current rating of the converters semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range. If the parallel connection of semi conductor is applied, the above current rating shall not be less than 140% of the above values.
- f) All power diodes shall be of silicon type with minimum V_{BO} rating at 2.5 times the rated operating voltage.
- g) The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise nor reducing its service factor due to harmonic currents generated by the inverter operation.
- h) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions / tools.
- i) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

1.4.4 Converter Transformer

- a) The converter transformer, if provided, shall be copper wound dry type. Insulation class of dry type transformer shall be H with temperature rise of body limited to 75°C. Dry type transformer shall preferably be mounted inside the drive system panel. The impedances of converter input transformers with more than one secondary winding for minimum 18 pulse systems shall be selected to ensure equal load / current sharing

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between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

- b) The transformation ratio, impedances, taps and secondary voltage shall be chosen by the drive vendor to optimize system performance.

1.4.5 DC link reactor

- a) Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- b) Unless otherwise specified, the reactor shall be dry type, air cored, air-cooled or fan cooled type located within the panel.
- c) Reactor shall be suitable for withstanding earth fault continuously and for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.
- d) Noise level shall not exceed value specified in NEMA TR-1

1.4.6 Output filter

- a) VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance free and self-healing type.
- b) The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

1.4.7 Protection, Control, Metering, Indication and Annunciation

- a) The Bidder shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

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- b) Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.
- c) Protective Relays:
For details on protective relays used, refer to Technical Specifications on MV Switchgear
- d) Operator Control Panel
- i. Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to start/Stop, Local/Remote, auto/manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
 - ii. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
 - iii. Operator console shall have facility /port to connect external hardware such as Lap-Top etc. Console shall have facility for upload and download of all parameter settings from one drive to another identical drive for start up and operation.
 - iv. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing up stream breaker after all required process parameters are achieved.

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- v. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.
 - vi. Suitable interface with DCS to be provided for control and status signals of VFD.
- e) Local Motor Control Station
- i. The local motor control station shall be installed near the motor. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
 - ii. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current.
 - iii. Requirement of controls and indications required in the Local Control Station shall be as specified in the data sheet.
- f) Protective Features:
- The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:
- i. Incoming line surge protection
 - ii. Under / Over voltage protection
 - iii. Phase loss, phase reversal protection.
 - iv. Programmable Over current protection and under load protection.
 - v. Motor differential protection for motor rated above 1000 kW
 - vi. Inverter Fault.
 - vii. Over frequency operation.
 - viii. Ventilation loss,
 - ix. Over temperature of equipment.
 - x. Over speed of motor.

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- xi. Specific motor protection, including motor winding, bearing temperatures, over-current, overload, negative phase sequence, locked rotor and earth fault protections etc.
- xii. System Earth fault protection.
- xiii. Excitation system protection for synchronous motor
- xiv. Over and under frequency, rotor earth fault, field failure protection for synchronous motor
- xv. Additional protection for drive system

g) Control features

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

- i. Start/Stop
- ii. Speed control (Raise/lower)
- iii. Forward/Reverse(if Specified)
- iv. Auto/Manual /test mode
- v. Local/remote
- vi. Emergency stop
- vii. Start/stop for by pass starter (where specified)
- viii. Trip-Remote Breaker
- ix. Excitation control system for synchronous motors
- x. Sequential switching of filters

h) Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- i. Input AC Current
- ii. Input AC voltage
- iii. Input AC frequency
- iv. Output voltage
- v. Output current VFD / Bypass
- vi. Output frequency
- vii. Motor thermal state

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- viii. Drive thermal state
- ix. Motor speed
- x. Motor energy meter
- xi. DC Link voltage
- xii. Hour Run
- xiii. Voltage and current meter for excitation system for synchronous motor.
- xiv. KVAR, power factor meter for synchronous motors
- xv. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

i) Indications

Bidder shall provide indications as required for normal operation and for easy maintenance, which shall not be limited to the following indications both at local and at plant DCS.

- i. Motor running
- ii. Motor stopped
- iii. VFD System Fault
- iv. System ready to start
- v. AC mains ON
- vi. Motor over speed
- vii. Rectifier output 'ON'
- viii. Motor zero speed
- ix. Remote breaker trip
- x. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e., door mounted keypad or through hardwired indicating lamps/LEDS.

Potential free contacts of items i- iv shall be wired separately for remote indications in DCS.

j) Audio-visual annunciations

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- i. The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter, output transformer etc.
- ii. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.
- iii. Audio-visual window annunciations shall be provided on the front of the panel All annunciations as required for normal and satisfactorily operation of the drive system shall be included as per Bidder standards. These annunciations can be part of operator console panel or separately mounted type.
- iv. Bidder shall include audio-visual alarm as required for normal operation and maintenance of the system but not be limited to the following,
 - Rectifier fuse failure
 - Main AC failure
 - Inverter fuse failure
 - Inverter overload
 - Inverter high temperature
 - Cooling system failure
 - Motor failed to start
 - Transformer failure
 - Excitation system failure for synchronous motor
 - Battery monitoring healthiness
 - Communication and measurement system un healthy
 - Motor temperature high
 - Harmonic filters monitoring
- i. Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminals of DCS I/O panels for remote alarm and monitoring.

k) Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available for a period of minimum 4 days (96 hours) after a shut down even though no supply

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would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

1.4.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle lamps (CFL) etc. shall operate on 240 volts single phase AC.

All control circuit shall operate at voltage of 110V AC or 220V DC.

Bidder shall include supply of all control transformers, protective devices, required accessories etc. and any other control supply voltage as required for the system.

1.4.9 Maintenance features

The controller design shall incorporate the following maintenance features:

- a) Modular construction
- b) All components shall be easily accessible.
- c) Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

1.4.10 Painting

- a) All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.
- b) After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be as per manufacturer's standard, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

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- c) All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

Final paint shade shall be light gray and dove gray 631 and 632 as per IS-5 for indoor and outdoor equipment respectively unless otherwise specified

1.5 Tests

The Routine and Type Tests to be performed on the drive system in the presence of the purchaser of consultant shall be as follows:

1.5.1 Type Tests

For each rating and type of VFD, the Bidder shall submit for Owner's approval, the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

All type tests shall be conducted as per relevant standards and test certificates of similar panels conducted within last 5 years shall be furnished.

1.5.2 Routine tests

- a) Visual Inspection
- b) It involves checking of the various equipments/components fault diagnostic unit, Wiring, Terminals, earthing ratings etc.in line with the approved drawings and visual inspection shall not be limited to the following:
- c) Insulation Test
- d) Light Load and Functional Test
- e) Load characteristics test
- f) Load duty test
- g) Checking of Auxiliary Devices
- h) Checking the properties of the control equipment

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- i) Checking the Protective Devices
- j) Checking of control and functional requirements
- k) High voltage test
- l) Leakage and pressure test for cooling water system where provided
- m) Shaft current/bearing insulation
- n) Automatic restart/re-acceleration

Additional tests on switchgears and dry type transformers shall be carried out based on the requirement defined in the technical specification.

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data and Manuals

The engineering services scope and the documentation to be issued with the bid are described hereafter. The list shows the minimum requirements for the documentation, so that any additional documentation considered as necessary will be added to this.

- a) Engineering, manufacturing, delivering and test schedule
- b) Sub-Supplier lists.
- c) General arrangement drawings(plan, elevation, section view) with dimensions
- d) Foundation drawing including loading data.

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- e) Technical Data sheets.
- f) Electrical and control wiring diagram.
- g) Terminal arrangement drawing, interconnection wiring diagram.
- h) Cross sectional drawing.
- i) Inspection and test plan.
- j) Manufacturing Quality Plan.

1.7 Ratings and requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table 2.0

Sl. No	Technical Parameters		
		6.6 kV	415 V
1	Manufacturer Name	[By Bidder]	[By Bidder]
2	Model No.	[By Bidder]	[By Bidder]
3	Application		
4	Quantity		
5	Enclosure Protection Rating	IP-31	IP-31
6	Output Current Rating at ambient temperature	[as per requirement]	[as per requirement]
7	% derating considered for specific ambient	As per IEC	As per IEC
8	Rated Voltage (volts) Input	6.6 kV AC ± 10%, 3-phase	415 V ± 10%, 3-phase

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Sl. No	Technical Parameters		
		6.6 kV	415 V
9	Output Frequency Range (Hz)	[By Bidder]	[By Bidder]
10	Number of Phases and Frequency (Hz)	3 Phase, 50 Hz (+ 3% to -5%)	3 Phase, 50 Hz (+ 3% to -5%)
11	Rectifier type & Design	[6/12/18 Pulse Diode Bridge]	[6/12/18 Pulse Diode Bridge]
12	Inverter type & Design	[as per requirement]	[as per requirement]
13	Min/Recommended / Max switching frequencies (kHz)	[as per requirement]	[as per requirement]
14	Filters	[as per requirement]	[as per requirement]
	Line Side	[as per requirement]	[as per requirement]
	Load Side	[as per requirement]	[as per requirement]
15	Output Modulation Method	PWM	PWM
16	Speed Accuracy (+/ - %)	[as per requirement]	[as per requirement]
17	Response time (speed)	< 5ms with nominal Torque	< 5ms with nominal Torque
18	Response time (Torque)	[By Bidder]	[By Bidder]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
19	Type of cooling	[Natural/forced/water] cooled	[Natural/forced/water] cooled
20	Whether VFD is suitable for outdoor installation	No	No
21	Drive Control Capabilities		
	Start/Stop Push button	ON/Speed Increase/Speed decrease From DCS	ON/Speed Increase/Speed decrease From DCS
	Modbus control	Yes	Yes
22	Load parameters at rated voltage & frequency		
	Output Frequency (Hz)	[0 to ± 120Hz]	[0 to ± 120Hz]
	Full Load current (Amp)	[By Bidder]	[By Bidder]
	VFD Heat dissipation (w)	[By Bidder]	[By Bidder]
23	VFD Efficiency		
	At Full rated Torque	[Approx 98% (Only drive)]	[Approx 98% (Only drive)]
	At 75% of full load torque	[By Bidder]	[By Bidder]
	At 50% of full load torque	[By Bidder]	[By Bidder]
24	Drive Power factor range		
	At rated speed, Torque	[≥ 0.98 (Fundamental)]	[≥ 0.98 (Fundamental)]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
25	DC Voltage	[1.35 times of supply voltage]	[1.35 times of supply voltage]
26	Fundamental power factor	≥ 0.98(At nominal Load)	≥ 0.98(At nominal Load)
27	Switching Frequency	[By Bidder]	[By Bidder]
	Drive Dimensions	[By Bidder]	[By Bidder]
	Length	[By Bidder]	[By Bidder]
	Height	[By Bidder]	[By Bidder]
	Depth	[By Bidder]	[By Bidder]
	Weight	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E15

**TECHNICAL SPECIFICATION FOR EMERGENCY DIESEL
GENERATOR**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E15**1.0 EMERGENCY DIESEL GENERATOR (EDG)****1.1 General**

This specification is intended to cover the *[design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning]* of EDG Set with its all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code	Name of Standard
IS: 1460 / IS 3977	High Speed Diesel (HSD) or Light Diesel Oil (LDO)
IEC 60034 / IS 4722 / BS 2613	Alternator
IS:10000, BS:5514	Diesel Engine
IS 7372	Battery
BS 5514	Governor
IS 12075 / BS 5000: Part-III	Alternator Vibration
IS 13947: Part-1	Control Panel Degree of Protection
ISO: 8528(Part-IV)	Reciprocating internal combustion engine driven alternating current generating Set.
IEEE: 446	Recommended practice for emergency and standby power system for commercial and industrial application.
ISO 3046	Reciprocating Internal Combustion Engines-Performance

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ISO 8528	Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets
NEMA MG 1-22	Synchronous Generators-Salient Pole Type
IEEE C57.13	Requirements for Instrument Transformers
SAE J1349	Engine Power Test Code - Spark Ignition & Diesel Underwriters Laboratories, Inc
IEC 60651	Sound level meters.
IEC 60529	Classification of degrees of protection provided by enclosures.
IEC 60909 (Part 0 To 4)	Short circuit currents in three phase AC systems.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity (IE) Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- EDG set shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The EDG set shall be suitable for operation in a highly polluted environment.
- [EDG Set shall be installed outdoor in weather proof acoustic enclosure or Indoor in DG room]. EDG Set shall be supplied complete with all consumables including lube oil.
- Power supply shall be normally supplied from normal power source. During loss of AC power supply (Plant blackout) EDG set shall automatically come into operation to provide power to the essential loads required for safe shutdown of the units as well as provide power supplies to auxiliary loads which required for personal safety and minimum plant maintenance during the blackout. EDG shall feed 415V, 50Hz AC power to Emergency PMCC which shall further distribute the power for safe shutdown of Steam turbine and other loads.
- Each EDG shall be provided with AMF (Automatic Mains Failure). Critical speed of DG shall not be lesser than 120% of the normal speed.

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- e. The sizing of DG set shall be based on the actual loads thrown on DG sets after the emergency and not the algebraic sum of all connected loads. The minimum capacity of diesel generating set shall be [-----kVA].
- f. EDG Set shall be started automatically in case of AC power loss. Manual starting facility from Control room shall also be provided.
- g. Wherever DG set is started with DC motor, separate automobile type battery with charger shall be provided for starting.
- h. Manual control of engine speed and generator voltage shall be provided through raise lower control switches on local control panel and also from DCS located at control room.
- i. The governor shall be provided with motor operated speed gear for remote adjustment of generator frequency. The Governor/ Excitation/ Control Systems shall permit operation of EDG Set without exceeding the active and reactive power limitation of the Generator.
- j. The periodic on load tests of the diesel generators shall be performed by operation in parallel with the grid, for this purpose each generator shall be equipped with both automatic and manual synchronizing systems for synchronization with the grid.
- k. DG sets shall be provided with one channel for auto control and one channel for manual control. DG sets shall have automatic starting sequence from the manually initiated command from remote/local. The starting time required for DG sets shall not be more than 15 seconds.

1.4 Specific Requirements

1.4.1 Starting & Control

- a. The DG Set shall have integrated control with automatic starting sequence from the manually initiated command from a single push button. It shall also have auto initiation through a 'No volt relay' and Auto position of auto/manual selector switch. The DG set shall also issue automatic closing command to its breaker on achieving rated voltage and frequency on its terminals.
- b. The starting time required from the initiating signal until the operating speed and voltage is attained and the engine and generator are ready to take load, shall not be greater than 30 seconds. Three attempt starting facility shall be provided using two impulse timers and a summation timer. The DG shall be capable of being stopped manually from remote and local. Interlock shall be provided in DG control panel to prevent shutting down operation as long as the circuit breaker at its generator output is closed.
- c. If electrical self starting system is provided, the source of energy shall be batteries backed up by battery chargers.

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- d. If compressed air starting is provided, 2x100% air compressors to meet the entire compressed air requirement of the diesel generating set with one number electric motor driven and another with diesel engine driven with manual cranking system shall be provided. Air receiver shall be provided with necessary piping, fitting and instrumentation.
- e. The starter motor shall conform to IS: 4722.
- f. Suitable thermal insulation together with jackets shall be provided on all exposed hot pipes and equipment to limit the surface temperature to 60 deg C.

1.4.2 Battery & Battery Charger

- a. The battery shall conform to the requirements of IS:7372 or relevant standard. A suitable battery charger using semiconductor rectifier shall be provided to recharge the battery within 10 hours. The minimum voltage at the end of load cycle shall not be less than 1.75 volts/ cell.
- b. The battery for starting the engine shall be capable of performing six (6) normal starts without recharging. In any case, continuous cranking for at least one minute shall be possible.

1.4.3 Diesel Engine

a. Type

The engine shall be 4-stroke, compression ignition, inline or vee engines, turbocharged and water cooled, diesel engine for emergency power requirements of the plant. The engine shall be of stationary type suitable for [Outdoor/ indoor] operation. The engine shall be provided with the necessary accessories and adequate control system allowing for an easy operation, starting and stopping

b. Combustion Air Intake System

The air for the engine requirements shall be drawn via an automatically oil wetted or self cleaning air intake filter designed to give adequate protection to the engine internals without excessive pressure loss.

c. Exhaust Gas System

The engine shall be provided with exhaust silencers extended outside the building. Suitable bellows to be provided in the exhaust duct. The DG stack should meet the pollution control board norms.

d. Constructional Requirements

- i) Diesel engine shall be mounted on visco damper type vibration dampening system and shall be complete with integral air intake through dry type air filters and exhaust systems, metering facility,

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speed regulation system, fuel injection system, lube oil system, primary cooling water system along with necessary filters, silencers, ducts, piping and fittings, valves, instruments, etc.

- ii) The generating unit shall be complete with all auxiliaries and its performance, torsional vibration, materials and workmanship, etc. shall be in accordance with the standard practices of diesel engine manufacturer's association in USA, IS-10000, BS-5514 or equivalent. The engine shall be properly balanced so as to transmit only small unbalanced forces to the foundation.

e. Diesel Oil System

- i) The diesel oil system as provided shall be complete with duplex type filters, hoses, piping, fittings, relief valves, supports, control and instrumentation and all other accessories to make it complete.
- ii) The fuel consumption of the engine at full and three quarters of its rated power output shall be indicated.
- iii) A day oil tank of [990 liters] fuel capacity shall be provided, mounted on fabricated steel platform. The tank shall be complete with level indicator marked in liters, two nos. of level switches, filling inlet with removable screen, an outlet, a drain plug, an air vent and necessary piping. The fuel tank shall be painted with oil resistant paint. All pipe joints shall be brazed/ welded.

f. Lubricating Oil System

- i) Automatic pressure lubrication shall be provided by a shaft driven gear type pump through an oil cooler and fine mesh filters to the end bearing, camshaft bearings, camshaft chain and gear drives, governor, air starting, distribution, auxiliary drive gears etc.
- ii) If pre-lubrication is required before starting of the DG set, than one (1) no. electrically operated and one (1) no. standby DC operated lube oil pump shall also be provided for the purpose.
- iii) All necessary accessories like pressure gauges, temperature and oil level indicators, pressure relief valves, bypass valves, pressure switches for alarm and control shall be furnished together with all inter connecting piping, fittings, supports, valves, etc.

g. Cooling System

Totally air cooled type DG sets are preferable. However, in case jacket water cooling system is offered, the same shall be in closed cycle and have radiator located in front of the engine with a fan driven mechanically from the engine shaft. Forced water circulation by means of pump driven by the engine shaft shall be employed. The radiator tube shall be of copper with sufficient transfer area. Heat exchanger/ cooling tower arrangement shall also be acceptable.

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h. Governing System

- i) The governor shall be electronic A1 type as per BS-5514.
- ii) The governor shall have necessary characteristics to maintain the speed substantially constant even with sudden variation in load. However a tripping shall be provided even if speed exceeds the maximum permissible limit.
- iii) A mechanical over-speed trip device shall be provided to automatically shut-off fuel in case the speed exceeds 110% of the rated value.

i. Ancillary equipment

The following minimum equipments shall be provided:

- i) *[Flywheel*
- ii) *Fuel piping*
- iii) *Tachometer/RPM indicator*
- iv) *Lubricating oil cooler (if applicable)*
- v) *Exhaust silencer and piping*
- vi) *Fuel and lubricating oil filters, air filters.*
- vii) *Temperature gauges for water and lubricating oil and pressure gauges for lubricating oil.*
- viii) *Hand barring gear.*
- ix) *Necessary foundation bolts and base channels for the engine, alternator, fuel service tank and for all other equipment included in this package.*
- x) *Base frames*
- xi) *Platforms and hand railing and access ladder (if applicable)*
- xii) *Starting equipment*
- xiii) *Protective equipment preferably in the form of fuel cut-off solenoid and suitable relays to protect the engine against low lubrication pressure.*
- xiv) *Lifting attachment for lifting the complete set or the engine alternator separately.*
- xv) *Radiator/ Heat Exchanger.]*

1.4.4

Generator

a. General

- i) The generator shall be of totally enclosed or screen protected drip proof and self air cooled type. The generator shall be driven by the diesel engine specified above and shall match the same in all respects. The generator shall conform to IS-4722, IEC-60034.
- ii) AC generator shall be supplied along with excitation system, AVR and include all necessary auxiliaries.

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iii) The Generator shall be star connected, 3-phase, 50Hz synchronous generator and shall have a continuous rating. The operating conditions shall be as follows:

- a) Voltage 415V
- b) Frequency 50Hz (+ 3 to -5%)
- c) Power factor 0.80

iv) The generator stator and rotor windings core insulation and all connections including main and neutral leads shall have class-F or better insulation.

v) Resistance element temperature detector shall be installed at the following locations :

vi) 6 nos. duplex or 12 nos. simplex RTD's in stator windings.

vii) 1 no. RTD element in each bearing.

viii) Suitably rated 240V, single phase, 50Hz, space heaters located in lower part of alternator shall be provided to maintain the internal temperature above the dew point to prevent moisture condensation on the insulation when the set is not running.

ix) Separate terminal boxes shall be provided for phase and neutral side of leads. The terminal boxes shall be dust proof, weather proof phase segregated double walled (metallic as well as insulated barriers) having degree of protection of IP-54 as per IS: 13947.

x) The terminal box shall be of sufficient size to conveniently terminate the size and number of cables. Suitable tinned copper pads shall be provided for power cable termination along with all necessary hardware and cable lugs. For single phase cables gland plate shall be of nonmagnetic material and shall be removable type. The necessary CT's for differential protection shall be provided on neutral side.

xi) Alternator vibration level shall not exceed the values as defined in IS:12075. Alternators in case driven by diesel engine shall be able to withstand vibration level of 9 mm/sec. as per BS 5000 Part III.

b. Stator

i) The stator laminations shall be designed and assembled as to minimize noise and offer minimum resistance to the cooling air flow. Coil ends and stator supports shall be designed as to withstand abnormal operating conditions.

ii) The stator windings shall be brought out to six insulated terminals in two separate terminal boxes. The alternator shall, be provided with three separate terminal boxes i.e. for the live and neutral stator connections and for control connections.

iii) The star connection shall be formed in the neutral terminal box. Terminal box shall be capable of withstanding short circuit current for

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1 sec. All terminals shall be of stud type. The terminal boxes shall be complete with lugs and double compression cable glands.

c. Rotor

- i) The rotor shall be built in accordance with the best modern practice and shall be designed to withstand safely all stresses due to overload and over speed.
- ii) The necessary inertia as required for proper regulation including at heavy rush loads shall be realized by the rotor design.
- iii) The rotor shall be designed to have a large margin between the running and critical speeds. The critical speeds of all rotating parts as well as the rigidity against vibrations shall be checked together with the Diesel engine manufacturer and must be confirmed by calculations.

d. Bearings

The bearing(s) shall be antifriction/sleeve bearings. Safe lubrication during start-up must be ensured to prevent bearing damages. Suitable precautions (i.e. bearing insulation) shall be taken to prevent harmful flow of shaft Currents.

e. Excitation System

- i) The generator shall be provided with complete excitation system capable of supplying the excitation current of the generator under all conditions of output from no load to full load and capable of maintaining voltage of the generator constant at any value with (\pm)10% of the rated voltage. It shall be possible to set the same from remote also. The type of insulation of the armature field winding of the exciter shall be class-B and the temperature shall not exceed the values specified in IEC-60034 Part-I for different parts.
- ii) The excitation system shall be of static excitation system/ brushless excitation system/any other modern excitation system.

f. Automatic Voltage Regulator

- i) The regulation system shall be provided with equipment for automatic and manual control. Necessary equipment shall be furnished for the following:
 - To prevent automatic rise of field voltage in case of failure of potential supply.
 - To initiate transfer from automatic to manual control of excitation on fuse failure in the generator potential signal.
- ii) The regulator shall regulate from generator current and potential signals.

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- iii) The above equipment shall be housed in self standing sheet metal cubicle, and shall be completely tested and wired.
- iv) The regulation equipment shall function correctly between the frequency variation of -5% & +3% and shall ensure a voltage variation not more than (\pm) 1% of the set point in steady operating condition between no load to full load.

g. Generator Neutral Grounding

The generator neutral shall be grounded as per manufacturer's recommendation taking into consideration that single phase to ground fault current shall be limited to less than 3-ph fault current.

1.4.5 Control, Measuring & Protection System

- a. The Diesel generator set shall be equipped with a local control board. It shall consist of the following panels:
 - i) Engine Control Panel
 - ii) Generator Control and Relay Panel
- b. All equipment shall be clearly arranged, and may be visualized by LCD or similar displays
- c. The necessary measuring transducers for transmission of generator parameters to the DCS shall be provided and shall be mounted and wired in the relay panel. For the remote control a serial interface [\[open protocol IEC 61850\]](#) to the DCS shall be provided.
- d. Engine Control Panel
 - i) The engine control panel shall be equipped with all instruments and control devices etc. necessary for operation and supervision of the Diesel engine and its auxiliaries at different modes of operation. It shall also be equipped with the fault annunciation device for the Diesel Engine set including all auxiliaries.
 - ii) Following alarms, annunciation, and instruments / gauges shall be provided in the Engine control panel as minimum. (The lists provided are indicative only).

e. [\[Measuring Instrument](#)

- Lubrication oil temperature gauge
- cooling water temperature gauge
- charge air temperature gauge
- cylinder and turbo-charger temperature gauge
- starting air pressure gauge
- lubrication oil pressure gauge
- speed indicator gauge
- Operation hours counter gauge.

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- Group Fault Annunciation
- diesel engine alarm
- diesel engine trip
- Diesel engine pre-lubrication/heating alarm
- Electrical trip
- electrical alarm
- Individual Alarms of Engine
- lubrication oil pressure low
- Cylinder cooling water pressure low
- Cylinder cooling water temperature high
- Exhaust gas temperature high
- Charging air temperature high
- Lubrication oil temperature high
- Fuel oil tank level too low
- Fuel oil tank level too high
- Starting air pressure low
- Pre p lubrication/heating fault
- Filter dirty
- Lubrication oil drain tank, level low.
- Fuel oil pressure low
- Fuel level low in day tank (Alarm and Trip)
- Individual Trips of Group Fault Annunciation
- Lubrication oil pressure too low
- Cylinder cooling water pressure too low
- Cylinder cooling water temperature too high
- Charging air temperature too high
- Lubrication oil temperature too high
- Over speed (two steps)]

f. Generator Control & Relay Panel

- i) The Control & Relay panel for the generator set with the provision for local starting shall comprise protection and metering equipment, indicating instruments. The panel shall be free standing; sheet steel enclosed having a degree of protection of IP-52 degree of protection as per IS: 13947 Part-I. Sheet steel thickness shall not be less than 2 mm.
- ii) All cables shall have bottom entry. Separate cable chamber shall be provided in the panel for all incoming and outgoing cables.
- iii) All auxiliary devices for control, indication, measurement, protection and alarm shall be mounted on the front door of the panel. Alarm/indications shall also be annunciated in central control room. Remote start /stop operation facility shall be provided from central control room.

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- iv) Wiring for control and signaling indicating/metering circuits shall be done with PVC insulated copper conductors having 1100 V grade insulation.
- v) A tinned copper/ aluminium bar of adequate dimension shall be provided for earth connection complete with nuts and bolts as required for external connection to earth grid. All non-current carrying metallic parts of the mounted equipment shall be earthed. Doors and movable parts shall be earthed using flexible copper connections.
- vi) Engraved nameplates shall be provided for all devices mounted on the front of the panel.
- vii) Control panel shall be complete with space heater, cubicle lamp, 5/15A socket along with switch and fuse.
- viii) [The final paint shade shall conform to shade grey RAL 9002. The identification tag shall be white in colour shade RAL 9010.]
- ix) CT shorting links, test terminal blocks etc. shall be provided. All the equipment mounted inside the control panel shall be identified by lamicaid labels/ stenciling by paint.
- x) Panel shall be provided with panel illumination lamp operated by the door switch and thermostat-controlled space heater.
- xi) The protection shall include but not limited to the following
 - [3-phase Differential Current Protection (87T) (If Applicable)]
 - 3-phase Overload Alarm (49A)
 - 3-phase Voltage controlled Over current relay (51V)
 - Reverse power protection (32)
 - Generator Stator earth fault protection (64R)
 - Generator Under voltage(27)/ Over voltage protection (59)
 - Hand reset lockout relay].
- xii) The Metering shall include but not limited to the following
 - [3 no. AC ammeters of suitable range.
 - 1 no. AC Voltmeter of suitable range with selector switch.
 - 1 no. Wattmeter
 - 1 no. Watthour meter having accuracy of 1.0 class.
 - 1 no. frequency meter
 - 1 no. Power Factor meter.]

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xiii) Necessary pressure switches, level switches, thermostats, flow switches, auxiliary relays, etc. required for the above alarm and annunciation system shall be provided.

xiv) The following minimum instruments shall be mounted on each engine:

- *[Thermometers for lube oil temperature.*
- *Pressure gauges for lube oil, fuel oil and air starting systems.*
- *Differential pressure gauges across strainers and filters*
- *Speed indicator*
- *Exhaust pyrometers with temperature switch.*
- *Level switches for alarm and trip in day fuel oil tank.]*

xv) The following tripping and alarms shall be provided (The list provided are indicative only):

- *[Fail to start (Alarm)*
- *Overload (Alarm)*
- *Cooling water pressure low (Trip)*
- *Lube oil pressure inadequate (Trip)*
- *Over Speed (Trip)*
- *High cooling water temperature (Trip)*
- *Abnormal voltage (under and over voltage) (Alarm).*
- *Charger ON/OFF (Alarm)*
- *Fuel level low in day tank (Alarm and Trip)*
- *High lube oil temperature (Trip)*
- *Low air pressure in receiver (Alarm)*
- *Alternator stator temperature high (Alarm)*
- *Electrical protective relays operated (Trip)]*

xvi) Necessary current transformers and voltage transformers shall also be provided. All protective relays shall be of multifunction, microprocessor based, numerical type suitable for communicating with DCS system. *[Numerical Relays shall be interlinked to DCS through open protocol IEC61850. Suitable hardware, software, cabling and any other interface requirement shall be taken care].*

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- xvii) All provisions for manual as well as automatic starting of DG set shall be provided in the control and relay panel. Provision of synchronizing DG set with normal AC system shall be provided for testing and cut in/cut out of DG set without interruption of power supply.
- xviii) DG set essential controls, indications, alarms, etc shall be extended to DCS at central control room.

1.4.6 Sound proofing system

- a. The sound proofing system shall be designed to achieve a minimum 25dB insertion loss/ maximum sound level at ½ metre distance from enclosure/ acoustically treated room as per State Pollution Control Board norms. The ventilation system shall be of adequate design to ensure no deterioration in performance of DG.
- b. The sound absorptive layer shall comprise of bonded type mineral wool/ glass wool of adequate thickness and density to comply the design requirements.
- c. The exposed surface of lining inside room/ enclosure shall be retained in place by a adequately thick CRCA/ aluminium perforated sheet (not less than 0.8mm). Absorptive lining shall be provided between the perforated sheet and absorbing material. Necessary acoustic sealing shall be done in the panels/ modular unit joints.
- d. All hardware of mild steel shall be electro-galvanized.
- e. The door design shall be generally compatible to the enclosure design/ acoustic treatment of room. The bonded mineral wool slab of adequate thickness shall be used. The door shall be provided with heavy duty hinges and handles. The sealing shall be done with neoprene/ silicon rubber gasket to avoid leakage of noise. The size of the door shall be as per the room design/ functional requirements.
- f. Acoustic treatment of DG room shall be done. The following requirements shall be complied in case of acoustic treatment:
 - i. The acoustic treatment of wall, ceiling and other opening shall be done using galvanized steel sections. The framework shall be fixed on wall/ ceiling using expansion fasteners.
 - ii. Bonded mineral wool slab of required density and thickness shall be used for sound absorptive layer. This shall be concealed with perforated aluminium/ CRCA sheet. Suitable lining shall be provided between the bonded wool and perforated sheet.
 - iii. Necessary acoustic sealing shall be done in the panel joints.

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iv. In rolling shutter area, removable type of acoustic paneling shall be done to facilitate maintenance.

- g. Ventilation system of adequate capacity shall be provided. The system shall comprise of tubular axial flow fans for air intake and air exhaust. The ventilation shall be design to ensure required air flow rate as per manufacturer recommendations, after providing necessary acoustic treatment/ silencers in air flow path. The ventilation system shall be design to prevent leakage of sound and maintain required room temperature for comfortable working in the area not to deteriorate performance of DG.
- h. The construction of ventilation duct shall be similar to that of the enclosure/ room acoustic treatment
- i. The exhaust air from radiator shall be discharge through modular duct duly/ insulated of adequate size. The duct cross section shall be 1.5 times the cross-section of the radiator (radiator X-section is approximately 2mx2m).

1.4.7 Name Plates

- a. Nameplates with the equipment tag no. shall be fixed on each equipment. Nameplate shall be provided for each equipment /component and for each feeder mounted over each panel.
- b. Special warning labels shall also be provided wherever necessary inside or outside the equipment/panel.
- c. Engraved nameplates shall be anodized aluminium. Back engraved Perspex sheet will also be acceptable. Screws and not adhesives will fasten nameplates.

1.4.8 Painting

- a. All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface, free of scale, grease and rust.
- b. After cleaning, the surface shall be given primary coat of zinc rich polyurethane enamel based primer.
- c. Two final coats of polyurethane enamel paint of light grey shade (631 of IS:5) shall be given to the exterior surfaces.
- d. Sufficient quantity of touch-up paint shall be furnished for application at site.

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1.5 Tests

1.5.1 Type Test

For EDG set, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

1.5.2 Routine Tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Following tests among others shall be conducted.

- a. Material analysis and testing.
- b. Hydrostatic pressure test of all pressure piping.
- c. Static and Dynamic balance test of rotating parts at applicable over speeds and to determine the vibration level.
- d. Radiography and magna flux examination of material welds.
- e. Ultrasonic test of castings and forgings.
- f. Overall Mechanical and electrical inspection.
- g. Over speed at 120 rated speed and adjustment on emergency governor.
- h. Functional checks and adjustments of speed governor and control devices.

The generator shall be subjected to following tests:-

- a. High voltage tests on stator & rotor windings.
- b. Insulation resistance of stator and rotor windings.
- c. Temperature rise test.
- d. Measurement of resistance of stator & rotor windings.
- e. Open circuit and short circuit tests.
- f. Sudden short circuit test for determination of machine reactances and time constants.

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- g. Measurement of losses.
- h. Mechanical balance.
- i. Over speed test.
- j. Stator voltage and current balance.
- k. Stator phase sequence check.
- l. Deviation factor of wave shape.
- m. Overload capability test.
- n. Zero power factor test.

The Excitation system shall be subjected to the following tests

- a. High voltage test on stator & rotor windings.
- b. Insulation resistance of stator & rotor windings.
- c. Temperature rise test.
- d. Measurement of resistance of stator & rotor windings.
- e. Open circuit magnetization test.
- f. Measurement of losses.
- g. Response ratio test.
- h. Over speed test.
- i. Mechanical balance.
- j. Functional check and operation of relays, protection, metering and signaling schemes.
- k. Measurement of insulating resistance.
- l. High voltage test on panels.

The voltage regulator shall be subjected to the following test

- a. Sensitivity test.
- b. Response time test.

The diesel generating unit and the auxiliaries shall be assembled at the manufacturer's works and the following test shall be performed.

- a. Four (4) hours at full load followed by a 2 hours continuous load of 110%.
- b. Engine starting time.
- c. Fuel consumption test.

Additional tests shall be performed by the contractor to prove the following:-

- a. Automatic starting and interlocks.
- b. Governor responses.
- c. Over speed test and over speed trip.

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d. Freedom from vibration and noise.

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data & Manuals:

Drawings, data & manuals for the EDG Set shall be submitted as indicated below:

- a. *[General arrangement drawings (plan, elevation, section view) with dimensions.*
- b. *Technical Data sheets*
- c. *Foundation drawing including loading data.*
- d. *Schematics and wiring diagrams.*
- e. *Test reports*
- f. *Inspection and test plan*
- g. *Detailed bill of material.*
- h. *Manufacturing Quality Plan*
- i. *Engineering, manufacturing, delivering and test schedule*
- j. *Sub-Supplier lists*
- k. *Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.*
- l. *Instruction manuals of EDG. The manual shall clearly indicate method of installation, check-ups, and tests to be carried out before commissioning of the equipment.*
- m. *Bidders shall note that the drawings, data and manuals listed herein are minimum requirements only. The Bidders shall ensure that other*

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necessary write-ups, curves and information required to fully describe the equipment are submitted with their bids.]

1.7

Ratings and Requirements

Sl. No.	Description	Data for EDG
1.	Location	<i>[Outdoor with weather proof acoustic enclosure/ Indoor in the EDG room]</i>
2.	Generator	
i.	Type:	Three phase radiator cooled synchronous generator for direct coupling to the Diesel engine
ii.	Rated capacity	<i>[As per calculated size]</i>
iii.	Ambient temperature	50 deg C
iv.	Rated power factor:	0.85
v.	Rated voltage:	0.415 kV
vi.	Voltage regulation range:	<i>[+/-10 %]</i>
vii.	Rated frequency:	<i>[50 Hz, +3%,-5%]</i>
viii.	Rated speed:	Corresponding to the Diesel engine
ix.	Winding insulation (stator and rotor):	Class F
x.	Max. allowable temperatures as defined for insulation:	Class B
xi.	Voltage regulation	<i>[Not more than 3%]</i>
xii.	Overload capability	<i>[50 % for 15 seconds 10 % for one hour]</i>
xiii.	Excitation System:	Brushless excitation
3.	Engine	

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Sl. No.	Description	Data for EDG
i.	Type of duty	Emergency Diesel Generator
ii.	Noise level at works at one metre distance from DG set	As per NEMA Standard
iii.	Noise level at ½ metre distance from DG acoustic enclosure	Room shall be acoustically treated for 25dB insertion loss
iv.	Maximum speed	1500 rpm
v.	Duty	12 hours continuous running, of which one hour at 10% overload at rated speed
vi.	Governor	Electronic A1 type as per BS:5514
vii.	Fuel	All types of diesel fuel available in India
viii.	Vibrations	Maximum 250 microns peak to peak with anti-vibration pads
ix.	Fuel Tank Capacity	<i>[Shall be sized by bidder based on 8 hour operation of EDG set at full load]</i>
x.	Type of Engine cooling	<i>[Air Cooled / Forced Water Cooled]</i>
xi.	Type of starting	<i>[Electric self starting or by compressed air]</i>

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-C
DETAILED TECHNICAL SPECIFICATION-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
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	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
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	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
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* * * * *

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1 GENERAL

This specification is intended to provide the technical guidelines for the fully coordinated Control & Instrumentation (C & I) system for the balance of plant (BOP) systems and its Auxiliaries of [210/215/220/250] MW, Coal fired Subcritical Thermal Power Plant.

The technical specification shall serve as the guide specification for the proprietary controls of Mechanical balance of plant (BOP) System and its Auxiliaries, equipments as also various stand alone system controls included as part of sub-packages, as in case of system auxiliaries.

It is to be noted that where equipment or system for the BOP systems and its auxiliaries are described, it shall be understood that the quantities described are per unit basis, i.e., identical sets to be furnished for each of the units (If plant have multiple units). Where equipment or systems for common facilities are described, it will be understood that the quantities described are the total quantities required.

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2 SYSTEM DESCRIPTION

C&I system shall consist of all local instruments Viz. Pressure Gauge, Temperature Gauge, limit switch, other field sensors, Local panel & push button station, control room equipment, as required erection hardware & interconnecting cables required for the control & monitoring of the entire balance of plant (BOP) systems. A dedicated PLC based control system shall be provided for each of BOP systems for operation, control, and interlocking, tripping and all associated equipment whenever required under specified abnormal conditions.

All 6.6 KV drives shall be provided with fluid coupling temperature/ bearing Temperatures measurement & shall be measured with Duplex RTD. Temperature Measurement sensor shall be provided for all bearing temperature measurement. Stator winding temperature measurement element shall be duplex type and all temperature measuring points shall be connected to PLC. Winding temperature high alarm shall be generated in the PLC system. 6.6 KV drives shall also be provided with vibration monitoring devices and shall be connected with PLC.

2.1 General Requirements

1. The Control and Instrumentation system for each package of Balance of Plants shall be standalone and geographically distributed PLC automation system, control panels / desks, field & remote instrumentation, cables and all other interfacing equipments as required for interfacing with Plant DCS system.
2. The control and instrumentation system for BOP systems shall be designed and constructed to meet all the specification requirements. All instruments/ equipments offered shall be capable of satisfactory operation for prolonged period of time and shall perform accurately and safely under the environmental & operating conditions described in the specification.
3. All equipment, and accessories furnished under the specification shall be from the latest proven control and instrumentation product range of qualified manufacturers whose successful performance has been established by a considerable record of satisfactory operation in power stations. C&I devices & systems shall employ latest state-of-the art technology to guard against any obsolescence. In any case, it shall be required to ensure supply of spare parts for lifetime of the plant.
4. Design requirements as specified in the specification shall be followed while selecting the control and instrumentation items.
5. Each item included in this specification shall be inspected and tested for full compliance with specification requirements, completeness, proper assembly, satisfactory operation, cleanliness and state of physical condition as applicable.

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6. Each component and system shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/ card, power supply, peripheral etc. shall be established, considering its failure rate/ Mean Time Between Failures (MTBF), Mean Time To Repair(MTTR), such that the availability of the complete C&I system is assured for 99.7%.
7. To ensure smooth and optimal maintenance, easy interchange ability and efficient spare parts management of various C&I items/ PLCs, it shall be ensured that each C&I item/ PLC is of same make, series and from same family of hardware (as far as practicable).

2.2 PLC system

PLC system shall be redundant with respect to Power Supply, Processor and Communication. Redundant Input card shall be used for measurement of Critical points related to protection of the equipment. All output commands to MCC/SWGR shall be provided through interposing relay. The control panel shall be IP 55 protection class.

The control system shall have hooter with required hardware and driven from PLC output. Test, Accept and Reset Push Button shall be connected to the PLC system and programmed for alarm annunciator.

A table top mounted PC loaded with editable programming software and HMI shall be provided and placed on a table located on the side of the control panel. There shall be facility of operation from LCD based Operator's station.

2.3 Interfacing With Plant DCS

Systems shall be facilitated with the interface facility requirements with plant DCS. BOP system PLC shall be linked with plant DCS through redundant Unidirectional OPC link in addition to some hardware interface signals.

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3 DESIGN PHILOSOPHY

This section covers the design philosophy which shall be used for all control & instrumentation system for BOP System & its auxiliaries.

1. Pressure indicators shall be used wherever indicating type Pressure transmitters are not envisaged. The applications include:
 - a) Suction and discharge lines of pumps, including header section, if two or more pumps are employed for the same service.
 - b) All input and output lines of process equipments.
2. Pressure Switches shall be avoided as far as possible and in place, smart pressure transmitters with soft limit value monitoring in control system shall be used. The applications shall include the following:
 - a) On all process lines / Equipments where parameter abnormality / status including pre trips alarms to be communicated to the operator in control room.
 - b) For all permissive and protection conditions governed by safety operation of the equipments. e.g. pressure adequate, pressure very high / very low conditions.
 - c) For all interlock conditions, governing starting of standby equipment or subsequent equipments for safety operation of the system.
 - d) Inlet and outlet of filters / strainers.
3. Differential Pressure Switches (indicating type) shall be used across filters/strainers for remote monitoring.
4. Smart Pressure Transmitter shall be used for all control applications and as demand by the process. Pressure stubs with isolating valves shall be used.
5. Differential Pressure Transmitter shall be used for all the requirements of differential pressure, flow, level measurement. Pressure stubs with isolating valves shall be used.
6. Temperature indicators (Thermometers) shall be used for following applications
 - a) On all process lines where local indication is warranted by the system either for monitoring or testing.
 - b) On the inlet/outlet of equipments such as Coolers for both the fluid media.
7. Differential temperature indicator shall be used across suction and discharge service.

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8. Temperature Elements: RTDs shall be used for casing metal temperature monitoring and bearing temperature monitoring of HT drives/motors.
- a) Six nos. (2 nos. per phase) Resistance temperature detectors (RTD's) shall be used for all HT motors, for winding temperature monitoring. Each element shall be 3-wire type, duplex with thermo well assembly. RTDs shall be terminated in the external terminal box, for connection to various Control systems of plant BOP.
 - b) 1 no. duplex PRT-100 type RTD shall be used for each bearing of HT equipment and its driving equipment (motor).
 - c) All RTDs shall be PRT-100 type with each element being 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to BOP Control system.
 - d) For process temperature up to 200 degree C, RTD shall be used. Beyond 200 °C temperature thermocouple to be used.
 - e) Temperature measurement shall have upscale / down scale protection features not to cause major process upset in case of sensor failure.
9. Level gauges shall be used on all tanks and the maximum length of one gauge glass shall not exceed 1 meter. The gauge glasses shall be stacked to cover the complete height of the tanks including over flow level. There shall be an overlap of minimum 100mm, when more than one level gauge is required.
10. Level switches: The instrument shall be used for the following applications:
- a) On all equipments (storage vessel) where parameter abnormality/status has to be communicated to the operator in the control room.
 - b) All permissive, interlock and protection conditions governed by the safe operation of the equipment.
 - c) The instrument shall be external cage type with SW connection with isolation facility for surface mounted tanks and top mounted with still pipe for all sumps. Still pipes shall be used with adequate supports.
 - d) Radar type level switches shall be used for bulk material bunkers/hoppers.
 - e) Conductivity type level switches shall be used for DM water services.
11. Level Transmitters Stubs with impulse pipes, root valves for mounting Level transmitters shall be used on process equipments where continuous remote monitoring and/or control of level is envisaged. Wherever necessary standpipes or float chambers and also makeup line shall be used for filling up the constant level vessel.
- a) The instrument shall be differential pressure type or torque tube type for other applications.

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- b) Radar type level transmitter shall be used for bulk material bunkers/hoppers.
 - c) Admittance or Radar type shall be for sludge and slurry applications.
12. Flow Glasses shall be used at the outlet of the pipe lines and shall be employed under the following conditions:
- a) Coolers
 - b) The instrument shall be rotary type with glass mounted for indication
 - c) Up to 6 inch on-line flow glasses shall be supplied and above 6 inch bypass type flow glasses shall be used. Sight flow and variable flow indicators shall be used for low pressure and low temperature applications.
13. Pneumatically Operated Control Valves shall be used for all control application. If the process demands any other control, then control valves shall be used for those applications also. Where a single control valve cannot meet the turn down ratio as dictated by the process, control valves with split range application shall be used.
- a) All bypass valves of control valves shall be motor operated valves suitable for inching operation provided with position transmitters.
 - b) All integrated bypass valves shall be motor operated.
 - c) Pressure test points & drains shall be used across each control valve
14. The pneumatically operated control valves shall be used with Smart Positioners, diagnostics and HART compatibility. Control Valve diagnostics shall be transmitted through this HART Protocol to control system.
15. Solenoid Valves shall be used for all pneumatic control valves hooked up with process interlock requirements and where direct tripping is involved. All solenoid valves shall be uniformly rated for 24V DC or 220V DC. The number of ways for solenoid valve shall be used as indicated below:
- a) On line two (2) way solenoid valves shall be used, where process line of less than 2 inch with low pressure & temperature application is involved.
 - b) Three (3) way solenoid valves shall be used commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder. E.g.: Pneumatic operated spray water block valve.
 - c) Four (4) way solenoid valves shall be used for operating double acting cylinders (If applicable). E.g.: Pneumatically operated on-off type dampers.
 - d) Dual coil, latch, unlatch type Solenoid valves shall be supplied for equipment trips/critical applications.
16. Position Transmitters shall be used for all motorized inching valves. Position transmitters shall be 24 V DC, 2 wire, non-contact type.

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17. Air Filter Regulators along with gauges shall be used in each of the:
 - a) Air supply line to valve positioner/power cylinders
 - b) Air supply line to pneumatic interlocked block valves
18. Interposing relay for interface to the following:
 - a) Solenoid valve (if output module cannot directly drive SOV) - Relays with contact rating of minimum 2 Amps.
 - b) DC Starter ((if output module cannot directly drive) - Relays with contact rating of minimum 0.2 Amps.
 - c) Hardwired signal exchange – as required.
19. For all HT rotating equipment bearings provision for mounting vibration probes shall be used.
20. Junction Boxes/Field termination cabinet: All JBs /FTCs shall be FRP. Junction Boxes shall be used for:
 - a) Termination of all sensors located equipment wise.
 - b) Termination of Duplex Thermocouples / RTDs
 - c) Termination of limit switch, torque switch, position transmitter and control demand, independently for each valve.
 - d) Area wise or Elevation wise bunching of cables.
21. Instrumentation & control cables and Prefabricated Cables with Anti-Rodent treatment shall be used to:
 - a) Connect field instruments to field junction boxes/Local Panels. For switches, both the SPDT contacts of switches shall be wired up to the J.B.
 - b) Connect limit switches, torque switches and position transmitters to their respective field junction boxes.
 - c) Compensating cable shall be supplied for connection between the element and the respective junction boxes / system cabinets as per guidelines.
 - d) Prefabricated cable for connecting between system cabinets, marshalling cabinet to system cabinet, system cabinet to Relay Rack, system cabinets to engineering work stations etc.
 - e) Entire C&I cable within the battery limits.
22. All field instruments including electronics located outside control room areas shall be tropicalized and shall be designed to work in site specific atmosphere/climatic conditions and enclosed in dust tight, waterproof and weatherproof enclosures. In general, transmitters and switches installed at

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outdoor location shall be mounted in closed type transmitter enclosure. For other areas (indoor), open type racks may be used for installation of transmitters and process switches.

23. All alarm shall be displayed in the control system HMI/LCD. However where local panels are used for local operation/monitoring, PLC driven alarm annunciation system with LED type lamps for local panel shall be used.

24. Pressure, temperature and flow test points shall be used in line with latest performance test code requirements.

In general, pressure and temperature test points shall be used for the following services:

- a) At the discharge of all pumps
- b) At the inlet and outlet of each control valve

25. The ranges of the instruments shall be selected based on the following philosophy:

- a) For pressure measurements, the maximum operating pressure shall be within 70 to 80% of the maximum scale range.
- b) For temperature measurement, the maximum operating temperature shall be within 80 to 90% of the maximum scale range.
- c) For pressure switches and temperature switches, the set points shall fall within 40% to 70% of the scale range selected.
- d) For level measurement, the maximum of the range shall cover the overflow point or six inches from the top of the vessel and the minimum of the range shall be six inches above the bottom of the vessel. Also, the gauge glasses shall be stacked with overlap to cover permissive, alarm and trip levels.
- e) For flow measurement, the maximum range shall be fixed at about 10 to 15% above the maximum operating flow

26. Spring-loaded/ Cage clamp type terminals shall be used for termination of instrumentation cables at field JB's, FTCs and local panels.

27. Signal Exchange Between BOP Equipments/System and control System

- a) All the signals required for interlock/alarm/SER purpose (to be implemented in the Local control System) shall be hardwired.
- b) All binary outputs provided to local panels/sensors for connection from control System shall be potential free contacts with a rating of 0.2 amps at 220 V DC or 2 amps at 24 V DC or 5 amps at 240 V AC. All check backs to control System shall only be potential free contacts.

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- c) All analog outputs provided to local panels/sensors for connection from control System shall be isolated 4-20 mA DC.
 - d) Command outputs from control System to motorized valve actuator shall be logic level signal (24 V DC) and necessary interposing relays suitable to accept 24 V DC logic level command signal shall be used in MCC module for MOV actuator.
28. All indication lamps shall be LED type.
29. All interposing relays shall be Plug in type with screw type base & LED for status indication.
30. All Limit Switch shall be Non-Contact type. If there is constraints because of process conditions/space, mechanical lever actuated Limit switch may be used.

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4 DESIGN CRITERIA

This section covers the general design criteria to be adopted in designing the Control & Instrumentation system for the BOP System Packages and Miscellaneous systems.

4.1 General Requirements

Ambient Conditions

Instruments, devices and equipment for location in outdoor / indoor / air-conditioned areas shall be designed to suit the environmental conditions indicated below and shall be suitable for continuous operation in the operating environment of a coal fired Power plant and also during periods of air conditioning failure without any loss of function, or departure from the specification requirements covered under this specification.

Table 4.1
Protection Class Requirement

Ambient Temperature (outside temperature)	Pressure	Relative Humidity	Atmosphere	Required Protection class of panels /cabinets /desks
Outdoor Location				
55 °C max	Atmosphere	100%Max	Air (dirty)	IP 65
4 °C min	Atmosphere	5 % Min	Air (dirty)	IP 65
Indoor Location				
55 °C max	Atmosphere	95% Max	Air	IP 54
4 °C min.	Atmosphere	5 % Min	Air	IP 54
Air-conditioned Area				
24 +/- 2 °C normal	Atmosphere	95% Max	Air	IP 44
50 °C Max.	Atmosphere	5 % Min	Air	IP 44
a) For Ventilated enclosures, protection class shall be IP 42. b) For hazardous areas the protection class shall be in accordance with the requirements of the relevant NEC code for the location. c) For PCs, OWS, EWS, Servers, Printers and other peripherals, maximum temperature limit shall be 35 °C, For LCD the same shall be 25 °C & for UPS the same shall be 40 °C				

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4.2 Codes & Standards

All equipment, system and service covered under this specification shall comply with the requirements of the latest statutes regulations and safety codes as applicable in the locality where the equipment/systems shall be installed.

The equipment, systems and services furnished as per this specification shall conform to the latest edition of codes and standards mentioned in this section. However in the event of any conflict between the requirements of two standards or between the requirements of any standard and this specification, all equipments under this specification shall be given tropical treatment for the climatic conditions prevailing at site as described under project data. Tropical protection shall conform to IS-3202 or any other applicable international standard for protection of Electrical power equipments against climatic conditions.

Reference Codes and Standards

The design, manufacture, inspection, testing, site calibration and installation of all equipment and systems covered under this specification shall conform to the latest editions of codes and standards mentioned below and all other applicable ANSI, ASME, IEEE, NEC, NEMA, ISA, DIN, VDE and Indian Standards and their equivalents.

Temperature Measurement

- Instrument and apparatus for temperature measurement ASME PTC 19.3
- Temperature measurement - Thermocouples ANSI-MC 96.1.
- Temperature measurement by electrical resistance thermometers – IS: 2806.
- Thermometer-element-platinum resistance-IS-2848 / DIN 43760/ IEC 751

Pressure Measurement

- Instrument and apparatus for pressure measurement - ASME PTC 19.2
- Bourdon tube pressure and vacuum gauges - IS 3624

Flow Measurement

- Instrument and apparatus for Flow measurement – ASME PTC 19.5 Interim supplement, Part-II
- Measurements of Fluid flow in closed conduit – BS 1042 / ISO 5167.

Electronic measuring Instruments & Control hardware

- Automatic null balancing electrical measuring instruments - ANSI C 39.4
- Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5.

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- Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1.
- Dynamic response testing of process control instrumentation - ANSI MC 4.1: ISA-S26.
- Surge withstand capability (SWC) tests - ANSI C 37.90a IEEE Std. 472. IEC - 254.1.
- Printed circuit boards - IPC TM-650, IEC 326 C
- General requirements and tests for printed wiring boards - IS 7405 (Part-I)
- Edge socket connectors - IEC 130-11.
- Requirements and methods of testing of wire wrap terminations DIN 41611 Part-2.
- Dimensions of attachment plugs & receptacles ANSI C73.
- Direct acting Electrical Indicating Instruments: IS-1248.
- Machinery Protection Systems: API 670

Electronic Cards, Subassemblies & Components

1. Unpackaged

- Vibration IEC 68.2.26
- Shock IEC 68.2.27
- Drop & Topple IEC 68.2.31

2. Packaged

- Vibration, Drop & Static Compression – NSTA

3. Electromagnetic Compatibility

- Electrical Fast Transient – IEC 801.4
- Surge Withstand – IEC 255.4
- Radiated Electromagnetic Field – IEC 801.3
- Electrostatic Discharge – IEC 801.2
- Electromagnetic Emissions – VDE 0871, Class B

Instrument Switches and Contacts

- Contact rating - AC services NEMA ICS Part-2 125, A600
- Contact rating - DC services NEMA ICS Part-2-125, N600.

Enclosures

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- Types of enclosures - NEMA Std. ICS-6-110.15 through 110.22 (Type 4 to 13).
- Racks, panels, and associated equipment - EIA: RS-310-B (ANSI C83.9)
- Protection Class for Enclosure, Cabinets, Control Panels and Desks - IS-13947 & IEC 529.

Apparatus, enclosures and installation practices in hazardous areas

- Classification of hazardous area - NFPA Art. 500, Vol.70.
- Electrical Instruments in hazardous dust locations - ISA-RP 12.11
- Intrinsically safe apparatus - NFPA Art.493 Vol.4.
- Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Art. 496.

Annunciator

- Specifications and guides for the use of general purpose annunciator - ISA RP 19.1.
- Surge withstand capability tests - ANSI C.37.90a and IEEE std. 472

Interlocks, Protections

- Relays and relay system associated with electric power apparatus - IEEE std.3.13.
- Surges withstand capability tests - ANSI C.37.90a and IEEE Std. 472.
- General requirements & tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I).
- Boiler safety interlocks - NFPA Section 85B, 85D, 85E, 85F, 85G.

Control Valves

- Flow Equation for Sizing Control Valves – ANSI/ISA-75.01.01 (IEC 60534-2-1 Mod)
- Control Valve Seat Leakage – ANSI / FCI 70.2
- Face to face Dimensions of Control Valves – ANSI B16.10, ISA – S75.03 & ISA – S75.16
- Steel Pipe, Flanges & Flanged Fittings – ANSI B16.34
- Control Valve Capacity Test Procedure – ISA – S75.02
- Industrial Process Control Valves - IEC 534

Process Connection and Piping

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- Codes for pressure piping power piping ANSI B31.1
- Seamless carbon steel pipe ASTM A-106.
- Forged and Rolled Alloy steel pipe flanges, forged fittings, valves and parts - ASTM A-182.
- Material for socket welded fittings - ASTM A-105.
- Seamless Ferritic alloy steel pipe - ASTM A-335.
- Pipe fittings of wrought carbon steel and alloy steel - ASTM A-234.
- Composition bronze or metal castings - ASTM B-62.
- Seamless copper tube, bright annealed ASTM B-168.
- Seamless copper tube - ASTM B-75.
- Dimensions of fittings - ANSI B-16.11
- Valves flanged and butt welding ends - ANSI B16.34.
- Nomenclature for Instrument tube fittings ISA-RP-42.1.

Instrument Tubing

- Seamless carbon steel pipe - ASTM - A106.
- Material for socket welds fittings - ASTM - A105.
- Dimensions of fittings - ANSI B16.11
- Code for pressure piping, welding, hydrostatic testing - ANSI B31.1.
- Nomenclature for Instrument Tube Fittings – ISA RP 42.1
- Seamless Stainless Steel Tubes ASTM A 312 TP 304

Cables

- Thermocouple extension wires/cables - ANSI C 96.1.
- Colour coding of single or multi-pair cables - ICEA S-61- 402. (Third edition) NEMA WCS.
- Guide for design and installation of cable systems in power generating stations (insulation, jacket materials) - IEEE Std. 422.
- Requirements of vertical tray flame test - IEEE 383.
- Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B-33 - 81.
- Oxygen index and temperature index test - ASTM D-2863.
- Smoke generation test - ASTM D-2843 and ASTM E-662.

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- Acid gas generation test - IEC-754-1.
- Swedish chimney test - SEN - 4241475 (F3)
- Instrumentation cables and internal wiring IS-1554 and IS: 5831
- Mono-mode Fibre – ITU-T G.652 for Optical Fibre Cable
- IEEE 1138/ IEC 1089 / EIA-455 B for Optical Fibre Cable

Cable Trays, Conduits

- Guide for the design and installation of cable systems in power generating station (cable trays, support systems, conduits) - IEEE Std. 422, NFPA-70.
- Guide for the design and installation of cable systems in power generating station (Cable trays, support systems, conduits) Test Standards, NEMA VE-1.
- Galvanizing of Carbon steel cable trays - ASTM A-386-78.

4.3

Power Supply

All instruments and control devices shall be designed to operate on power supplies as follows:

- Electric:
 - 230 volts AC, 50 hertz, single-phase for low torque drives with guaranteed satisfactory operation when equipment is continuously energized at any voltage from 216VAC to 264VAC.
 - 24V DC for PLC.
 - 24 VDC, 110VAC or 230 VAC for Field Instruments.
- Pneumatic:

Clean, dry, and oil free instrument air at 4.2 to 8.6 bars gauge. All necessary pressure reducing controls, where required, shall be furnished.

4.4

Standard Ranges of Analog Signals

The ranges of analog signals shall normally be as follows:

- Electric -- 4 to 20 mA dc.
- Pneumatic -- 0.2 to 1.0 kg/cm².

The use of any signal range other than the above shall not be acceptable.

4.5

Contact Ratings

The ratings of all instrument contacts used for alarms and interlocks shall be as follows:

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Table 4.2
Contact Ratings

Voltage Rating (volts)	Continuous Rating	Switching Rating (break)
a) 240 AC	480 volt-amperes	1200 volt-amperes
b) 220 DC	60 watts	200 watts
c) 24 DC	12 watts	25 watts

The ratings of all microprocessor-based controller or programmable controller output contacts shall be as required by the controlled devices. Where necessary for higher current ratings or isolation, interposing relays shall be used.

4.6

Reliability and Availability

- Each component and system shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
- Detailed reliability calculations shall be used for each system/ equipment (with the help of a schematic of various sub-system connected in series or in parallel as the case may be and MTBF & MTTR values for the various equipments). Availability calculation shall be as per IEEE Standard-P1046 or equivalent.
- When more than one device uses the same measurement or control signal, the transmitter and other components/ module shall be fully equipped to provide all signal requirements. The system shall be arranged so that the failure of any monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.
- To ensure availability, adequate redundancy in system design shall be used at hardware, software and sensor level to satisfy the availability criteria. For the protection system, independent sensing device shall be used to ensure adequate safety of plant equipment.

4.7

Standardization & Uniformity of Hardware

To ensure smooth and optimal maintenance, easy interchange ability efficient spare parts management of various C&I instruments, ensure that all instruments/devices (Processor modules, input/output modules, power supply modules etc.) are of the same family of hardware. For example, all 4-20 mA electronic transducers, control hardware, control valves, actuators instruments/ local devices etc. being furnished shall be manufacturer specific.

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4.8 Redundancy

1. Reliability of the Control System shall be established by judicious incorporation of redundancy. In general all critical parts shall have hot standby feature to render the system immune to any single failure.
2. Measurement system (MS), Closed Loop Control System (CLCS) and Open Loop Control System (OLCS) shall all be configured with redundancy at processor modules, communication modules, data bus and power supply modules.
3. Both CLCS & OLCS shall be configured with I/O channels redundancy for each sensor/signals. Where redundant sensors are provided redundant I/O channels shall be used for each sensors/signals.
4. Two out of three measurements philosophy shall be adopted for the control of all closed and critical open loop variables for reliability of operation. The control system shall select the median value for the normal control purpose.

4.9 Operability & Maintainability

1. The design of the control systems and related equipments shall adhere to the principle of 'Fail Safe' operation wherever safety of personnel / plant equipment is involved. 'Fail Safe' operation signifies that the loss of signal or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips are avoided/minimized.
2. The types of failure which shall be taken into account for ensuring operability of the plant shall include but not be limited to:
 - Failure of sensor or transmitter,
 - Failure of main and/or redundant controller/other modules,
 - Loss of motive power to final control element,
 - Loss of control power.
 - Loss of instrument air
3. The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:
 - Standardization of parts.
 - Grouping of functions.
 - Interchangeability.
 - Malfunction identification facility/self surveillance facility.
 - Easy modular replacement.

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- Fool proof design providing proper identification and other features to preclude improper mounting and installation.
- Appropriate derating of electronic components and parts.

4.10 Metering Bases of Units

The following system of units shall be followed throughout the specification unless otherwise mentioned.

Table 4.3
Metering Bases of Units

S.No	Parameter	Unit
1	Pressure	Kg/sq. cm
2	Differential pressure	mm of H2O column or Kg/sq. cm
3	Draught	mm of H2O column
4	Vacuum	mm of Hg
5	Temperature	Degree Celsius
6	Flow	Tonnes / hr or Kg/hr
7	Flow (Air / Gas)	Tonnes / hr or N. Cu. M /hr
8	Density	gm / c.cm
9	Level	mm or M

4.11 Grounding System

All panels, desks, cabinets shall be used with a continuous bare copper ground bus. The ground bus shall be bolted to the panel structure on bottom on both sides. The bolts shall face inside of panels.

The system ground shall be isolated from the panel ground with suitable isolators. All internal component grounds or common shall be connected to the system ground, which shall be fabricated of copper flat (size 25 mm x 6 mm min, length as applicable).

Shield on instrumentation cables shall be grounded on panel side. When shielding termination is required in cabinets furnished under this specification, suitable terminals shall be furnished on copper flat forming system ground. System and shield ground shall be connected to earthing strip at 0.0 meter level using suitable size of cable.

4.12 Drive Control Philosophy

The Drive control & measurement philosophy for the project is detailed in this section.

1. Bi-directional drives (inching or open/close)
 - (a) All bi-directional drives shall be operable from Remote i.e. from CCR/LCR.

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- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Open/Close commands, generated in control system shall be issued to MCC module through interposing relays. Latching of commands shall be used in control system logic which shall be reset by Limit/Torque switch feedback. The Limit/Torque switch feedback from drive shall be directly wired to Control System.
- (d) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
- (e) Following signal exchange shall be envisaged between Drive & Control system:
 - Open Limit Switch (Both NO & NC contacts)
 - Close Limit Switch (Both NO & NC contacts)
 - Open Torque Actuation
 - Close Torque Actuation
 - Position feedback (4-20 mA, two wire electronic type) for inching drive
- (f) Following signal exchange shall be envisaged between MCC & Control system:
 - Switchgear available
 - Switchgear disturbance
 - Open Command
 - Close Command

2. Unidirectional LT drives

- (a) Unidirectional LT drives shall be operable only from Remote i.e. from CCR/LCR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays.
- (d) Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
- (e) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.

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- (f) Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives greater than 90 KW. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules.
- (g) Following signal exchange shall be envisaged between MCC & Control system:
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Start Command
 - Stop Command
- (h) All Numerical relays/Intelligent controllers for LT drives shall be interfaced to Control System through IEC 61850 protocol.

3. Solenoid Operated drives

- (a) Solenoid operated drives shall be operable only from Remote i.e. from LCR/CCR.
- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Open/Close commands shall be generated in Control system & shall be issued to the Solenoid through interposing relays.
- (d) Necessary process interlocks shall be realized in Control system.
- (e) Following signal exchange shall be envisaged between solenoid drive & Control system:
 - Open Limit Position
 - Close Limit Position
 - Open Command
 - Close Command

4.13

HT drives

1. HT drives shall be operable only from Remote i.e. from LCR/CCR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
2. Remote manual operation of all drives shall be carried out from OWS.

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3. Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays located in respective MCC modules.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
5. Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
6. Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules
7. Following signal exchange shall be envisaged between MCC & Control system:
 - Switchgear available
 - Switchgear disturbance
 - Master Trip relay Operated
 - On Feedback
 - Off Feedback
 - Trip Feedback
 - Emergency stop feedback
 - Start Command
 - Stop Command
 - Current Feedback
8. All Numerical relays/Intelligent Controllers for HT drives shall be interfaced to Control System through IEC 61850 protocol.

4.14 Variable Frequency Drives (VFD)

1. VFD shall be operable from Remote i.e. from CCR/LCR & from VFD Local Display unit. In addition, Local pushbutton shall be used only for emergency stopping of drive.
2. Remote manual operation of VFD shall be carried out from OWS.

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3. Remote Start/Stop commands shall be generated in Control system & shall be issued to VFD Panel through interposing relays located in VFD Panel.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided in the field. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to VFD panel.
5. Necessary Electrical protections shall be realized at VFD module whereas process interlocks & protections shall be realized in Control system.
6. Following signal exchange shall be envisaged between VFD & Control system:
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Trip Feedback
 - Emergency stop feedback
 - Start Command
 - Stop Command
 - Current Feedback
 - Speed feedback
 - Speed Setpoint
7. The VFD shall also be interfaced with control system via Modbus soft link.

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5 CONTROL AND INSTRUMENTATION FOR BOP SYSTEMS

5.1 General

1. The design of the control system and related equipment shall adhere to the principle of "fail safe" operation at all system levels (i.e.) loss of signal, loss of power or failure of any component should not cause a hazardous condition; and at the same time prevent occurrence of false trips and provide reliable and efficient operation of the plant under dynamic conditions and attainment of maximum station availability.
2. The plant BOP systems includes the following mechanical systems:
 - Raw Water Intake System
 - Pre-treatment Plant & Effluent Treatment Plant
 - DM Water Plant
 - Circulating Water System With Cooling Tower
 - ACW/CCW System
 - CW Chlorination System
 - Compressed Air System
 - Fuel Oil System
 - Fire Fighting System
 - Miscellaneous Systems
 - Self Cleaning Strainer
 - Mill Reject Handling System (MRHS)
 - HVAC System
3. For operation and control of the balance of Plant systems and miscellaneous systems, Bidder shall provide Microprocessor based Programmable Logic Controller based control and instrumentation system which shall cover the total functional requirements of the plant which includes sequence control, interlock & protection, monitoring, alarm, data logging, fault analysis etc. The integral instrumentation for monitoring, Protection and smooth operation of all the Plant and machineries shall be envisaged.

5.2 Raw Water Intake System

1. The Raw Water Intake System shall be operated, monitored and controlled through a dedicated PLC, located suitably in Raw water pump house.
2. The PLC shall be redundant and operated through PC based HMI station (OWS cum EWS). PLC with HMI station shall be located in the control room of Raw water pump house.

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3. PLC shall be networked with the DCS by dual redundant communication link – based on Ethernet TCP/IP using bidirectional OPC connectivity, on fibre optic cable.

a. Field Instrumentation

1. All instruments like pressure indicators, pressure switches, level control instruments, level indicators, level switches with alarm contacts, control valves, flow indicators etc. to facilitate effective control of the system, shall be furnished by the Bidder. Any other instruments not mentioned in this specification but considered necessary for the safe & satisfactory operation of the system shall also be furnished by the Bidder.
2. In general, instrumentation sensors, transmission, measuring and computing hardware shall be electronic type. All signals from the field instruments / equipments shall be wired to the PLC. Electronic analog signal transmission from field to PLC shall be through transmitters. Generally all transmitters shall be SMART, 2-wire with 4-20 mA DC output.

b. Operation & Control Philosophy

1. Necessary control, protection, permissive & interlocks shall be achieved in PLC.
2. Starting and stopping of Raw Water Intake Pumps shall be suitably interlocked with the opening and closing of their motorised valves, in the discharge line of the pumps. Pumps shall trip in case of very high discharge pressure in case of accidental closure of discharge valves.
3. An interlock shall trip all Raw Water Intake Pump from very low level of water in the sump of the RW pumps.
4. Raw Water Intake Pump shall have auto-starting facility. The standby pump shall be started automatically in case of tripping of any running pump or if its discharge header pressure falls below a preset low value.
5. Each Raw Water Intake pump and associated motors shall have vibration monitoring facility (applicable for HT motors only). Necessary vibration transducers, monitors and suitable pads etc. shall be provided. Vibration probes shall be mounted on motors & pumps in X-Y direction on both DE & NDE bearings. All vibration parameters shall be monitored in CCR.
6. Each Raw Water Intake pump and associated motors shall be provided with temperature sensors to interlock & monitor bearing / winding temperatures in PLC.
7. A local Emergency Push button Station shall be provided for emergency tripping of the respective Pump.
8. Electrical breakers located at Raw Water Intake Pump House shall also be controlled from PLC and interfacing shall be through PLC

c. List of Measurement & Control

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1. An indicative list of measurements & controls is given below. However, the bidder shall provide all required measurements, controls, alarms & interlocks; as required for safe, efficient & satisfactory operation of the system, as per the requirements.
2. Ultrasonic type level transmitters shall be provided for sump level for interlock with raw water pumps logic.
3. Following minimum instruments shall be provided:
 - Low-level switches to shut down the raw water pumps.
 - Raw water turbidity & pH measurement
 - Discharge pressure gauge & Transmitter for individual pumps & at the common header.
 - Flow meter to measure flow of water at the Outlet common header of Raw Water Intake Pumps.
 - Oil level indicator for DE & NDE Bearings.
4. Any measurement / control not listed but essential for completing the process in total shall also be in the scope of the bidder

5.3 Water Treatment & Effluent Treatment Plant System

1. PLC based control has been envisaged for Water Treatment & Effluent Treatment Plant through Remote I/O racks located suitably in plant area.
2. The operation of Water Treatment & Effluent Treatment Plant shall be through OWS/LCD located in respective Control room.
3. Bidder shall provide all the integral instrumentation for monitoring, Protection and smooth operation of all the Plant and machineries. The controls shall be designed to provide automatic sequential operation of start-up, running & shutdown of the system along with protection & interlocks as required.
4. All measurements like flow, pressure, level, temperature, turbidity, chlorine, pH, conductivity, ORP shall be taken to PLC for indication, alarm, interlocking, data collection and recording.
5. Local measurement/ monitoring of pressure, temperature, flow, level etc. for different mediums and utilities, as required for the process shall be provided.
6. Pressure gauge at discharge of the pump and pressure transmitter at the discharge header line for pressure monitoring shall be provided.
7. Tanks/sumps shall have level gauges for local indication and level transmitters shall be used for interlocking with the pumps for dry run protection and for tanks/sumps overflow.
8. Motor winding and bearing temperature measurement shall be provided.
9. All the local gauges & switches as required for the process shall be provided and indicated in the offer. All the indication, alarm & interlock functions required to

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be provided in the PLC system for the respective measurement & control loops shall be included in the offer.

10. In general, instrumentation sensors, transmission, measuring and computing hardware shall be electronic type. All signals from the field instruments / equipments shall be wired to the PLC. Electronic analog signal transmission from field to PLC shall be through transmitters. Generally all transmitters shall be SMART, 2-wire with 4-20 mA DC output.

a. Control & Operation Philosophy

1. The operation and control of the Water Treatment & Effluent Treatment Plant shall be performed from dedicated PLC located in respective control rooms through two nos. (2) Operator Stations and one (1) number Engineering/Operator Work Station. The One (1) No. 52" LCD shall be configured to display alarm and also serve for normal operation.
2. One (1) no. dot matrix printer shall be provided which shall be connected to the data highway and One (1) no. A4 size Colour Laser jet printer shall be provided which shall be connected directly to the engineering work station. The required furniture such as operator desk, chairs, etc shall be provided by the bidder. The PLC shall be interfaced to DCS through redundant OPC link by fibre optic cable as well as some signals shall be hardwired to DCS for monitoring purposes.
3. The PLC shall be interfaced to the Switchgears and Numerical Protection relays through a redundant serial link with open protocol.
4. Local Push Button Station shall be provided for all motors, which shall be controlled from PLC. Each station shall contain start & stop push buttons for unidirectional motors and open, close and lockable stop push buttons for motor operated valves. Necessary Local/Remote selection facility for the drives shall be provided in the respective MCC.
5. Sump pumps shall operate automatically through level switches based on sump water level.
6. The operation philosophy shall be as following:
 - High-High: Start operating pump. In case of fail to start, standby pump shall start and shall be annunciated
 - Low: To annunciate
 - Low- Low: Stop operating pump(s).

5.4 DM Water Plant System

1. Demineralisation plant shall be operated, monitored and controlled through a PLC based Control System by OWS/LCD located in the Local control room in DM plant building.
2. The operation of the DM plant shall be "semi-automatic", that is, the back washing of filters and regeneration of all the exchangers shall be done by

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manually initiated sequential control and after that change from one step of sequence to next shall be automatic. Once a filter/exchanger has been backwashed/ regenerated, it shall not be put back into service automatically, but operator shall have to do manually through a selector switch. On exhaustion of unit, the particular filter/exchanger shall be completely isolated from the system automatically and an alarm status displayed on the OWS/LCD.

3. All valves in DM plant shall be operable from control room.
4. Complete stream shall be automatically isolated from the service in case any of the following takes place and an alarm displayed on the OWS/LCD.
 - On reaching high differential conductivity of effluent or on exceeding the totalised flow of decationized water through cation exchanger, whichever occurs first.
 - On reaching higher conductivity and/or silica of effluent at outlet of anion exchanger or on exceeding the totalised flow of DM water through anion exchanger, whichever occurs first.
 - On reaching higher conductivity of effluent at outlet of mixed bed exchanger or on exceeding the totalised flow of deionised water through MB unit or on reaching high silica content of effluent at MB outlet, whichever occurs first.
5. On reaching high differential pressure across the pressure sand filter, the operator shall initiate operation of backwashing/ regeneration/ rinsing of each pressure exchanger/ ACF/ Exchanger unit and after that the change from one step of the sequence to the next shall be automatic.
6. Auto-Manual operation shall be possible for degassed water pumps, degasser blowers, MB blowers, DM supply pumps PSF blowers, DM transfer pumps and neutralisation pit pumps. Auto/ Manual selection shall be done from the PLC Workstation. Each pumps/ blowers shall be provided with one stop push button (PB) at field (near to drive), which shall be lockable in stop position. This PB shall be treated as 'Emergency Stop' and shall trip the drive whenever pressed.
7. Although the basic operation of DM plant is semi-automatic in nature, some of the operation like unloading & transfer of acid and alkali shall be manual while the transfer of acid & alkali from the measuring tanks to the each exchanger units is automatic. The neutralization and transfer of regeneration effluent shall be done manually.
8. DM tank selection interlock shall be provided.
9. Following is the list of minimum measurements for the DM Plant for remote monitoring/interlocks/alarms etc.
 - Pressure measurement at PSF, ACF inlet, SAC inlet, SBA inlet & MB inlet
 - DP measurement across PSF, ACF bed, SAC bed, SBA bed & MB bed.
 - Flow measurement by Rotameter for local indication at PSF, ACF inlet, SAC inlet, SBA inlet & MB inlet.

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- Flow measurement with totalizer for remote indication at PSF, ACF outlet, SAC outlet, SBA outlet & MB outlet.
- Conductivity & pH measurement at SAC rinse outlet, SBA outlet, SBA rinse outlet, MB outlet & MB rinse outlet.
- Measurement of conductivity ratio comparison for SAC outlet.
- Silica Analyzer at the outlet of SBA and MB.
- Turbidity measurement at the outlet of PSF & ACF.
- Sodium Analyzer at the outlet of SAC.
- Ultrasonic Level measurement for DM storage tank & Degasser tank.
- For all tanks & sumps, level measurement shall be provided for remote as well as local monitoring.
- For all pumps discharge pressure measurement shall be provided for local as well as remote monitoring.

5.5 CW & Cooling Towers System

5.5.1 CW SYSTEM

1. The Operation, Control & Monitoring of the CW Pumps & drives along with associated motorized operated valves, instruments etc. shall be from DCS through RIO located at Circulating Water Pump House Control Room.
2. In addition to operation from Central control room, it shall be envisaged to provide an extended DCS Operator station in Local control room in CW pump house building for operation & monitoring.
3. Starting and stopping of CW pumps shall be suitably interlocked with the opening and closing of their butterfly/motorised valves, in the discharge line of the pumps. Pumps shall trip in case of very high discharge pressure in case of accidental closure of discharge valves.
4. An interlock shall trip all CW pumps from very low level of water in the fore bay of the CW pumps.
5. CW pumps shall have auto-starting facility. The standby pump shall be started automatically in case of tripping of any running pump or if its discharge header pressure falls below a preset low value.
6. Necessary speed switches to detect reverse rotation shall be provided to prevent motor switching "ON" while rotating in reverse direction. Alarm in DCS shall be provided for reverse rotation.
7. Necessary flow switch, as applicable shall be provided to ensure cooling water flow on bearing cooling water lines.
8. Each CW pump and associated motors shall have vibration monitoring facility. Necessary vibration transducers, monitors and suitable pads etc. shall be

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provided. Vibration probes shall be mounted on motors & pumps in X-Y direction on both DE & NDE bearings.

9. Each CW pump and associated motors shall be provided with temperature sensors to interlock & monitor bearing / winding temperatures in DCS.
10. A local Emergency Push button Station shall be provided for emergency tripping of the respective Pump.
11. Electrical breakers located at CW Pump House shall also be controlled from DCS.

5.5.1.1 List of Measurement & Control

- a) An indicative list of measurements & controls is given below. However, all required measurements, controls, alarms & interlocks; as required for safe, efficient & satisfactory operation of the system, as per the requirements shall be envisaged.
- b) Unless otherwise stated, all monitoring & control of the process parameters shall be achieved in the DCS and displayed in OWS in CCR/LCR.
- c) Following measurements are required, as minimum for the CW system:
 - Level transmitter (ultrasonic type) 3 nos. in each pump suction chamber (for 2/3 submergence protection logic).
 - Ultrasonic Flow meter on re-circulation line.
 - Pressure gauge at the discharge of each pump.
 - Pressure transmitter at the discharge of each pump.
 - Electro-hydraulic operated butterfly valve with position switches & feedback transmitter, at the pump discharge.
 - Motor operated butterfly valve with position switches & feedback transmitter in the recirculation line and make-up water line.
 - Level transmitter for pump thrust bearing oil level measurement.
 - Flow meter for pump thrust bearing cooling water line.
 - Flow meter for pump gland sealing water line.
 - Pressure gauge on pump thrust bearing cooling water line.
 - Pressure gauge on pump gland sealing water line.
 - Oil level indicator for DE & NDE Bearings.
 - RTD (duplex) for pump thrust bearing metal parts and oil bath temperature measurement.
 - RTD (duplex) for motor winding and bearing temperature measurement.
 - Pump speed measurement.
 - Pump reverse speed detection.
 - Vibration monitoring for pump thrust bearing and motor driven/non-driven end.

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Any measurement / control not listed but essential for completing the process in total shall also be included.

5.5.1.2 Reverse Rotation Monitoring System

For each of the CW pumps, a reverse rotation monitor each comprising of at least two nos. proximity sensors, processing electronics with output of 4-20 mA (corresponding to speed) interconnecting cables, speed display in rpm, normal, reverse indication and required channel alarm contact shall be provided.

Vibration monitor shall be mounted on Vibration Monitoring Panels to be located in CW Pump House Control equipment room. All cabling from the sensors up to these panels shall be included.

Table 5.1
Specifications for Reverse Rotation Monitoring System

S.N	Features	Minimum Requirements
Reverse Rotation Sensor		
1	Type	Proximity type
2	Mounting	Bracket mounted as per Manufacturer standard
3	Operating Temperature	60 Deg. C
4	Enclosure material	Stainless steel
5	Enclosure protection	IP 65 or better
6	Grounding	Insulated housing
7	Cable connector	½" NPT (F)
8	Accessories	Mounting adaptor kit, special cable, junction boxes, etc. and flexible conduit upto monitor
Reverse Rotation Monitor		
1	Type	Dual channel for two proximity sensors (reverse speed), microprocessor based, field configurable
2	Location	On Vibration Monitoring Panel
3	Input	Pulse
4	Supply voltage	24V DC
5	Accuracy	± 0.1 % of monitor full scale value (typical)
6	Display	LCD Type, speed in rpm Power on / System Ok status LED Alarm (Alert & Danger) status LED
7	Diagnostics	Sensor or other fault indication LED as per Manufacturer Standard
8	Local Reset	On Monitor front panel
9	Output	4-20 mA DC isolated per channel to DCS

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S.N	Features	Minimum Requirements
10	Output Load	600 Ohms (typical)
11	Alarm set point	Dual Relay Outputs (Potential free contact for high and high-high per channel independently adjustable throughout the range.) for DCS interface

5.5.2 IDCT

1. The Operation, Control & Monitoring of the IDCT fans & drives along with associated motorized cell isolation valve, instruments etc. shall be from DCS through RIO located at Circulating Water Pump House Control Room.
2. In addition to operation from Central control room, it shall be envisaged to provide an extended DCS Operator station in Local control room in CW pump house building for operation & monitoring.
3. The data network of DCS shall be extended using redundant link on fibre optic cable up to Local control room for installation of one operator workstation at each of the Local control room.
4. To achieve these operational & functional requirements, DCS Remote I/O (RIO) Cabinets are foreseen (located at CW pump house control equipment room) with suitable soft communication link with main DCS.

Necessary control, protection, permissive & interlocks shall be achieved in DCS.

a) Modes of Operation:

The fans can be started in SOLO mode or in GROUP mode. The selection for individual and Group operation shall be made from OWS. Further, any of the fans can be put either in STANDBY mode or NOT IN STANDBY mode.

i). GROUP Mode

• START In Group Mode:

On receipt of the GROUP START command from OWS, all pre-selected fans (except for the fans selected as "STANDBY") would start sequentially one after another after pre-defined time gap between start of the fans.

• STOP in Group Mode:

On receipt of the GROUP STOP command from OWS, all the running fans shall be tripped simultaneously. GROUP STOP command shall have priority over and already executing GROUP START command.

ii). SOLO Mode:

In the OWS, for each individual FAN, a separate START/STOP Button shall be provided. The START button shall be enabled only when the SOLO mode is selected. A fan can be started in SOLO mode immediately by pressing the START button. The fan can be stopped either by pressing the STOP push-button (of the corresponding Fan) or GROUP STOP button.

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b) Interlock and Protection

• **Following shall be the Start-up permissive for the fans:**

1. MCC Healthy
2. Oil Level Not Very Low
3. Emergency PB not pressed
4. Gear box oil Temperature not high

• **Following shall be the protections for Fan tripping:**

1. Oil Level Very Low
2. Emergency PB Pressed
3. Vibration Very High
4. Motor Overload
5. Gear box Temperature very high

Control System shall issue OPEN/CLOSE command for Electrical Breaker operation and monitor status.

The close status of motorized cell isolation valve and the ON/ OFF /TRIP status of fans shall be indicated in OWS. Operator shall be alerted through audio visual indication during the condition when the fan of any cell is ON and the corresponding cell isolation valve is closed or vice-versa.

c) Signals at Main Plant Control Room

1. Close status of cell isolation valve
2. ON, OFF, TRIP Status of all fans, vibration level (analog), Hot & cold water temperatures (analog)

d) Modification of Set-Points etc.

In OWS, there should be a provision to modify the ALARM and TRIP set-point for the vibration monitoring system as well as for the sequence times under proper password protection and available only to the system maintenance engineer/ administrator. The operators can, however, view the settings.

e) List of Measurement & Control

1. An indicative list of measurements & controls is given below. However, all required measurements, controls, alarms & interlocks; as required for safe, efficient & satisfactory operation of the system, as per the requirements shall be envisaged.
2. Unless otherwise stated, all monitoring & control of the process parameters shall be achieved in the DCS and displayed in OWS in CCR/LCR.
3. Following measurements are required, as minimum for the Cooling tower system:
 - Vibration switch at gear box of each Fan
 - Oil Level switch at gear box of each Fan
 - Pressure gauge at hot water header for local indication of hot water header pressure.

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- Temperature gauge at hot water header for local indication of hot water header temperature.
 - Temperature Gauge for each Gear Box.
 - RTD (duplex) for hot water temperature measurement.(Inlet header of Cooling Tower)
 - RTD (duplex) for Cold water temperature measurement.(Outlet header of Cooling Tower)
 - RTD (duplex) for each Gear Box
 - Pitot tube along with manometer for Flow measurement.
4. Any measurement / control not listed but essential for completing the process in total shall also be included.
 5. Necessary limit switches shall be provided for each butterfly valve on Cooling water header valves & riser valves of each cell to indicate valve open / close condition.
 6. RTD shall be provided to measure hot water & cold water temperature at Inlet & Outlet of cooling tower.
 7. Pressure Gauge & Temperature Gauge shall be provided at hot water header for local indication of hot water header pressure and temperature.

5.6 ACW/CCW System

1. The Operation, Control & Monitoring of the ACW Pumps, CCW Pumps & drives along with associated motorized operated valves, instruments etc. shall be from DCS through RIO cabinet located at Pump House Control Room.
 2. Starting and stopping of ACW & CCW pumps shall be suitably interlocked with the opening and closing of their butterfly/motorised valves, in the discharge line of the pumps. Pumps shall trip in case of very high discharge pressure in case of accidental closure of discharge valves.
 3. An interlock shall trip all ACW & CCW pumps from very low pressure of water in the common header at inlet.
 4. ACW pumps & CCW pumps shall have auto-starting facility. The standby pump shall be started automatically in case of tripping of any running pump or if its discharge header pressure falls below a preset low value.
1. A local Emergency Push button Station shall be provided for emergency tripping of the respective Pump.
 2. All control logics, process interlocks etc. shall be realized in DCS.
 3. All alarms shall be annunciated in OWS at CCR.
 4. Status of following shall be indicated in CCR:
 - PHE inlet header temperature
 - PHE outlet header temperature

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5. The following field instruments with accessories shall be envisaged with ACW/CCW pumps:

- Pressure gauge at each pump discharge.
- Pressure transmitter at each pump discharge.
- Pressure switch at each pump pump discharge.
- Pressure transmitter at pump discharge header
- Local temperature gauges shall be provided on the suction header of the closed cooling water pumps.
- Temperature Elements shall be provided on the common discharge header of the cooling water heat exchangers for monitoring the outlet temperature.
- Temperature Elements shall be provided on the inlet of the cooling water heat exchangers for monitoring the cooling water temperature.
- Local temperature gauges shall be provided on the inlet of the cooling water heat exchangers.

5.7 CW Electro Chlorination (As Applicable)

1. PLC based control shall be envisaged for CW Chlorination System & associated auxiliaries through Remote I/O racks located suitably in Electro chlorination plant area.
2. The operation of chlorination plant shall be through OWS/LCD located in DM Plant Control room. In addition to this a Local control panel suitably located in chlorination plant skid shall be provided with illuminated pushbuttons, lamps, audio-visual alarm annunciation, Process value indicators etc.
3. The Electro chlorination operation shall be designed for fully automatic control.
4. ON/OFF/TRIP status of all pumps, blowers, agitators and drive motors for other equipment under Bidder's scope of supply, ammeters for drive motors wherever required shall be displayed in control panel.
5. All drive motors shall be provided with arrangement of local starting and stopping. Local starting shall be possible through remote/local selector switch in control panel or in MCC. Tripping of drive motors locally shall be permissible irrespective of position of remote/local selector switch. Provision for locking the local stop push buttons after tripping the motor from local push button shall be there.
6. Following shall be the list of minimum measurements for the Chlorination Plant for remote monitoring/interlocks/alarms etc. However the system shall be provided with these and other measurements as necessary for the offered system.
 - Pressure Gauge, Pressure transmitter & Flow Switch at the discharge of booster pump.
 - DP Gauge & Switch across inlet strainer.

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- Level gauge, Level transmitter & Level switch for Sodium hypochlorite storage tank.
- Pressure Gauge, Pressure transmitter & Flow Switch at the discharge of Degassifier blower.
- DP gauge across suction filter of Degassifier blower.
- Pressure gauge, Pressure transmitter & Flow meter at the discharge of Hypochlorite dosing pumps (Continuous & shock dosing)
- Level gauge, Level transmitter & Level switch for dilute hypochloric acid storage tank.
- Pressure Gauge & Flow Switch at the discharge of dilute hypochloric acid pump
- Hydrogen & Chlorine Gas leak detector analyzers.

Safety & supervisory equipments shall be provided such as Chlorine Leak Detectors, Safety Shower, Gas masks etc.

5.8

CW Gas Chlorination System (As Applicable)

1. PLC based control shall be envisaged for CW Chlorination System & associated auxiliaries through Remote I/O racks located suitably in Gas chlorination plant area.
2. The operation of chlorination plant shall be through OWS/LCD located in DM Plant Control room. In addition to this a Local control panel suitably located in chlorination plant skid shall be provided with illuminated pushbuttons, lamps, audio-visual alarm annunciation, Process value indicators etc.
3. The gas chlorination operation shall be designed for fully automatic control.
4. All drive motors shall be provided with arrangement of local starting and stopping. Local starting shall be possible through remote/local selector switch in control panel or in MCC. Tripping of drive motors locally shall be permissible irrespective of position of remote/local selector switch. Provision for locking the local stop push buttons after tripping the motor from local push button shall be there.
5. The system shall be complete with all piping, valves, sampling equipment, controls, instrumentation and other accessories. A control panel shall be provided for the circulating water chlorination system which shall be complete with motor control switches, indicators and annunciators etc.
6. All local instruments like pressure, flow, temperature & level gauges, switches, analysers, detectors and erection hardware etc as required for safe and trouble-free operation of the plant shall be provided. These shall be subject to Owner's approval.
7. The control panel shall house the controls for the pumps, fans, valves, heaters, etc including tripping and status indications. Control logics and Interlock between various equipments with the system shall be realised in relay based local panel

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for auto start/ stop of the pumps etc. and process isolation. The panel shall accommodate indicators, annunciators, push buttons, selector switches, indicating lamps, control switches, auxiliary relays, contactors etc. The location and design of panel shall be to Owner's approval.

8. All necessary instruments, status contacts etc. in control panel suitably wired up to terminal block for data logging in the unit Main Control room.
9. A comprehensive annunciation system consisting of windows shall be installed on the panel for indicating the abnormal conditions of operation in the system. These shall include tripping of motors/pumps, operation of protective switches, process abnormalities, tripping of breakers, Chlorine leakage etc. The sequence for annunciation schemes shall be to Owner's approval as specified. The annunciation windows shall be mounted on the control panels.
10. A chlorine residual analyser with a NEMA 4X rated enclosure shall be furnished to monitor the chlorine residual in the circulating water as it exits the condenser. The analyser shall be capable of continuously monitoring total chlorine residual in the range of 0 to 3 mg/l. The analyser shall comply with the latest requirement of the approved codes for monitoring chlorine residual in the cooling water discharge. The analyser shall be furnished complete with a year's supply of reagents.

5.9 Compressed Air System

5.9.1 Control Philosophy

1. The compressed air systems shall be provided with microprocessor-based control system for each compressor and shall be fully automated, using the manufacturer's standard control package, with single button system start/stop from the CCR/Compressed Air System PLC and with status/alarm information provided to the CCR operator via the DCS or to the Compressed Air System PLC. Local control units with display shall be provided for the compressors to allow local operation & monitoring. In addition, local panel shall be provided for operation & monitoring of other equipments like dryers. Selection of duty operation shall be via the DCS at the CCR or the Compressed Air System PLC. All common logics for compressors such as selection, auto change over, duty cycle etc. shall be implemented in DCS/PLC.
2. Isolation valves on instrument air distribution headers and sub-headers shall be provided with a pressure gauge, downstream of the valve, located at a suitable operational position.
3. The control equipment shall interface (via Modbus) with the DCS/PLC such that the operator can monitor the operation of the compressors and be aware of problems as and when they occur.
4. A protection system shall be provided to shut down the compressed air systems in emergency situations. The protection system shall be independent of the

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DCS/PLC and any proprietary control systems and shall be operational under all operational conditions. An interface to the DCS/PLC from the protection system shall be provided to advise the operator that the protection has operated and the cause for its operation.

5. The control scheme shall be suitable for operating the compressors such that all the compressors shall be equally loaded and ensures power consumption is also optimized.
6. In case the air compressor with individual microprocessor based control system, then the same shall be connected to the DCS/PLC via modbus.
7. Any of the compressor and Air drying Plant may be selectable for "shut down ", "working "or "standby" duty.
8. On tripping of working equipment, the standby equipment shall come into operation automatically in case of very low air pressure in the system.
9. All abnormal conditions use for tripping the compressor or any other equipment shall be provided with pre-trip audio-visual indication/annunciation in the control panel.
10. Independent switches shall be used for alarms (annunciations) and tripping or interlock.
11. An electrically operated automatic valve shall be provided on cooling water supply line of each compressor & dryer (if applicable) which shall be automatically shut off the cooling water supply, in case any of the compressor/dryer is not running for more then set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor.
12. All important and critical measurements required for protection of equipments shall be provided with adequate redundancy.
13. The following indications shall be made available in the control panels
 - Status of each compressor
 - Instrument air pressure low /high
 - Service air pressure low/high
 - Dew point of instrument air
 - Status of each ADP

5.9.2 Measurement Philosophy

Following is the list of minimum required measurements for Compressors & driers. However, additional measurements required, if any, for efficient operation of the offered system, shall also be included.

A. Measurements for Compressors

- Indication of suction pressure after suction air filters for each compressor.

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- Indication of pressure of compressed air after 1st stage, after Inter cooler and after 2nd stage & after after- cooler.
- Indication of temperature of compressed air after 1st stage outlet and after after- cooler.
- Indication of pressure of compressed air in each air receiver.
- Indication of pressure of lube oil after oil filter.
- Indication of differential pressure across lube oil filter.
- Oil Level of Indication of lube oil sump.
- Sight glass in common cooling water return line from each compressor.
- Indication of pressure at the supply & return line of common header of cooling water of compressor cooling circuit.
- Indication of Flow measurement at the common discharge airline.

B. Measurements for Air Driers

- Indication of pressure on each pressure vessel
- Local Indication of differential pressure at pre-filters and after-filters
- Indication of pressure on air line before adsorber
- Indication of pressure on dry compressed air line outlet
- Indication of temperature on return cooling water line after reactivation air cooler
- Indication of temperature on air line after reactivation air cooler
- Indication of temperature on adsorber

C. Measurements at CCR

- Indication of Air pressure of individual compressor discharge header and on each air receiver.

5.9.3

Alarms & Interlocks Philosophy

Following is the list of minimum required alarms & interlocks for operation & monitoring of Compressors & driers. However, additional alarms & interlocks required, if any, for efficient operation of the offered system, shall also be included.

A. Alarms & Interlocks for Compressors

Following audiovisual alarms and interlocks shall be provided for each compressor.

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Table 5.2
Alarms & Interlocks for Compressor

S.N	Signal	Alarm/Trip
1	Suction pressure of air after suction filter low	Alarm
2	1 st stage suction air pressure low	Alarm/Trip
3	Temperature of air after 1st stage very high	Alarm/Trip
4	Temperature of air after Inter cooler, after 2 nd stage & after after-cooler	Alarm/Trip
5	Pressure of air after after-cooler high	Alarm/Trip
6	Temperature of cooling water to each compressor high	Alarm
7	Temperature of cooling water to each compressor too high	Alarm/Trip
8	Flow of cooling water from each compressor low	Alarm
9	Flow of cooling water from each compressor too low	Alarm/Trip
10	Differential pressure across lube oil filter high	Alarm
11	Pressure of lube oil to compressor low	Alarm
12	Pressure of lube oil to compressor too low	Alarm/Trip
13	Temperature of lube oil to compressor high	Alarm
14	Motor winding temperature high	Alarm/Trip
15	Manual tripping	Alarm

B. Alarms & Interlocks for Air Driers

Following audiovisual alarms and interlocks shall be provided for each Air Drier.

Table 5.3
Alarms & Interlocks for Air Drier

S.N	Signal	Alarm/Trip
1	Temperature of reactivation air high	Alarm
2	Cooling air flow low	Alarm
3	Cooling air pressure low	Alarm
4	Heater temperature high	Alarm/Trip

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S.N	Signal	Alarm/Trip
5	Temperature of cooling water from reactivation air cooler high	Alarm

5.10

Fuel Oil System

1. The control objective of the Fuel oil instrumentation and control system is to provide a safe and reliable means of unloading, storing and transferring of HFO & LDO. The fuel oil handling instrumentation system shall be grouped into two categories: local indication and remote indication. Local indication includes gauges, sight glasses, thermometers etc. Remote indication is measured at the process equipment and transmitted to the DCS/PLC for the purpose of control, monitoring, recording and trending.
2. When the unloading header & the piping at the pump suction becomes filled with oil and the steady supply is ensured by level switch at the suction pipe standpipe, the unloading pumps shall be started manually from push buttons in the local control panel located in the fuel oil unloading pump house. These pumps shall, however, trip automatically in the event of high level in the respective oil (LDO or HFO) storage tank or low level at the suction stand pipe.
3. The differential pressure across the suction duplex strainer high initiates alarms to change the duplex strainer position.
4. The transfer pumps to day tank shall be started manually from push buttons in the local control panel. These pumps shall trip automatically when the level in the source storage tank goes low or the level of respective day oil tank goes high. These pumps shall also be prevented from starting in case of low level in the respective source storage tank or high level in respective day oil tank or high pressure drop across the respective suction strainer. Stand-by pump shall start automatically whenever any operating pump trips due to any fault (mechanical/electrical) or discharge header pressure goes low.
5. The drain oil pumps shall start/stop automatically on drain oil tank high/low level initiation. Further there should be provision for alarm also. The standby pump shall also operate automatically in case the operating pump trips.
6. Local emergency stop push button shall be provided for all electrical drives.
7. Steam flow to HFO storage and day tank floor coil heater shall be controlled by pneumatically operated control valve (ON-OFF type) to maintain the desired oil temperature.
8. Steam flow to suction header of HFO day tanks shall be regulated through pneumatically operated control valve on the steam supply line to the suction header and the same shall be actuated from heater outlet oil temperature.
9. The Control panel shall include start/stop push buttons for all drives, indicators, status indication lamps etc. and shall also include annunciators (alarm &

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indication) with TEST/ ACKNOWLEDGE/ RESET push buttons, described below:

- High & low level in each HFO storage and day tanks.
- High & low level in LDO storage and day tanks.
- High & low level in drain oil tanks.
- High temperature in each HFO storage and day tanks.
- Low temperature in each HFO storage and day tanks.
- High differential pressure across each suction strainer for HFO pumps.
- High differential pressure across each suction strainer at LDO pumps.
- Unloading pump discharge pressure high.
- Unloading pump suction stand pipe (LDO/HFO) level low.
- Level control for condensate flash tank.

10. The following signals shall also be made available to central control room:

- All tanks levels.
- HFO day tanks temperature at multiple levels.

5.11 Fire Fighting System

5.11.1 General

1. Fire protection system shall be a dedicated microprocessor based system in a separate control room. Instrumentation and controls for fire alarm and detection system shall be Microprocessor based and should be in accordance with NFPA 13, 15, 6, and 72 as well as TAC.
2. The annunciation panel at pump houses shall indicate the status of each pump, system pressure, operation of hydrant and/ or spray system, failure of starting of pumps, healthiness & failure of batteries/ chargers, main supply, low level of fuel oil tanks of diesel engines, tripping of pumps, low level / very low level of water level in the water supply system, selection status of batteries & chargers of panels and diesel engines etc. Alarms from these panels shall also be available to operator at fire station and at central monitoring station.
3. A comprehensive fire alarm indication and protection control system shall be provided across the plant. Each building and plant area, including fuel oil tank bund area, shall be provided with a local fire alarm control panel. These panels shall monitor and control the detection and protection devices within the specified area. Each fire zone shall be provided with manual and automatic fire detection and audio visual alarms.
4. The local panels and the master fire alarm panel shall be interconnected to form a local area network. The network shall have in-built redundancy such that a single fault on the system shall not inhibit operation of the network.
5. The control systems shall monitor the operation of individual devices, individual loops and system faults and alert the CCR operator to operation of devices, failure of loops and system failures.
6. The detector cable and other control cable shall be armored, screened and twisted FRLS type in external areas and shall be of unarmored FRLS type inside

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the buildings (in conduits). However, the cables associated with "Coal conveyor-detection & protection system (within Coal handling plant)" and unit control & control equipment room shall be of short term fire proof type conforming to category "s" as per BS: 6387.

7. Fire detection system using LHD (Linear Heat Detector) shall be provided for Cable trays, Cable trenches etc. For Cable installations a rate of temperature rise detection system shall be installed.
8. A design philosophy document shall be used which stating the criteria for the fire detection and protection systems and in particular for zoning of the plant, selection of the control system, the detectors, their positioning, precautions against spurious signals, the interfaces between the fire detection and HVAC systems, the remote/local operation of fire dampers, smoke extraction fans and smoke vents, local indication of dampers, smoke extraction fans and vents and the operation of the fire protection systems etc. It shall be ensure that, wherever possible, the zoning of the fire systems shall coincide with the zoning of the HVAC systems to simplify sequencing, interlocking and tripping of the HVAC and fire systems under operational, fire and emergency conditions. All necessary interfaces to other systems shall be envisaged.
9. The addressable type panels at common control room shall receive signal from sensors from various areas/ equipments.
10. The Main Fire Alarm Panel to be located at Fire Control Room shall cover the fire detection and protection system of the complete (all the areas) plant. This shall give audio -visual annunciations for fire in each of the risk area / equipment/ status of the fire protection system as well as system operator open /short circuit status of detector or control cabling etc. Further this shall activate a hooter/sounder in each of the area provided with fire/smoke detection system.
11. Number of area panels with alphanumeric mode and LED(cluster type) indication to be installed in control rooms of, DM Plant , ESP Control Room(s), Switchyard control building, all pump houses and any other suitable area. In case of detection of fire, the fire signal (audio-visual) of particular area shall appear in the respective area panel and main fire alarm panel, Also it shall be annunciated in the fire Station repeater panel.
12. The Main Fire Alarm Panel, Repeater Panels and Area Panels shall be networked using RS 485 interface with fibre optic cable including all related accessories. All required hardware, software, cabling, interface cards, etc in this regard as per system requirement shall be considered. A provision shall be kept to add/remove panels from the network. In network connection two spares cores shall be used in case of fault in working cores.
13. The addressable panel shall evaluate the signals received from the detectors, transmit the fire or trouble alarms (audio-visual) to prearranged points, supervise and monitor the complete fire detection & extinguishing circuits, initiate control functions like stoppage of Coal conveyers, closure of fire doors, shutdown of air-conditioning and ventilation plant/equipment, closure of fire dampers in a/c &

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ventilation system etc. Opening smoke extraction vents, switching on smoke extraction equipment, emergency lighting, tripping of transformer lockout relays etc.

14. Bidder shall provide required electrical contacts relay (upon detection of fire) in their fire alarm panel to enable the complete output function for equipments/hydrants for tripping of conveyors etc.
15. All the circuits from the detectors to the panels and the circuits from the panels to the actuating devices (such as solenoid valves, deluge valves, push buttons etc.) Shall be closed loop type and shall be supervised for open and short-circuiting. The trouble signal shall also be annunciated in the respective panels.
16. Facilities shall be provided on the fire alarm panel for simulating fire conditions, sensitivity adjustment, isolation of detectors etc. From the panel.
17. Complete fire detection, alarm monitoring and annunciation system from the panels shall be operated on dc supply, suitably converted by a dedicated rectifier bank taking supply from each of the panel. Further each panel shall be provided with 2x100% batteries and 2x100% battery chargers with provision for automatic change over from mains to batteries, automatic charging etc.
18. Each set of battery shall be of adequate capacity to supply fire detection and alarm system and as well actuating devices such as solenoid valves etc. for a period of 12 hours from the instant of charger/ AC failure. The batteries shall be of maintenance free sealed Nickel-Cadmium type. In the battery rooms, wherein electrical spot type detectors are to be provided, apart from smoke detectors, alarm shall be provided whenever fire is detected by either type of detectors. The coverage factor for the electrical type detector shall not exceed 25 m² per detector.

5.11.2 Fire Detection

1. The total coverage of the fire detection system shall detect heat, smoke and flame by suitably placed detectors throughout the plant and buildings. Detectors shall be located within rooms, corridors and all ceiling and floor voids. The detectors shall initiate an alarm at the local alarm panel and where necessary initiate the appropriate protection systems. Examples of these actions are:
 - Control/monitoring of air/smoke vents/smoke extraction fans
 - Closing and reporting of fire dampers and closing of fire doors
 - Switching on emergency lights
 - Control/monitoring of extinguishing systems
 - Generation of appropriate plant tripping signals, HVAC systems, transformers, fans, switchgear etc)
 - Initiate audio visual alarms.
2. The plant shall be divided into discrete fire zones, the zones shall not overlap. Each zone shall be annunciated on the relevant local fire panel. Electrical and electronic equipment rooms shall be individually zoned. Each detector shall be

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identified in relation to its alarm loop. Each detection alarm loop shall not be loaded more than 80% of its nominal capacity

3. The Fire detection system shall comprise of following fire detection devices & sensors:

a) Multisensor type detection system (Below the ceiling or below the false flooring as the case may be)

- i) All switchgear / MCC, control rooms, Control Equipment Rooms, UPS/ Battery charger rooms, various C&I rooms, Battery room, etc of main plant, ESP, Switch yard control building, water system control building. MCC/ control rooms of all the auxiliaries e.g. Fuel oil system, Fire Water pump house, ECW system, A/C & Ventilation System, Water PT plant, DM plant, Chlorination Plant, Effluent treatment plant, CW pump house, CW chemical treatment plant, Raw water pump house(within plant boundary), miscellaneous pump houses, etc.
- ii) Below false ceiling areas of all air-conditioned room of main plant building, ESP building, service building, administrative building, auditorium and various control rooms of auxiliaries as defined in SL. No. (i) above and return air ducts of inert gas protected areas.
- iii) All the cubicles or panels (inside) of the main plant control room, control equipment room and UPS / Battery charger areas.

b) Photo electric type smoke detection system (above false ceiling areas)
All Control rooms of the different areas of the plant.

c) Combination of Multi-sensor and Photoelectric type smoke detection system
Combination of both multisensor and photoelectric smoke detectors for above & below false ceiling of Inert gas protected areas and various cable galleries protected by MVW Spray system.

d) Linear heat sensing cable detection system
Cable Galleries and Fuel oil tanks (floating roof type) covered under MVW Spray System. However, in case of fixed roof tanks probe type heat detectors shall be provided instead of LHSC.

e) Quartzoid bulb heat detection system
Equipments protected by HVW spray system and Fuel oil tanks, Fuel skids and fuel oil unloading & pressurizing pump houses protected by MVW spray system.

f) Probe type heat detectors for LDO tanks.

g) For buildings / enclosures with High height like GIS Switchyard, Auditorium, etc. Beam Detectors shall be provided for fire detection system.

4. Smoke Detection System

- a) In the areas where only smoke detectors are envisaged upon detection of fire, the same shall be annunciated in the respective panels and shall activate a local hooter/sounder in areas where fire is activated.

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- b) Wherever both the multisensor type & photoelectric type smoke detection systems are provided cross zoning of the signal shall be provided to initiate the fire extinguishing system of that area such as automatic MVW spray system of cable galleries, fire extinguishing system of Control rooms/Control Equipment Rooms.
- c) One Multisensor shall be provided for return air ducts of each room which shall consist of intake probe, detector housing, and exhaust pipe etc. The detector shall be mounted outside the duct.
- d) The design coverage area for smoke detectors (to be considered) shall not exceed 25 Sq.mm. for each detector. However, in areas where more than one type of detectors are provided with cross-zoning philosophy for alarm or activation purpose, each 25 Sq.mm. shall have only detector of alternate type.

5. Detection System for Coal Conveyors

i) Linear Heat Sensing cable

- a) The LHS cable detector for each conveyor to be provided for both forward and return conveyors and shall be mounted. Suspension of LHSC through flexible chains is a preferred arrangement. Further, LHS cable shall be provided for return side of conveyors inside the bunker house.
- b) The detection zone/loop divisions of LHSC system shall match with the MVW spray system.
- c) Upon detection of fire either by QB detector or LHSC detector, the spray system shall be initiated. It shall also initiate spray system for the two adjacent zones after a time delay settable at site.
- d) The LHSC detector shall be provided with suitable interface unit which shall generate/ make the signal compatible with fire alarm panel.
- e) Type: Digital Operating Voltage: 24V DC, Conductor Material: Steel, Approval: FM/UL

ii) Infra Red detectors

- a) Infra Red type (IR) detectors shall be suitable for detecting moving fires in Coal conveyors. IR detectors shall stop the conveyor upon detection of fire and give audiovisual annunciation locally and in fire alarm panel.
- b) Each of the Infra Red type (IR) detectors shall be provided with its own purging arrangement using blowers, hoses, etc and required power supply shall be derived from the fire alarm panel. Alternatively, separate blowers (2x100%) for purge air supply for all the detectors and the complete air piping from the blowers to each of the IR detector shall be provided.

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6. Mill and Air Heater Fire detection system

Adequate number of thermocouples type fire detection system for each Mill and Air –heater shall be provided as composite & complete units with all required signals & accessories with adequate redundancy shall be provided.

The controls & protection required for the Mill detection system and air heater fire detection system shall be implemented using rate-of-rise algorithm taking care of manufacturer's recommendation.

7. Detection System of Cable Galleries

- i) In cable galleries, MVW spray system shall be actuated either by detection of fire by Linear Heat sensing cable detectors or by fire signal from Smoke (after cross zoning) detection system. Apart from the automatic operation of spray system in the detected zone, the adjacent two zones shall also be sprayed with water automatically after a set time delay simultaneously.
- ii) LHSC detector shall run in a zigzag fashion (with an included angle of minimum 90°) at least in each of the top tray, bottom tray and in every alternate tray. The Mounting arrangement of LHSC detector shall be as per manufacture's standard practice.
- iii) The detection zone/loop divisions shall match with MVW spray zone.

5.11.3

Fire Alarm Initiation System

1. Addressable Manual Alarm Stations/ Call points

- Manual alarm stations shall be provided throughout the plant and buildings and also cover open areas of the site. They shall be provided at strategic locations adjacent to exits from & along the peripheries of process areas such that no person needs to travel more than 30 meters to reach a call point. In addition they shall be located at each exit from and along corridors in all buildings on site.
- Each unit shall be surface mounted at a height of 1.4 meters & shall be provided with a striker connected to the station by chain.
- All manual alarm stations shall require a double action to activate the alarm. They shall be the break-glass, pushbutton type and once activated shall only be reset with a unique key.
- All manual alarm stations/ call points shall be addressable i.e. fitted with an electronic code & wired in loops such that any alarm indication shall be identified to the Fire Control panel as a specific location.
- They shall be red in colour as per DIN standard RAL 3000 and suitable for surface or flush mounting in a weather proof housing of IP 67. Manual call points installed in hazardous areas shall be explosion proof type.
- The addressable call points shall be provided with an integral red LED to indicate activation.

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2. Audible And Visual Alarm Systems

- Audible and visual alarms (Flashing Alarm Beacons) shall be provided for all plant areas and buildings. Fire alarm horns shall produce distinctive, loud, penetrating tones which command instant recognition as fire alarm signals. The sound level shall be approximately 105 dB at 1 metre distance.
- The Flashing alarm beacons shall be direct ignition, Xenon type. It should be powered from 24 V DC, negative earthed supply.

3. Overall Plant Wide Evacuation Sirens

Electric and pneumatic general alarm sirens rated at a maximum of 120 dB at 30 metre sound output shall be provided and installed at suitable locations to cover the entire station. They shall be designed to radiate sound equally in all directions for event coverage and to provide dependable service. The alarm systems shall meet the relevant NFPA codes.

4. Analogue Addressable System

- Complete system and all major/critical equipments such as detectors, panels etc shall be approved and listed by UL/FM/LPCB/VDS/TAC.
- All types of smoke & heat detectors shall be of analogue addressable type. Conventional detectors with interface modules are not acceptable. Each zone of LHSC detector and each IR detector shall be provided with interface module.
- All the fire detection systems, process actuated switch devices such as pressure/flow/temperature switches and relays of control functions shall be hooked up with the analogue addressable fire detection and alarm system. Required addressable interface units shall be provided for various switch devices to make them addressable.
- The wiring shall be of style 7 as per NFPA-72 with loop / short circuit isolators.
- Each of building / areas shall be considered as a zone and isolators shall be provided zone wise. In case of large building, isolators shall be provided for every 20 devices.
- The complete system shall include, but not be limited to the following:
 - Master system CPU.
 - Analog addressable fire detection and alarm system panels including alarm modules, system supervisory control modules, auxiliary output control modules etc.
 - PC based monitoring station with color graphic display terminal with programming and historical archiving facility along with laser printer.
 - Power supplies, batteries and battery chargers.
 - Analog addressable type heat detectors and analog addressable type

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smoke detectors.

- Non addressable type conventional detectors (linear heat sensing cable detector/ infra red type heat detector) and switching devices each with its own addressable interface modules.
 - Software and hardware as required for complete operation of the system.
 - Complete wiring/cabling including its conduits/trays/fixtures etc.
- g. The fire alarm control panel shall function as a communication interface between central processing unit and sensors. This panel shall have facility to process the input signal and to control all the input data received from initiating and indicating devices.
 - h. Fire alarm control panel shall have filters to ignore false alarm and increase sensitivity to real fire from sensors. The sensitivity of each detector should be automatically raised if detectors are gradually polluted due to dust and dirt entering inside the detector. If detectors are more polluted the control panel shall give a warning. The trouble report shall indicate the location of device requiring service.
 - i. The fire alarm control panel shall have separate LCD display to indicate the address of each device and clear text about the location of the alarm/trouble. It shall record the event within the non-volatile system historical memory.
 - j. Fire alarm control panel shall have printer to print out the alarm/ trouble occurrences.
 - k. The CPU shall serve as the systems central processor. Software shall be designed specially for fire alarm annunciation system applications and shall provide to monitor status of processing alarms according to priorities, controlling/processing communications and synchronizing all system activities.
 - l. The video display unit shall be the primary operator for data retrieval, alarm annunciation, commands and programming functions.
 - m. The system shall be able to recognize and indicate an alarm condition in a degrade mode of operation, in the event of processor failure or the loss of system communications to the circuit interface panels.
 - n. Field testing facility shall be provided by the system for either the complete system specified area or a specified device while maintaining full function of areas not under test.
 - o. All devices shall be individually identifiable for its type, its zone location, and alarm set value, alarm and trouble indication by a unique alpha numerical label.
 - p. The software logic modules and system database shall be programmable

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using a MS - windows compatible program on pc-at at site and required hardware shall be included. The system software program shall be password protected and shall include full upload and download capability and during program upload or download through the pc, the capability of alarm reporting shall be retained. The software shall be downloaded to a pc for editing.

- q. The system shall support the use of color graphic display terminal for the display of information in an appropriate format.
- r. The system shall include software for system data base, historical event log, logic, and operating system. The system shall require no manual input to initialize in the event of a complete power down condition. It shall return to an on line state as an operating system performing all programmed functions upon power restoration.
- s. Activation of any fire alarm initiating device shall display (LCD alpha numeric display) message in describing the device originating the alarm condition at the central monitoring station, at alarm panel, simultaneously at the repeater annunciation panel and shall initiate the associated protection systems & other related control functions. Similarly activation of any supervisory circuit, (supervised valve closure, air pressure abnormal, fire pump trouble, water pressure low, etc.) Or receipt of trouble report (primary power loss, open or grounded initiating or signaling circuit wiring, battery disconnect etc) shall display at the fire alarm control panel the origin of supervisory condition or origin of trouble condition as the case may be. It shall also record the occurrence of the event, the time of occurrence and the device initiating the same.
- t. System configuration shall be menu driven and capable of being operated by, a person with no previous computer programming experience.

5. Addressable System Hardware

- a. The detectors shall be self compensating for ambient temperature and humidity.
- b. The detectors shall display a steady LED when in the alarm state. The led shall flash when in stand by or normal mode.
- c. The monitor system shall retain in local memory, minimum four pages of system activity, allowing scrolling of the data. It shall be capable of logging events to a hard disk drive for future retrieval. The number of events shall be limited only by the hard disk drive capacity.
- d. At least one spare loop shall be provided in addressable type fire alarm panel located in unit control room and in CHP control room with complete loop card and all other accessories so that the system can be expanded in future. Further at least 10% of loop capacity be left free in each of the

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connected loop in all the panels, so that, additional devices may be connected to the system in any of the loop in future.

6. Telephone Auto Dialler

The main fire alarm panel shall include a telephone auto dialler in to it. It shall be possible to record a minimum of 6 (six) voice message into the auto dialler on field. It shall be possible to program / configure a minimum of 6 telephone numbers into the auto dialler on field. The auto dialler shall activate during the fire and convey a voice message to programmed numbers indicating the area under fire.

5.12 Miscellaneous Systems

The miscellaneous system shall cover the following sub-systems as per the plant requirement as mentioned below:

1. Self Cleaning Strainer
2. Mill Reject Handling System (MRHS)
3. HVAC System

5.12.1 Self Cleaning Strainer

Self Cleaning Strainer shall be operated and controlled either from DCS through remote IO panel or separate PLC control system.

1. When the differential pressure across the strainer in operation goes high, as sensed through limit value monitoring in DCS/PLC of the respective Differential Pressure Transmitter across strainer, the motorized backwash drain valve shall be given auto open command. After full opening of the backwash drain valve the geared motor shall get auto start command. The backwashing operation, so achieved, shall be continued for preset duration.
2. On completion of backwashing for the above mentioned preset duration, the geared motor shall get an auto stop command .On stopping of the geared motor; the backwash drain valve shall be closed on auto command from DCS/PLC.
3. Such cleaning operation for preset duration shall take place as and when the differential pressure across the strainer goes high.
4. In case the system does not reach normal condition by the above mentioned periodic backwashing cycles and the differential pressure across the strainer in operation rises further the following operational mode shall be resorted to:
5. When the DP across the strainer reaches very high value, as sensed by Differential Pressure Switch across strainer or limit value monitoring of respective Differential Pressure Transmitter, the periodic backwashing of the strainer shall be suspended. The standby strainer shall be put into operation on auto by opening of the inlet and outlet motorized butterfly valves. After putting the standby strainer into operation the first strainer can be isolated manually by the operator by closing the inlet and outlet motorized butterfly valves.

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6. The following local indication lamps shall be provided for each strainer. These lamps shall be driven from the output modules of Station DCS located in Remote I/O panel or PLC:
 - a) Gear Motor On
 - b) Gear Motor Off
 - c) Gear Motor Trip
 - d) Backwash Valve Open
 - e) Backwash Valve Close
 - f) DP High
 - g) DP High – High
7. The following annunciations shall be provided on OWS screen of DCS/PLC:
 - a) DP across strainer High
 - b) DP across strainer High – High
 - c) Gear motor trip / fails to start
8. The Open Close, On, off status of gear motors, backwash valves and inlet outlet butterfly valves of each strainer shall also be monitored in OWS screen of station DCS/PLC.
9. The control room operator shall be able to operate the gear motor, backwash drain valve and inlet outlet butterfly valves of each strainer by issuing manual commands from OWS on his discretion. Under such cases, manual operations shall override the auto command from DCS/PLC as mentioned above.
10. The gear motors of each Self Cleaning Strainer shall be provided with local emergency stop push buttons for emergency local stopping of motor.

5.12.2 Mill Reject Handling System (MRHS)

1. The operation of the Mill Reject Handling Plant and associated systems shall be performed through One (1) no. Operator Stations and one (1) number Engineering/Operator Work Station.
2. One (1) no. dot matrix printer (per unit) shall be provided which shall be connected to the data highway and One (1) no. A4 size Colour Laser jet printer (per unit) shall be provided which shall be connected directly to the engineering work station. The required furniture such as operator desk, chairs, etc shall be provided. The Mill Reject Handling PLC shall be interfaced to DCS through redundant OPC link by fibre optic cable as well as some signals shall be hardwired to DCS for monitoring purposes.
3. The PLC shall be interfaced to the Switchgears and protection relays through a redundant serial link with open protocol.
4. Local Pneumatic Control panels shall be provided near each conveying vessel for local control/manual operation & indications. This panel shall have start/stop,

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- Probe/Timer mode selector switch, Pressure gauges for Seal air, Conveying air; Purge & Probe override Pushbuttons etc.
5. The CMRH system shall be capable of operating in both probe mode as well as timer mode.
 6. Following is the indicative list of measurements for the system. These measurements shall be available in OWS of PLC at the MRHS control room.
 - Indication of conveying air pressure on individual supply line after discharge header, after air receiver.
 - Indication of instrument air pressure on individual supply line after discharge header, after air receiver.
 - Indication of fluidizing blower air pressure at the discharge of each blower.
 - Indication of fluidizing blower air pressure at the common discharge header.
 - Indication of level in pyrite bunker (ultrasonic type).
 - Indication of differential pressure across Bag filters.
 7. Following local gauges shall be envisaged for the system in addition to other local instruments as felt necessary:
 - Local indication of cooling water pressure.
 - Local indication of pressure at the discharge header of each compressor.
 - Local indication of pressure at discharge line of each air blower.
 - Local indication of temperature at discharge line of bunker aeration blower.
 - Local indication of differential pressure across each Bag filter.
 - Local indication of Conveying air pressure on each denseveyor.
 - Local indication of dome valve seal air pressure for each denseveyor.
 - Local indication of Vessel pressure for each denseveyor.
 8. Following is the indicative list of alarms and interlocks for CMRH system to be executed through PLC. All alarms shall be available in PLC.
 - Conveying air pressure low.
 - Instrument air pressure low.
 - Seal air pressure low
 - Conveying air common header discharge pressure low.
 - Level in Pyrite bunker high.
 - Air blower discharge pressure low.
 - Pyrite hopper level high
 - Pyrite hopper temperature high
 - Bag filters DP high.
 - All plate valves Open/Close status
 - Trouble in any hopper during cleaning operation.
 - Any alarm not specifically mentioned but needed for safe and coordinated operation.
 - All tripping shall have alarm- annunciation

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9. Under level mode of operation, the conveying cycle initiation signal shall be generated by the hopper level switch. Under timer mode of operation the initiation signal shall be generated by the suitable delay timer. Under both the modes of operation, the conveying cycle shall be identical.
10. In the pyrite hopper temperature switch shall be provided for sensing high temperature & provision shall be provided for water spray.

Plate valves shall be provided with Proximity type limit switches for open & close status indications.

5.12.3 HVAC System

1. HVAC system shall be controlled from PLC based Control System.
2. The basic function of the system shall be to closely control & monitor temperature & humidity condition inside the air conditioned spaces, to optimize/minimize energy consumption by automated operation, to provide remote centralized monitoring & control for various mechanical facilities including sequential Start/Stop of whole HVAC system, to generate maintenance data & alarms, activating/deactivating water valves to start/stop water flow through chiller/condenser circuit, programmed start/stop of AHU as per operating requirements & for maintaining the room temperature/RH by controlling 3 way mixing valves at chilled water line, humidifying system & duct heater, to operate all the drives & provide all necessary controls for safe, reliable & efficient operation of HVAC system.
3. In the event of failure of the HVAC system PLC, the LCP's shall be provided with facilities to operate the plant systems and plant items. These facilities shall include, as a minimum, a mimic showing the status of the plant system and items, annunciator panel, local indicators, controls, sequences, interlocks, etc.
4. Microprocessor based Controls shall be provided for Chilling Unit as per manufacturer's standard practice along with facilities to interface with HVAC PLC to meet the requirement of all system operation & control.
5. Air Washer Unit shall be started/stopped by initiation from Remote IO of HVAC PLC and the starting/stopping of fans & pumps shall be automatic upon such initiation. Operation of pumps shall be interlocked with the low level of water in the sump. High level of the sump shall be annunciated in the HMI. Auto/manual selector switches shall be provided in the panel.
6. Microprocessor based Controls shall be provided for Package AC as per manufacturer's standard practice.
7. Safety interlocks and trips shall be operational under all circumstances.
8. 3 way mixing valves shall be provided at the Chilled Water Return line of each AHU to control the flow of chilled water through the cooling coil or by pass the same with respect to the set point of the temperature and humidity sensors of the return air to individual AHU.

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9. On-Off Thermostat shall be provided for each compressor to maintain constant chilled water temperature at evaporator outlet.
10. Temperature & Flow measurement shall be provided in chilled water inlet & outlet line across AHUs to monitor the air conditioning load of each area.
11. Flow Switch shall be provided at outlet of each chiller & each condenser for starting/running of compressor.
12. The standby Condenser Water Pump, Chilled Water Pump, AHU, fresh air fan shall be started automatically when working equipments are stopped/tripped. Auto manual selector switch & Working/standby selector switch for pumps/AHU/Fresh air fan shall be provided.
13. Water chilling Unit shall be equipped with Superheat Control through thermostatic expansion valve & temperature element at chiller outlet.
14. The return air path of each AHU room shall be provided with a temperature and RH sensor to control and monitor the operation of 3 way mixing valves, Heaters and humidifiers. The values of the temperature sensors and Humidity Sensors shall be indicated in the Graphics page of PLC system.
15. Pressure & Temperature measurement of Cooling tower at inlet of condenser shall be provided. Same shall be interlocked with operation of Air conditioning system.
16. The water flow through the Chilled Water Pumps and Condenser Water Pumps shall be measured by the Flow meter installed at the main header for Chilled Water and Condenser Water.
17. Air Stat shall be provided in the supply air duct to trip all stages of the Strip Heaters when supply air temperature reaches the point beyond the set point.
18. Geyser Stat shall be provided in the Pan Humidifier tank to trip the Pan Humidifier when the temperature of the water reached above set point.
19. Co-ordination with the fire detection, fire fighting and gas detection systems shall be provided. On receipt of signals from these systems the HVAC control system shall operate the HVAC plant in such a way as to minimise the effects of fire, smoke and gas escapes. Automatic, manual and remote manual control of the operation of fire dampers, smoke extraction fans and smoke ventilators shall be provided.
20. All motorized fire dampers shall be in the open position during normal running condition. The dampers shall be closed on receipt of the fire signal from the Fire Fighting System. Closure of Fire damper shall raise an alarm in the system. Once the fire dampers are closed, the respective AHU fans and the Fresh Air Fans shall be stopped automatically.

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6 PROGRAMMABLE LOGIC CONTROL (PLC)

6.1 General Technical & Design Requirements

Programmable Logic Controller (PLC) shall be microprocessor-based system. The PLC shall be versatile, expandable, user friendly and latest state of art technology. The system shall be envisaged for the purpose of sequential operation, protection and interlock, data acquisition system, alarm functions, closed loop control and data archiving for fully automatic operation. Logic controller shall be used with adequate and reliable protection safeguard for various equipments and to assist the operator for easy safe and efficient starting and stopping of various drives in the process. The system shall be designed by selecting high-grade components of proven quality and proper design of system electronics. The system shall be able to operate satisfactorily with reference to the specified environmental conditions as indicated in the specification.

1. The system shall be modular in construction and expandable in future by adding additional electronic modules, which shall be easily accessible for maintenance and repair. The modules shall preferably be Rack/Rail mounted. The types of modules shall be kept to minimum possible in order to have interchangeability and spares inventory.
2. The system shall have extensive self-diagnostic hardware and software features for easy and fast maintenance of the PLC. Safety barriers shall be used for intrinsically safe input / output circuits.
3. The PLC shall have very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and electromagnetic disturbances expected in a power plant.
4. The system shall be programmed as per the logic requirements required for the functioning of the systems and equipment.
5. Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.
6. On-line replacement of any module shall be possible in such a way that the removal and addition of the module shall be possible without de-energizing the system or causing any interruption in the system while replacing a faulty module except for the inputs /outputs which are being handled by that module. However, in case of triple modular redundant or dual PLC configurations, there shall not be any process upset while replacement.
7. PLC shall be used with 20% hard wired installed spare I/O Channels.
8. The system shall be capable of handling the long-term storage of data for 15 days and retrieval.

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9. The system shall be used with programming and diagnostic facility. Each PLC (Except ESP PLC) shall be used with one no. Laptop of latest configuration with programming software & communication cable.

6.2 PLC System Configuration

The BOP Systems such as (Pre-treatment Plant, DM Water Plant, Raw Water Intake System, Compressed Air System, Fuel Oil System, ACW/CCW system, Miscellaneous Systems) shall be operated, monitored and controlled through a centralized and dedicated PLC, located in the respective Local Control Rooms.

The PLCs shall be redundant and operated through PC based station (OWS, EWS). A large video display (LCD type) is also shall be envisaged. PLC with work station and the large display shall be located in the local control room of BOP systems. Additionally an OWS is envisaged to be installed in the Central Control Room for monitoring. Operation and control shall also be possible from this OWS under predetermined conditions.

Remote Input-Outputs (RIO) concept shall be envisaged. RIO shall be located at different geographical locations as per the actual requirement in order to optimize the cable engineering and strength of signals to be communicate with control system (RIO room/ Local control room, compressor house for Conveying & Instrument Air System, Raw water intake, Pretreatment Plant, CW system, MCC room etc.) and shall communicate to the BOP DCS system and PLC located in the local control rooms, through dual redundant fibre optic cable links.

PLC shall be networked with the Plant DCS by dual redundant communication link – based on Ethernet TCP/IP using bidirectional OPC connectivity, on fibre optic cable. The data network shall be extended using redundant link on fibre optic cable up to central control room for installation of one operator workstation at the central control room.

6.3 Input/output Sub system

1. I/O subsystem shall be suitable for accepting discrete inputs, BCD inputs and analog inputs. The I/O modules shall be mounted in the I/O racks.
2. Each I/O shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 500 V DC.
3. Each module shall have LED for each digital I/O channel to indicate the status of each input / output. Redundancy in I/O level shall be maintained as per the process requirement.
4. PLC inputs shall be used with potential free dry contacts. All the inputs shall be double ended i.e., two wires per input and not common return for all inputs. The contact interrogation voltage for input contacts shall be 24V DC minimum. Each input channel shall be protected by separate fuse.

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5. Output contacts from the PLC shall be potential free dry contacts. Each output shall be short-circuit proof and protected by fuse.
6. Visual indication of fuse blown must be provided for each input and output channel.
7. There shall be at least 20% spare capacity available on input & output modules, over and above the system requirement.
8. All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
9. PLC shall have the following monitoring features:
 - Power supply monitoring.
 - Contact Bounce filtering.
 - Optical isolation between input and output signals with the internal circuits.
 - In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode.
 - Further, keying-in of individual wire connectors shall be used to ensure that only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs.

6.4 Processor Sub system

1. The processor sub system shall include CPU, memory, power supply, communication interface etc.
2. Dedicated PLC's shall be envisaged for each Auxiliary system. The processor shall have capability to implement all the control functions required. The processor shall have sufficient memory for storage of the program instructions as applicable to the logic requirements. CPU shall be of 32/64 bit or upgraded version of microprocessor.
3. Memory shall be non-volatile, preferably EEPROM type. However, in case volatile memory is provided, battery backup shall be used for a minimum of three months to keep the stored program intact. A battery drain indication shall be used at least one week before the battery gets drained. Memory shall be used with adequate capacity with 40% spare capacity under worst loading condition.
4. The healthiness of processor hardware and software shall be continuously monitored by watchdog timer.
5. PLC's shall be used as a minimum with dual redundant processor subsystem including CPU, memory and power supply. Redundancy shall be used such that, in case of failure of the main processor, the standby processor shall take over automatically and vice - versa. The changeover shall be bumpless and shall not result any process or system upset.

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6. In case of failure of complete processor system i.e., both processors, outputs shall take fail safe state automatically.
7. The scan time of programmable controller shall be of the order of 100 milliseconds or better. Scan time of PLC is defined as the cycle time taken by the system to read input, process input executing logic and update control output for all the logics configured within the system. Other activities like diagnostic routines, output / dump of data to peripherals, or any other activity which consume processor time shall also be accounted while computing scan time.

6.5 Communication Sub system

1. The communication subsystem shall provide reliable and high speed data transfer between the processor subsystem, I/O subsystem, PLC console and other devices connected to the system.
2. Redundancy in communication subsystem shall be used, such that on the failure of the active device, communication link or bus, the redundant device communication link or bus shall take-over automatically without interrupting the system operation. The communication bus shall be of coaxial / Fiber optic type.
3. Information about the failed device shall be displayed locally as well as on the PLC console. It shall be possible to manually switch-over the communication from main bus device to redundant bus device without interrupting the PLC functions.
4. The PLC shall have provisions of communication interface facility with Plant DCS system in order to make the entire system operational from CCR. Bi-directional, Redundant soft links shall be used in the PLC for the connectivity with the Plant DCS.
5. Following shall also be included in the system:
 - Cables required for interfacing with DCS.
 - Implementation of Tags and establishing the Link.
 - Any other software/hardware required.

6.6 System Power Supply

1. For PLC system, redundant 24 V DC power supply shall be used. The required power supply cable shall be used from the UPS DCDB & ACDB for respective package control system of plant BOP.
2. For separately mounted I/O racks, separate power supplies shall be used. Power supply module shall be of ample capacity to supply all modules. In addition 20% spare capacity for future shall be used. All the drives shall be switched ON/OFF through 24V DC coupling relays to be provided in HT/LT SWGR panels.
3. For the Operator Stations and Engineering Station the power supply shall be from the 230 VAC UPS system.

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6.7 PLC Console

1. PLC Console or operating panel/display panel shall be used as operator Interface station for control and monitoring of the plant. This shall be done through dynamic mimic displays and control displays.
2. PLC console shall also be used for program storage, display, fault diagnostic and alarm monitoring. It shall be possible to modify, add or delete the application program on-line without affecting the outputs. It should be possible to modify or create new displays from PLC Console.
3. Isolation shall be used between programming terminal and related subsystems, if there is any possibility of high voltage from TFT being transmitted to other subsystems.
4. The PLC system shall have provision to shift the Operator Station/ Engineering Station to the CCR in future with third party interactive communication facility.

6.8 Displays

The system shall be capable of reading the status of equipments, acquiring the analog signals, displaying the status in the form of mimic diagram, video trend, bar graph, periodic display, alarm display, alarm overview display, logs such as hourly/shift/daily logs, alarm logs etc.

Displays include plant mimic diagrams, which shall include the complete auxiliary plant system indicating each major components of the system and the operating status of individual equipment and devices

6.9 Alarms

1. The system shall display history of alarms in chronological order of occurrence on the Operator Station TFT. At least three (3) levels of alarm priority shall be available which shall be displayed in different color. It should be possible to display and print alarms. System shall have all alarm related functional keys like acknowledge, reset etc. Other design features like set point / dead band adjustment, alarm priority, manual and automatic inhibition based on predefined logic etc. shall be used.
2. The alarm display shall be built bottom up with the most recent alarm at the top of the list. When a point returns to normal, the associated alarm line shall change color suitably and on acknowledgement, the line shall be blanked out.
3. The alarms below the blank lines shall move upward to fill the empty lines. If the capacity of the OWS display page is exceeded, alarm history shall be stored in memory to accept the over- flow. This alarm history shall be displayed upon operator demand.
4. When a point goes into an alarm state and appears on the alarm screen, the time of alarm shall flash until acknowledged by the operator. Acknowledgement by

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the operator shall cause the time to stop flashing. All alarm initiations and return to normal, shall be logged on a printer.

6.10 System Software

1. Complete licensed software for PLC based system including the communication software system shall be supplied and implemented to meet completely the specification requirements.
2. Application software shall be built based on approved logic diagram, graphics etc and shall include controls, graphics, logs, trends, history, report generation etc.
3. The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics.
4. Diagnostic software shall have the capability to provide information about the failed module / system either in the form of a system configuration display or provide information in the form of a statement.
5. The software's shall not be machine specific. All software licenses shall be valid for the continuous service life of the plant and equipment.
6. Password security shall be used in order to ensure security level to the plant operation.

6.11 Peripherals

Following Peripherals shall be used for ESP PLC only:

1. VDU/ TFT shall be multi-sync, 21" color monitor with intelligent terminal and key board. TFT shall be used with graphic and mimic capabilities with minimum 64 distinct colors. The graphic resolution shall be 600x 1280 dots minimum with 0.25 mm dot pixel and refresh rate shall be 85 Hz or better
2. Suitable optical filter for minimum secondary glare shall be used.
3. One number black & white laser printer shall be used for printing A4 size paper. Printing speed shall be minimum 24 ppm. The printer shall be heavy-duty type with minimum 50,000 pages/month printing capability, 600 dpi resolution, 128 MB memory and 3000 sheet input capability.

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UNINTERRUPTED POWER SUPPLY (UPS)

Refer Chapter 18 of SG package-1 (if procured under SG)

Refer Chapter 19 of TG package-2 (if procured under TG)

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8 FIELD INSTRUMENTS & FINAL CONTROL ELEMENTS**8.1 Pressure / Differential Pressure / Flow / Level Transmitter**

Table 8.1
Specifications for Pressure / Differential Pressure / Flow / Level Transmitter

S.N	Features	Minimum Requirements
1	Type	Microprocessor based 2 wire type, HART protocol compatible
2	Sensor Type	Capacitive/ Piezo-electric
3	Output Signal	4-20 mA signals superimposed with HART signal.
4	Signal Processing Unit	Microprocessor based
5	Overpressure	150% of max. operating pressure. For vacuum service, the element shall have under – range protection to full vacuum
6	Turn-down Ratio	10:1 for vacuum / very low pressure applications. 100:1 for other applications.
7	Stability	± 0.1% of calibrated span for six months up to 70 Kg/cm ² and ± 0.25% for range more than 70 Kg/cm ² (g).
8	Span and Zero drift	± 0.015% per deg. C at max span & 0.11% per deg. C at min. span.
9	Enclosure Class	Weather proof as per IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500
10	Zero & span adjustability	Continuous, tamper proof, remote as well as manual from instrument with zero suppression and elevation facility.
11	Local Indicator	To be provided
12	Display	Digital LCD Integral Display (minimum 5 digit)

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S.N	Features	Minimum Requirements
		Engineering Unit
13	Process connection	½ " NPT (F)
14	Electrical Connection	½ " NPT
15	MOC of Electrical Housing	Aluminum Alloy or better
16	Ambient Temperature	65 Deg. C
17	Operating Voltage	16 – 48 Volts DC
18	Load	600 Ohms (minimum) at 24 Volts DC
19	Accuracy	± 0.075% of span or better
20	Response Time	100 millisecond or better
21	Adjustment/ calibration/ maintenance	Port/provision for Centralized PC based system maintenance.
22	Diagnostic	Self Indicating feature
23	Accessories	Diaphragm seal, pulsation damper, siphon, 2-valve, 3-valve or 5valve manifolds.

1. All transmitters shall be equipped with all necessary accessories like valve manifolds, mounting bracket etc. Pulsation dampeners shall be used where the process media is unstable for measurement such as at the discharge of a pump. For absolute pressure transmitter, 2 valve manifold; for gauge / vacuum pressure transmitter, 3 valve manifolds and for DP / level / flow transmitter, 5-valve manifold shall be provided. In case if it becomes necessary to use a DP transmitter for pressure measurement then a 3 valve manifold shall be used in place of 2 valve manifold.
2. Pressure transmitter shall have easily accessible span, zero and time constant adjustments. A range suppression / elevation device shall be used wherever required.
3. For pressure / differential pressure transmitter, proof pressure shall be 200% of maximum static process pressure.

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4. All transmitter cases shall be dust – tight and rugged. Weather – proof and explosion – proof cases shall be used in outdoor and hazardous areas respectively. Protection clause shall be of IP 67 or better.
 5. Transmitters for pressure / DP measurements of liquid shall always be installed below the sampling point, preferably with the connection at the top.
 6. Transmitters for pressure / DP measurements for gases and air shall always be installed above the sampling point, preferably with the connection at the bottom.
 7. Transmitters with diaphragm seal system shall be considered when
 - The process temperature is outside of the normal operating ranges of the transmitter and cannot be brought into those limits with impulse piping.
 - The process is corrosive and would require frequent transmitter replacement or unusual materials of construction or
 - The process contains suspended solids or is viscous and may plug the impulse piping or
 - There is a need to make density or interface measurements or
 - The process medium may freeze or solidify in transmitter or impulse piping.
 8. Diaphragm seal shall be either capillary type or direct mounted type depending upon the application. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.
 9. Differential pressure type level transmitters shall be used for range above 1219 mm, for services requiring purge or where liquid might boil in external portions.
 10. Differential pressure type level transmitters for use on corrosive service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type DP transmitter shall be considered for special application. Diaphragm material shall normally be stainless steel or any other special alloy.
- Differential pressure type flow transmitters shall have in-built square-root extractors.

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8.2 Temperature Transmitter

Table 8.2
Specifications for Temperature Transmitter

S.N	Features	Minimum Requirements
1	Type	2-Wire, Smart (HART)
2	Output Signal	4-20 mA signals superimposed with HART signal.
3	Signal Processing Unit	Microprocessor based
4	Accuracy	± 0.075 % of span or better
5	Local Indicator	To be provided
6	Display	Digital LCD Integral Display (minimum 5 digit) Engineering Unit
7	Input	Ohm input from Pt-100 RTD/ mV signal from thermocouples
8	Stability	± 0.1 % of reading or 0.1° C, whichever is greater, for 24 months for RTDs. ± 0.1 % of reading or 0.1 °C, whichever is greater, for 12 months for thermocouples
9	Output	4-20 mA DC, linear
10	Load	600 Ohms (minimum) at 24 Volts DC
11	Power Supply	24 VDC, 2- Wire Loop Power
12	MOC of Electrical Housing	Aluminum Alloy or better
13	Enclosure Class	Weather proof as per IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500

- The temperature transmitter of following types (2-wire Loop Powered temperature transmitter) compatible with RTDs shall be used.

Single Input DIN-rail mounted Temperature Transmitter

These shall be suitable for mounting on DIN-rails in Panels/JBs in air conditioned room. This temperature transmitter shall be the ones which are especially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category.

Dual-input Temperature Transmitter with Indicator

These shall be suitable for mounting on pipes/ supports. Indicator shall be used with these transmitters. These transmitters shall have bump-less change over

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facility to second sensor in case first sensor fails .This changeover is to be alarmed. Protection class shall be IP67 minimum.

2. Transmitters shall be used with following features:
 - Sensor drifts alarm for sensor failure prediction
 - Differential & average temperature measurement if required.
 - Automatic switch-over to back-up sensor on primary sensor failure.
 - Accepts any combination of two sensor types (RTDs, T/Cs, mV or ohms)
 - Ambient temperature compensation
 - Fault detection for electronics & sensors with fail-safe alarming.
 - Provision of built-in CJC
3. Transmitters to be used for RTD sensors shall be used with RTD EMF correction features so that it shall detect and eliminate EMF errors which are the result of small voltage produced by RTD sensing elements.
4. The product and make shall be selected so that with one make of transmitter all applications with respect to measuring range, temperature sensor (resistance thermometer) and connection type (2/3/4) wire connection of resistance thermometers) shall be covered.
5. Transmitters shall be capable of communication with HART (Highway Addressable Remote Transducer) communicator. HART communicator shall be used with transmitters for tuning / configuring / diagnosing / maintenance of the transmitters. It shall meet the intrinsic safety requirement if required depending upon the application.
6. All transmitters' cases shall be dust-tight and rugged. Weather-proof and explosion-proof cases shall be used in outer and hazardous areas respectively.

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8.3 Resistance Temperature Detector (RTD)

Table 8.3
Specifications for RTD

S.N	Features	Minimum Requirements
1	Type	3 / 4 wire , Pt-100 (100 ohm at 0 deg C) (as per DIN 43760)
2	No. of Element	Duplex
3	Housing/Head	IP-65/Die cast Aluminium. Plug in connectors are to be provided for external signal cable connection
4	Sheathing of RTD	Metal sheathed , mineral insulated, ceramic packed
5	Calibration and accuracy	As per DIN-43670 Class-A for RTD
6	Stability	Zero & span drift within 0.1% of span for a 6 month period.
7	Characteristic	Linear with respect to temp, within $\pm 1/2$ percent of top range value
8	Standard	As per DIN-43670 for RTD & ASME PTC-19.3 for Thermowell
9	Accessories	a) Adjustable Nipple-Union-Nipple with thermo well connection / plug in connectors
		b) Compression fittings / unions
		c) Flanges etc.
		d) Thermowell as per requirement

- RTDs shall be of duplex, platinum three / four wire type with a nominal resistance of 100 ohms at 0°C and conform to DIN 43760 / BS 1904.
- Stability of RTD over full range shall be better than 0.05 ohms and the repeatability figure shall be better than 0.02 ohms. Accuracy shall be of the order of 0.15% or better and response time shall be less than 20 seconds with thermo well.
- The protective-sheath material shall be SS 316, seamless tubes using compacted magnesium oxide packing for insulation. The insulation resistance at 540°C shall not be less than 5 mega-ohms.

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8.4 Thermowell for Temperature Elements

1. The design of the thermo well shall take into consideration the temperature, pressure, medium and fluid velocity specified in the process in accordance with ASME Standard PTC 19.3.
2. Welded type thermo wells with 38 mm O.D. for welding & ½" NPT internal threads shall be used for pressure above 100 kg / sq cm or temperature above 400 deg C. Socket weld type thermo well with 34 mm O.D. for welding & ½" NPT internal thread, shall be used for pressure between 40-100 kg/cm² and temperature up to 400°C. Screwed type thermo wells with ½" NPT internal threads & M33X2 (M) outer threads shall be used for pressure below 40 kg/cm² and temperature below 400°C. For pipes having probability of prolonged vibration, seal welding may be done all around after tightening the thermo well within the base.
3. RTD used in air path shall be supported by suitable protection tube of adequate strength with welded cap at the end. The connection size of the temperature detector with the protection pipe shall be adjustable flange type. The length of the protection pipe shall be such that it supports at a distance nearly 2/3rd length of the immersed temperature detector inside the duct using a heat insulated ring support in between.
4. Thermo wells used in Mill classifier Outlet area shall be made of suitable material of sufficient abrasion resistance such as alloy cast iron / 'Ni-hard' / Tungsten Carbide of hardness approx. 400 BHN. Protection rod in front of thermo wells for mill classifier if required shall be used.
5. Thermo well manufacturing drawing covering material specification, dimensional details, details of special treatment, finish etc. as well as test procedure. Material certificate shall have to be furnished for each thermo well.
6. Wherever any approval is necessary from any recognized body / authority during manufacturing of high pressure wells.
7. The thermo well immersion depth (U) shall be sufficient to eliminate conduction error. A general rule which may be followed is to use an immersion length equaling a minimum of 10 times the diameter of the protective tube or well. In general, immersion length of thermo wells for different line sizes shall be as follows:

Table 8.4
Thermowell Immersion Length

S.N	Line Size	Immersion Length
1	From 4" to 6"	65 mm
2	From 8" & onwards	140 mm
3	Vessels	400 mm

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8.5 Temperature Switch

Table 8.5
Specification for Temperature Switch

S.No	Feature	Minimum/Maximum Requirement
1	Switching Range	0 to 250° F or -20 to 120°C
2	Display Type	3-digit LED Display
3	Display Resolution	±0.5° below 100°F ±1° at 100°F and above Switch Status
4	Indicator	Single red LED, on when temperature is above set point
5	Accuracy	
		32°F to 160°F: ±1°F
		0°F to 31°F: +6°F/-2°F
		161°F to 230°F: +2°F/-4°F
		231°F to 250°F: +2°F/-5°F
		Max. Pressure: 1150 PSIG
		Ambient Temp Range: -4°F to 140°F
6	Sensor Element	Pt-100 RTD
7	Housing and Probe Material	316L Stainless Steel
8	Electrical Data Power	24 VDC ±20%
9	Switch Type	Transistor NPN or PNP based on model number
10	Switch Rating	300 mA Max. short circuit protected
11	Switch Logic	User programmable N/O or N/C
12	Response Time	0.5 Sec.
13	Dampening	Programmable averaging over 2, 4, 8, 16, 32, or 64 samples
14	Electrical Connection	4-Pin Micro-DC male plug
15	Electrical Protection	NEMA 4/IP 65
16	Other Functions	<ul style="list-style-type: none"> • Lockout Code • Setpoint • Switching Hysteresis • Window Switching • Switch Logic • Dampening

1. Temperature switches shall be of liquid filled or vapor actuated system. The bulb shall be of stainless steel with S.S. armored capillary tube of adequate length for installation.

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2. Switching elements shall be snap acting, shock and vibration – proof. All switches shall have two electrically independent SPDT contacts with facility of external adjustment for set point and dead band.
3. Temperature switches shall have an accuracy of $\pm 0.1\%$ or better of full-scale range. All switches shall be repeatable within ± 0.5 percent of scale range.
4. The electrical contact railings for all switches shall be 5 amps at 240 V 50 Hz or 0.25 amps at 220 V dc.
5. Switch enclosure shall be cast aluminum, cable entry through compression type cable glands / 3 / 4" NPT conduit connections.
6. All switches shall be provided with thermo wells unless other wise specified.
7. Materials for construction for thermo well shall be SS 316 / SS 304 / SS 310 depending upon the application. Thermo well shall be designed and manufactured as per ASME PTC 19.3, based on operating and maximum values of process conditions. Thermo well shall be drilled from solid bar stock.
8. On-off differential of switches shall be adjustable. Adjustable range shall be suitable for switch application. Actuation set point shall be adjustable over full scale range.

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8.6 Pressure Gauge/ Differential Pressure Gauge

Table 8.6
Specification for Pressure Gauge/ DP Gauge

S.N	Feature	Minimum Requirement
1	Type	Bourdon / Bellows / Diaphragm
2	Sensing Element Material	AISI 316 SS
3	Movement Material	AISI 304 SS
4	Case Material / Protection Class	SS / IP 65
5	Dial Size	150 mm (local) / 250 mm (Remote)
6	Scale	Black lettering on white background in 270 °C arc
7	Range Selection	Normally operate at 75% of its maximum pressure range. Instruments measuring varying pressures shall operate in a band of 60% of its maximum pressure range.
8	Over range Protection	150% of maximum range by internal stop. External stop below zero.
9	Adjustment	External Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
10	Stop at Max. Reading	Shall be used
11	Element Connection	Argon welding
12	Process Connection	½" NPT(M) bottom connection for local mounting, back connection for panel mounting
13	Accuracy	+/- 1.0 % of full scale or better
14	Operating Ambient Temperature	50 °C (Max. continuous)
15	Safety Feature	Neoprene Safety Diaphragm (Blowout disc) at the back
16	Window	Shatter-proof glass
17	Chemical Seal Unit	SS 316 Flange and Diaphragm, PTFE coated / block, Silicon Oil filling fluid
18	Accessories	Snubber for pulsating fluid applications / 3-way gauge cock / 2-valve manifold / Pigtail / Gauge Saver, if maximum or Design Pressure is very high than the Operating Pressure / Counter Flanges / Bolts, Nuts, Gaskets / SS Tag Plate

1. Directly connected pressure measuring instruments shall be diaphragm, bourdon or bellow type elements depending upon the services conditions. In general, diaphragm elements shall be used in the range of 0 to 1000 mm water

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column pressure, bellow type element for ranges of 0 to 1 Kg/cm² and bourdon type element for ranges greater than 1 Kg/cm².

2. Primary element material shall be corrosion resistant to process fluid or diaphragm seals shall be used for protection.
3. Snubber shall be floating pin type, externally mounted and externally adjustable. It shall be used for all pulsating services.
4. Diaphragm seals, filled type or mechanical type shall be furnished where plugging of the element may occur or where suitable material is not available in highly corrosive services. When chemical seals are required, they shall be the clean out type with flushing connection.
5. Over-range protection shall be used to at least 150 % of range. For vacuum service, the element shall have under-range protection to full vacuum
6. Ranges of the gauges shall be so selected that the gauge normally operates in the middle third of the scale and conform to IS 3624 standard dials, wherever necessary.
7. The sensing elements for all gauges shall be properly aged and factory tested to remove all residual stresses and shall be SS 316 with forged socket and tip of the same material. Elements above 70 Kg/sq. cm range shall be bored instead of drawn.

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8.7 Temperature Gauge

Table 8.7
Specification for Temperature Gauge

S.N	Feature	Minimum Requirement
1	Type	Mercury filled
2	Sensing Element material	Bourdon AISI 316 SS
3	Movement Materials	AISI 304 SS
4	Case Material/Protection class	SS / IP65
5	Capillary Armouring	SS Flexible
6	Capillary	SS 316 (5 mtr. Length for Local & 15 metre for panel Mounting)
7	Bulb/Stem Diameter	12 mm
8	Dial Size	150 mm
9	Window	Shatterproof glass
10	Scale	Black lettering on white background in 270 °C arc
11	Adjustment	Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
12	Pointer	Externally Adjustable
13	Range Selection	Normal Process Temperature – approximately two third of Temperature range.
14	Stop at Max. Reading	Shall be used
15	Over range Protection	150% of FSD
16	Instrument Connection	Bottom connection for local mounting, back connection for panel mounting.
17	Process Connection	½" NPT with Thermowell
18	Performance :-	
a	Accuracy	+/-1.0% of full scale or better
b	Repeatability	Less than 0.5% of full range
c	Response Time	30 seconds (max.) with Thermowell and 15 seconds Bare.
15	Operating Ambient Temperature	50 °C (Max. continuous)
16	Accessories	Mounting brackets, Bolts, Nuts, Gaskets / SS Tag plate, SS Thermowell etc.

- Temperature gauges shall be dial thermometers (liquid spring / metal expansion thermometer), either rigid stem or capillary tube depending upon application; if this is not possible for design reasons, industry type liquid – in – glass thermometers shall be used.

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2. Case shall have back or bottom connection with adjustable gland to permit adjustment of thermometer into the thermo well.
3. Thermometer stem adjustable gland with union connection and bushing shall be suitable for ½ inch NPT connection.
4. Bi-metallic type dial thermometer, if used, shall be hermetically sealed, back or bottom connection type, with 150 mm dial.
5. The gauges shall be used with automatic ambient temperature compensation.
6. Scale ranges shall be selected so that normal process temperature in middle two – third of full scale range.

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8.8 Level Gauge

Table 8.8
Specification for Level Gauge

S.N	Feature	Minimum Requirement
1	Sensing Element & material	Tempered toughened Borosilicate gauge glass steel Armored reflex or transparent type
2	Body Material	Forged carbon steel / 304 SS
3	End Connection	Process connection as per ASME PTC and drain / vent 15 NB
4	Accuracy	+ 2 %
5	Scale	Linear vertical
6	Range Selection	Cover 125 % of max. of scale
7	Over Range Test	Test pressure for the assembly shall be 1.5 to the Maximum design pressure at 38 degree C
8	Housing	CS / 304 SS leak - proof
9	Identification	Engraved with service legend or or laminated phenolic Name plate
10	Packing	PTFE Teflon
11	Illumination	220 V, 50 Hz, 25 / 40 Watts either with deflector or diffuser (for transparent type level gauge) / 220V , 50 Hz, 25 /40 Watts with red and green filter for bicolor gauge
12	Accessories	Gasket for all KEL – F shield for transparent type vent and drain valves of CS / SS as per requirement

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S.N	Feature	Minimum Requirement
13	Others	Anti – Frost extension for low temperature service. Heating / cooling arrangement

- Level gauges shall be steel armoured reflex or transparent or bi –colour type, top and bottom connection as per pressure vessel standard of ASME PTC code and 15 mm NB (1/2 inch NPT) Drain and Vent connection.
- Body material and cover material shall normally be forged carbon steel, 304 stainlesssteel or other superior material.
- Reflex type gauges shall be used for clean and colorless liquids and transparent type for other liquids. For treated water, the transparent type with KEL – F shields shall be used to avoid their attack on the glands.
- The gauge glass must have a rating equal to or more than the vessel design pressure and temperature.
- The maximum length of a single gauge glass shall not exceed 1400 mm. Where large range is required, multiple gauges of preferably equal lengths shall be used with 50 mm over – lapping in visibility.
- Stand – pipes shall be used for multi – gauge glass and level controller installation and on horizontal vessel with top and bottom connections to have visibility of the complete span. The stand pipe shall not be used with block valves.
- Primary isolation valves shall be used In addition to the gauge glass valves unless otherwise specified. When the process fluid may create lugging or leakage problem, gauge valves may be omitted. For low temperature liquid having high vapor pressure at ambient temperature, isolation and gauge valves shall not be permissible. Safety valve shall be used at the vent connection of the gauge glass where isolation is required.
- Bi – colour level gauges shall have following features:
 - Temperature equalizing column expansion bend and chain patterned hand – wheel

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8.9 Pressure/ Differential Pressure Switch

Table 8.9
Specification for Pressure/DP Switch

S.N	Feature	Minimum Requirement
1	Type	Piston for high pressure application Bellow/Diaphragm for low pressure application
2	Sensing Element material	AISI 316 SS
3	Wetted Parts material	AISI 316 SS
4	Case Material	Epoxy coated Die Cast Aluminium
5	Setter Scale	Black graduation on white linear scale. Graduation 0 – 100% with red pointer for set points.
6	Over range for Pressure / Vacuum Switch	150% of maximum pressure
7	Set Point	Adjustable throughout switch operating range.
8	Static Pressure for Differential Pressure Switch	Maximum Line Pressure or Static Pressure on either side without permanent deformation or loss of accuracy.
9	Adjustments	Internal – set point Differential adjustable feature
10	Process Connection	½" NPT(M) bottom connected
11	Switch Configuration	2 SPDT / 1 DPDT
12	Switch Rating	230 V, 5A AC / 220 V, 0.25 A DC/24 V, 2A DC
13	Switch Type	Snap acting, shock and vibration-proof
14	Cable Connection	½" ET conduit connections or compression gland
15	Enclosure Class	Weather proof as per IP 65 with corrosion

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S.N	Feature	Minimum Requirement
		resistance coating.
16	Accuracy	1 % of span up to 3Kg/cm2 0.5% of span for more than 3 Kg/cm2.
17	Repeatability	0.5% of span
18	Accessories	
a)		Snubber for pulsating fluid application.
b)		Tag Number, service engraved in SS tag plate
c)		Teflon back-up sheath protection, as required.
d)		i) Remote diaphragm seal with SS 316 armored capillary for typical application. MOC of seal material shall be as per process fluid requirement. ii) Silver coated diaphragm for corrosive services like chlorinated water.
e)		Retention ring and screws for surface mounting.
f)		3-way Gauge Cock (SS 316) for PS / 5-Valve Manifold (SS 316) for DPS.
g)		mp for 2 '' pipe, bolt & nut.

1. The pressure switches shall have sensing elements made of copper alloy or stainless steel sealed diaphragm and piston actuated for high pressure service and bellows for low pressure / vacuum service.
2. Low differential pressure switches for low static pressure ranges shall be diaphragm type with snap action switch elements.
3. Low differential pressure switches for high static pressure shall be elbows and torque tube type and snap – action switch elements and metric scale dial indicators.

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4. For corrosive, viscous process fluids diaphragm sealed with completely filled inert liquid shall be used. Material of diaphragm and wetted parts shall be selected considering the nature of process fluid.
5. The sensing elements shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand at least 150 % the full scale pressure without any damage or permanent deformation.
6. Actuation set point, dead band shall be internally adjustable throughout the range with tamper proof facilities.
7. Electrical connection for the switch devices shall be suitable for plug in type connection.
8. Process connection shall be ½ inch NPT. Process piping connections shall include necessary union, nut, nipple, tail pipe, isolation valve and test connection to permit servicing, testing, calibration and removal of the instrument device.
9. Pressure switches shall be tested as per BS – 6134.

8.10

Capacitance Type Level Switch

Table 8.10
Specification for Capacitance Type Level Switch

S.N	Feature	Minimum Requirement
1	Type	Capacitance type
2	Probe	Rod or Suspended Electrode
3	Material	SS 316
4	Insulation	PTFE/PP/Kynar part/full as required
5	Repeatability	± 0.5 % of full range or better
6	Accuracy	± 0.5 % of full scale or better
7	Working temperature	As per process requirement
8	Probe length	As per requirement
9	Probe Mounting	1 ½" Flanged
10	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact
11	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC

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S.N	Feature	Minimum Requirement
12	Enclosure	IP 65
13	Housing	Cast aluminum epoxy coated weather proof
14	Cable connection	½ " NPT with Cable gland
15	Ambient Temperature	60 °C (max.)
16	Electrical Connection	Plug-in type
17	Accessories	Counter flange, Cable gland, Prefab cable etc.
14	Set point	Adjustable
15	Accessories	All mounting accessories

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8.11 Float/Displacer Type Level Switch

Table 8.11
Specification for Float/Displacer Type Level Switch

S.N	Feature	Minimum Requirement
1	Type	Float/Displacer type
2	Float/Stem/Displacer Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
7	Process connection	As per requirement
8	Over-range proof	150% of max. design pressure
9	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact
10	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
11	Enclosure	IP 65
12	Hydro Test	Chamber – 100% at 1.5 times rated pressure or as per ANSI flange rating Float – 1.1 times of operating pressure
13	Electrical Connection	Plug-in socket
14	Accessories	All mounting accessories

1. Level Switch shall work on gland less magnetically coupled float or displacer operated mechanism having separate float chamber.
2. Float, stem and displacer shall be 316 stainless steel.
3. Level switch body, cage and process connections shall be designed to withstand the maximum pressure and temperature of the operating fluid.
4. A setting adjustment on the level set point of + / - 25 mm shall be used. The adjustment shall be made externally to the switch.
5. The accuracy & repeatability of the switch shall be within +/- 0.5 % of full-scale range. On – Off differential shall be adjustable.

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6. Process connections of the cage shall be 25 NB male plain nipples connected through socket / welded isolation valves of adequate rating.
7. Level switch connections shall also include 15 NB test and drain connections to permit servicing, testing, calibration of the instrument.
8. The switching elements shall be snap-acting, shock-proof and vibration-proof. All switches shall have two electrically isolated SPDT contacts with provision of external adjustment of set points and dead bands. The contact ratings shall be 5 amps at 240 V AC 50 Hz or 0.25 amps at 220 V DC.
9. Switch enclosures shall be cast aluminium, weather-proof, NEMA -4X type with cable entry through compression type cable glands / ¾ "NPT conduit connections. Switches located in hazardous areas shall have dust-ignition-proof enclosure as per NEC article 500 provisions.

8.12

Ultrasonic Level Transmitter

Table 8.12
Specification for Ultrasonic Transmitter

S.N	Feature	Minimum Requirement
1	Application	Level measurement in silos, sump water level etc.
2	Medium	Coarse, hard solid materials like ash etc. Materials may be slowly falling through the detection range.
3	Type	Non contact Microprocessor based 2 wire type, HART protocol compatible Ultrasonic Transmitter
4	Principle	Time of flight
4	Sensor Material	Corrosion resistant material to suit individual application requirement.
5	False signal tolerance	Transmitter shall be capable of ignoring false echoes from internal tank / sumps obstructions such as pipes, heating coils or agitator blades. Also transmitters shall have adjustable damping circuitry.
7	Range	Capable of covering the complete level span of tank/vessel taking care of blocking distance, frequency, attenuation due to surface, obstructions, vapours etc.
8	Output	4 – 20 mA DC with 600 ohms load with HART compatibility.
9	Display	minimum 4 characters display with Integral keypad, access protected by user code.
10	Diagnostics	Loss of echo alarm etc.
11	Resolution	+/- 0.1 % of range or better

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S.N	Feature	Minimum Requirement
12	Accuracy	+/- 2 mm or 0.2% of span
13	Repeatability	3 mm or better
14	Operating temperature	0 to 60 °C
15	Power supply	24 V DC + / - 10 %
16	Mounting	Flanged connection at top of covers / side walls as per requirement.
17	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

1. The power and frequency of transmission for the transmitter shall be selected to assure a sufficient signal / noise ratio.
2. The transmitter shall be designed with an electronic circuit having the features such as temperature compensation, rejection of unnecessary echoes and noises and adjusting 'zero' and 'span'. It shall consist of sensors, electronic unit and accessories.

8.13

Guided Wave Radar Type Level Transmitter

Table 8.13
Specification for Guided Wave Radar Type Transmitter

S.N	Feature	Minimum Requirement
1	Application	Level measurement of vessel under vacuum or low pressure application
3	Type	Guided wave radar
4	Principle	TDR (Time domain reflectometry)
5	Probe Material	SS 316
6	Accuracy	5 mm or better
7	Resolution	+/- 0.1 % of range or better
8	Signal Output	4 – 20 mA DC with 600 ohms load with HART compatibility
9	Power Supply	24 V DC + / - 10 %
10	Display	Integral
11	Mounting	External cage type
12	Transmitter housing Protection Class	IP-65 with corrosion resistance coating

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S.N	Feature	Minimum Requirement
13	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

8.14

RF Type Level Switch

Table 8.14
Specification for RF Type Level Switch

S.N	Feature	Minimum Requirement
1	Application	Solids
2	Particle size	Fine dust to 400 mm
3	Process Temperature	0 – 100 °C
4	Vessel pressure	up to 60 bar
5	Insertion length	As required
7	Mounting	Side or top or top vertical at $\pm 15^\circ$
8	Process connection	40 NB thread or flanged
9	Protection Class	IP 67
10	Electronics	Remote
11	Cable connection	½ "NPT cable gland Plug-in cable connector

8.15

Turbine Flow Meter

Table 8.15
Specification for Turbine Flow Meter

S.N	Feature	Minimum Requirement
1	Type	Turbine(in line full-bore, based on magnetic pick of pulses)
2	Output Signal	Pulse
3	Material of Construction	a) Body : AISI 316 b) Rotor: AISI 431 or 410 c) Bearings: Tungsten Carbide / Stellite Sleeve
4	Flow rate range	As required.
5	Linearity	0.25% or better.
7	Repeatability	0.02% or better.
8	Ambient temperature	50 °C
9	Mounting	On-Line mounting with ANSI RF flanges of

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S.N	Feature	Minimum Requirement
		stainless steel.
10	Enclosure	IP 65
11	Electronics	Solid State
12	Power Supply	240V AC, 50Hz.
13	Input	Input from Sensor
14	Display	4 1/2 digit LCD
15	Output	Isolated 4-20mA DC
16	Measuring Accuracy	0.5% of full scale range
17	Totalized Value	Required
18	Housing	IP-65 (Explosion proof for NEC Class-1, Division 1 area)
19	Nameplate	Tag number, service engraved in stainless steel tag plate
20	Accessories	clamping strip, bracket, prefab cable etc. Calibration or cofigurator kit. ¾" ET cable gland

8.16

Mass Flow Meter

Table 8.16
Specification for Mass Flow Meter

S.N	Feature	Minimum Requirement
1	Measuring Principle	Coriolis Mass flow
2	Primary Element	Flow Tube of 316SS or better
3	Heating Arrangement	Integral with Flow Element
4	Temperature Control For Heating	To be provided
5	Measured quantities	Mass Flow rate, Total Mass Flow, Density, Temperature as minimum.
7	Input Signal Processing	Digital Processing.
8	Display	Digital Display (LCD).
10	Turn Down Ratio	100:1
11	Accuracy	± 0.2% of measured value
	Repeatability	± 0.05%
	Housing	IP 65 (Explosion proof for NEC Class-1, Division 1 area)
	Hazardous duty Version	FM Standards.
	Accessories	Counter flanges, Mounting nuts, bolts, gaskets etc.

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8.17

Vortex Flow Meter

Table 8.17
Specification for Vortex Flow Meter

S.N	Feature	Minimum Requirement
1	Type	Vortex
2	Output Signal	Pulse
3	Material of Construction	AISI 316
	Sensor Seal	PTFE / higher based on temperature
	Flow range	As required.
4	Linearity	0.25% or better.
5	Repeatability	0.02% or better.
7	Ambient temperature	50 °C
8	Mounting	On-Line mounting with flanges of stainless steel.
9	Enclosure	IP 65
10	Accessories	Nuts, bolts, gaskets etc.
11	Electronics	Solid State
12	Power Supply	240V AC, 50Hz.
13	Input	Input from Sensor
14	Display	4 1/2 digit LCD
15	Output	Isolated 4-20mA DC
16	Measuring Accuracy	0.5% of full scale range
17	Totalized Value	Required
18	Housing	IP-65 (Explosion proof for NEC Class-1, Division 1 area)
19	Nameplate	Tag number, service engraved in stainless steel tag plate
20	Accessories	clamping strip, bracket, prefab cable etc. Calibration or cofigurator kit. ¾" ET cable gland

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8.18 Flow Switch

Table 8.18
Specification for Flow Switch

S.N	Feature	Minimum Requirement
1	Type	Vane actuated/Differential bellow type
2	Vane/bellow Material	SS 316
3	Repeatability	± 0.5 % of full range or better
4	Accuracy	± 0.5 % of full scale or better
5	Working temperature	As per process requirement
7	Process connection	As per requirement
8	Over-range proof	150% of max. design pressure
9	No. of contact	2 NO. + 2 NC, SPDT, snap action type dry contact, shock & vibration proof
10	Rating of contacts	5A, 240 V AC / 2A, 24 V DC / 0.25 A, 220V DC
11	Enclosure	Cast Aluminium/IP 65
12	Cable connection	Compression type cable gland/ ½" NPT Conduit connection
13	Electrical Connection	Plug-in socket
14	Accessories	All mounting accessories

8.19 Rotameter

Table 8.19
Specification for Rotameter

S.N	Feature	Minimum Requirement
1	Type	Variable area Linear scale
2	Fluid media	Water/Oil
3	Float Material	SS 316
4	Accuracy	± 2 % of full scale or better

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S.N	Feature	Minimum Requirement
5	Working temperature	0 to 70 °C
6	Process connection	As per requirement
7	Over-range proof	150% of max. design pressure
8	Enclosure	Transparent toughened glass/IP 65
9	Accessories	Flange, orifice in case of bypass Rotameter

Rotameter shall be used for low flow & low viscosity applications of liquid.

8.20

Sight Glass Indicator (Flow Glass)

Table 8.20
Specification for Flow Glass

S.N	Feature	Minimum Requirement
1	Application	Online observation of fluid flow in Pipeline
2	Type	Double window for pressurized pipe with rotary wheel for installation in horizontal or vertical pipeline. Full view for non-pressurized pipeline.
3	Size	Double window up to 12" and 600 lbs rating. Full view up to 6" and 150 lbs rating.
3	Body Material	SS 316
4	Glass	Pyrex tempered glass
	Others	Rotor & wetted parts shall be bronze All accessories shall be SS316
5	Protection class	IP-65
6	Connection	Screwed up to 50 NB size Flanged ANSI 150 RF – above 50 NB size
7	Accessories	Name plates, mating flanges with gasket, bolts & nuts etc.

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8.21 Flow Elements

a) Orifice Plate

Table 8.21
Specification for Orifice Plate

S.N	Feature	Minimum Requirement
1	Type	Concentric as per ASME PTC – 19.5 (Part III); ISA RP – 3.2, 960; BS – 1042; ISO 5167
2	Material	SS 316
3	Thickness	3 mm for main pipe diameter up to 300 mm and 6 mm for main pipe dia above 300 mm.
3	Beta ratio	0.34 to 0.7
4	Tapping's	Flanged weld neck 3 pairs of tappings.
5	Material of Branch Pipe	Same as main pipe
6	Root Valve type	Globe
7	Root Valve material	SS 316
8	Root Valve size	1"
9	Accessories	Root valves, flanges, vent / drain hole (as required)

- Each orifice plate shall be used with a handle on which the orifice diameter, pipe diameter and pressure tap distances are stamped. This information shall be so located that it can be read without removing the orifice plate from pipe line.
- The standard primary element shall be thin plate, square-edge concentric orifice plate mounted between a pair of weld-neck type orifice flanges with flange taps. The minimum pressure rating of flanges shall be 300 pounds ANSI. The material of the orifice plates shall be SS 316 in general. Orifice plates shall be not less than 3 mm thick for nominal pipe diameters up to and including 300 mm, and not less than 6 mm thick above 300 mm NB pipe.
- Quadrant edge or quarter circle orifice plates shall be used for highly viscous liquids and for pipe Reynolds Number below 10,000. Conical entrance type of orifice plates shall preferably be used for very highly viscous liquids up to Reynolds Number below 250. Vent and drain holes shall be used wherever necessary.

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4. Orifice diameter shall be selected, so that d/D ratio is between 0.20 to 0.70 for gas and up to 0.75 for liquids.
5. Metering orifices shall not be installed in lines less than 1 ½" (40 mm) the lines shall be blown to the 1 ½" (40 mm) size for the meter run, keeping the d/D ratio within limits.
6. Restriction orifices and integral orifice transmitters do not require upstream or downstream straight pipe runs.
7. The orifice plate shall be supplied and fitted in conformity with ISO. When the pipe diameter is larger than the value specified in ISO, the restriction ratio shall be decided by extending the specific curve externally.
8. The length of straight pipe run required for metering accuracy shall be in conformity with ISO. When it is extremely difficult to comply with the standard, a minimum straight length of 10D (D = pipe inner diameter) on the upper stream and a minimum length of 5D on the downstream shall be considered.
9. All orifice plates shall be supplied with matching flanges of material and pressure rating not less than the rating of the associated pipe system.
10. For pipeline sizes of 500 mm and less, the orifice plates shall be an integral unit comprising of carrier ring assembly, tapping arrangement on both upstream as well down stream side. For line sizes more than 500 mm, the orifice plate shall be disc type. For disc type orifice plate, suitable corner tapping arrangement on both upstream as well as downstream side shall be used. All tapping arrangements shall be complete with a piece of impulse pipe line and a shut – off valve suitable for specified line pressure.

8.22 Control Valves

8.22.1 Introduction

The control valves and accessories equipment shall be designed, constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Boiler & Pressure Vessel code, Indian Boiler Regulation (IBR) & ISA or acceptable equal standards.

8.22.2 Control Valve Design & Sizing

1. The design of all valve bodies shall meet the specification requirements and shall conform to the requirements of ANSI for dimensions, material thickness and material specification for their respective pressure classes.
2. The valve sizing shall be suitable for obtaining maximum flow conditions with valve opening at approximately 80% of total valve stem travel and minimum flow conditions with valve stem travel not less than 10% of total valve travel. All the valves shall be capable of handling at least 120% of the required maximum flow. Further, the valve stem travel range from minimum flow condition to maximum flow condition shall not be less than 50% of the total

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valve stem travel. The sizing shall be in accordance with the latest edition of ISA Handbook on control valves. While deciding the size of valves, it shall ensure that valves outlet velocity does not exceed 8 m / sec. for liquid services, 150 m/sec. Manufacturer shall furnish the sizing calculations clearly indicating the outlet velocity achieved with the valve size selected by him as well as noise calculations.

3. Control valves for water applications shall be designed to prevent cavitations, wire drawing, flashing on the downstream side of valve and downstream piping. Thus for cavitations / flashing service, only valve with anti-cavitations trim shall be used. Detailed calculations to establish whether cavitations shall occur or not for any given application shall be furnished.
4. Trim shall be multistage type having sufficient number of discrete pressure drop turns (stages) to ensure elimination of vibration, erosive – action, cavitations. Identify the number of pressure drop turns in the given equipment and shall also provide calculation demonstrating compliance to the trim exit velocity.
5. To prevent flow induced vibration and to protect the valve internals from foreign particles such as weld slag flow, direction shall be a flow to close (over the plug) configuration for liquid applications. To maximize noise attenuating benefits and to allow for constant fluid expansion, flow direction shall be under the plug for gas applications.
6. Control valves for application such as SH spray control, RH spray control, Heavy oil pressuring & control system shall have permissible leakage rate as per leakage class V. All other control valves such as low and high range feed control valves etc shall have leakage rate as per leakage class IV.
7. The control valve induced noise shall be limited to 85 dBA at 1 meter from the valve surface under actual operating conditions. The noise abatement shall be achieved by valve body and trim design and not by use of silencers.
8. The characteristic of the control valves shall be determined based on the application / service.
9. On supply air or electrical failure for pneumatic / electrical drive, the valve shall remain full closed, open or stay – put position as per process safety requirement.

8.22.3 Valve Construction

1. Proper selection of valve type and material of construction to meet operating requirement.
2. All valves shall be of globe body design and straightaway pattern with single or double port unless otherwise recommended by the manufacturer to be of angle body type. Rotary valve may alternatively be offered when pressure or pressure drops permit.
3. Valves with high lift cage guided plugs & quick change trims shall be supplied.
4. Cast iron valves are not acceptable.

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5. Bonnet joints for all control valves shall be of the flanged and bolted type for easy dis – assembly. Bonnet joints of internal threaded or union type shall not be acceptable.
6. Plug shall be of one – piece construction either cast, forged or machined from solid bar stock. Plug shall be screwed and pinned to valve stems or shall be integral with the valve stems.
7. All valves connected to vacuum on down stream side shall be used with packing suitable for vacuum applications (e.g. double vee type chevron packing).
8. Valve characteristic shall match with the process characteristics.
9. Flanged valves shall be rated at not less than ANSI pressure class of 300 lbs.
10. Teflon shall be used for valve gland packing to suit process requirement.
11. The valve body shall be marked to show direction of flow.

8.22.4 Valve Materials

1. The control valve body material shall be
 - Carbon steel as per ASTM – A216 GR WCB for non – corrosive, non – flashing and non – cavitations services below 275 deg c temperature.
 - Alloy steel as per ASTM A – 217 GR WC 9 for severe flashing / cavitations services.
 - Alloy steel as per ASTM A – 217 GR WC 6 for low flashing / cavitations services.
 - 316 SS for condensate service below 300 deg C like condensate normal and emergency make – up controls etc.
2. The control valve trim material shall be
 - 17 – 4 PH SS for services listed above at bullet 1st, 2nd & 3rd points
 - 316 SS for services listed at 1 and 4th point for above bullet points
 - 316 SS with stellite faced guide parts and bushings for remaining applications.

8.22.5 End Preparation

Valve body ends shall be either butt welded / socket welded, flanged or screwed. The welded ends wherever required shall be butt welded type as per ANSI B 16.25 for control valves of sizes 65 mm and above. For valves sizes 50 mm and below welded ends shall be socket welded as per ANSI B 16.11. Flanged ends wherever required shall be of ANSI pressure – temperature class equal to or greater than that of the control valve body.

8.22.6 Valve Actuator

1. The regulating control valves shall be furnished with pneumatic actuators. Proper selection and sizing of valve shall be done for actuators in accordance with the

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pressure drop and maximum shut off pressure and leakage class requirements. The valve actuators shall be capable of operating at 60 °C continuously.

2. Valve actuators and stems shall be adequate to handle the unbalanced forces occurring under the specified flow conditions or the maximum differential pressure specified. An adequate allowance for stem force, at least 0.15 kg / cm² per linear millimeter of seating surface, shall be used in the selection of the actuator to ensure tight seating unless otherwise specified.
3. The travel time of the pneumatic actuators shall not exceed 10 seconds.
4. For quick opening / closing services (such as fuel oil shut – off valve), the actuator shall be pilot solenoid operated pneumatic drive; the rating of solenoid shall be 24 V DC.
5. Selection of actuator shall be such that it meets the requirements of thrust / torque, stroke length, angular movement, full scale travel time, repeatability & accurate positioning for successful operation of final control element.
6. All the actuators shall have also provision for manual operation during emergency / maintenance along with graduated local position indicator.

8.22.7 Control Valve Accessory Devices

All control valve accessories such as air locks, hand wheels / hand-jacks, limit switches, SMART positioners, diffusers, external volume chambers, reversible pilot for positioners, tubing and air sets, solenoid valves and junction boxes etc. shall be used as per the requirements.

Table 8.22
Specification for E-to-P converter

S.N	Feature	Minimum Requirement
1	Air Supply	1.5 Kg/Sq. cm
2	Input Signal	4-20 mA DC
3	Output Signal	0.2 to 1.0 Kg/ Sq. cm
4	Linearity	0.5 % of span or better
5	Hysteresis	0.1 % of span or better
6	Ambient Temperature Effect (-20 to + 60 °C)	<0.2 % of span per Degree centigrade
7	Mounting	Close to Actuator
8	Protection class	IP-65

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S.N	Feature	Minimum Requirement
9	Enclosure	Die cast Aluminium
10	Drift	+/- 2% of set point per hour

Table 8.23
Specification for Smart Positioners

S.N	Feature	Minimum Requirement
1	Input	4-20 mA DC
2	Power Supply	24 V DC Loop powered
3	Type of Electronics	Microprocessor based with self diagnostic facility & digital communication by means of HART Protocol
4	Valve position sensing	Non-Contact type with 4-20 mA DC Output
5	Enclosure Type/Material	Weather & Dust proof to IP-65/ Die cast Aluminium
6	Ambient conditions	Suitable for - 30 to + 80 °C temperature & 0-95% Humidity
7	Operating Range	Suitable for Full range & Split Range operation
8	Modes of operation	Suitable for Direct & reverse valve action
9	Flow characteristics	Suitable for Linear & Equal percentage Characteristics
10	Fail safe/Freeze feature	Required
11	Air Capacity	Sufficient to handle the Valves Selected/Boosters to be supplied if required.
12	Air supply pressure	To suite the Air Supply Pressure / Quality available
13	Process Connection	1/4" NPT
14	Characteristic Deviation	< = 0.5% of span

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S.N	Feature	Minimum Requirement	
15	Ambient Temperature effect	< =0.01%/Deg C or better	
16	Configuration	Remote Calibration, Auto & Manual Calibration shall be possible	
17	Cable Entry	½" NPT, Side or Bottom Entry to avoid water ingress	
18	Accessories	a)	Display with push buttons for configuration and Display on the positioner itself (Password Protected / Hardware Lock).
		b)	For Supply & Output Pressure, Filter Regulator and other accessories shall be used as on required basis for making system complete
		c)	Valves Mounting Assembly For Sliding Stem / Rotary / Single Acting / Double Acting on required basis

1. SMART positioner shall be a Double stage positioner. The first stage of the positioner shall be typically a flapper-nozzle that serves as a high-gain pre-amplifier. This sensitivity shall be maintained over a wide range of dynamic conditions. Second stage shall be a power amplifier that provides power to drive the actuator. Preferably this shall be a pneumatic relay. Spool Driven type SMART positioners are not preferred due to Higher Dead Band and Poor responsiveness. The SMART positioner shall have pressure sensors to measure the pneumatic outputs to the actuator.
2. The control algorithm for the positioner shall use feedback signal from the motion of the pneumatic relay beam instead of pressure feedback to minimize pneumatic related effects and for stable and smooth response of the control valve. The SMART positioner shall have user adjustable tuning sets to identify the optimum tuning for the total valve assembly. SMART Positioner with HART Communication facility shall communicate all the valve diagnostics to Plant DCS.

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Table 8.24
Specification for Air Filter Regulator (AFR)

S.N	Feature	Minimum Requirement
1	Type	Constant Bleed type
2	Inlet Pressure	10 Kg/Sq. cm (maximum)
3	Output	Adjustable from 0-2 Kg/Sq. cm or 0-7 Kg/Sq. cm (Continuous) as required
4	Filter Element	5 microns
5	Filter Element Material	Phosphor Bronze
6	Bowl Material	Metallic
7	Drain	Automatic
8	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
9	Process connection	¼ " NPT
10	Accessories	All mounting accessories. 2" dial size Pressure gauge.

Table 8.25
Specification for Position Transmitter

S.N	Feature	Minimum Requirement
1	Power Supply	24 V DC Loop powered
2	Type	Non-Contact/ LVDT type
3	Output	4-20 mA DC/ Linear
4	Accuracy	+/- 1%
5	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
6	Cable Entry	½" NPT, Side or Bottom Entry to avoid water ingress.

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S.N	Feature	Minimum Requirement
7	Accessories	All mounting accessories

Table 8.26

Specification for Limit Switch (Non Contact Type)

S.N	Feature	Minimum Requirement
1	Type	Non-contact type inductive Proximity/Namur type
2	Sensing distance	10 mm minimum
3	Hysteresis	Maximum 10% of sensing distance
4	Indicator	LED indication
5	Protection class	IP 67
6	Integral Cable	1 mtr.
7	Power supply	24 V DC/ 8 V DC
8	Mounting	Flush mounting with check nut
9	Other Feature	Explosion proof enclosures shall be used wherever required by the application. Shock & Vibration proof.

8.22.8 Test & Examination

- All valves shall be tested in accordance with the quality assurance programme agreed which shall meet the requirement of IBR and other applicable codes.
- The tests shall include but not but limited to the following:
 - Non-destructive test as per ANSI B – 16.34.
 - Hydrostatic shell test in accordance with ANSI B16.34 prior to seal leakage test.
 - Valve closure test and seal leakage test in accordance with ANSI B16.34 and as per the leakage class indicated under clause no. B.6.
 - Functional test: The fully assembled valves including actuators control devices and accessories shall be functionally tested to demonstrate times from open to close position.

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- All control valves shall be tested with the positioners for accuracy of positioning and reproducibility over the full range of travel.
 - CV Test: CV test shall be carried out as type test on each size, type and design of the valves as per AISA 75.02 standard.
 - Magnetic particle inspection shall be performed on all machined surfaces of valves having ASA rating of 1500 lbs ASA or greater. All carbon steel valves with 1500 lbs ASA or greater shall receive 100% radio graphic examination in accordance with ASTM – E71.
3. The certificate shall be in the prescribed forms III A & III C and shall be endorsed by an Inspection Authority recognized by the Indian Boiler Regulations.

8.22.9

Pneumatic Power Cylinder

Table 8.27
Specification for Pneumatic Power Cylinder

S.N	Feature		Minimum Requirement
1	Applicable standard		ISO 6431
2	Mounting Type		Fixed Position mounting/ Trunion mounting
3	Material	Cylinder	Seamless Steel Tube
		Piston rod	Hard Chrome Plated Steel
		Tie rod	Stainless steel
		End Cover	Cast Iron
		Sealing	Polyurathane
4	Control Signal		4-20 mA DC signal to Smart positioner with HART protocol for modulating purpose. Solenoid valve operating on pneumatic line for open & closing purpose of ON-OFF Damper.
5	Supply Air		0-7 Kg/cm ²
6	Accuracy		Better than +/- 1%
7	Repeatability		Better than 0.5 % of full travel
8	Hysteresis		Less than +/- 0.2% of full travel
9	Dead Band		+/- 0.1%

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S.N	Feature	Minimum Requirement
10	Selection	Based upon thrust/torque, stroke length, angular movement, full scale travel time, repeatability, space factor etc. Provision for air-to-open or air-to-close operation
11	Accessories	Air lock relay, hand wheel, AFR, Volume booster, Limit switch, Positioner, Solenoid valve, position transmitter & all required mounting accessories etc.
12	Fail safe operation	Stay put for regulating duty

8.23

Solenoid Valves

Table 8.28
Specification for Solenoid Valves

S.N	Feature	Minimum Requirement
1	Operating Principle	Electromagnetic (noiseless), Pilot operated
2	Coil Voltage Rating	24 V DC (in general)/220 V DC/230 V AC/ 110 V AC as required
3	Ways	3 ways in general others as required
4	Port size	¼ " NPT all ports
5	Body	SS Bar stock/Brass
6	Trim	AISI 316 SS
7	Manual Operation	In built
8	Duty	Suitable for continuous Energisation
9	Sealing	Airtight & leak proof
10	Coil Enclosure	SS 316/Moulded type
11	Insulation class	Class H
12	Coil Casing	IP-67
13	Mounting	Suitable for mounting On pipe or in panel

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S.N	Feature	Minimum Requirement
14	Cable connection	½ " NPT Cable gland
15	Accessories	Mounting Bracket, nuts, bolts etc.
16	Other Features	LED Indication

8.24

Dew Point Meter

Table 8.29
Specification for Dew Point Meter

S.N	Feature	Minimum Requirement
1	Type	Sensor- Hyper Thin Film high capacitance Al2O3, Transmitter- Microprocessor based 2-wire loop powered
2	Accuracy	± 5.5°F (± 3°C)
3	Repeatability	± 0.9°F(± 0.5°C
4	Storage temperature	-40°F to + 176°F (-40°C to + 80°C)
5	Local Indication	To be provided
6	Input Resolution	0.1 °C dew point
7	Power Supply	24 VDC
8	Output	4 - 20mA
9	Enclosure material	Die – cast Aluminium
10	Enclosure protection	Weatherproof IP 65
11	Electrical connections	½ " NPT
12	Process connection	As per requirement
13	Accessories	All required mounting accessories.

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pH Analyzer

Table 8.30
Specifications for pH Analyzer

S.N	Feature	Minimum/Maximum Requirement
1	Type	Cell-flow through type
2	Sensor	Glass, ORP or antimony electrodes, Pt 100 Temperature sensor
3	Range	0 to 14
4	Temperature compensation	Automatic 0 to 130°C with Pt 100 Manual 0 to 130°C in steps of 1°C
5	No. of stream	Single
6	Measuring Error	+/- 0.2% FSD
7	Stability	</- 0.001 pH per week Temperature / temperature
8	Error	0.001 pH/deg.C
9	Measuring cycle	<2 seconds
10	Reproducibility	+/- 0.1% FSD
11	Output signal	4-20 Ma
12	Linearly	0.10%
13	Calibration	<ul style="list-style-type: none"> • Computer assisted 2 point • Any of 2 calibration solution within pH 0 to 14 for the zero and slope
14	Zero Adjustment	+/-2 pH for glass electrodes +/- 5 pH for antimony electrodes
15	Slop Adjustment	70 to 110% of the theoretical slope of glass electrodes / 70% to 120% of the theoretical slope of antimony electrodes.
16	Storage of measured values	Last measurement to be retained during calibration and programming
17	Indication	3.5 digit LCD
18	Data Input	Sealed touch keyboard with keys
19	Protection	IP 65.

- The Analyzer System shall have:
 - Open corrosion resistant drain to waste header.
 - Automatic temperature compensation shall be provided if required.
- All chemical reagents required for 12 months operation shall be supplied

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Conductivity Analyzer

Table 8.31
Specifications for Conductivity Analyzer

S.N	Feature	Minimum/Maximum Requirement
1	Type	For Condenser Hotwell - Removable type cells For others - Flow-through cells.
2	Range	0-1, 0-10, 0-100 micromho /cm (for specific conductivity) micromoh /cm log scale (for cation conductivity)
3	No. of stream	Single
4	Temperature compensation	Automatically with Pt 100 or manually in steps of 0.1 °C selectable
5	Temperature coefficient	Adjustment in steps of 0.1 % per deg.C within 0 to 10% per deg. C
6	Reference temperature	25 °C
7	Error of Measurement	+/- 1 % of calibrated span
8	Response Time	</- 1 sec
9	Measuring cycle	< 5 sec
10	Signal Output	4-20 mA
11	Indication	3.5 digit LCD
12	Calibration	slope adjustment (cell constant adjustment)
13	Programming	Polycarbonate membrane-switch key board for Programming
14	Enclosure Material	Epoxy coated cast Aluminium
15	Protection	IP 65
16	Other	Dual cation exchange column shall be provided for cation conductivity.

1. The Analyzer System shall have

- Open corrosion resistant drain to waste header.
- Automatic temperature compensation shall be provided if required.
- All chemical regents required for 12 months operation shall be provided

8.27

Silica Analyzer

Silica Analyzer shall be offered with following features as a minimum:

- Multi-Channel operation
- User friendly menu operated programming

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- Automatic calibration
- Built in printer with facility for printing historical data with statistics analyzer
- Serial interface option

Table 8.32
Specifications for Silica Analyzer

S.N	Feature	Minimum/Maximum Requirement
1	Type	continuous colorimetric
2	No. of Steam	multi stream
3	Order of steam selection	Programmable Sequence
4	Range	0 – 50 ppb 0-500 ppb
5	Error of measurement	+/- 2 ppb with respect to a solution containing 100 ppb SiC2 (40 mm flow cell) +/- 25 ppb with respect to a solution containing 100 ppb SiO2 (8 mm flow cell) +/- 5% whichever is greater
6	Reproducibility	</- 5% of measured value
7	Response Time	< 10 minutes (including sample switching)
8	Calibration	Automatic 2 point zero and slope programmable 1-240 hrs.
9	Transmitter	function central <ul style="list-style-type: none"> • Display in connection units • Diagnostics • Alarm status • Calibration constants
10	Display	LCD matrix, menu operated
11	Output	4 to 20 mA/Sample limit alarm/System alarm (no Sample, no reagent, calibration error)
12	Material	Panel - Epoxy coated stainless steel Cabinet - stove enameled steel Pump Tubing - PVC
13	Serial Interface	RS 232 or RS 485 or as per requirement Minimum Data Stream

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S.N	Feature	Minimum/Maximum Requirement
14	Requirement:	<ul style="list-style-type: none"> No. of Channels Alarm Status Date of last calibration Calibration solution concentration Calibration constants Channel member Silica concentration

1. The Analyzer System shall have

- Open corrosion resistant drain to waste header.
- Automatic temperature compensation shall be provided if required.
- All chemical reagents required for 12 months operation shall be provided

8.28

Sodium Analyzer

The Sodium Analyzer shall be provided as per following features as a minimum:

- Microprocessor based with temperature compensation
- Fully automatic calibration
- Analog / digital output
- Serial Interface

Table 8.33
Specifications for Sodium Analyzer

S.N	Feature	Minimum/Maximum Requirement
1	Type	Continuous flow through sample
2	No. of stream	Multi stream
3	Measuring range	0 to 20 ppb 0 to 200 ppb
4	Error of measurement	< 5% of the reading or < +/- 0.05 ppb, whichever is greater
5	Response Time (90% of full scale)	< 2 minutes < 3% of the reading or < +/- 0.03 ppb, whichever is greater
6	Transmitter	Digital Backlit display – Display of concentration valve in ppb/ppm, electrodes signal in mv, sample temperature in deg.C, sample flow rate in l/hour. Analog contacts, 1 system alarm TemperatureRelay Output - 2 adjustable min/max.Output – Two 4 to 20 mA compensation – Automatic
7	Serial Interface	RS 232 or RS 485 or as per requirement

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S.N	Feature	Minimum/Maximum Requirement
8	Error Report	<ul style="list-style-type: none"> Excessive zero drift Slope value out of the acceptable range Lack of sample Temperature & flow over-range or under range

- The Analyzer System shall have
- Open corrosion resistant drain to waste header
- Automatic temperature compensation shall be provided if required.
- All chemical reagents required for 12 months operation shall be supplied.

8.29

Turbidity Analyzer

Table 8.34
Specifications for Turbidity Analyzer

S.N	Feature	Minimum/Maximum Requirement
1	Type	light reflection principle
2	Accuracy	</- +/- 2% low range </- +/- 5% high range
3	Response Time	</- 5 minutes
4	Range	20-500 NTU
5	No. of Stream	Single

The Turbidity Analyzer shall be provided with following features as a minimum:

- Microprocessor based with self diagnostics
- Debubbling chamber & bubble rejection circuitry
- Display & output signal averaging
- NEMA 4 x enclosure if required.

8.30

Chlorine Analyzer

The chlorine analyzer shall use colorimetric DPD chemistry (N,Ndiethyl-p-phenylenediamine) to continuously measure either free or total residual chlorine, the selection of which depends on the different set of reagents installed in the instrument.

The analyzer shall be of low maintenance design capable of continuous operation for not less than 30days without attendance. A controller shall be provided for control of the chlorination process. The analyzer shall have selftesting diagnostics and a LCD/LED display on the cubicle front to display the reading of system status. One 420 mA analogue signal output and alarms for system abnormal status shall be provided for remote monitoring and alarm initiation.

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Table 8.35
Specifications for Chlorine Analyzer

S.No.	Features	Minimum Requirements
1	Type	Colorimetric DPD chemistry and Microprocessor based.
2	Operating range	0-5 mg/litre or total residual chlorine
3	Output	4-20 mA DC (isolated) into 600 ohm
4	Readout	Digital indicating meter for direct Readout
5	Accuracy	$\pm 5\%$ or 0.035 mg/L as CL ₂ , whichever is greater
6	Precision	$\pm 5\%$ or 0.005 mg/L as CL ₂ , whichever is greater
7	Minimum Detection Limit	at least 0.05 mg/litre
8	Cycle time	Less than 3 minutes
9	Sample Conditioning Inlet Pressure	1 to 75 psig
10	Sample Flow Required	200 mL per minute minimum flow rate required
11	Sample Temperature Range	5-400C temperature
12	Operating ambient	5-40°C temperature
13	Ambient humidity	Up to 90% relative humidity at 40°C
14	Power supply	240V, 50Hz, 1 Phase
15	Alarm Facility	2 HI and 2 LO independently adjustable over span.
16	Accessories	<ul style="list-style-type: none"> • Reagents • Reagent Kit for Free Chlorine Testing • Reagent Kit for Total Chlorine Testing

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[Logo of Utility]

S.No.	Features	Minimum Requirements
		<ul style="list-style-type: none">• Installation Kit & Maintenance Kit• Special cables up to transmitter with flexible conduit• Others as required
17	Applicable Standard	ANSI/UL

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9 PROCESS CONNECTION PIPING

Installation and testing of all required material for completeness of impulse piping system, sample piping system and air piping system as per the requirements of this clause on as required basis for the connection of instruments and control equipment to the process and make the system complete.

Control and instrument piping & connections shall generally be designed in accordance with the following criteria and these criteria shall be closely co-ordinated with Mechanical Piping / Erector to fulfill the Mechanical Design Criteria also. This is a guideline for Piping design & selection.

1. Pressure connections and piping up to the root valves for all pressure indicators, pressure switches, pressure transmitters, etc., shall be as indicated for miscellaneous piping.
2. Temperature indicators, temperature controllers, temperature switches, temperature detectors, and test well connections shall be used.
3. Flow transmitter connections and piping up to the root valves shall be 25 mm for all piping except orifice flanges, where 15 mm piping and valves shall be used.
4. Level switch connections and piping up to root valves shall be 25mm.
5. Level controllers and level transmitters of the displacement type shall have connections and piping up to root valves of 50 mm.
6. Level controllers and level transmitters of the differential pressure type shall have connections and piping up to root valves of 25 mm.
7. Instrument columns at tanks and pressure vessels shall generally be 65 mm minimum.

a) Design Pressure and Temperature

Instrument primary piping design pressure and temperature shall be selected consistent with the requirements discussed in Mechanical Design Criteria of this specification, for the process pipe to which the instrument primary piping is connected. The following general criteria shall also apply:

Instrument primary piping for other systems shall be designed for 1-½ times the maximum sustained process pressure and temperature (plus 20°C).

b) Sizes of Instrument Primary Piping

Instrument primary piping shall not be smaller than the connection at the process pipe root valve and/or the following (metric sizes are nominal):-

1. 20 mm for pressure measurement piping with a design pressure equal to or less than 42.0 bar and a design temperature equal to or less than 400°C.
2. 25 mm for pressure measurement piping with a design pressure greater than 42.0 bars or a design temperature greater than 400°C.

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3. Flow and level measurement by differential pressure shall also use primary piping conforming to the above requirements; however, flange tap connections may be of 13 mm size.
4. Float actuated level switch devices shall be supported on connecting piping not smaller than 25 mm.
5. Level controllers and transmitters of the displacement float type shall be supported on connecting piping not smaller than 50 mm.
6. Instrument columns for float actuated level switches and displacement float devices shall be piping of not less than 65 mm.
7. Primary piping internal diameter shall not be less than 8 mm between the process connection and instrument blow down valve.

c) Materials for Instrument Primary Piping

Material for instrument primary piping connecting to the root valve shall preferably be the same as that used in the process system to which it is connected. Higher strength materials may be substituted in the interest of standardization; however, welding procedures at the point of joining the instrument primary piping to the process piping must be appropriate to the combination of materials involved. Copper may be used only for compressed air services that use copper process piping.

d) Insulation of Instrument Primary Piping

Instrument primary piping connecting to high temperature systems, which might become hot enough to injure personnel during blow down of the instrument line, shall be insulated where such hazard exists. Insulation materials, exterior finish, and metal lagging shall conform to the standards adopted for the process piping.

All materials supplied shall be suitable for intended service, process operating conditions and type of instruments used and shall fully conform to the requirements of this specification.

e) Process Connection Size

Size of tapping point, stub no and size of Root valves for different type of measurements.

These shall be as follows:

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Table 9.1
Process Connection Stub & Root valve

S. N.	Quantity of root valves (Nos.)	Size of stub and root valves	Service condition
A. Pressure and Differential pressure measurement			
1	2	25NB	> = 62 bar or 425degree C
2	1	15NB	< 62 bar and 425 degree C
B. Level Gauge and Switch			
1	2	25 NB	> = 62 bar or 425 degree C
2	1	25NB	< 62 bar and 425 degree C
C. Level Transmitter (Displacement Type)			
1	2	40NB	> = 62 bar or 425degree C
2	1	40NB	< 62 bar and 425 degree C
D. Stand pipe for Level measuring instrument			
1	2	80 NB	> = 62 bar or 425degree C
2	1	80 NB	< 62 bar and 425 degree C
E. Flow measurement			
1	2	25NB	> = 62 bar or 425degree C
F. Level measurement			
1	1	25NB	< 62 bar and 425 degree C

9.1 Impulse Piping, Tubing, Fittings, Valves & Valve Manifolds

All impulse pipes shall be of seamless type conforming to ANSI B36.10 for schedule numbers, sizes and dimensions etc. The material of the impulse pipe shall be same as that of main process pipe. For various applications specification of impulse pipe materials and associated fittings and valves shall be as given in Table –13.2 (Process Connection Piping).

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Table 9.2
Process Connection piping

S. N	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
1	Water system	SCH.80 21.34m m OD	12.7 mm ODX 1.65mm THK	SS316	ASTM-A-106-Gr-B (carbon steel)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
						3000LBS	400LBS
						3000LBS	150LBS
2	Instrument air system	SCH.40 21.34m m OD(pipe through out)	12.7 mm ODX 1.65mm THK	SS316	IS 1239 Heavy Class (Galvanized)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
						3000LBS	150LBS
3	Service air system	SCH.40 21.34m m OD	12.7 mm ODX 1.65mm THK	SS 316	IS 1239 Heavy Class (Black)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
						3000LBS	150LBS
						3000LBS	150LBS

Notes:-

1. Impulse pipe thickness shall be selected as per ANSI B 36.10. based on the schedule indicated against each service.
2. Wherever impulse tubes are provided, all the fittings required for these shall be SS316.

The following guidelines shall also be considered along with the Table 9.2 for size, material and rating for impulse line/tube fittings and accessories:

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a) Impulse line / tube fittings and accessories

1. Nipple shall be used for root valve size more than ½ inch and the nipple size shall be same as the root valve size. Reducer / adapter shall be used to suit instrument connection, where nipple, root valve size is more than ½ inch.
2. Bulk head fitting socket welded type to be provided at instrument rack / enclosure.

b) Fittings

1. All fittings except the last fitting connecting to the instrument shall be socket welded. The size of the fittings shall be same as the impulse line size.
2. The fitting connecting to the instrument shall have a size and thread to suit the instrument connection.

c) Instrument Valves

1. Type of the valve shall be needle valve with built in drain valve.
2. Sizing of the valve shall be ½".

d) Right / left threaded fittings

1. This shall be used for installation / removal of instruments without disturbing the tubing / piping.
2. A suitable adapter shall be used to install the instruments on ½" right-left threaded fittings.

- e)** A ½" vent line with a ½" isolation valve shall be used in the instrument rack for air and compressible fluids or other wise if the installation call for eg., for liquid service where the transmitter is located at a higher elevation than the tapping point.

- f)** Stainless steel tube shall be used inside enclosures and racks from tee connection to valve manifold and then to instrument. For high pressure/temperature applications the material shall be ASTM A 213 TP 316H and for other applications material shall be ASTM A 213 TP 316L. The wall thickness of the tube shall be in accordance with the ANSI B31.1 standard.

All fittings shall be forged steel and shall conform to ANSI B16.11. The material of forged tube fittings for shaped application (e.g. tee, elbow etc.) shall be ASTM A182 Gr. 316 H for high pressure/ temperature applications (as defined above) and ASTM A182 Gr. 316L for other applications. The material for bar stock tube fitting (for straight application) shall be 316 SS. Metal thickness in the fittings shall be adequate to provide actual bursting strength equal to or greater than those of the impulse pipe or SS tube, with which they are to be used.

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The disc and seat ring materials of carbon steel and alloy steel valves shall be ASTM A-105 and ASTM A-182, Gr. F22, hard faced with stellite (minimum hardness - 350 BHN.) The surface finish of 16 RMS or greater is required in the area of stem packing. The valve design shall be such that the seats can be re-conditioned and stem and disc may be replaced without removing the valve body from the line.

The valve manifolds shall be of 316 s Furnishing Recommended protection interlock logics stainless steel with pressure rating suitable for intended application. 2-valve manifold and 3 valve manifold shall be used for pressure measurements using pressure transmitters/ pressure switches and differential pressure transmitters/ switches respectively. 5-valve manifold shall be used for remaining applications like DP, flow and level measurements.

For Pressure/D.P gauges in fluid application two-way globe valve on each impulse line to the instrument and in air application two way gate valve on each impulse line to the instrument shall be used near the instrument. These shall be in addition to the three way gauge cock provided along with the pressure/D.P gauges.

Table 9.3
Specification for Seamless SS Pipe

S.N	Property	Requirement
1	Reference	ASTM A-312 TP-316
2	Material Grade	TP-316
3	Type	Seamless/Plain end
4	Size	½" NB
5	Schedule	40/60/80
6	Standard Length	5 metre

Table 9.4
Specification for Seamless SS Pipe Fittings

S.N	Property	Requirement
1	Reference	ASTM A-182 F-316
2	End Connection	Socket welded
3	Type	Forged conforming to ANSI B16.11
4	Size	½" NB
5	Rating	3000/6000/9000 lbs
6	Type of Fittings	Reducing coupling, Male-Female reducer, Straight coupling, Equal Tee, Three Piece Union, Elbow, Cap etc.

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Table 9.5A
Specification for Seamless SS Tube (1/2")

S.N	Property	Requirement
1	Reference	ASTM A-213 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	½" OD X 2.1 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness
8	Test	Flare, Hardness, Ball & Bubble test
9	Standard Length	5 metre

Table 9.5B
Specification for Seamless SS Tube (1/4")

S.N	Property	Requirement
1	Reference	ASTM A-269 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	1/4" OD X 1.2 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness
8	Test	Flare, Hardness, Ball & Bubble test
9	Standard Length	5 metre

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Table 9.6
Specification for Seamless SS Tube Fittings

S.N	Property	Requirement
1	Reference	ASTM A-182
2	Material Grade	SS 316 forged
3	Type	Double ferrule double compression
4	Ferrule	SS 316
5	Size	To suit SS tubing & NPT end connection
6	Type of fittings	Male/Female connectors, elbow, Equal & Unequal Tee, Cross, Straight connector, bulk head unions, etc. as required to suit the installation.

Table 9.7
Specification for Instrument Valve Manifolds

S.N	Property	Requirement
1	Type	Two valve manifold/Three Valve Manifold Five valve manifold
2	Mounting	Remote 2" pipe mounting
3	Construction	Single Block (Bar Stock)
4	Material	Forged body & bonnet AISI 316 SS
5	Ports	½" NPT
6	Rating	420 Kg/ cm ² at ambient
7	Packing	PTFE Wafer
8	Seat & Stem	AISI 316 SS
9	Plug	AISI 316 SS free to turn on stem/ 17-4 PH
10	Handle	AISI 316 SS
11	Connection	Straight
12	Accessories	Plug for all ports Mounting Bracket, nut, bolts etc.

9.2

Air Supply Piping

1. All pneumatic piping, fittings, valves, air filter cum regulator and other accessories required for instrument air for the various pneumatic devices/ instruments shall be used.
2. This shall include as a minimum air supply to pneumatically operated control valves, actuators, instruments, continuous and intermittent purging requirements of Local Instrument Enclosures (LIE) etc.
3. For individual supply line and control signal line to control valve, 1/4 inch size light drawn tempered copper tubing conforming to ASTM B75 shall be used. The thickness of copper tubing shall not be less than 0.065 inch and shall be PVC

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coated. The fittings to be used with copper tubes shall be of cast brass, screwed type.

4. All other air supply lines of 1/2 inch to 2 inch shall be of carbon steel hot dipped galvanized inside and outside as per IS-1239, heavy duty with threaded ends. The threads shall be as per ASA B2.1. Fittings material shall be of forged carbon steel A234 Gr. WPB galvanized inside and outside, screwed as per ASA B2.1. Dimensions of fittings shall be as per ASA B16.11 of rating 3000 lbs.
5. Instrument air filter cum regulator set with mounting accessories shall be used for each pneumatic device requiring air supply. The filter regulators shall be suitable for 10 kg/ sq.cm max. inlet pressure. The filter shall be of size 5 microns and of material sintered bronze. The air set shall have 2 inch size pressure gauge and built in filter housing blow down valve.
6. All the isolation valves in the air supply line shall be gate valves as per ASTM B62 inside screw rising stem, screwed female ends as per ASA B2.1. Valve bonnet shall be union type & trim material shall be stainless steel, body rating 150 pounds ASA. The valve sizes shall be 1/2 inch to 2 inch.

Table 9.8
Specification for Instrument Air Header

S.N	Property	Requirement	
		For Panel	For Field
1	Material	SS 316	SS 316
2	Inter Connection	2" NPT (M)	1" NPT (M)
3	Header Take-Off	SS 316	SS 316
4	Take-Off Connection	½" NPT (M)	½" NPT (M)
5	Take-Off Valve	½" Ball Valve SS 316	½" Ball Valve SS 316
6	Drain	½" Ball Valve SS 316 at the lowest point	½" Ball Valve SS 316 at the lowest point

Table 9.9
Specification for CS Pipe

S.N	Property	Requirement
1	Reference	ASTM A-106 Gr. C
2	Material	Cold Drawn Seamless CS
3	Type	Seamless/ threaded ends as per ASA B2.1/ Hot dip Galvanised from Inside & outside as per IS-1239
4	Size	½" to 2" NB
5	Schedule	80/160
6	Standard Length	5 metre

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Table 9.10
Specification for CS Pipe Fittings

S.N	Property	Requirement
1	Reference	ASTM A-234/ ASA B16.11
2	Type	Forged/ hot dip galvanised from inside & outside
3	Size	½ " to 2" (as required)
4	Rating	3000/6000/9000 lbs.
5	End Connection	Threaded as per ASA B2.1
6	Type of Fittings	Reducing Coupling, Male-Female reducer/ Straight Coupling/ Equal Tee/ Three piece Union/ Elbow/ Cap etc.

Table 9.11
Specification for CS Globe Valve

S.N	Property	Requirement
1	Reference	ASTM A-105/ASTM B62
2	Type	Globe
3	Construction	Forged body cadmium plated
4	Rating	PN 40/PN 160/ PN 320/ PN 400
5	End Connection	Screwed Female ends as per ASA B2.1
6	Material	Body- Carbon steel Stem- Hardened Steel Plug- AISI 316 SS Seat- SS Stellite
7	Size	½ " to 2 " as required
8	Packing	Teflon/Grafoil as required
9	Hand wheel	CS
10	Yoke	ASTM A105
11	Design Standard	As per ANSI B16.34

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10 INSTRUMENTATION CABLES & ACCESSORIES**10.1 Specifications of Instrumentation Cables****a) Common Requirements**

Table 10.1
Specification of Instrumentation Cables- Common Requirement

S.N	Property	Requirement
1	Voltage grade	600 V (Peak Value)
2	Codes and Standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6 , VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification
3	Continuous operation suitability	At 70 deg. C for all types of cables, while 205 deg C for Type-C cables
4	Progressive automatic on-line sequential marking of length in meters.	To be provided at every one meter on outer sheath.
5	Marking to read 'FRLS'	To be provided at every 5 meters on outer sheath except for type-C cable.
6	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet.
7	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8	Ovality at any cross-section	Not more than 1.0 mm
9	Others	<div>a)</div> Durable marking at intervals not exceeding 625 mm shall include manufacturer's name , insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacture to be provided. <div>b)</div> Cables shall be suitable for laying in conduits, duct, trenches, racks and underground-buried installation Repaired cables shall not be acceptable

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b) Specific Requirements

Table 10.2
Specification of Instrumentation Cables- Specific Requirement

S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
A.	Conductors				
i.	Cross section area				
ii.	Conductor material	ANSI type KX	ANSI type SX	High conductivity annealed tin coated copper	ANSI type KX
iii.	Colour code	Yellow-red	Black-Red	As per VDE-0815	Yellow-red
iv.	Conductor Grade	As per ANSI MC 96.1		Electrolytic	As per ANSI MC 96.1
v.	No. & dia. of strands	n (nom)			
vi.	No. of Pairs	2, 6	2	4, 8, 12, 16, 24, 48,	2
vii.	Max. conductor resistance per Km (in ohm) at 20 deg. C	As per ANSI MC 96.1		73.4 (loop)	As per ANSI MC 96.1
viii.	Reference Standard	As per ANSI MC 96.1		VDE 0815	As per ANSI MC 96.1
B.	Insulation				
i.	Material	PVC type YI 3 with FRLS properties			Teflon (i.e. extruded FEP)
ii.	Thickness in mm (Min/Nom/Max)	0.25 / 0.3 / 0.35			0.4 / 0.50
iii.	Volume Receptivity (Min) in ohm-cm	1x10 ¹⁴ at 20 deg. C & 1x 10 ¹¹ at 70 deg.			---
iv.	Voltage rating	1100 V peak operating voltage			
v.	Reference Standard	VDE 0207 Part 4			VDE 0207 part 6 & ASTM D 2116.
vi.	Core diameter above insulation	Suitable for cage clamp connector			
C.	Pairing & Twisting				
i.	Max. lay of pairs (mm)	50			
ii.	Single layer of numbered binder tape on each pair provided	Yes			
iii.	Unit formation of four pairs with printing of no. of Unit provided	NA		Yes	NA
iv.	Conductor / pair identification as per VDE0815	NA		To be provided	NA
D.	Shielding				
i.	Type of shielding	Al-Mylar tape			
ii.	Individual pair shielding	No		To be provided for Type-F cable	No
iii.	Minimum thickness of individual pair shielding	No		28 micron	No

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
iv.	Overall cable assembly shielding	To be provided			
v.	Minimum thickness of overall cable assembly shielding	55 micron			
vi.	Shielding coverage	100% with at least 20% overlap			
vii.	Drain wire provided for individual shield	NA		Yes (for F-type) 7 -strand 20 AWG (0.51 mm2) annealed Tin coated copper	NA
viii.	Drain wire provided for overall shield	Yes (for F-type) 7 -strand 20 AWG (0.51 mm2) annealed Tin coated copper			
E.	Fillers				
i.	Non-hygroscopic, flame retardant	To be provided			
F.	Outer Sheath				
i.	Material	Extruded PVC compound YM1 with FRLS properties			Teflon (i.e. extruded FRP)
ii.	Minimum thickness at any point	1.8mm			0.4 mm
iii.	Nominal Thickness at any point	> 1.8mm			0.5mm
iv.	Color	Blue			
v.	Resistant to water, fungus, termite & rodent attack	Required			
vi.	Oxygen index as per ASTM D-2863	Not less than 29%			NA
vii.	Temperature index as per ASTM D-2863	Not less than 250 deg. C			NA
viii.	Acid gas generation by weight as per IEC-60754-1	Maximum 20 %			NA
ix.	Smoke Density rating as per ASTM D-2843	Maximum 60% (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as ASTM D-2843)			NA
x.	Reference Standard	VDE 207 part 5			VDE 207 Part 6 & ASTM D 2116
xi.	Armour	Galvanised steel wire armoured type conforming to IS-3975			
G.	Electrical Parameters				
i.	Mutual capacitance between Conductors. At 0.8KHz (Max.)	200 nF / Km		120 nF / Km for F type 1000 nF / Km for G-type	200 nF / Km
ii.	Insulation resistance (Min.)	100 M ohm / Km			
iii.	Cross talk Figure (min.) at 0.8 KHz	60 dB		60 dB	NA
iv.	Characteristics impedance (Max) At 1 KHz	NA		320 ohm for F type 340 ohm for G type	NA
v.	Attenuation Figure at 1 KHz	NA		1.2 dB / Km	NA
H.	Complete Cable				

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
i.	Complete Cable assembly	Shall pass Swedish chimney test as per SEN-SS 4241475 class F3.			NA
ii.	Flammability	Shall pass flammability test as per IEEE-383 read in conjunction to this specification			NA
I.	Accessories				
i.	Cable accessories of flame retardant quality	Yes. (Accessories such as harnessing components, markers, bedding, cable jointer, binding tape etc.)			
J.	Cable Drum				
i.	Type	Non-returnable wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.			
ii.	Outermost layer covered with waterproof paper	Yes			
iii.	Painting	Entire surface to be painted			
iv.	Length	1000m + 5% for up to & including 12 pairs 500m + 5% for above 12 pairs			

c) Type Test

Table 10.3
Type Test Requirement for Cables

S.N	Item	Test Requirement	Standard
1	Conductor	Resistance Test Diameter test Tin coating test (drain wire)	VDE – 0815 IS – 10801
2	Insulation	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
3	Inner sheath	Loss of mass Heat shock Hot deformation Shrinkage Cold bend / Cold impact test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
4	Outer sheath	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming Colour fastness to water Cold bend / Cold impact test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831 IS – 5831 IS – 5831

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S.N	Item	Test Requirement	Standard
		Oxygen Index test Smoke Density test Acid gas generation test	ASTM D – 2863 ASTM D – 2843 IEC – 754 – I
5	Filters	Oxygen Index test Smoke Density test Acid gas generation test	ASTM D – 2863 ASTM D – 2843 IEC – 754 – 1
6	AL-MYLAR Shield	Continuity test Shield thickness Overlap test	Yes Yes Yes
7	Overall cable	Flammability Noise interference Dimensional checks Cross talk Mutual capacitance HV test Drain wire continuity	IEEE 383 & IEC – 332 IEEE -TRANSACTION IS – 10810 VDE – 0472 VDE – 0472 VDE – 0815

d) Routine Test

To be carried out during various stages of manufacture.

1. Insulation & jackets: All tests as per IS – 5831 except insulation resistance, voltage & spark test shall be as per BS – 5308, Part II
2. Armor test as per IS – 3975
3. Conductor resistance
4. Cable capacitance and L/R ratio.

e) Acceptance Test

These following tests shall be carried out as acceptance test:

1. Continuity test
2. Voltage test as per BS – 5308 Part II
3. Conductor resistance and drain wire resistance
4. Cable capacitance and L/R ratio test.
5. Tests for uniformity of galvanization of armor as per IS – 2633
6. Oxygen and temperature index test as per ASTM D – 2863
7. Dimensional checks for overall diameter and under armour / over armour diameter.
8. Checking of drum length & overall length tolerances.

Immediately after completion of electrical tests, the ends of the cable shall be sealed to prevent ingress of moisture with suitable PVC / Rubber caps

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10.2 Specifications of Optical Fibre Cables (OFC)

1. OFC shall be installed on cable tray, duct bank, cable trench installation as necessary. For outdoor applications the cable shall be armoured with Poly Ethylene sheathing. In all cases cable shall be routed through suitable grade HDPE permanently lubricated protection pipe as per IS-4984, IS-12235 & TEC.G/CDS-08/01 of suitable size @ 53% fill factor.
2. The optical fibre core shall be of ultrapure fused silica glass coated with UV cured acrylate suitable to withstand temperature of about 80 deg. Centigrade continuously.
3. OFC shall be 4 / 8 / 12 core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor / indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multi-mode fibres on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties & to be identified with the manufacturer's name, year of manufacture, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
4. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. steel central member, Loose buffer tube design, 4 fibres per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly or better material etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile 1000 N minimum. The compressive strength of cable shall be 3000N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 DegC to 70 DegC.
5. The splicing loss of any two fibres in any case shall not exceed 0.10 db/splice.
6. The total additional attenuation above the nominal attenuation due to regular splices, repair splices, connectors, temperature variation, ageing etc. shall be indicated.
7. Fibre coloring shall conform to EIA/TIA-598. The color-coding shall be permanent thus withstanding normal handling; e.g., during termination, testing, or cable relocation. Refer to EIA – 359 for color identification and coding.
8. Cables shall be designed & tested in accordance with ISO 11801, TIA-568 & ICEA 596 and Performance specifications shall be measured in accordance with the Fibre Optic test procedures(EIA/TIA -455 documents) test procedures of IEC-60793 & IEC-60794
9. The OFC shall generally conform to the following specifications

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Table 10.4A
Specifications for Single Mode Optical Fibre

S.N	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@1310 nm	0.4 dB/km
		@1550 nm	0.3 dB/km
2	Mode field Diameter	@1310 nm	$9.2 \pm 0.4 \mu\text{m}$
		@1550 nm	$10.4 \pm 0.8 \mu\text{m}$
3	Maximum Cable Cut-off Wavelength		1260 nm
4	Maximum Zero Dispersion Wavelength		1321.5 nm
5	Minimum Zero Dispersion Wavelength		1301.5 nm
6	Maximum Zero Dispersion Slope		0.092 ps/nm ² ·km
7	Maximum Polarization Mode Dispersion		0.2 ps/ $\sqrt{\text{km}}$
8	Gigabit Ethernet Length 1000BASE-LX		2-5000 mtrs.
9	Ten Gigabit Ethernet Length	10GBASE-LX	2-10000 mtrs.
		10GBASE-LX4	2-10000 mtrs.
10	Maximum Core/cladding Concentricity Error		0.5 μm
11	Cladding Diameter		$125.0 \pm 1.0 \mu\text{m}$
12	Cladding Non-circularity		1 %
13	Coating Diameter		$245 \pm 5 \mu\text{m}$
14	Maximum Coating Concentricity Error		12.5 μm
15	Temperature Dependence (-60 to +85C)		0.05 dB/km
16	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		0.05 dB/km
17	Minimum Proof Test		100 kpsi
18	Bending Induced Attenuation (100 turns, 75mm diameter)		0.5 dB

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Table 10.4B
Specifications for Multi Mode Optical Fibre

S.N	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@850 nm	3 dB/km
		@1300 nm	0.7 dB/km
2	Overfilled Launch Bandwidth	@850 nm	200 MHz·km
		@1300 nm	500 MHz·km
3	Gigabit Ethernet Length	1000BASE-SX	2-300 mtrs.
		1000BASE-LX	2-550 mtrs.
4	Ten Gigabit Ethernet Length	10GBASE-SR	2-33 mtrs.
		10GBASE-LX4	2-300 mtrs.
5	Numerical Aperture		0.275 ± 0.015
6	Core Diameter		62.5 ± 3.0 µm
7	Maximum Core Non-circularity		6 %
8	Maximum Core/cladding Concentricity Error		3 µm
9	Cladding Diameter		125.0 ± 2.0 µm
10	Cladding Non-circularity		2 %
11	Coating Diameter		245 ± 10 µm
12	Maximum Coating Concentricity Error		12.5 µm
13	Temperature Dependence (-60 to +85C)		0.2 dB/km
14	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)		0.2 dB/km
15	Minimum Proof Test		100 kpsi
16	Bending Induced Attenuation (100 turns, 75mm diameter)		0.5 dB

10. The cables shall be supplied in non-returnable strong wooden (or alternatively steel) drums provided with lagging of adequate strength, constructed to protect

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the cable against any damage and displacement during transit, storage and subsequent handling and stringing operations in the field.

11. Test on Fibre optic cable:

Table 10.4C
Type Test Requirement for Fibre Optic Cables

S.N	Test Requirement	Standard
A	Optical Characteristics of Fibres	
1	Attenuation	IEEE Std. 1138 IEEE STD. P1222 (EIA/TIA – 455-61,78A) (IEC 793-1-C1A,B,C)
2	Cut off wavelength	IEEE STD. 1138 IEEE STD P1222 (EIA-455-80, 170) (IEC-793-1-C7A,B)
3	Fibre Dispersion	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-168A,169A,175A) (IEC-793-1-C5A,B,C)
4	Frequency Response	IEC-793-1-C2B
5	Mode Field Diameter	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-164A,165A,167A) (EIA-455-174) (IEC 793-1-C9A,B,C,D)
6	Temperature Cycling	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-69A) (IEC 793-1-D1)
B	Mechanical Characteristics of Fibres	
1	Abrasion	IEC 793-1-B4
2	Core Concentricity	IEC 793-1-A3
3	Macro Bending	EIA/TIA-455-62A (IEC 793-1-C11)
4	Micro Bending	IEC-793-1-C3
C	Proof Test	IEC-793-1-B1
D	Strippability	IEC 793-1-B6
E	Visual Examination	EIA/TIA-455-13 (IEC 793-1-B5)

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10.3

Instrumentation Cable Interconnection & Termination Philosophy

The cable interconnection philosophy to be adopted shall be such that expensive grouping of signals by large scale use of field mounted Group Junction Boxes (JBs) at strategic locations. (Where large concentrations of signals are available, e.g. valves limit and torque switches, switchgear) is done and consequently cable with higher number of pairs are extensively used. The details of termination to be followed are mentioned in the following Table:

Table 10.5
Instrumentation Cable Interconnection & Termination Philosophy

S.N	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
1.	Limit, Torque switches of valves / dampers / drives (integral junction box)	Marshalling cubicle / Marshalling cum Termination Cubicle / Local group JB	Plug-in connector	Posts mount cage clamp type	G
2.	Transmitters, E/P converters, process actuated switches mounted in LIE / LIR	Integral junction box of LIE / LIR	Plug-in connector	Cage clamp (rail mount)	F, G
3.	RTD heads	Local junction Box	Plug-in connector	Cage clamp (Rail mount) type	F
4.	Thermocouples	Junction Box	Plug in connector	Cage clamp (Rail mount) type	A, B, C *
5.	Other Field Mounted Instrument	Local JB / Group JB	Plug in connector	Screwed, Cage clamp (Rail mount) type	F (For analog signals) G (For Binary Signals)
6.	Junction Box (For Thermocouples for interlock and protection)	Marshalling Cubicle / Marshalling cum Termination Cabinet	Cage clamp (Rail mount) type	Screwed, Cage clamp (Rail mount) type	A, C *. These signals shall preferably through 6 pair cable
7.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Group JB	Cage clamp (Rail mount) type	Cage clamp (Rail mount) type	F, G
8.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Marshalling Cubical / Marshalling cum termination Cabinet	Cage clamp (Rail mount) type	Posts mount cage clamp type	F, G
9.	Marshalling Cubical / Termination Cabinet	Electronic system cabinet	Cage clamp post mounted type	Plug-in connector / Other System as per manufacturer's Standard	Internal Wiring

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Notes:

1. Normally 10% spare cores shall be used when the numbers of pairs of cables are more than four pairs.
2. For analog signals, individual pair shielding & overall shielding & for binary signals only overall shielding of instrumentation cables shall be used.
3. * For high temperature applications only.
4. Instrument Cabling for instruments / equipment of specialized / proprietary Control System shall be as per manufacturer's standard.

10.4

Terminal Blocks

1. All terminal blocks shall be rail mounted/post mounted, cage clamp type with high quality non-flammable insulating material of melamine suitable for working temperature of 105 deg. C. The terminal blocks in field mounted junction boxes, temperature transmitters, instrument enclosures/racks, etc. shall be suitable for cage clamp connections. The terminal blocks in Control Equipment Room logic / termination / marshalling cubicles shall be suitable for the post mounted cage clamp connection at the field input end. The terminal blocks for control system Input/ Output connections from/to SWGR/MCC, shall be used with built in test and disconnect facilities complete with plug, slide clamp, test socket etc.
2. All the terminal blocks shall be used complete with all required accessories including assembly rail, locking pin and section, end brackets, partitions, small partitions, test plug bolts and test plug (as specified above for SWGR connections), transparent covers, support brackets, distance sleeves, warning label, marking , etc.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams. At least 20% spare unused terminals shall be used everywhere including local junction boxes, instrument racks/enclosures, termination/marshalling cabinets, etc. All terminal blocks shall be numbered for identification and grouped according to the function. Engraved labels shall be used on the terminal blocks.
4. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
5. Internal wiring in factory pre-wired electronic equipment cabinets may be installed according to the applicable standards as to wire size and method of termination or internal equipment. Terminal blocks for connection of external circuits into factory pre-wired electronic equipment cabinets shall meet all the requirements as specified above.

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10.5 Internal Panels, Cabinets, System Cabinet Wiring Philosophy

1. Internal panel/cabinet wiring shall be of multi-stranded copper conductor with FRLS PVC insulation without shield and outer sheath meeting the requirements of VDE 0815.
2. Wiring to door mounted devices shall be done by 19 strand copper wire provided with adequate loop lengths of hinge wire so that multiple door opening shall not cause fatigue breaking of the conductor.
3. All internal wires shall be used with Tag identification of printed type (partex labels) at both ends. All wire directly connected to trip devices shall be distinguished by one additional red color.
4. All external connection shall be made with one wire per termination point. Wires shall not be tapped or spliced between terminal points.
5. All floor slots of desk/Panels/cabinets used for cable entrance shall be used with removable gasketed gland plates and sealing material. Split type grommets shall be used for prefabricated cables.
6. All the special tools as may be required for solder less connection.
7. Tag identification for internal wires shall be printed (partex labels)
8. Wire sizes to be utilized for internal wiring shall be as per following table.

Table 10.6
Wire Size for Internal Wiring

S.N	Application	Wire Size
1	Current (4-20mA), low voltage signals (48 V)	0.5 Sq. mm
2	Ammeter/ Voltmeter circuit, control switches etc. for electrical system.	1.5 Sq. mm
3	Power supply and internal illumination.	2.5 Sq. mm minimum (shall be as per load requirement)

10.6 Cable Installation & Routing

1. All cable assigned to a particular duct/conduit shall be grouped and pulled in simultaneously using cable grips and suitable lubricants. Cables removed from one duct/conduit shall not be reused.
2. Cables shall be segregated as per IEEE Std. 422. In vertically stacked trays, the higher voltage cable shall not be in higher position and instrumentation cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other system shall be as follows:
 - From 11KV/6.6KV/3.3KV tray system - 900 mm
 - From 415KV tray system - 600 mm
 - From control cable tray system - 300 mm

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3. Cables shall terminate in the enclosures through cables glands. All cable glands shall be properly gasketed. Fire proof sealing (to prevent ingress of dust entry and propagation of fire) shall be used for all floor slots used for cable entrance. Compression cable glands (double for armored and single for other cables) shall be used.
4. All cables shall be identified by Tag. Nos. provided in approved format at both the ends as well as at an interval of 5 meters.
5. Line voltage drop due to high resistance splices, terminal contacts, insulation resistance at terminal block, very long transmission line etc. shall be reduced as far as practicable.
6. The cables emanating from redundant equipment/devices shall be routed through different paths. The above segregation of cables & wiring for redundant equipment / devices shall be in accordance with IEEE-Std-422

10.7

Cable Laying

1. Cable shall be laid strictly in line with cable schedule. In general, the cable routing from the local instrument to JB shall be such that the cable go away from the hot zone.
2. Identification tags for cables.
Indelible tags to be provided at all terminations, on both sides of wall or floor crossing, on each conduit/duct/pipe entry/exit, and every 20 m in cable trench / tray.
3. Cable tray numbering and marking.
To be provided at every 10m and at each end of cables way & branch connection.
4. Joints for less than 250 Meters runs of cable shall not be permitted.
5. Buried cable protection
With concrete slabs; Route markers at every 20 meters along the route & at every bend.
6. Road Crossings
Cables to pass through buried high density PE pipes encased in PCC. At least 300 mm clearance shall be used between.
 - HT power & LT power cables,
 - LT power & LT control cables,
 - LT control & instrumentation cables,
 Spacing between cables of same voltage grade shall be in accordance with the derating criteria adopted for cable sizing.
7. Segregation (physical isolation to prevent fire jumping)

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- a) All cable associated with the unit shall be segregated from cables of other Units.
- b) Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire.

8. Cable clamping

All cables laid on trays shall be neatly dressed up & suitably clamped/tied to the tray. For cables in trefoil formation, trefoil clamps shall be used.

9. Optical fibre cables inside conduits shall be laid on cable trays wherever available and feasible. In areas where the same are required to be buried, the same shall be buried in separate trench approx. 1.6 meter depth, to be laid in 2" GI/rodent proof HDPE conduits covered with sand, brick and soil along the pipe line route.

10. While crossing roads-to be laid in GI/rodent proof HDPE conduits with sand filling at bottom and sand, soil filling at top with cement concrete;

While crossing canals/river- to be laid in GI/rodent proof HDPE conduits within Hume pipe.

10.8

Cable Accessories

1. Cables, which terminate in cabinets of draw out sections, shall have sufficient cable coils in the bottom of the cabinet to permit full withdrawal of draw out sections without disconnecting the cables. When prefabricated cables with factory connectors on both ends are longer than required, the excess cable shall be coiled in the bottom of one or both termination cabinets.
2. No splices shall be made in conductors for instrument and control circuits except where required at connections to devices equipped with factory installed pigtails. Such splices shall be made only in approved splicing boxes of fitting with removable cover. The splices shall be made with sufficient slack left in the wire to permit withdrawal of the splice from the splicing boxes for ease of future disconnection of the splices. All exposed conductor or connector surfaces shall be covered with a minimum of three half-lapped layers of all weather vinyl plastic electrical tape. Taping shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the other insulation or connections requiring insulation.
3. Proper grounding of all equipments shall be done. Further, proper termination of cable shield shall be verified and the grounding of the same shall be coordinated so as to achieve grounding of all instrumentation cable shields at same potential. This shall be completed prior to system tests.
4. Take full care while laying/installing cables as recommended by cable manufacturers regarding pulling tensions and cable bends.

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10.9

Cable Conduits

1. Conduits shall be generally used for interconnecting cables from field instruments to Local JB's. All unarmoured cables shall be installed in conduit. All rigid conduits, couplings and elbows shall be hot dipped galvanized rigid mild steel in accordance with IS: 9537 Part-I and Part-II. The conduit interior and exterior surfaces shall have continuous zinc coating with an overcoat of transparent enamel lacquer or zinc chromate. Flexible metal conduit shall be heat resistant lead coated steel, water leak, fire and rust proof. The temperature rating of flexible conduit shall be suitable for actual applications. The flexible metal conduit shall be constructed with interlocked corrosion resistant steel & manufactured in accordance with UL1 & NEC Article 348.
2. All grounding bushings within all enclosures shall be wired together and connected internally to the enclosure grounding lug or grounding bus with 8 AWG bare copper conductors. Conduit runs to individually mounted equipment shall be grounded to the cable tray grounding conductor with 12 AWG bare copper conductors.
3. All rigid conduit fittings shall conform to the requirements of IS: 2667. Galvanized steel fitting shall be used with steel conduit. All flexible conduit fittings shall be liquid tight, galvanized steel. The end fittings shall be compatible with the flexible conduit supplied.
4. All individually mounted equipment and devices shall be connected to the supply conduit, using not more than one meter of flexible conduit adjacent to the equipment or device. Flexible conduit shall be installed in all conduit runs, which are supported by both building steel and structures subject to vibration or thermal expansion.
5. Special areas, such as Control Rooms in which external noise is to be minimized, shall have flexible conduit in conduit runs where the runs cross from the main building framing to the Control Room framing.
6. Conduit supports shall be furnished and installed in accordance with these specifications. Support material shall comply with the requirements.
 - a) Hanger rods shall be 12 mm diameter galvanized threaded steel rods.
 - b) Single conduit support shall be one-hole cast straps and clamp backs. Multiple conduit bank supports shall be constructed of special galvanized support channels with associated conduit clips.
7. Conduit sealing, explosion proof, dust proof and other types of special fittings shall be used as required by these specifications and shall be consistent with the area and equipment with which they are installed. Fittings installed outdoors and in damp locations shall be sealed and gasketed. Hazardous area fittings and conduits sealing shall conform to NEC requirements for the area classification.

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8. Double locknuts on all conduit terminations shall be used. Water tight conduit unions and rain tight conduit hubs shall be utilized for all the application which shall be exposed to weather. Moistures pockets shall be eliminated from conduits.
9. Conduits shall be securely fastened to all boxes and cabinets.

10.10 Cable Sub Trays & Support

1. The cable sub-trays and the supporting system, to be generally used between Local/Group JB's and the main cable trays. It is the assembly of section and associated fitting forming a rigid structural system used to support the cable from the equipment or instruction enclosure up to the main cable trays (trunk route). The material of cable tray shall be GI.
2. The covers on the cable sub-trays shall be used for protection of cables in areas where damage may occur from falling objects, welding spark, corrosive environment, etc. & shall be electrically continuous and solidly grounded. The cable trays shall not have sharp edges, burrs or projections injurious to the insulation or outer sheath of the cables.
3. The supporting arrangement of cable tray system shall be able to withstand the weight of the cable and cable tray system. The supporting interval shall not be more than the recommended span for the above loading for the type of cable tray selected. The tray shall not overhang by more than one meter from the support at the dead end. As far as practicable the cable sub-tray system shall be supported from one side only, in order to facilitate installation and maintenance of cables.
4. Install the estimated quantities and size of sub trays / troughs including all required fittings and adaptors on as required basis.

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Table 10.7
Specifications for Cable Tray

S.N	Feature	Minimum Requirement
1	Material	Mild Steel as per IS-2062
2	Thickness	Not Less than 2 mm
3	Finish	Hot Dip galvanised as per IS-2629, 2633 & Zinc Coating as per IS-4579
4	Length	2.5 Mtr. +/- 10 mm
5	Width	W +/- 3mm
6	Inward Bend	25 mm
7	Coupler Plate	Thickness 2 mm, length 100 mm, Width 50 mm
8	Coupler plate material	MS with Hot dip galvanised
9	Nuts, Bolts, washer etc.	As required/ Hot dip galvanised
10	Cover	Dome Fixed type, Thickness 1.2 mm (Minimum)
11	Cover Material	Hot dip galvanised MS sheet

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11 SYSTEM CABINETS, PANELS & JUNCTION BOX

11.1 General Requirements

1. All control panels, system cabinets, local panels and local instrument enclosures, racks shall be furnished fully wired with necessary provision for convenience outlets, internal lighting, grounding, ventilation, space heating, anti-vibration pads and accessories as per IS:5039 as required for completeness of the system.
2. All panels & cabinets shall be free standing type and have bottom entry for cables unless otherwise specified. The bottom of panels, cabinets, enclosures shall be sealed with bottom plate, compression cable glands and fire proof sealing material to prevent ingress of dust and propagation of fire. The Cabinets shall be designed for front & back access to components, terminals and wiring.
3. The cabinets shall be used with bottom glanding plate which shall be removable from inside and shall be used with sufficient no. of knockouts. All knockouts shall be used with pluggable grommets.
4. The cabinets shall be of max. 2200mm height including base channel. The base channel shall be of 100 ISMC. All cabinets shall be of same height. Construction shall be modular.
5. System & non-system cabinets shall have "look alike" appearance.
6. All electronic system cabinets shall be designed for 50 deg C operating under maximum ambient temperature without air conditioning system in service. Further cabinets, panels shall be so designed that temperature rise due to heat load does not exceed 10 deg. C above ambient temperature under all operating conditions. Necessary louvers, fans, limited packing density, adequate spacing between instruments, devices etc. shall be used to maintain temperature rise within permissible limits.
7. Panels, cabinets enclosures wiring shall be arranged to enable the removal of modules/instruments and devices without unduly disturbing them.
8. All panels, cabinets, enclosures interiors shall be illuminated with rapid start fluorescent strip fixtures with door actuated switches. Door switch terminals shall be shrouded. All illuminated lights shall be used with isolation switch in addition to door switch for maintenance & switching off when not required. Illumination light shall be used on both front & back sides if both sides are provided with equipments/instruments/terminal blocks requiring maintenance.
9. Sufficient number of power receptacles with disconnect switches shall be installed within panels, enclosure and racks.
10. The local instrument enclosures/racks shall be used locally for mounting of electronic transmitters and switches, etc.
11. Exterior steel surface shall be sand blasted, ground smooth, filed, primed, sanded and smooth enamel painted to give a good finish subject to minimum paint

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thickness of 65-75 microns for sheet thickness of 3 mm and 50 microns for sheet thickness of 2mm. Minimum 2 coats of primer and two sprays of final finish colour shall be applied to all surfaces.

12. The colour of the panel's interior shall be brilliant white. External colour of the panels shall be as RAL 7032 for LIE/ LIR and RAL 7035 for control room system cabinets.
13. All panels, enclosures, system cabinets, marshalling cabinets shall be used with a minimum of 20% spare terminations and system cabinets shall be used with spare space for 20% additional modules fully wired with connectors etc. in excess of the total requirement of the system design when the cabinets are delivered. The spare space capacity shall be distributed evenly throughout the cabinets.

11.2

System Cabinets

Table 11.1
Specifications for System Cabinets

S.N	Features	Minimum Requirements
1	Application	For housing Signal conditioning cards, input/output cards, processor cards, power supply units etc.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Anti vibration pad	Required, 15mm
9	Painting	Interior- Brilliant White Exterior- RAL 7035
10	Cabinet Dimension	To be decided during detail engineering
11	Grounding	M6 earthing stud shall be used
12	Ventilation	Fans & louvers with brass mesh required
13	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
14	Lifting arrangement	Removable lifting eyebolts shall be used

1. Beacon Lamps shall be used in each cabinet to indicate panel having fault condition.

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2. The racks in system cabinets shall have provision along with plug in sockets/back plane to house accommodate the spare slots/modules as specified elsewhere.
3. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots & details of the card type/service shall be inscribed on this metal tag.
4. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
5. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
6. All cabinets shall have common key for locks.
7. Door shall have concealed type of hinges with 120 degree swing.
8. Door latches shall be of the three-point type to ensure tight closing.
9. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material.

11.3

Marshalling Cabinets

Table 11.2
Specifications for Marshalling Cabinets

S.N	Features	Minimum Requirements
1	Application	For termination of all cables originating from field.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Terminal Blocks	Rail mounted cage-clamp suitable for conductor size up to 2.5 mm ² & fused type with LED indication for power supply (24 VDC, 230 V AC, 110 V AC etc.) for instruments & equipments.
9	Anti vibration pad	Required, 15mm
10	Painting	Interior- Brilliant White Exterior- RAL 7035
11	Cabinet Dimension	To be decided during detail engineering

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S.N	Features	Minimum Requirements
12	Grounding	M6 earthing stud shall be used
13	Ventilation	Fans & louvers with brass mesh required
14	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
15	Lifting arrangement	Removable lifting eyebolts shall be used

1. Separate Marshalling cabinets for the system shall be supplied for terminating all cables originating from the field and for distributing the signals to different functional panels and cubicles.
2. The terminal blocks shall be cage clamp type. Fused terminal blocks hinged at one end to facilitate easy isolation shall be used wherever necessary. All cabinets shall be used with spare terminals for the spare inputs/outputs as specified elsewhere in the specification. The type of terminals for terminations from cabinets/panels shall match with the pre fabricated cables and pins supplied.
3. The terminals for field cables shall be arranged in a logical order of equipment/system wise.
4. The marshalling cabinets, the terminal blocks, the terminals and the electronic hardware if any, shall have identification numbers.
5. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
6. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
7. All cabinets shall have common key for locks.
8. Door shall have concealed type of hinges with 120 degree swing.
9. Door latches shall be of the three-point type to ensure tight closing.
10. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material

11.4 Local Instrument Enclosure & Racks

1. Transmitters and switches, devices, etc. mounted in the field shall be suitably grouped together and mounted in local instruments enclosures in case of open areas of the plant and in local instrument racks in case of covered areas. These local instrument enclosures and racks shall be furnished as per the project requirements.
2. The local instrument enclosures shall be constructed of 2 mm sheet plate and shall be of modular construction with one or more modules and two end assemblies bolted together to form an enclosure. Vibration dampeners shall be installed for supporting each enclosure. The internal layout shall be such that the

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impulse piping/ blow down lines are accessible from back doors of the enclosure and the transmitters etc. are accessible from front side for easy maintenance. Gaskets shall be used between all mating sections to achieve protection class of IP-65.

3. The local instrument racks shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be used with a canopy to protect the equipment mounted in racks from falling objects, water etc. The canopy shall not be less than 3 mm thick steel, and extended beyond the ends of the rack. Bulk heads, especially designed to provide isolation from process line vibration shall be used. The junction box for racks also shall conform to IP 65 protection class.
4. The junction box of Local Instrument Enclosure & Racks shall be used with hinged type door, latch for locking & gland plates for cable entry. All terminals in junction box shall be of rail mounted cage clamp type suitable for conductor size up to 2.5 Sq. mm.

11.5

Local Junction Boxes

Table 11.3
Specifications for Junction Box

S.N	Features	Minimum Requirements
1	No. of Ways	32 (2X16) with 20% spares terminals
2	Material & Thickness	3 mm thick FRP
3	Protection class	IP-65 for outdoor/ IP 55 for Indoor
4	Cable entry	Bottom
5	Mounting	Suitable for Wall/column/structures mounting
6	Terminal Blocks	Rail mounted cage-clamp type suitable for conductor size up to 2.5 mm ²
7	Grounding	M6 earthing stud shall be used
8	Gland plate	Removable type
9	Door	Single Lockable door with gasket, able to open sideways, turnable hinge based, latch type lock without handle with common key.
10	Accessories	Tag plate, clamps, fixtures, bolts (SS), nuts (SS), Gasket (Neoprene), cable glands (SS), Lugs (Brass), Fire proof compound for sealing.

1. All JB's for outdoor application shall be used with individual canopies to prevent ingress of water.
2. All JB's shall have provision to add 10% additional TB's.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams.

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4. Separate Terminal blocks shall be used for Analog & Digital Signals & also for signals with different voltage levels.
5. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
6. Separate shield bus shall be used with screw connection for terminating cable shields.
7. All spare cable entries shall be used with plugs.
8. All wires in JB shall be neatly dressed & ferruled.
9. Double deck type terminal block shall not be used.

Table 11.4
Specifications for Cable Glands

S.N	Features	Minimum Requirements
1	Type	Double compression
2	Entry Thread	½ " NPT
3	Material	Brass
4	Finish	Cadmium Plated
5	Protection	IP-54 or better
6	Accessories	Neoprene gasket, Locknut, Reducer etc.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-II
SECTION-II, PART-D
DETAILED TECHNICAL SPECIFICATION- CIVIL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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1 INTRODUCTION

This specification covers the design, preparation of general arrangement, construction as well as fabrication drawings, supply of all labour as well as materials and construction of all Civil, Structural as well as Architectural work on EPC basis for Renovation and Modernisation of Mechanical Balance of Plant structures for the existing [Name of project...] Thermal Power Project of [210/215/220/250] MW capacity. Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope shall be as per Volume-II, Section-I, CIVIL SCOPE OF WORK.

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2 *[BUILDINGS & STRUCTURES]*

Design and construction of new buildings, structures, foundations etc. as well as repairing / retrofitting of existing buildings, structures, foundations shall take into account requirement for operation and maintenance of all equipments and its users. The buildings will have good architectural features. The surrounding areas shall be properly micro levelled and graded. The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials fittings and finishes.

- *Due consideration shall be given for adequate natural lighting and ventilation for both plant and non-plant buildings.*
- *Retrofitting / repair works / new constructions shall not cause damage to the existing structures. The temporary supports shall not be allowed on the existing structures for any of these works unless the loads are minor and may not cause any damage to any existing structure. However in such a case Bidder shall take approval from the Owner/Consultant prior to initiating the work.*
- *Internal finishes shall be provided with latest available materials approved by Owner/Consultant with due consideration of the functional aspect of the area.*
- *External finishes shall be provided with latest materials approved by Owner/Consultant for improving the aesthetics.*
- *The orientation of the important buildings shall be in line with the existing site condition and function as such.*
- *Each building shall have its own identity. However, a total homogeneity shall be maintained in the design of all buildings.*
- *Adequate frontage shall be provided to all important buildings to create a better visual impact.*
- *All other civil and structural buildings shall be developed in conjunction with the above aspects.*

All Civil, Structural and Architectural works of the following systems shall be covered under this package.

- a) Fuel Oil Handling and related auxiliaries*
- b) Circulating water system*
- c) Water Treatment Plant and Effluent Treatment Plant*
- d) RCC Chimney*
- e) Cooling Tower*

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- f) Hydrogen Plant*
- g) Fire detection and protection system*
- h) Inter Plant Piping & Interplant Cabling racks*
- i) Civil works for general illumination*
- j) Raw Water Reservoir and Plant Makeup Water Pump House*
- k) Raw Water Intake System*
- l) Workshop*
- m) Any building inadvertently left out in the above list, however required for proper functioning of the power plant as per system requirement stipulated under Mechanical & Electrical section of this specification shall also be included.]*

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3 DESIGN REQUIREMENTS

3.1 Location

Geographical location of the plant site is approximately between [11°34'00" N] to [11°35'00" N], Latitude and [79°26'00" E] to [79°27'00" E], Longitude.

3.2 Ground Condition

Subsurface condition: The natural ground surface level approximately varies from [60 m to 74.5 m] from MSL.

[The soil profile in the plant area can be broadly classified into 3 layers namely laterite, cemented sand and cemented silt in general as per detail soil investigation report. Top soil upto a depth ranging from 0.4 m to 0.75 m is entirely non-uniform. The underlying layer is laterite whose depth varies from 4.0 m to 5.5 m followed by deep layers of cemented silt and cemented sand].

The ground water table (GWT) at finished ground level shall be considered for foundation design purposes.

The detailed soil investigation report conducted for plant shall be made available to Bidder for required replacement / refurbishment / retrofitting of Foundations, if any.

Bidder is advised to carefully study the content of detailed Soil investigation report for the existing type of foundations and design of new ones.

The type, size, depth of the foundation shall be based on the detail soil investigation report provided by OWNER.

3.3 Climatic Condition

a) Temperature

Maximum : [42.8] °C

Minimum : [15.6] °C

For design purpose, maximum temperature to be considered: [50.0] °C

minimum temperature to be considered: [.....] °C

b) Rain fall

Minimum : [42.8 mm in May]

Maximum : [329.8 mm in October]

Peak hourly rain fall: [183mm] (corresponding to 50 years return period)

[Note: Maximum per day rainfall as per weather report has been considered conservatively as peak hourly rain fall which will be used for drainage system design etc.]

Annual average: [676.2 mm to 1856.3 mm & average 1265.7 mm]

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3.4 Seismic Zone

The site is located in [Zone III] as per IS: 1893-2002. Zone factor shall be [0.10]. Importance factor shall be considered as [1.75].

3.5 Wind Zone

The site is located in wind speed zone [50 m/s] as per IS: 875 (Part 3)-1987.

3.6 Loads and Load Combinations

All new structures shall be designed and old structures requiring modification shall be checked for the most critical combinations of dead loads, imposed loads, equipment loads, wind loads, seismic loads, temperature loads, forces developed due to differential settlement and any other loading conditions which can occur during the design life of the facility.

(a) Dead Loads

Dead loads consist of the weights of the complete structure with finishes, fixtures, partitions, wall panels and all existing / modified / replaced equipments of semi-permanent nature including storage structures (Tanks, bins etc.) partitions, roofing, piping, cable trays, bus ducts etc. The content of storage structures etc. shall be measured at full capacity for this purpose.

The piping loads (for empty, operating and test conditions), cable tray loads and the contents of the storage structures shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing load for uplift.

The following unit weight of material shall be considered for computation of loads. Loads given in IS: 875 (part-I) shall be made use of for material not listed below.

Table 2.1
Weights of Material

Material	Unit weight (kN/m ³)
Plain cement concrete	24.0
Reinforced cement concrete	25.0
Structural steel	78.5
Brick work	19.0
Cement plaster	21.0
Floor Finish	24.0
[Coal]	11.0

(b) Superimposed Live Load (SILL)

Listed below is the minimum SILL for the areas involved. Floors and supporting members subjected to heavy equipment live loads shall be designed on the basis

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of the equipment loads specified by vendor or specifically defined SILL whichever is greater.

The specific minimum floor SILL is listed below:

Table 2.2
Superimposed Live Load (SILL).

S.No	Description	SILL Value
a)	Roof	
	Flat accessible roof	1.5 kN/m ²
	Flat accessible roof with HVAC equipments, etc.	5 kN/m ²
	Flat inaccessible roof	0.75 kN/m ²
	Sloped Roof	As per code IS: 875 (Part-2)
b)	All building floors & Stairs	5 kN/m ²
c)	Walkways of Conveyor Galleries	5 kN/m ² or Concentrated Load of 3 kN at centre which ever is critical
d)	M.C.C. Floor	10 kN/m ²
e)	Equipment Load	As applicable
f)	Culverts & its allied structures including Concrete pipes	Class "A" / Class "70R" as per IRC standard whichever is higher / load due to bull dozers
g)	Underground basement,	Surcharge of 10 KN/m ²
h)	Vehicular traffic	Surcharge of 20 KN/m ²
i)	Covers for Channels	Surcharge of 10 KN/m ²
j)	Pump Houses	
	Operating Floor Slab	15 KN/sqm or as required by equipment supplier whichever higher
	Workshop	10 kN/m ²
k)	Other areas:	
	• RCC floors (Offices, laboratories, conference rooms and general floors)	5 kN/m ²
	• Balconies	5 kN/m ²
	• Chequered plate / gratings	5 kN/m ²
	• Walkways	3 kN/m ²
	• Toilets	2 kN/m ²

- In addition to LL, Hung loads for electrical, ventilation & air conditioning minimum of 0.5 kN/m² shall be considered.

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- Load of 1 kN/m² shall be considered as hung load for piping unless otherwise mentioned. However, the actual loads will be as furnished by the supplier. The stringent most will be followed.
- For other areas LL shall be considered as per IS: 875 (Part-2).

(c) Seismic Load

The proposed plant is located in Seismic [Zone-I] as per IS: 1893, Seismic force on the structures will be considered accordingly.

(d) Wind Load

The proposed plant is located in Wind Speed Zone of [50 m/s] as per IS: 875 (Part 3). The wind force on the structures will be considered as follows:

Table 2.3
Wind Speeds

Description	Wind Speed
Basic Wind Speed V _b (at 10m above mean ground level)	[50 m/sec]
Risk coefficient K ₁ (for 100 years)	[1.07]
Category of terrain	[Category 1]
Factor K ₂	As per IS: 875
Topography factor K ₃	As per IS: 875

For the design of structures, wind force on Equipment, supported on frame including all fixtures, piping, staircase, ladder, etc, shall be considered.

Design of structures shall be checked for the condition of wind load with gust factor.

(e) Earth Pressure Loads

For earth pressure the worst condition with dry / submerged and active, passive or at rest shall be considered. The pressure coefficient shall be adopted as recommended in Soil Report or for the backfill material used.

(f) Temperature Loads

The total temperature variation shall be considered as 2/3rd of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the average between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50 % of the total considered temperature variation with temperature load applied with positive and negative sense.

For design purpose average maximum annual variation shall be taken as [+50°C] to +5°C.

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Coefficient of thermal expansion of steel shall be taken as per IS: 800 where the value is given as $12 \times 10^{-6}/^{\circ}\text{C}$. Coefficient for thermal expansion for concrete shall be taken as per IS: 456.

(g) Thermal Loads (during operating condition)

When thermal loads (such as produced by temperature changes in piping, equipment and structures) results in friction between equipment and supports (exchangers) or piping and supports, the friction force will be taken as the operating load on the support multiplied by the applicable friction coefficient given below:

Table 2.4
Thermal Loads

Description	Value
Surfaces	Friction coefficient
Rolling supports	0.05
Steel to steel	0.30 (longitudinal) and 0.10 (lateral)
Concrete to steel	0.30

(h) Equipment Loads

Static and dynamic loads of major existing / modified / replaced equipments shall be based on the manufacturer's data of the specified equipments and shall be considered in design in addition to the live load.

Equipments to be tested for hydraulic test, tanks and piping design loading shall include hydraulic test loading. Weight of equipments, ducts, tanks, pipes, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads applicable.

(i) Cranes, Hoists, Monorail and Elevator loads

All lifting beams and monorails shall have their design loads increased for impact factor. Loads for overhead cranes, hoists, monorails and elevators shall be taken as per IS: 875.

100 % of the lifted load including elevator live load plus the cab weight shall be considered for the elevator support beam design. Pedestals in elevator pits shall be designed assuming impact factor as per IS codes.

(j) Vibration and Noise

The design shall ensure that vibrations from any moving machinery transmitted from its immediate foundations to adjacent buildings or areas of the same building shall be suppressed in accordance with the recommendations of relevant codes of practice.

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(k) Other Loads

- Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance loads, creep and shrinkage shall also be considered in design of all structures.
- Roof girders / trusses in the service / maintenance bay shall be designed for crane erection loads.
- Dust loads
All buildings / structures shall be designed for a dust load of 1 kN/m² for flat roof and 0.5 kN/m² for sloped roof.
- Construction /Erection/Maintenance Loads
The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing as far as possible. However, construction or access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.
- Future Loads
Loads from future expansion shall be considered when so directed by the Owner/Consultant. Future loads may include any of the loads listed above.
- Surge Loads
Surge loads may occur in some vessels or equipment. In such cases, the magnitude and direction of the load shall be given by the equipment supplier.

(l) Basic Load Cases

Following basic loads shall be considered for analysis and design:

Dead load	: DL
Superimposed dead load	: SIDL
Self weight of permanent equipment	: EL
Steam piping (Static & Dynamic) & other piping loads	: PL
Cable loads	: CL
Live load on floor / walkway	: LL
Superimposed live load	: SILL
Live load on roof	: LLR
Seismic load	: SL
Wind load	: WL
Load due to soil pressure	: SP

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Load due to surcharge	: SCL
Load due to hydrostatic pressure	: HP
Load due to temperature	: TL
Hoist, monorail loads	: MR1
Crane Loads	: CRL
Special loads	: SPL

(m) Load Combinations

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load combinations shall be taken as per IS: 456, IS: 800 & IS: 875 (all parts) and other relevant IS codes.

Wind and seismic forces shall not be considered to act simultaneously.

Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loading.

(n) Load Combinations for underground structures

- For the design of sub structure only liquid pressure from inside and no earth pressure and ground water Pressure and surcharge pressure from outside (applicable only to the Structures which are liable to be filled with water or any other liquid) shall be checked.
- For the design of sub structure combination of earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside shall be applied.

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4 EARTHWORK AND ROCKWORK

4.1 General

This section applies to all earth and rockwork required for the replacement / refurbishment / retrofitting of existing foundations or construction of new buildings foundations (if any), any types of structure and burying service lines in the ground.

The Bidder shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the detailed soil investigation and of the available information and instruction given in writing by the Owner/Consultant.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Owner/Consultant. All necessary precautions shall be taken to cause the minimum possible alteration or disturbance to the other existing foundations, material lying under and adjacent to the excavation final lines.

4.2 Fill Materials

The fill materials used and source are to be examined and approved. Excavation materials can be used if they fulfil the requirements.

a) Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials, which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas etc.

b) Ordinary fill shall have the following properties:

- Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.
- The intention is to use ordinary fill for non-built areas.

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c) Special fill:

- Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks.

4.3 Excavation

The works shall be excavated either by hand or by use of excavating plant and tools acceptable to the Owner/Consultant.

Last 300 mm shall be excavated by hand tools only to ensure that natural conditions of soil at foundation level should not be disturbed. In case if over excavation has been done, the depth of soil over excavated shall be filled with M10 Grade concrete and no earth filling shall be allowed to fill over excavated earth.

Also excavation by hand may be required close to existing installations, existing foundations and/or underground services, but subject to special instruction of the Owner/Consultant.

The Bidder shall carry out all kind of earth and rockwork for the following particular works as defined hereafter (where applicable):-

- Clearing and grubbing
- Excavation of topsoil
- Open cut excavation
- Backfilling
- Safety precaution during earthwork
- Mining or underground excavation (if required)
- Grading
- Replacement of material
- Trench excavation for service lines
- Embankments
- Archaeological findings

4.4 Safety Precautions

The Bidder shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc shall be to the Bidder's debit. The additional moving of soil resulting from such damages will not be paid for.

4.5 Over Excavation

Bidder shall ensure that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

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4.6 Stockpiles and Disposal

Excavated material from the works selected by the Owner/Consultant for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on site as directed by the Owner/Consultant.

The Bidder shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Owner and shall not be permanently deposited elsewhere. The Bidder shall trim and form the edges of spoil to profiles and levels as directed by the Owner/Consultant.

Distance of stockpiling of excavated material from the pit edge shall be minimum 1.5 meters or half of the depth of the pit whichever is higher. The placing of materials within the waste disposal areas shall be made in layers not exceeding 0.50 m in thickness in order to obtain an appreciable degree of compaction by means of transportation equipment and/or if required by appropriate compaction equipment.

All traffic to or from the waste disposal areas shall run over the surface of such areas in order to achieve compaction.

4.7 Preparation of Foundation

All earth surfaces against which concrete is to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Owner/Consultant and then protected by means of a lean concrete layer, 7.5 cm or PCC thickness as shown in the design drawings, whichever is greater. No concrete is to be poured until formation is inspected and approved by the Owner/Consultant. No structural concrete shall be poured against earth surface. Shuttering shall be used at sides and PCC shall be provided below foundations.

4.8 Backfilling

Foundations and structures shall be backfilled with approved material compacted in layers not exceeding 150 mm by suitable equipment upto the required designed levels.. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Owner/Consultant.

Density requirements as per standard Proctor Test shall be in accordance with relevant parts of IS: 2720 and all tests shall be made by/on under the supervision of Owner/Consultant at Bidder's own expenses, at optimum moisture content:

- a) Backfilling of foundations and under grade slabs - 98%
- b) Under roadways and parking areas - 98%

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c) Embankment

- 95%

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Owner/Consultant after compaction tests have been made.

Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the sub-grade.

Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Owner/Consultant.

4.9 Soil Replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange. The suitability of soil for its use for filling shall be as per provisions of Indian Standards.

Prior to the commencement of work, three samples shall be taken from the anticipated borrow area and tested in respect of IS: 2720 or Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

These three samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of not more than 15 cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for watering of soils.

The fill material shall be compacted by vibratory roller (min. weight 20T.). However for small compaction works such as small patches etc., comparatively low weight compactors or other compaction methods may be used after taking approval from Owner / Consultant. The minimum required degree of compaction should be as defined under "Tests and Properties". One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Owner/Consultant. The Bidder shall either provide all required laboratory facilities and staff to perform the tests or he shall co-operate with an experienced soil testing laboratory, subject to the approval of the Owner/Consultant.

Filling work may be continued in case all tests performed show satisfactory results.

4.10 Pipe Bed Preparation

Pipe beds shall be constructed to guarantee the uniform transmission of loads. The bearing section for supported profiles shall cover at least an arc of 90°.

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Pipes shall be bedded in an earth foundation of uniform density and carefully shaped by means of a template supported at the desired grade, to fit the lower part of the pipe exterior.

Where rock in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such a manner as to provide a compacted earth cushion having a thickness under the pipe of not less than one quarter of outside pipe diameter with a minimum allowable thickness of 20 cm if not otherwise specified.

Where a firm foundation is not possible at the grade established due to soft, spongy or other unstable soil, all such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed and replaced with suitable selected materials as approved by the Owner/Consultant, properly compacted to provide adequate support for the pipe.

4.11 Protection of Existing Utilities and Services

During modification/rehabilitation of existing structures or construction of new structures, the Bidder shall provide all protection for existing utilities and services as may be required by his modification and construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Owner/Consultant.

In addition to the requirements as specified, herein the Bidder shall comply with the following requirements:

- a) Use all necessary precautionary and protective measures required to maintain existing structures, utilities, services and appurtenances that must be kept in operation. In particular, the Bidder shall take adequate measures to prevent undermining of existing structures and utilities/services presently in service.
- b) Protect existing or new utilities and services where required by the Bidder's operations and/or as directed by the Owner/Consultant. The Bidder shall be responsible for bracing and supporting existing structures, utilities and services to prevent settlement, displacement or damage.

4.12 Dust Control

The Bidder shall use all means necessary to control dust on roads, dismantling/demolition and modification areas, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

4.13 Dewatering during Construction

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a

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comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the detail soil investigation and/or information given in writing by the Owner/Consultant.

Ground water control for keeping the construction pits dry shall be included in the Bidder's scope of work.

The method and technique shall be based on the IS: 3764.

The scope of supply includes removal of all equipment, plants, pipes, machinery, etc for modification /rehabilitation of existing foundations and re-installation of all equipment, plants, pipes, machinery, etc and its removal after completion including operation & maintenance of the equipment during the construction period.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that alterations and extensions can be made at any time throughout the operating time, if necessary. Reserve units shall be kept ready for service when failure of any of the installed units occurs.

The Bidder has to consider the possibility of a temporary failure of any pump, diesel engine and/or the electric power service and shall install emergency power units with sufficient capacity to feed the necessary power to the installed unit at the moment of failure. The Bidder shall submit to the Owner/Consultant, the detailed method of the envisaged pumping system for dewatering, the pump capacity and the standby reserve units. The Bidder shall adjust the system if required by the Owner/Consultant.

The Bidder must ensure that any dewatering works will not cause any interference to his own work and to those of other Bidders working elsewhere on site. Any damage occurring during the above mentioned period should then be made good by the Bidder at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least *[0.50]* m below the foundation level.

4.14 Equipments

All equipments, instruments, machineries, tools, pipelines, etc required for execution of the water control shall be kept in good working condition throughout the operation period.

4.15 Execution

The Bidder shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to the Owner/Consultant for information and checking every working day. For that

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purpose, the lowering of the water table shall be controlled by piezometers. The numbers and position of them shall be submitted to the Owner/Consultant's approval. The Bidder shall provide and maintain these piezometers at his own expenses during the dewatering works or as long as the Owner/Consultant requires it.

Pump operations shall not be stopped nor pipes, channels and equipment for dewatering and water control removed or altered in any way, except with the express permission of the Owner/Consultant. The Owner/Consultant will stipulate the time of removal. Until then, the pumps and water drainage facilities shall be kept in proper working order without extra payment being granted.

Pump sumps and channels:

Provision of pump sumps and channels of the dimensions required for each particular case shall include all necessary excavation of any kind of soil above and under water, backfill and consolidation, sheeting, bracing, stiffening, sealing, scaffolding accesses, as well as the disposal of water and all auxiliary works.

Routing of channels or pipes for discharge water shall be such as not to impede or obstruct any of the other works and/or operations.

The same shall be applicable for pump sumps. Prior to the determination of any arrangement of pump sumps, the Owner/Consultant's approval shall be obtained.

Routing and location of water discharge lines shall be submitted to the relevant authorities and to the Owner/Consultant's approval.

Difficulties during dewatering:

The Bidder shall consider all difficulties and additional work due to the presence of unexpected ground water during subsequent construction work. Where it is possible to keep off or divert such water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from Owner/Consultant has been obtained.

Ready for service condition:

The Bidder shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by the Owner/Consultant in this matter shall be carried out immediately.

Leakage:

Blockouts and pipe connections through structures and their closure, proper grouting of joints, etc or repairs in the event of leakage shall be the responsibility of the Bidder.

Piezometers:

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The ground water lowering effect is to be checked by piezometers in unfavourable positions (e.g. in the middle of the building pit) before starting the excavation. The piezometers are to be installed at unfavourable positions or in more permeable layers (in stratified sub-soil) below the bottom of the excavation. They serve to check whether or not the water pressure (head) has been sufficiently reduced in those layers below the bottom of the excavation, which are more permeable. Security against hydrostatic uplift is to be demonstrated by calculation.

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5 REINFORCED CONCRETE STRUCTURES AND FOUNDATIONS

5.1 General

All structures, building foundations, machines / equipment foundation, water retaining structures, trenches, pits, etc. shall be checked / designed as per latest relevant IS codes in general. Construction in general shall follow provisions of IS: 456 and IS: 3370 for normal and water retaining structures respectively.

5.2 Design Methodology

a) General

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456.

IS: 11384 shall be followed for design of steel concrete composite beam.

For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

b) Foundation and Underground Structures

Type of foundation system, i.e. isolated, strip, raft shall be decided based on the loading arrangement, load intensity and soil strata. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

Foundation system adopted shall ensure that settlement / relative settlement is as per provision of IS: 1904 and other Indian Standards. However, the settlement shall be restricted to a lower value, if necessary as per the system requirement.

All foundation including machine / equipment foundations shall be of RCC construction. All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian standards IS: 2974 and IS: 456. Raft foundations shall be designed as per IS: 2950.

All foundations shall be treated as per the guidelines prescribed in IS 456: 2000 against sulphate/other aggressive chemicals if found present in soil or as per the requirements of detail Geotechnical Investigation Report.

For design of underground structures, subsoil water level shall be assumed at Finished Ground level. All underground pits, tunnels, basements, cable and pipe trenches, etc. shall be designed as leak proof RCC structure, where depth of ground water table so warrants. In case of leakage in the above structures injection grouting method shall be applied to repair the structure according to

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the requirement of IS: 6494. Effects of uplift and reduction in bearing capacity due to underground water table shall also be considered.

For Subsoil conditions, Average ground water table, Foundation system, Earth Pressure Coefficient, refer to detail geo-technical investigation report of the site.

The soil conditions met during the foundation works especially in the foundation level are to be checked by the Bidder's soil Engineer, recorded and compared with previous known or investigated results. If essential differences occur, which could be detrimental to the structures, the Bidder has to inform the Owner/Consultant and to propose further measures. Foundation works in such areas are to be continued only after approval of such measures by the Owner/Consultant

If there is any doubt about the soil quality or if discrepancies appear with regard to the previous decisions or investigations stated by the Owner/Consultant, then additional measures are to be taken after consulting the Owner/Consultant (e.g. additional excavation and lean concrete fill)

Allowable settlements, elastic plus consolidation, shall be limited as follows: -

- i) Total settlement : 38 mm
- ii) Differential settlement : 6 mm

Foundations for equipment shall be designed to meet the total and differential settlement established by the equipment manufacturer if they are more stringent than the allowable settlements listed above. Foundations for buildings shall be designed to meet the total and differential settlement as required for the building function if they are more stringent than the allowable settlements listed above.

c) Movement and Expansion Joints

Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS: 8009 – "Code of Practice for calculation of settlement of foundation".

d) Foundations at Different Depths

Foundations at different levels should be based beyond a load-spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure)

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of the higher-level structures on the lower ones must be taken into consideration.

e) **Replacement**

If unsuitable soils are encountered below the grade slabs or basement floor, they are to be replaced by suitable layer wise compacted material down to the good bearing soil.

Materials and compaction method as well as quality control are described in clause 'Earth and Rockworks' of this section. Selected fill is to be employed below all grade paving and basement floors.

f) **Liquid Retaining Structures**

RCC water retaining structure like storage tanks shall be leak proof and designed as un-cracked section in accordance with IS: 3370 (Part 1 to IV) by working stress method. However the parts of such structures not coming in contact with liquid may be designed according to IS: 456.

Water channels and substructure of pump houses shall be designed as cracked section with steel stresses as per IS: 3370 (Part 1 to IV) by working stress method and limiting crack width to 0.2 mm.

All water retaining / storage structures shall be designed assuming liquid upto the height of wall irrespective of provision of any over flow arrangement. No pressure relieving devices shall be permitted in underground structures.

In all liquid retaining structures, PVC water bar shall be provided at each construction / expansion joint. The sequence of construction shall also be specified on drawings showing construction joints.

The walls shall be designed for a surcharge load of 2000 Kg/m² or actual whichever is higher.

Liquid Retaining Structure shall be checked for two loading conditions. With water inside up to operating level and no earth fill outside or water in one compartment and no water in the other compartment (where two compartments are provided).

Base slab / raft of all liquid retaining structure shall be designed to withstand the uplift pressure.

g) **Modification of the existing foundation (as required) for the new equipment supplied**

The new equipment shall be supported on an RCC deck which in turn shall be supported over steel helical springs and viscous dampers. The steel helical springs and viscous dampers shall be supported over structural steel beams which in turn shall rest over columns. The columns shall be supported over foundation. The modification of existing foundation may involve partial to full

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dismantling and reconstruction of new foundation as per design & constraints of space.

Precautions shall be taken not to disturb the basic building structure & other foundation and it shall be ensured that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

The contractor shall be responsible for maintaining all safety norms including the stability of existing structures. Any propping, shoring and under pinning required to this effect shall be put in place before the dismantling work is undertaken.

Wherever any existing concrete member is required to be partially dismantled, a coat of epoxy paint shall be applied to the exposed reinforcement and the cut surface of concrete shall be built up by providing 40 mm thick concrete with wire mesh.

h) Machine Foundations

General

Design of equipment foundation for block type machine foundation (if any) shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in mind the existing structural arrangement and space limitation.

The design of machine / equipment foundation shall be as per IS: 456 and IS: 2974. The provisions of DIN 4024 shall also be followed for machine foundations. All machine / equipment foundations and structures subject to vibrations shall be suitably proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

For the foundations supporting minor equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining part of building and other foundations. Joints at floor/ slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitable to ensure integral action.

The extent of foundation shall be based on the general arrangement of the equipment and the design requirement. However minimum width of any

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foundation shall not be less than one meter. Water table has to be considered at finished ground level for design of all foundations.

Suitable arrangement shall be made for prevention of transmission of vibration from the proposed foundation to the nearby structure/ foundation/ paving slab.

All design calculations and drawings shall be submitted to Owner for approval.

In case any modification to any existing nearby structural steel bracing/support system/ concrete work is required, the contractor shall check the adequacy of the design of the existing structures for the new loads. Suitable modification to the existing structure as required shall be carried out by the contractor.

Loose pockets if any found below the foundation shall be removed and filled up with PCC of grade M10.

Loads

All static and dynamic forces / loads which equipment supplier considers applicable shall be considered for analysis and design of machine foundations.

Foundation Sizing

The outline plan dimensions of foundations as given by the machine supplier will be adopted. The height of foundation will be selected after taking into consideration soil strata and operating level of the machine. The eccentricity of common CG of machine and foundation with respect to the centroid of base area should not exceed 5 % of the corresponding base dimensions of foundation. Partial contact between the foundation and soil strata shall be considered wherever applicable. The footing will be checked for minimum contact area of 80 % and maximum bearing pressure will be calculated for the actual contact area only.

Analysis and Design

The minimum grade of reinforced cement concrete shall be M25, unless specified otherwise.

The analysis and design of machine foundations will be carried out to ensure the following:

- Compliance with the manufacturer's requirements and relevant standards
- No resonance phenomenon of a disturbing nature to machine operation should exist at the normal running speed
- Calculations to be performed for dynamic as well as static cases for reinforced concrete block type pedestal
- Soil bearing capacities
- Deep foundation capacities
- Lateral earth pressures
- Allowable settlements
- Structure, equipment and environmental loadings

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- Equipment performance criteria
- Access and maintenance requirements
- Temporary construction loadings

The foundation will be designed for the most critical combinations of forces and moments, resulting from all possible combinations of the various loading from the equipment system. The foundation sections will be sized and reinforced adequately for bending moments and shear stresses and uplift.

The foundation shall be checked for overturning, sliding and uplift as per relevant IS Codes. The foundation will be checked for overturning with minimum and maximum vertical loads.

For analysis of machine foundation following data will be furnished by the equipment manufacturer:

- Loading diagram showing static and dynamic loads and points of application of loads
- Operating speed of machine
- Weight of rotating parts, maximum eccentricity of rotating mass from the geometric axis of rotation
- Location of C.G. of machines in all three axis
- Mass moment of inertia
- Allowable amplitude / velocity of vibration at machine bearing points
- Temperatures at various areas during operation

While designing following aspects shall also be taken care of:

- All dynamic foundations shall be isolated from building foundations. The isolation gap shall be of minimum 25 mm.
- Natural frequencies of structures and components shall be away from running speed of equipment by at least 20 % generally but for important ones it shall be away by at least 30 %.
- For design of foundation of large fans etc., provision shall be kept in the foundation for addition of mass / area for retaining of the foundations if required at a later date

However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral loads shall be 1.5
- Factor of safety against sliding shall be 1.5
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5. Uplift check shall be carried out during construction stage also.

For miscellaneous machines, most suitable type of foundation shall be provided. Foundation for pumps, and minor rotating equipment etc., are usually in the form of solid block foundations, resting on the ground or on a floor of the building. At such machine supports, floor may be thickened and extra reinforcement may be provided. Also the machines, which are almost vibration free, light to moderately heavy, may be supported in the above manner. Rubber

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or neoprene pads under some of these machines to reduce transmission of vibrations to the supporting floor will be provided if required.

All block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456. Suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining foundations.

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25°C when placed. For maintaining the temperature of 25°C in the top decks of machine foundations, crushed ice shall be used in mixing water.

Non-Shrink Grout for Equipment Foundations

Special non-shrinking grout of approved make shall be provided in strict accordance with the manufacturer's instructions / specifications. Ready mix non-shrink grout of GP2 brand or equivalent, of approved make shall be used for base grouting of major rotating equipments.

i) Increase in Stresses

Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

Bearing capacity of the soil shall be allowed to be increased by 25 % under seismic/ wind load condition.

j) Elevated Foundations

Design of all equipment foundations shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in view the existing structural arrangement and space limitation. Adequacy of the design of the existing structures, for the new loads shall be, checked by the contractor. Suitable modification as required shall be carried out by the Contractor and complete design for the same shall be furnished to owner for approval. Where ever new columns/foundation is required the same shall be designed and constructed by the contractor as per relevant Indian Standard Code.

For the foundations of the all equipments details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic

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forces as per IS:1893. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Design of RCC foundations/as well as structures, checking of design of existing structure shall be carried out by working stress method. A fatigue factor of 2.0 shall be considered for dynamic forces.

The foundation general arrangement shall be such that the spring units are placed over the structural steel beams. The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The vibration amplitudes at the bearing locations shall not exceed the limits as per VDI 2060 or limits specified by the machine supplier whichever is more stringent. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

The grade of concrete for the top deck shall be M35.

k) Steel Helical Springs and Viscous Dampers

The supporting structural beam and columns shall be designed for the loads transferred through springs and all other loads such as piping loads, seismic loads as per IS:1893. The stiffness of the beams supporting the springs shall be at least 10 times the stiffness of the springs supported over it along both vertical and horizontal direction.

The scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implied for the successful completion of the work for which these specifications are intended.

Scope of work of the bidder shall include manufacturing, testing, supply, transport to site, pre-stressing, erection, supervision of erection, release of pre-stress, alignment, commissioning etc of Steel helical springs and viscous dampers:

- Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
- Frames for pre-stressing of spring elements.
- Suitable hydraulic jack system including electric pumps, high-pressure tubes etc. required for the installation, alignment etc, of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.
- Any other items which may be required for the complete installation and satisfactory commissioning of the spring system.

Supervision of complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

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The steel helical springs and viscous dampers supplied should be of proven make. The bidder or his sub-contractor should have designed spring supported machine foundations, manufactured, supplied and installed steel helical springs and viscous dampers (conforming to DIN 2096 & DIN2089) and viscous dampers (providing damping resistance in all three planes) for not less than 2 (two) machine foundations of heavy rotating machine systems.

The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of units.

All design calculations and drawings shall be submitted to Owner for approval.

5.3 Stability of Structures

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like underground storage tanks, pits, trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For the purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area of the base slab shall be taken in to consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS: 456 and other latest relevant IS codes. However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum
- Factor of safety against sliding shall be 1.5 minimum
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In cases where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

5.4 Minimum Thickness of Concrete Structural Elements

The following minimum thickness shall be followed:

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Table 2.5
Minimum Thickness of Concrete

S.No	Description	Thickness, mm
a)	Suspended floor / slab / walkways /canopy slabs, etc.	125
b)	Ground floor slab (non-suspended)	150
c)	Water Retaining slabs / walls	200
d)	Cable/pipe trenches/underground pits/Laundry walls and base slab	125
e)	All footings (including raft foundations)	300
f)	Parapets	125
g)	Sunshades	75 at edge
h)	Precast louvers / fins	50
i)	Precast trench cover slabs / floor slabs / louvers	75
j)	Paving	100
k)	Basement walls and base slab	200
l)	Underground tank:	
	Below ground water table	200
	Above ground water table	150

From fire resistance point of view minimum cover to reinforced concrete members shall be as per Table 16A of IS: 456.

5.5 Minimum Heights for Pedestal of Steel Columns

Pedestals to Steel Columns for building structures:

Top of RCC foundations (pedestals) shall normally be kept at a minimum [250 mm] above finished floor level (FFL) unless specified otherwise. Foundation levels for columns shall be decided to accommodate underground services, pits, trenches, etc.

Stair and ladder pedestal shall be kept [200 mm] above the finished floor level.

Pedestals to Steel Columns for Equipment structures:

- a) Equipment in open area : as required [(300 mm min)]
- b) Equipment in covered area : as required [(150 mm min)]
- c) Structures and equipment
Supplied by vendor : as per vendor's data subject to minimum as specified above.

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5.6 Minimum heights for encasement of steel columns

In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following:

- a) Open area : [300 mm] above paved level
- b) Covered area : [150 mm] above FFL

5.7 Concrete Works

i) General Description, Proportions and Mixing

Mix Design

At the commencement of the contract the Bidder shall make preliminary tests to determine the proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling and placing and when concrete hardens, it shall have the required strength, durability and surface finish. The Bidder shall get approval of Owner/Consultant to such proportions before he starts concreting. However, such approval shall not relieve the Bidder of his responsibility to produce concrete having compressive strengths as laid down in the foregoing Table.

No departure from the approved proportions will be permitted during the works unless and until the Owner/Consultant gives written authorisation for any change in proportion. The Owner/Consultant shall have authority at any time to check whether the mixing of concrete is being carried out according to the approved proportions.

For the all major and important R.C. works and for all special works, the design of mixes shall be made by the Bidder at his own cost, for each grade of concrete as well as for various workability. The design of mixes shall be made according to I.S. 10262 or any other approved standard methods.

The concrete made by designing the mix is termed hereinafter as "Design Mix Concrete".

The cement content for various grades of concrete shall be based on design mix. However, irrespective of requirement of cement found out from design mix, cement content of concrete shall not be reduced below the quantities specified as under.

Grade of concrete	Minimum cement content per Cu.m finished concrete
M-15	290 kg
M-20	320 kg

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Grade of concrete	Minimum cement content per Cu.m finished concrete
M-25	380 kg
M-30	not less than 400 kg
M-35	not less than 400 kg

Water Cement Ratio

Where a particular water cement ratio is stipulated in the design or drawing along with the characteristic grade of concrete the design of mix shall be carried out by adjusting the other variable factors to obtain the characteristic strength of concrete with stipulated water cement ratio.

In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, such as water retaining structures, basements, underground premises, tunnels, pump houses, pre-stressed structure, thin precast members etc. the water cement ratio shall be kept low and preferably not exceeding 0.45.

The water cement ratio, as achieved in the Mix Design, or as specified in the drawings shall be adhered to strictly and shall not be varied without the permission of the Owner/Consultant.

Workability

The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling & placing so that after compaction it becomes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

The workability of fresh concrete at the place of batching/mixing shall be measured by compacting factor test and at the place of disposition by means of slump test. During the finalisation of Trial Mixes, the relationship between compacting factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS:1199.

Normally, in the condition of low water cement ratio as well as for medium/high workability, the workability shall be achieved by increasing the cement content, in consistent with added water.

In cases where the cement content is to be limited to reduce the heat of hydration, and the water/cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of plasticiser or air entraining agent. In such cases the method of mixing and dosage of the plasticiser/air entraining agent shall be according to the manufacturer's specification and with the approval of the Owner/Consultant.

The usual limits of consistency for various types of structures are given below:

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Limits of consistency

Degree of Workability	Slump in mm with Standard - Cone		Use for which concrete is suitable as per IS : 1199
	Minimum	Maximum	
Very low	0.0	25.0	Large mass concrete structure with heavy compaction equipment, roads and the like.
Low	25.0	50.0	Uncongested wide and shallow R.C.C structures
Medium	25.0	75.0	Deep but wide R.C.C structures with congestion of reinforcement and inserts
High	75.0	125.0	Very narrow and deep R.C.C structures with congestion due to reinforcement and Inserts

Durability

The durability of concrete, depending on the exposure condition, is to be taken into account while designing the mix. For given aggregates, the cement content should be sufficient to make sufficiently low water cement ratio and Appendix A of IS: 456 shall be taken as guideline for durability considerations.

Minimum fire rating of 2 hours shall be considered where fire hazard is expected and accordingly minimum cover shall be taken as per Table 16 A of IS: 456. For structures below ground level which are exposed to sulphate attack, requirement of cement shall be as per Table 5 of IS: 456. Intermixing of different grades of concrete in the same structure shall not be allowed in a particular element.

Mix design concrete shall be used for all areas other than plain concrete work used for lean concrete, screeds and backfill.

The following minimum grades of concrete as per IS: 456 shall generally be used for the type of structures noted against each grade.

Table 2.6
Grades of Concrete

Concrete mix/Grade	Type of structure
1:5:10	Fill concrete
1:4:8	Blinding layer below foundations, trenches and underground structures, foundation below brick wall, etc. Minimum thickness of layer shall be 75 mm

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Concrete mix/Grade	Type of structure
M15	Plinth protection work around buildings
M25	Base plate encasement, encasement of structural steel work, all RCC paving work, ground floor slabs, cable and pipe trenches, precast concrete work etc.
M30	All RCC structures and equipment foundations, super structure, grade beams, columns, roof slabs and all underground RCC structures, cable and pipe rack foundation, pedestals etc. water retaining structures below and above ground etc.

Inter mixing of different grade of concrete in the same structure shall not be allowed normally.

ii) Trial Mixes

- Before concreting commences, the Bidder shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation. Only materials which the Bidder intends to use for concreting (including all admixtures) shall be used in the trial mixes.
- Test cubes from trial mixes shall be made and tested in accordance with IS: 516.
- As per IS: 456 and IS: 516, three separate batches of concrete should be made, workability of each batch determined and three test cubes shall be made from each batch for each age (e.g. for 7 and 28 days) at which tests are required. The strength shall conform to target mean strength as per IS: 456 – Requirements for design mixes.
- The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength and if the average strength of the nine cubes is not less than recommended by IS: 456 and IS: 516, trial mixes.

iii) Quality and Testing

Not more than 5% of the test results may fall below the 28 days specified strength. Making and curing of test specimens shall be in accordance with relevant IS: 456, IS: 516 and IS: 1199.

All mixes can only be placed following approval by the Owner/Consultant. The mean strength shall exceed the characteristic strength by a margin of 1.65 times the standards deviation expected from the batching plant. However, no standard deviation less than 3.5 N/mm² shall be used as a basis for designing a mix.

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iv) **Trial Mixes and Field Tests**

Sufficient laboratory trial mixes shall be prepared to show that concrete complies fully with the specified performance criteria. The following tests are to be included:

- Air content < 1%
- Slump: Piles 170 + 25 mm, regular work 80 + 20 mm as per IS: 1199
- Fresh and hardened concrete densities
- Field trial mixes shall be carried out under full-scale site conditions as per IS: 4925 (for structural concrete only).
- Where directed by the Owner/Consultant, concrete incorporating reinforcement details shall be cored to assess stratification of mixes. Cores of 150 x 200 mm (diameter and length) shall be used.
- Each trial mix shall have 9 x (150 x 150 x 150 mm) cubes taken to measure 24 hours/7 days and 28 day compressive strengths. These trials shall be run for three consecutive days (for structural concrete only).
- At least 3 x sets of field trials shall be tested according to the provisions laid down in laboratory testing.
- The average 28 day characteristic strength for trial mixes shall be as per IS: 456. Failure to comply shall result in the mix having to be re-designed.
- All test results shall have to be complied before approval can be given.

v) **Consistency of Concrete**

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests measured in accordance with IS: 1199 and shall not exceed the values given in clause 7.1 of IS: 456-2000.

vi) **Mixing of Concrete**

- The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way and shall comply with the requirements of IS: 456, IS: 1791 and IS: 12119.
- The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than 2 (two) minutes after all the materials and water are in the drum.

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- Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

Bidder shall arrange the test Laboratory for all the quality tests and ensure that all necessary testing work shall be carried out in compliance with the standards.

5.8 Strength of Concrete

i) Testing of fresh concrete by means of test cubes

- All test cubes shall be made and tested for compressive strength in accordance with IS: 456, IS: 516 and IS: 1199.
- The minimum required strength for different classes of concrete shall be as shown in clause "General description and proportions and mixing" here above.
- The grade of concrete required will depend partly on the particular use and the characteristic strength needed to provide the structure with adequate ultimate strength and partly on the exposure conditions and the cover provided to any reinforcement.
- A minimum of four test samples (of six test cubes each) shall be taken on each concreting day (from the same mix) and for at least each 40 m³ of concrete mixed. At least one sample shall be taken for each shift.
- For columns, beams and cantilevers seven (7) cubes for every 15 m³ of concrete poured shall be taken. The concrete for test samples shall be taken directly from the concrete mixer and shall be handled (vibrated etc) under similar conditions to those prevailing during the construction. The moulds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.
- The strength level of each type and each strength concrete will be evaluated separately and the concrete strength will be considered satisfactory if:
 - Compressive strength: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-
 - The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column 2 of table 11 of IS: 456.
 - Any individual test result complies with the appropriate limits in column 3 of table 11 of IS: 456.
 - Flexural strength: When both the following conditions are met, the concrete complies with the specified flexural strength:-
 - The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm².

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- The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2 .

- g) If the results are less than those specified, the Owner must suspend all concreting work and order further tests. Any concrete found not to comply with the specification shall be broken out and replaced to the satisfaction of the owner.
- h) The Bidder shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

ii) Testing of concrete in structures

- a) The types of tests described hereinafter are applicable to the finished parts of the structures. They may be used in routine inspection and for quality control.
- b) Type of tests:
 - Cutting cores: The procedure used shall comply with the requirements of IS: 516 or an approved equivalent standard.
 - Gamma radiography: The testing shall be carried out in accordance with the requirement of IS: 13311, part 1 or equivalent.
 - Ultrasonic test: Such tests may be used to obtain approximate indications of the strength of the concrete in the structures (IS: 13311, part 1).
 - Electromagnetic cover measuring devices: Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design (IS: 13311, part 1).
 - Rebound hammer test: Such tests may be used to obtain approximate indications of the strength of the concrete (Ref. IS: 13311, part 2).
 - Load tests of structures or parts of structures: If the results of the above mentioned check tests show that the quality of the materials is inadequate or if other defects are revealed, the owner may require a loading test to be made.
- c) For the purpose of testing floors, roofs and similar structures and their supports, the test load shall be equivalent to the sum of the characteristic dead load and one-and-a quarter times (1.25 times) the characteristic imposed load for a period of 24 hours which the works or part thereof to be tested have been designed.
- d) Wherever certain procedures for testing of parts in structures are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Owner/Consultant.
- e) If within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under superimposed load, the test

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may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.

- f) If the result of the test is not satisfactory, the Owner/Consultant shall instruct that the part of the works concerned be taken down or cut and reconstructed to comply with this specification. The Bidder shall at his own cost take down or cut out and reconstruct the defective work.
- g) The Owner/Consultant may require other tests to be made. Number of samples, tests and types will be as per Owner requirements.
- h) All the costs for the above mentioned tests shall be borne by the Bidder.

5.9 Materials

a) Storage of materials

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Storage of materials shall conform to IS-4082 "Recommendation on stacking and storage of construction materials and components at site". Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Bidder.

b) Cement

OPC/PPC Cement of reputed make conforming to relevant codes, shall be used for all Concreting works and the certificate of manufacturer shall be furnished with each batch. Cement used shall be ordinary Portland cement unless the chemical nature of the soil warrants special cement for structures below ground level.

Sampling and Testing of Cement

- All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties as required by relevant IS: 8112 for grade 43 and IS-12330 for sulphate resistant cement.
- The manufacturer's test certificate will normally be accepted as proof of compliance with the specification, but the Owner may order further tests of a character specified in the appropriate Indian standards. The confirmatory tests are to be conducted by a recognized quality control organization. The Bidder shall bear all expenses required for the preparation, dispatch, and tests of the samples. In case the results of such tests show any sample to be inferior to specifications, the whole consignment from which the sample was taken shall not be used and shall be immediately removed from the site.

Delivery and Storage of Cement

- The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture,

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date of original loading, destinations en-route, date of unloading, intended date of delivery to site.

- The Bidder shall obtain and provide to the owner the manufacturer's average test certificate for each consignment of cement to the works.
- The certificates shall be provided before the consignments are required for use and shall show the chemical composition and physical properties determined in accordance with the relevant standard.
- Samples shall be taken from each consignment of cement and tested as directed by the owner in an approved independent laboratory.
- Consignments shall be used in the order in which they were delivered.
- Bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the owner before any cement is delivered to site.
- Each consignment of cement shall be separately stored for ease of access, identification, inspection and sampling. Sufficient stocks shall be maintained on site to ensure the proper progress of the works and the stock holdings shall be to the approval of the owner.
- No cement from any consignment shall be used in permanent works without the approval of the owner.
- Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter or which has been contaminated or is otherwise unsatisfactory in the opinion of the Owner/Consultant will be rejected and shall be removed from site without delay.
- The Bidder shall be responsible for satisfying himself that the performance characteristics of cement are not such as to necessitate excessive cement content or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete notwithstanding apparent compliance with this specification.

c) Reinforcing steel

General

Reinforcing steel used in reinforced concrete shall comply with the following standards:-

Deformed bars shall be of grade Fe500 and conform to IS: 1786.

Mild steel shall conform to IS: 432.

Mesh reinforcement shall conform to IS: 1566.

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Binding wire

Binding wire for general use shall be annealed wire 16/18/20 BWG conforming to IS 280. The number of strands shall be as per IS specification.

Reinforcement supports

- Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing; supporting, and fastening the reinforcement.
- Spacers shall be cast from concrete of the same quality as that in which they will be embedded.
- Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.
- Binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the Bidder shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

Certificates

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analyzed and the date of such tests and analyses and that such tests and analyses comply in all respects with the standards. The following tests shall be carried out on reinforcement:-

- Cast analysis
- Carbon equivalent value
- Tensile strength, yield stress, elongation
- Bend test
- Bond classification
- Chemical analysis

Stock of reinforcing steel

In order to ensure due progress of the works, the Bidder shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted as satisfactory by the Owner/Consultant.

Rejection

The owner at his discretion may order random testing of the reinforcement steel and in the event of any failed test reject the entire lot notwithstanding the manufacturer's or coating applicator's certificates.

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The Bidder shall remove all rejected reinforcing steel from the site without delay at his own expense.

Storage

All bars for reinforcement and steel fabric reinforcement shall be stored on the site under cover on timber or concrete supports suitably spaced and of sufficient height to keep the steel not less than 150 mm clear of the ground.

Bar-bending Schedules

The Bidder shall prepare bar bending schedules based on the detailed reinforcement drawings. These shall be presented to the Owner/Consultant for review. The Bidder is fully responsible for their completeness and correctness in every way nor shall any claim for extra cost or time be allowed on the grounds of errors or discrepancies which may arise between drawings and schedules.

d) Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. pH value of water shall not be less than 6.

Only potable water shall be used. Tests and quality of water shall be in accordance with IS: 456 or equivalent.

e) Aggregates

General

The aggregates for concrete shall be crushed natural rock subject to Owner's approval.

The aggregate to be used in the work shall be supplied from an established pit or quarry.

The concrete supplier shall obtain from the aggregate producer, or otherwise provide current test, examination, and inspection reports performed and certified by an approved laboratory for submittal to the Owner/Consultant.

As a minimum, this information shall include the following items:-

- Item 1

A comprehensive description, with current photographs of the pit or quarry, including but not limited to, identification by name and location, type of deposit, age, potential reserves, primary products by size including average gradation based on previous six (6) months production and the range for each sieve size; mining methods, process equipment, quality control organization and laboratory; the primary and alternate means of product transportation; listing of primary and secondary users of the product.

- Item 2

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Petrographic examination in accordance with IS: 2386 (Part-8) and ASTM C-295 performed by a qualified concrete aggregate petrographer. This report shall be based on material produced and examined within the previous six (6) months and must be representative of the current production.

• **Item 3**

Coarse aggregate shall be sampled from current production in accordance with IS: 2386 (Part 1 to 8). Three [20 mm, 10 mm & 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:

IS 2386(Part 1): Methods of test for aggregates for cement: Part 1 Particle size and shape (Amendments 3)

IS 2386(Part 2): Methods of test for aggregates for concrete: Part 2 Estimation of deleterious materials and organic impurities (Amendment 1)

IS 2386(Part 3): Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking

IS 2386(Part 4): Methods of test for aggregates for concrete: Part 4 Mechanical properties (Amendments 3)

IS 2386(Part 5): Methods of test for aggregates for concrete: Part 5 Soundness

IS 2386(Part 6): Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregates (Amendments 2)

IS 2386(Part 7): Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity

IS 2386(Part 8): Methods of test for aggregates for concrete: Part 8 Petrographic examination

ASTM C-295 Standard guide for petrographic examination of aggregates for concrete

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the Owner/Consultant shall meet the requirements of IS: 383 and IS: 456.

Testing is to be carried out at the following intervals:

Table 2.7
Grades of Concrete

Type	Coarse Agg.	Fine Agg.
Grading	Daily	Daily
Specific Gravity	7 days	7 days
Magn Sulphate soundness	30 days	-
Clay, Silt and dust content	Daily	Daily
Shape (elongation and flakiness)	3.5 days	-
Los Angeles Abrasion	Initial stage only	Initial stage only

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Type	Coarse Agg.	Fine Agg.
Moisture content	2 days	Daily
Drying shrinkage	Initial only	Initial only
Organic impurities	30 days	30 days
10% fines value for concrete	7 days	-

Combined grading shall also be done on a daily basis.

Storage and handling of aggregates

- Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent wind blown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.
- Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect against wind blown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.
- Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.
- Rescreening Coarse Aggregate: Rescreening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If rescreening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.
- Natural or manufactured sand shall be allowed to drain until it has reached somewhat uniform moisture content before it is used.

Fine Aggregate

Fine aggregate source shall be manufactured crushed stone or river sand, excluding fines, which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone nor 4% for natural sand.

The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

Crushed Stone Sand

- i) Concrete subject to abrasion 1% by weight

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- ii) All other concrete 3% by weight

There shall be no clay or fine silt present.

The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on an IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS: 383.

The grading of the aggregates should be such as to produce a concrete of the specified proportions, which will work readily into position without segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of silt adhering to the aggregate is found to be unacceptably high.

Coarse Aggregate

Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The unit weight of the coarse aggregate shall not be less than 2.5 t/m³. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm² when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

Samples of aggregates shall be submitted to the Owner/Consultant, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the Owner/Consultant have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

f) Concrete additives

Use of Concrete Additives

Concrete additives approved by the Owner/Consultant shall be used to improve consistency, workability, quality and strength of the concrete.

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Chemical admixtures manufacturer shall provide certified test reports from qualified independent laboratories showing actual test results indicating material that complies in all respects with the applicable specification.

Admixtures used in concrete shall conform to the appropriate specification and requirements as indicated below:-

- Air entraining admixtures shall conform to IS: 9103.
- Water reducing and retarding admixtures shall conform to IS: 9103. Accelerating admixtures shall not be used.
- High range water reducers shall be naphthalene-sulfonated polymer based material. No admixtures containing chlorides shall be used.
- Chemical admixture suppliers shall provide certified test reports with each shipment indicating compliance with the appropriate specification. The test reports shall include the chloride content of the admixture, specific gravity and solids content.
- Fibers: Polypropylene fibers shall be collated, fibrillated polypropylene fiber of approved manufacture.
- Admixtures used in production of concrete shall be the same as used in establishing the required concrete mix and shall be used in accordance with the manufacturer's directions.
- Liquid admixtures shall be stored in such a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations

Accelerating and Retarding Additives

Such additives shall only be used in case of necessity and after obtaining the written approval of the Owner/Consultant.

Plasticizers and Air entraining Additives

Plasticizers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Owner/Consultant and in accordance with the manufacturer's instructions.

5.10 Dismantling/Demolishing and Modification in PCC&RCC

- The dismantling implies, carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of a structure. This includes chipping work, cutting of reinforcement, making holes/opening etc. in concrete members, according to the required shape, size and profile at all elevations.
- The term demolition implies, taking up or down or breaking up of a structure/member, in part or full, as specified or shown in the drawings or as directed by Engineer.

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- In a structural member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as directed by the Engineer.
- All material obtained from the demolition/dismantling work shall be property of the Owner, unless otherwise specified.
- All serviceable materials obtained, shall be separated out and stacked properly upto a lead of [500 meter] or shall be returned to OWNER's stores and all unserviceable materials, rubbish etc., shall be disposed off as directed by the Engineer, upto a lead of [2kms].
- The dismantling / demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process or work.
- Necessary propping, shoring and under pinning shall be provided for safety of adjoining work or property which is to be left intact, before dismantling/demolishing work.
- All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall be taken to keep the dust nuisance down. Safety requirements stipulated in IS: 4130 shall also be followed.
- As and where necessary, the dismantled/demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Engineer. Wherever required, temporary enclosures shall be erected to minimize the dust or moisture infiltration.
- Wherever fresh concrete is laid over old concrete, to ensure proper bond between old concrete and fresh concrete, the surface of old concrete shall be thoroughly cleared by removing all loose particles and coat of epoxy paint shall be applied.

5.11 Minimum Cover to Foundation Bolts

Minimum distance from the centre line of foundation / anchor bolt to edge of pedestal shall be the maximum of the following:

Clear distance from the edge of base plate / base frames to the outer edge of the pedestal shall be minimum 50 mm

Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm

Clear distance from the edge of sleeve or anchor plate to the edge of pedestal shall be 75 mm

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5.12 Miscellaneous Requirements

Fillets at the junction of roof and vertical walls shall be provided with cast in-situ cement concrete 1:2:4 (nominal mix) followed by 12 mm thick 1:4 cement mortar.

A screed layer not less than 100 mm thick of cast in-situ concrete of nominal mix 1:3:6 shall be provided below all water retaining structures. A sliding layer of craft paper or bitumen paper shall be provided over the screed layer to destroy the bond between screed and base slab.

Plywood formwork shall be used for all water retaining / conveying structures and for all over ground concrete works. For other areas steel/ plywood formwork shall be used.

Unless specified 20 mm and down graded aggregates shall be used for all structural concrete works. However 40 mm and down graded aggregates may also be used under special conditions for foundation.

Tolerance for formed and concrete dimension shall be as per IS: 456.

5.13 Major Equipment Foundation

Special requirements for concreting of major equipment foundations shall be as given below:

Coarse Aggregates

Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali aggregate reaction. Materials, which contain high percentage of reactive silica, shall not be used. In exceptional cases of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations, which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundations).

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25° C when placed. For maintaining the temperature of 25° C in the top deck of machine foundations, crushed ice shall be used in mixing water.

Admixture

Plasticizer cum retarder/accelerating type admixture shall generally be added to the concrete for promoting workability in addition to retarding / accelerating setting time for mass concreting work. The Bidder shall submit the mixing proportion/report after conducting the design mix as per the relevant codes and standards. The slump of concrete shall generally be in the range given below:

Block foundation : 100mm to 150mm

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Column : 100mm to 150mm

Formwork

Plywood formwork shall be used for the top deck of all machine foundations. Any other type of formwork required to be used may be permitted subject to prior approval of the OWNER/CONSULTANT after submission of the required data.

Scheme for Concreting

Batching plants shall be mobilized for all RCC works. Concrete pump shall be mobilized for Fan foundations etc. Arrangements for stand-by Plant and Equipments shall also be made.

Placing of Concrete

Base mat as well as top deck of machine Foundations shall be cast in a single pour. However the BIDDER shall submit method statements for various structures and shall get the prior approval from the OWNER/CONSULTANT before placing the concrete.

Ultrasonic Testing

Ultrasonic pulse velocity test shall be carried out for the top deck of all machine foundations to ascertain the homogeneity and integrity of concrete. In addition, additional cubes (at the rate of one cube per 150 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values. Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the BIDDER shall rectify the defects suitably using cement / epoxy grout etc.

5.14 Transport of Concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods, which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The Concrete shall be transported by transit mixers of adequate capacity. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Owner/Consultant.

The Bidder shall obtain permission well in advance of any concrete pour.

5.15 Concreting Operations

Inspection prior to Concreting

All concreting methods shall be subject to the approval of the Owner/Consultant.

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Concrete placing shall not be started until the Owner/Consultant has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

Placing of Concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The Bidder shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

The temperature of concrete shall not exceed 40°C measured at discharge into the works.

The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable differential temperature between any two points in the same element is 15°C. Additional temperature control measures during construction (such as the use of insulated formwork) will be required. Bidder to prepare a process control chart and method statement verifying measures to achieve these requirements.

Temperature monitoring of concrete work is required where:

The minimum dimension of any casting is 0.8 metres or more, or otherwise instructed by the Owner/Consultant.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours time shall be subject to the same treatment as the construction joints.

Concrete shall not be dropped into place from a height exceeding 1.5 metres. Trunking and chutes to Owner/Consultant's approval shall be used for any concrete to be deposited from a height exceeding 1.5 m.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

5.16 Compaction and mechanical vibration of concrete

As concrete is being placed it shall be compacted by mechanical vibrators complying with IS: 2505, IS: 2506, IS: 2514 & IS: 4656, to obtain a dense material free from honeycombing, free from water and air holes.

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The Bidder shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation/bleeding caused, but complete compaction of the concrete is achieved.

5.17 Finish of concrete

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

5.18 Construction, expansion and contraction joints

Construction joints

The number of construction joints should be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subject to agreement between the Owner/Consultant and the Bidder before any work commences. Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Concrete should not be allowed to run to a featheredge and vertical joints should be formed against a stop board.

The top surface of a layer of concrete should be level and reasonably flat unless design considerations make this undesirable. Joint lines should be so arranged that they coincide with features of the finished work.

If a kicker (i.e. a starter stub) is used it should be at least 70 mm high and carefully constructed. The kicker must be incorporated with the previous concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

The maximum horizontal length of wall to be poured in one operation in any one direction is 7.5 metres. A period of 7 days to be allowed between adjacent pours except where water stops are provided when this can be reduced with Owner/Consultant's approval. Alternatively a gap of 600 mm width shall be left between adjacent pours and filled after 7 days from the date of formation subject to Owner/Consultant's approval.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is

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exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible a vibrator should be used.

Where the Owner/Consultant considers that special preparation is necessary, i.e. for an in-situ structural connection, preparation should be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush, which is sufficient to remove the outer mortar skin and expose the larger aggregate. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking of hardened surfaces should be avoided.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.

Joints shall be straight and vertical, except where otherwise specified, and concrete surfaces on both sides of the joint shall be flush. Where necessary, water stoppers of a type approved by the Owner/Consultant shall be embedded in the concrete. The water stopper should be made of high quality material, which must obtain its resilience through the service life of the structure for the double function of movement and sealing. The surface of water stoppers should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints the water stopper should be provided with anchor parts. The cross-section of the water stoppers should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

All joints between structural steel and concrete parts shall be sealed by a suitable permanent flexible compound.

5.19 Concreting at night

When approval is given to carry out concreting operations (under control of the Owner/Consultant) at night or in places where daylight is excluded, the Bidder has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

5.20 Protective measures for concrete

In general, the cover of rebars shall be as per IS: 456 taking into account the site conditions. However, the minimum concrete cover shall not be less than:

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Concrete parts above ground (external surface)	: 40 mm
Concrete exposed to underground & groundwater	: 50 mm
Isolated footings	: 50 mm
Raft	: 75 mm
Slabs	: 25 mm
Beams	: 25 mm
Columns	: 40 mm

Immediately after the compaction of the concrete has been finished, the Bidder shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constant moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Owner/Consultant. Where formwork cannot be removed within 24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Owner/Consultant's approval to the use of a particular curing compound and to the method of application will only be given after the Bidder has completed satisfactory site trials and a sample panel has stood for at least 28 days.

Where large sections of concrete are poured, special precautions to the approval of the Owner/Consultant shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete.

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind, however light, shall be allowed on concrete which has not properly set and the Bidder shall prevent any load to be imposed on the concrete structures until it has been declared by the Owner/Consultant to be ready to carry loads.

5.21 Concrete with Special Properties

General requirements

The pre-condition for obtaining concrete with special properties is that it should be made with the appropriate composition, that it is placed in such a way that segregation does not occur and further that it is fully compacted and given appropriate curing.

Waterproof concrete

This concrete must meet the provisions of IS: 3370. Waterproof concrete must be sufficiently dense (impermeable).

Waterproofing and protection of underground concrete structures

Water aggressive to concrete should be kept away from the fresh concrete.

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Concrete, which is exposed for a prolonged period to “very severe” chemical attack, must be protected against direct access of the aggressive substances.

The protection, which is to be laid as protection to all concrete surfaces in contact with the ground, shall consist of an approved waterproofing membrane. The membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane.

Such membranes shall be PVC sheets of minimum 0.35 mm thickness with knobs of Maxlock.

The waterproof membranes shall be installed in strict accordance with manufacturer’s instructions.

The membranes shall extend 15 cm above ground level.

When setting forms and reinforcing steel caution shall be exercised to avoid damage to the impervious membrane. The surface of the impervious membrane extending outside the forms shall be protected during subsequent operations.

Any puncture or damaged areas shall be cleaned and patched according to manufacturer’s instructions.

Concrete with high wearing resistance

Concrete which is exposed to severe mechanical action, e.g., due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, should possess high wearing resistance and correspond at least to grade M30.

The aggregate upto 4 mm size should consist predominantly of quartz or materials of at least equal hardness; the coarser particles should consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action, it will be necessary to use special hard materials. The particles of all types of aggregate should have a moderately rough surface and be of compact shape. The combined aggregate should be as coarsely graded as possible.

Furthermore, the concrete should be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete should be kept moist for at least 7 days after placing.

Finishing of formed surfaces

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that shall be covered with earth backfill. Exterior surfaces that shall be exposed above grade and all interior surfaces, except those not usually exposed to view shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

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Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed. The resulting recesses shall be cleaned, wetted, and filled with patching mortar. Patches on rubbed surfaces shall match the texture of the adjacent concrete.

Finishing of unformed surfaces

No surface treatment shall be required for buried or permanently submerged concrete. As a minimum, unformed surfaces shall be finished by screeding and floating. Surfaces requiring a trowelled finish shall be finished by screeding, floating, and trowelling.

Float finished and screeded surfaces shall be finished to provide a flat profile within a 6 mm deviation as measured from a 3 m straightedge. Trowel finished surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 3 mm when measured from a 3 m straightedge.

Screeding

Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

Floating

The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and colour.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

Trowelling

The exposed portions of the tops of equipment bases, tops of interior curbs, and the surfaces of interior slabs not receiving a separate finish shall receive a steel trowel finish. Trowelling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Trowelling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

Surfaces to be covered with neoprene-hypalon coatings shall be lightly trowelled but not burnished.

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Brooming

Brooming shall follow the float finish for exterior surfaces where a nonslip surface is required. Brooming shall be done with an acceptable steel or fiber broom not less than 450 mm wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1.5 mm and 3 mm deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

Aggregate Exposure

Surface mortar shall be removed and the aggregate exposed from surfaces that shall be covered with mortar, concrete, or grout at a later time.

Edging

Unless specified otherwise, exposed edges of floated or troweled surfaces shall be edged with a tool having a 6 mm corner radius.

Finishing mortar

Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 102 kilograms of concrete sand to one sack of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 50 mm.

Separate finishes

Certain slabs surfaces shall be finished with a separate concrete finish or floor covering.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances. Low areas shall be filled. High spots shall be ground slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 3 mm from a 3 m straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the drawings or a float finished surface set 3 mm low and levelled with trowel finished fill material.

Surfaces that receive a mortar set quarry tile, ceramic tile, or vitrified finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 6 mm as measured from a 3 m straightedge.

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5.22 Formwork

Design and construction

For stability and type of formwork and support framing used, IS: 14687 is to be observed.

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section) "Dimensional Tolerances".

The Bidder shall submit in sufficient time in advance for the approval of the Owner/Consultant the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Particular attention must be paid to the formwork supports and braces to avoid any slip when the concrete is poured.

Materials for formwork

Forms shall be constructed from steel or from sound timber well seasoned and free from shakes. Plywood lining for forms shall be of timber, which is resin-bonded and water repellent.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete. Where a slope exceeds 1 V: 2 ½ H, formwork shall be provided for the top of the concrete faces and anchored to prevent flotation.

The details of fair-faced concrete facades have to be to the satisfaction of the Owner/Consultant. The concrete surface for facades has to be absolutely stainless and all efforts have to be taken to achieve this. All the proposed formwork shall be properly designed before its usage.

Grading of formwork and of finished concrete surfaces

Quality of formwork, materials to be used and treatments of surface are graded according to the finish of the concrete surface as given in IS: 14687.

The type and treatment of the formwork lining (plywood, metal, plastics, etc) should be appropriate to the grade of concrete finish required.

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Preparation and inspection of formwork

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces, which are not oiled, shall be wetted thoroughly to prevent warping.

Erection and placing of formwork

All formwork shall be erected and placed in accordance with the construction drawings approved by the Owner/Consultant. Shuttering shall be true to line and braced and strutted to prevent deformation under weight and pressure of the wet concrete, live loads, wind and other forces. The deflections shall not exceed 3 mm.

The formwork for beams and slabs shall be erected so that the form on the sides of the beams and of the soffits of slabs can be removed without disturbing the beam soffit.

If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Wherever necessary, panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc shall be fixed to the formwork carefully.

Panels shall be put together to ensure a perfect fit at the joint and fixed in both directions.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on the drawings as "Fair-faced Formwork".

Where concrete surfaces are covered (non-exposed surfaces), the formwork shall be referred to and marked as "Sawn Formwork".

Internal spacers and ties, if any, shall be so arranged that after removing of the forms no holes shall extend through the concrete, in the case of watertight concrete or to be closed by plastic plugs and epoxy mortar in all other cases.

All formwork will be inspected and approved by the Owner/Consultant before concrete placing commences but this shall not relieve the Bidder of any of his responsibilities under the contract.

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Striking of formwork

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

In accordance with IS: 456 clause 11.3.1, the striking period for cast in-situ concrete under certain conditions may be taken as follows: -

Table 2.8
Formwork

Type of Formwork	Minimum period before striking formwork
Vertical formwork to columns, walls, beams	16 to 24 hours
Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs:	
1) Spanning upto 4.5 m	7 days
2) Spanning over 4.5 m	14 days
Props to beams and arches:	
1) Spanning upto 6 m	14 days
2) Spanning over 6 m	21 days

Special care is necessary in the case of components, which have to carry nearly the full-calculated load as soon as the formwork is struck.

Columns, piers and walls are to be struck before the beams and slabs supported by them. Scaffolds, formwork supports and self-supporting floor formwork are to be carefully lowered by releasing the devices.

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

To keep deflections through creep and shrinkage to a small amount, auxiliary supports should be left in place or immediately repositioned after striking.

5.23 Water stoppers

Water stoppers shall be of PVC or equivalent and shall be eye-letted with a minimum 25 cm width. Type and manufacturer shall be submitted to the Owner/Consultant's approval.

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All intersection pieces shall be prefabricated by the manufacturer and only welding of butt-joints in running lengths will be allowed to be carried out on the site.

The site welding of butt-joints shall be executed by using the manufacturer's purpose-made electrically heated jig and work shall be done by competent and trained personnel only. The manufacturer's instructions shall be carefully observed.

The wings of the water stoppers shall be formed with corrugations or bulbs to achieve a good bond. Moreover, the water stoppers shall conform to the following requirements:-

- The tensile strength not less than 10 N/sq.mm when tested.
- The ultimate elongation shall not be less than 22% when tested.
- The tear resistance shall not be less than 2 N/sq.mm when tested.
- The material shall not crack when tested.
- Under accelerated elongation, the tensile strength shall not be less than 8 N/sq.mm and the ultimate elongation shall not be less than 200%.

The water stoppers shall be installed so that they are securely held in position during the placing of concrete, which shall be fully and properly compacted around the water stoppers to prevent voids or porous areas. Adequate clearance between the reinforcement and all the water stoppers shall be kept to permit proper compaction of concrete.

No holes or nailing shall be made through any water stopper for fixing purposes. Jointing by lapping two pieces of water stoppers shall not be permitted.

The free edges of water stoppers shall at all times be protected from direct sunlight.

5.24 Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed and if required the concrete may be protected for few more days as per the design mix / approved methodology.

Trowelled surfaces except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane-curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

Water curing

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application

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shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water may be interrupted for surface rubbing. The concrete surface shall not be permitted to dry.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap and kept saturated for the remainder of the curing period.

Membrane curing

Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at coverage of not more than 7.4 sqm/litre. Membrane curing shall not be used on surfaces that shall be covered at a later date with mortar, concrete, damp proofing, tile, or any coating. Membrane curing shall not be used on cast-in-place concrete bases for field-erected tanks. Membrane curing will be permitted only after prior approval of the OWNER/CONSULTANT.

Floor sealer

All concrete floors shall be given two coats of clear floor sealer in addition to that applied as membrane curing compound. The first coat shall be applied at the end of the curing period before any traffic is permitted on the floor. The second coat shall be applied after the floor has been cleaned in preparation for the final inspection. Floor sealer shall be applied in strict accordance with the manufacturer's recommendations.

5.25 Waterproofing/Damp proofing

A waterproofing seal shall be provided for all below grade structures where applicable by external tanking with PVC sheets of 1.0 mm thickness with knobs for membrane type waterproofing. In addition, joints in deep underground structures shall be provided with structural waterproofing.

Damp-proof course 40 mm thick, consisting of cement concrete 1:2:4, with admixture of approved water-proofing compound shall be laid at plinth level for walls of all buildings for protection of super-structure against moisture and dampness.

5.26 Repair of damaged and defective concrete

Concrete after its final setting shall be inspected by the Owner/Consultant and any cracks, honeycomb areas, segregations, etc shall be marked. No repairs shall be carried out until directed by the Owner/Consultant.

Surface defects in formed concrete shall be repaired to the satisfaction of the Construction Manager within 24 hours. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 25 mm shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the concrete is placed.

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Defective concrete shall be replaced within 48 hours after the forms have been removed.

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6 PRESSURE GROUTING

The work shall consist of drilling grout holes, exploratory holes and check holes, pressure testing, pressure washing, and injecting suspension grout under pressure, and shall include furnishing of all materials, labor, and equipment as described and specified.

6.1 Materials

a) Cement

Portland cement shall be contains less than 0.6 percent alkali.

b) Aggregate

Aggregate shall be non reactive and shall be washed before use. When sources of aggregate are changed, test reports shall be provided for the material from the new source prior to commencing grout work. Fine aggregate shall be sand or crushed stone.

c) Admixtures

Admixtures shall be compatible with the grout and shall comply with the manufacturer's recommendations. Admixtures shall be added to the grout mix separately.

Water Reducing Retarder: Water reducing retarder shall comply with relevant Indian standard or as approved by Owner.

Lubricant: Lubricant additive for cement pressure grouting shall be Intrusion Prepakt Intrusion Aid, Sika Intraplast N, or as approved by Owner.

d) Water

Water for washing aggregate, for mixing and for curing shall be potable, shall not contain more than 1000 mg/l of chlorides as Cl, nor more than 1300 mg/l of sulfates as SO₄, and shall not contain impurities which may change the setting time by more than 25 percent or a reduction of more than 5 percent of the compressive strength of the grout at 14 days when compared to the results for grout made with distilled water.

e) Grout

Drypack Grout

Drypack grout shall be a mixture of approximately one part cement, 1.5 parts sand, water reducing retarder and sufficient water to make a stiff workable mix, branded Dry Pack or approved equal.

Cement Grout

Cement grout shall be a mixture of one part cement, two parts sand proportioned by volume admixtures for pressure grouting and sufficient water to form a workable mix.

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Nonsrink Grout:

- Non-shrink expansive flowable grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticiser admixture shall be added in the grout. For grouting of base of machine foundation high strength ready mixed non-shrink flowable grout shall be used.
- Type and grade of grouting for structural columns and equipment bases shall be as indicated. Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M 30.
- Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipment. For secondary posts, stair and ladder base, etc. grouting shall not be less than 25 mm thick.
- Special grout, where specified on the drawings, shall be provided in strict accordance with the manufacturer's instructions/specifications. Pre-mixed Grout Conbextra GP-2 of 'FOSROC' make or equivalent of crushing strength 650 kg/cm² for major equipment foundations and Conbextra GP-1 or equivalent having crushing strength of 450 kg/cm² for other foundations where concrete grade M30 or higher is provided
- Forms and shims used to obtain adequate clearance shall not be removed and the anchor bolts shall not be tightened for at least three days after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and edge of the foundation shall be finished smooth to allow drainage away from the base. Attachment of interconnecting piping of machinery and complete load transfer of machinery shall not be done before the bolts are tightened. During this period, grouting work shall be properly cured using rags/gunny bags.

In view of extremely small proportion (about 0.01% by weight of cement) of the aluminium powder required, it is necessary to take all precautions to ensure thorough mixing. It is advisable to mix the blend of aluminium powder thoroughly with sand and cement before water is added because aluminium powder has a tendency to float on water.

- Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement: 1 admixture: 1 sand), or as per manufacturer's instructions.

Pre-mixed non-shrinking grout shall be used as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

Epoxy Grout for Crack Repair and Dowel Anchorage

Except for applications involving pressure grouting or crack injection, epoxy shall be a high modulus, moisture insensitive, two components, 100 percent solids,

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thermosetting modified polyamid epoxy compound. The material shall equal which is capable of not sagging in horizontal or overhead anchoring applications.

Epoxy for applications involving pressure grouting or crack injection, shall be a high modulus, moisture insensitive, two components, injection grade, 100 percent solids blend of epoxy resin compounds. The material shall equal which is capable of achieving complete penetration of hairline and larger cracks.

Polymer Concrete for Resurfacing and Patching

Polymer concrete shall consist of a liquid binder and dry aggregate mixed together to make a flowable mortar. The liquid binder shall be a chemical and oil resistant, stress relieved, low modulus, moisture insensitive, two component epoxy resin compound. The binder material shall equal with a consistency similar to light weight oil for proper mixing with the aggregate. The aggregate shall be oven dry, kept in sealed packages until the time of mixing and be of size and consistency compatible with recommendations of the manufacturer of the liquid binder for the intended application.

Adhesive Resin for Dowel Anchorage:

Pneumatically operated caulk gun and automatically mixed at nozzle. Subject to compliance with one of the following: HIT RE500-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-2322), HIT-HY 150 MAX-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-3013), SET-XP Adhesive Anchoring Systems, Simpson Strong-Tie Co. (ICC ESR-2508).

6.2 Pressure Grouting Equipment

Pressure grouting equipment shall include a mixer and holdover agitator tanks designed to place grout at pressures up to 0.345N/mm² (50 psi). Gauges indicating grouting pressure shall be provided and the mixer shall be equipped with a meter capable of indicating to within 0.003 m³ the volume of grout placed.

6.3 Execution

Bonding compounds for use with grout is to be provided and installed per the manufacturer's recommendations.

a) Drypack Grout

Drypack grout is to be used for built-up surfaces, setting miscellaneous metal items and minor repairs.

Surfaces required to be built-up with drypack grout are to be roughened by brushing, cleaned and coated with the bonding compound before application of grout. The grout is to be applied to the required thickness.

b) Cement Grout

Cement grout is to be used for filling nonbearing portions of equipment pads and pressure grouting.

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Except for the specialized requirements for pressure grouting, grout is to be mixed and placed in the same manner as cast-in-place concrete. Grout is to be mixed for at least one minute and diluted grout is to agitated until placed.

c) **Non-shrink Grout**

Nonshrink, nonmetallic aggregate grout is to be used under equipment, bearing plates and column base plates. Nonshrink, metallic aggregate grout is to be used under rotating equipment where high strength and fatigue are of concern, to grout anchor bolts and to grout reinforcing steel. Grout is to be placed and cured in accordance with the manufacturer's recommendations.

Holes required for grouting shall be blown clean with compressed air and are to be free of dust or standing water. Horizontal holes for grouting are to be drilled at a slight downward angle and with the inserted dowel or bolt bent to match.

d) **Epoxy Grout**

Epoxy grout shall be used for repairing cracks by pressure grouting or gravity, repairing structural concrete and may be used for setting dowels or bolts in holes. Concrete is to be primed in accordance with the grout manufacturer's recommendations.

The use of epoxy grout must comply with the following restrictions:

- Limited to areas where exposure, on an intermittent or continuous basis, to acid, chlorine gas or to machine or diesel oils, is extremely unlikely.
- Limited to applications where exposure to fire or to concrete temperatures above the product heat deflection temperature or 120 deg F (40 deg C)(whichever is less) is extremely unlikely. Overhead applications are not allowed.
- Holes for the anchors shall be drilled (not cored), shall be blown clean with compressed air and shall be free of dust or standing water.
- The anchor type, size and embedment depth shall be as shown on the drawings and the anchor must be installed in accordance with the manufacturer's recommendations.
- The anchor must not be loaded until after the full curing period has elapsed.

e) **Pressure Grouting**

Prior to grouting, cracks and holes to be grouted shall be washed clean. Washing is not required for grouting soil voids. Once started, grouting shall be continuous until completed. In case of a mechanical failure or other stoppage of the work, the grout equipment shall be washed out sufficiently to ensure that fresh only grout is pumped when the work is restarted.

After grouting is completed, the Contractor shall remove the grouting plant and all related parts, equipment, and supplies from the site, including unused materials and waste.

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6.4 Field Quality Control

- The Testing Laboratory will Develop and utilize an effective method of field marking anchor and dowel test locations and results.
- Testing of grout mixes for conformance to manufacturer's specified strength: The independent testing laboratory shall take four test samples of each day's grout mix and test grout mix samples at 7 and 28 days. Test reports shall be submitted to the Owner for review.
- Test 25 % of reinforcing steel dowels installed with adhesive resin on a given day in tension using pullout procedure. Test to 80% of specified yield strength of the dowel with special inspection. Dowels specifically noted on the drawings as "No test required" do not require tension testing.
- If the failure rate of dowels exceeds 10 percent, testing will be increased to 100 percent of that day's installation of similar anchors or dowels. Testing will be reduced to 25 % of that day's installation when the failure rate is reduced to 10 percent or less. Failed dowels will be replaced at no additional cost to the Owner. The Contractor will produce daily reports of all testing activities; copies of daily reports will be submitted to the Owner in a timely manner.

6.5 Submittal

- Manufacturer's data shall be provided for bonding compounds, dry pack, non-shrink, pressure grout, retardants, epoxy grout, polymer concrete.
- Test reports, accompanied by a manufacturer's statement that previously tested material is of similar type, quality, and manufacture as that which is proposed for use on this projects, shall be submitted for Cement, Aggregates, Retardants, Bonding compounds and Epoxy resin
- The Contractor's testing laboratory shall provide evidence of correction of deficiencies noted in the inspection report before materials specified in this section are delivered to the job site.

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7 Retrofitting Works

7.1 General

- a) The Work shall, in general, conform to other works/items specified in this Specification.
 - If the specifications for any item are not available in in this Specification cited above, relevant BIS Specifications should be followed.
 - In case BIS Specifications are also not available, the decision of Engineer-in-Charge given in writing based on acceptable sound engineering practice and local usage shall be final and binding on the contractor.
- b) The work will be carried out in accordance with the architectural and structural drawings to be approved by Owner. The structural and architectural drawings shall have to be properly correlated before executing the work.
- c) For items where so desired, samples shall be prepared before starting the particular items of work for prior approval of the Owner and nothing extra shall be payable on this account.
- d) Materials brought at site of work shall not be used in the work before getting satisfactory Mandatory test results.
 - Equivalents for the various materials and the materials of approved make shall be got approved from the Owner in writing before using them on the work.
- e) The contractor shall submit the required documents regarding the genuineness of materials used such as manufacturer's certification that the firm has manufactured the supplied materials.
- f) The contractor shall get approved from the Owner the storage space for epoxy/polymer/patented/other manufacture of materials to ensure that the storage temperature is maintained between 5° C and 38° C unless recommended otherwise by the manufacturer.
- g) Contractor shall comply with manufacturer recommendations so as to comply with environmental conditions under which the repair materials may be applied.
- h) The contractor shall employ Principal Technical Representative & skilled site workers who shall have adequate qualifications and experience for the proper execution of such works and already performed works of this kind with success.
- i) Contractor shall advise all workers working with epoxies to avoid contact with eyes and skin, inhalation of vapours, and ingestion. Necessary protective and safety equipments in the form of hand gloves, welders' goggles, shall be provided by the contractor and used on site.

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- j) Care shall be taken to ensure that vibrations are well within acceptable limits for structural safety and users of the building.
- k) For the execution of protection and repair works, properly maintained plant and equipment permitting adequate treatment of the concrete substrate, proper execution of the work and determination of the required properties of the construction materials and construction measures must be present on the construction site.
- l) To ensure efficient and effective functioning, all plant and equipment must be checked on-site and at field material testing laboratory prior to first use and at appropriate intervals thereafter.

7.2 Chipping of Unsound/Weak Concrete Material

a) Purpose

To remove weak, loose or carbonated concrete over an area from its surface with pneumatically operated or power driven tools by chiselling, chipping etc.

b) Materials and Tools & Plants (T&P)

Power or pneumatically driven chisel, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator (0.2% phenolphthalein solution) with pH range at least up to 10.5 and clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support to relieve the structural member of stress and strains.

Step-2: Scaffolding, if necessary for the exterior members, shall be done for working upon the area.

Step-3: Working Platforms for interior members, if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if necessary.

Step-5: Mark off the area to be repaired using straight lines between corners. The marked area shall have 90° corners with the sides parallel or normal to the direction of the reinforcement. The marked boundaries for the repair area should be a minimum of 50 mm outside the perimeter of the spall. For a single spall, the repair area should have a minimum width of 100mm in any direction. If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair.

Step-6: Cut shall be made along the marked boundary, normal-to-the surface. It should be made with a diamond cutter blade. However, when diamond cutting is not practical, the normal cut can be made with a power driven chisel. Minimum

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depth of cut shall be 10 mm. In situations where the diamond saw could cut into the reinforcing steel due to inadequate concrete cover, the boundary edge should be formed manually by means of chisel and impact hammers. A cover meter could be used to estimate the depth of cover.

Step-7: Chipping to remove all the unsound and weak concrete material shall be done carefully from the damaged portions of structural members by adopting mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

e) **Tolerance**

The chipping tolerances shall be ± 5 mm.

f) **Chiselling**

Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer. Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm Mechanical Milling (single drum, rotary cutter head with Tungsten-carbide bits) is applicable for large areas where the concrete cover is to be removed. Care must be taken to avoid contact with the reinforcing steel as both the reinforcement and the cutter drum could be damaged. Rounded And Feathered Edges should be hand cut to form normal-to-the-surface boundaries. All the edges and cavities shall be square shouldered.

Step-8: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on concrete in contact and in the immediate vicinity of reinforcement soon after its chipping. As otherwise, chipped concrete surface in contact with air is likely to get carbonated soon after its coming in contact with atmospheric carbon dioxide.

Step-9: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, in case the concrete in contact and in immediate vicinity of the reinforcement is carbonated.

Step-10: Inspection and soundness testing, after concrete removal & cleaning, for weaknesses and delamination of exposed surfaces shall be visually carried out. If required, additional removal will be done.

Step-11: Cleaning of debris and dust shall be carried out from within the chiselled/ chipped area and its disposal as per direction of the Engineer-in-Charge.

7.3 Removing concrete all around reinforcement including from its behind

a) **Purpose**

To create an average clear air gap equal to nominal size of coarse aggregate plus 5 mm all around embedded reinforcement, in contact with carbonated

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concrete for rust removal & passivating its surface with fresh alkaline passivating coat and concrete/ mortar.

b) Materials and T&P

Power or pneumatically driven chiselling, abrading, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator i.e. 0.2% solution of phenolphthalein indicator for pH range preferably up to 11.5 or at least up to 10.5, clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support, if not done already, to relieve the structural member of stress and strains.

Step-2: Scaffolding & working platforms for the exterior members, if not already done and if necessary, shall be erected for working upon the area.

Step-3: Working Platforms for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if not already done and if necessary.

Step-5: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on freshly chipped concrete in contact and in the immediate vicinity of reinforcement.

Step-6: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, if the concrete in contact and in immediate vicinity of the reinforcement is carbonated. The concrete around reinforcement shall be removed so as to have a near uniform air gap of about 5 mm plus the nominal size of coarse aggregate to be used in repair concrete/mortar. However, the air gap shall not be less than 15 mm in any case. Power/pneumatic driven tools/chisels shall be used for such portions of carbonated concrete around reinforcement, which could not be removed manually, to achieve a near uniform required air gap all around including behind the reinforcement. Power Driven Chisels/Hammers are normally applicable for chiselling smaller depths up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger depth in excess of 50 mm.

Step-7: Cleaning of debris and dust shall be carried out from within the chiselled /chipped area and its disposal as per direction of the Engineer-in-Charge.

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7.4 Rust cleaning from reinforcement Steel

a) Materials and T&P

Chiselling, abrading, chipping, hammering, wire brushes, paint brush, abrading cloth, etc hand tools complete with accessories, tested and approved chemical rust remover.

b) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

c) Procedure

Step-1: Cleaning by manual method-

Remove the rust manually from all round the surface along the length of reinforcement, using hand tools like chisels, hammers, wire brushes, abrading cloth/paper, etc. This shall be continued manually along the length of the rusted reinforcement till such time that the steel surface is cleared of all rust that could be removed manually.

Step-2: Cleaning by chemicals –

Remove the Rust by using tested chemicals, if directed by Engineer-in-Charge, due to unsatisfactory results of manual rust removal. Chemical rust remover shall be brush applied over the reinforcement surface thoroughly all around the circumference and along the full length of rusted reinforcement. After 24 hours (or as prescribed by manufacturer) of its application, the surface shall be cleaned with wire brush and all loose particles removed. It shall be washed with water thoroughly and allowed to dry.

7.5 Cleaning Reinforcement and exposed concrete surface of loose and foreign material by means of sand blasting

a) Purpose

Clean the prepared concrete surface of all-loose, lightly sticking materials including the foreign materials, loose concrete, aggregates etc to provide a good bond with the applied repair material and clean the reinforcement surface of any minor rust remaining after manual and chemical cleaning to achieve shining bright metal.

b) Materials and T&P

Coarse sand conforming to Zone I or II as per IS: 383, Air compressor of a minimum 35 Kilowatt capacity, spray gun for sand, all related accessories for sand blasting, hand tools like wire brushes, chisels, etc

c) Testing of Materials and T&P

The sand shall be tested to conform to the specification.

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The air compressor shall be tested to perform to the required standards as laid down in specifications of shotcreting.

d) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

e) **Procedure**

Step-1: Specified tested coarse sand shall be collected at site in required quantity for sand blasting.

Step-2: Make available mechanical power driven air compressor in working condition at site with all required accessories for carrying out sand blasting as well as air blasting operations.

Step-3: Coarse sand shall be sprayed under pressure over the exposed surface so as remove all loose and foreign material and to cause an intense abrading of the reinforcement and removal of rust from entire surface of reinforcement to achieve shining bright surface. The sand blasted surface shall be subsequently cleaned with oil free air blast.

7.6 Providing drilling and inserting nipples along crack lines

a) **Purpose**

To fix injection nipples and seal the remaining portion of honey combed or cracked concrete /masonry for grout injection.

b) **Materials and T&P**

12 mm diameter approved PVC/aluminium /Galvanised Iron nipples, Chisel, hammer, power driven tool for chase cutting & drilling, hand operated blow out pump, sealing putty of polyester/epoxy/polymer modified mortar etc. and all related accessories and materials.

c) **Testing**

The sealing putty and the nipples shall be tested to conform to the manufacturers specifications. The power driven tools shall be test driven and their drill/cutting bits shall be tested for effectiveness before taking up the repair operation.

d) **Procedure**

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Personnel, Supervision, Product delivery, Storage and Handling etc.

Step-2: Identify the Cracks and mark the area for injection grouting.

Step-3: Prop & support the structural member, if required, to relieve it of stress and strains.

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Step-4: Open up cracked surface by making 'V' notch or groove of size 12 mm x 12mm.

Step-5: Remove plaster, if required, to identify and mark the honey combed area.

Step-6: Drill holes at least 25 mm diameter and 40mm deep along crack lines at spacing of 300 mm or thickness of the structural member, whichever is less. In honey combed area @ 9 nos per sqm. as directed by Engineer-in-Charge and up to 30 mm to 40 mm depth.

Step-7: Remove coarse debris and dust in opened up cracks and drilled holes by blowing oil free compressed air, if available with air compressor, otherwise with hand operated blow out pump. Concrete surfaces required to be grouted shall be free from all loose and unsound materials by means of mechanical abrasion using stiff wire brushes, after removing all loose areas with chisel and hammer. Area shall be made free from any deleterious materials, such as oil dust dirt etc. by means of oil free jet of compressed air. All prepared concrete surfaces shall be thoroughly inspected and got approved by the contractor.

Step-8: Insert 12mm dia specified injection nipples in holes drilled along crack lines and fix them by sealing only its sides with epoxy or polymer modified mortar.

Step-9: Seal the crack or the honey combed surface between the nipples by polymer modified mortar as may be approved by Engineer-in charge. The polymer used shall be of approved grade and applied as per specifications mentioned separately elsewhere. The polymer-modified mortar shall be moist cured for 1-3 days and allowed to gain strength before actual grouting commences.

7.7 Sealing of cracks by injection of advance grout

a) Purpose

To inject the specified grout into honeycombed or cracked concrete/ masonry

b) Materials and T&P:

Cement, sand. Water and admixture for cementitious grout shall be as per clause 5 of this specification.

Polymer: It shall be as specified and shall conform to ASTM-C-1059.

Hand/power operated grouting pressure pump/gun with pressure gauge. The grouting equipment shall be capable of supplying, mixing, stirring and pumping grout to the satisfaction of the Owner. The equipment shall have the capacity to inject grout at a pressure upto 7 kg per square centimeter measured at the grout connections. It shall be capable of mixing and pumping of cement sand grout 1:2 with water cement ratio ranging from 0.5 to 1.

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Air compressor with all related accessories for carrying compressed air to the required location. Hand operated blow out pump may be allowed by Owner for small crack depths/areas.

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing, Spray equipment/brush for application of polymer modified/ bonding cement slurry

c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured material (e.g. specified resin, hardener, polymer, cement, etc as may be required) shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: If directed by Owner, collect random samples of materials for test and send to approved laboratories so as to ensure that they satisfy the physical and mechanical properties. The grout pump and the pressure gauge shall be tested before taking up the repair operation.

Step-4: Identify the Cracks and mark the area for injection grouting.

Step-5: Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

- Prop & support the structural member to relieve it of stress and strains.
- Provide grouting nipples.

Step-6: Blow the compressed air followed by washing with water through nipples located at the highest level and downwards to ensure removal of even fine dust particles from the cracked surface, which could obstruct the free flow of grout material and impede its bonding with cracked surface (and drying with air blast wherever epoxy injection grout is to be used).

Step-7: Saturate the cracked surface in the vicinity of crack/honeycombed concrete/ masonry with water (but without excess water), only if the cementitious grout is to be injected. Otherwise, this step may be skipped.

Step-8: Prepare the injection grout as specified under clause 5 of this specification.

Step-9: Inject the approved & specified grout into the cracks by means of suitable gun or pump at a pressure of 1- 2 kg./cm² for epoxy grout and 4-7 kg./cm² for cementitious grout. In case of vertical cracks injection shall be started at the lowest nipple and continued until the injected grout begins to flow

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out at the next higher nipple. Whereas in other cases of horizontal locations, the injection shall be started from one nipple and continued until the injected grout begins to flow out at the other nipple.

The first nipple shall then be closed off and injection continued at the second until the grout flows out at the third. The process shall be repeated until the whole of the crack has been sealed. As soon as the system is cured, the nipples shall be cut.

In case of Honeycombed Area, each grout hole shall be grouted individually. Grouting pressures to be used in the work will vary with the conditions encountered and different areas and the pressure used shall be between 1 to 4 kg/cm². The sequence of injection shall be as per the direction of Engineer-in-Charge.

7.8 Providing and inserting shear key bars

a) Purpose

Shear key bars are used for providing a structural connection of the applied repair material with the substrate/parent surface for transfer of forces occurring at the interface.

b) Materials and T&P:

Epoxy cartridges and specified lengths and diameter of steel reinforcement.

Standard Power driven drilling/hammering equipment, Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

c) Procedure

Step 1: Mark the locations of shear keys and get the same approved for structural connection from the Owner.

Step 2: Drill holes to specified depth and diameter in concrete at marked locations for the specified dia of shear key bars.

Step 3: The drilled hole in dry state shall be cleaned with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump.

Step 4: Inject epoxy from the foil pack with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards.

Step 5: Insert the reinforcing bar and allow the epoxy adhesive to cure.

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7.9 Reinforcement for RCC works etc.

a) Purpose

To provide reinforcement in repair concrete for structural purposes, controlling effects of thermal variation or holding shotcrete/gunite material in position. The reinforcement material may comprise specified grade and quality with or without zinc coating.

b) Material & T&P:

Specified reinforcing material, necessary hand or power driven tools for cutting, bending, binding, transportation, handling and placement etc. Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

c) Procedure

The general requirements, placing in position, measurement etc. shall be generally followed as in clause 4 of this specifications excepting those specifications provided in the following clauses.

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Testing of Material: The requisite number of test specimens of specified reinforcing material shall be collected from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements before use on the work.

Step-3: Execution:

The required reinforcement as per approved detailed drawings in the form of round bars or welded wire fabric in such a way so as to cause the least interference with placement of repair material.

d) Overlaps:

Lapped reinforcing bars shall not be tied together. They shall be separated by at least 50 mm wherever possible. Wire mesh shall be lapped by 1-1/2 squares in all direction. Minimum requirement of lap length of bars shall be as specified in I.S. 456.

e) Clearance around reinforcement:

Sufficient clearance shall be provided around the existing exposed and additional reinforcement to permit complete encasement with sound repair material.

f) Cover:

Minimum cover to reinforcement shall be as specified under clause 4 or as per I.S. 456. As far as possible the bars shall be arranged so as to permit shooting from opposite side.

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g) **Fixing:**

Reinforcement shall be fixed to existing shear key bars and depth gauges driven into the concrete with wires and secured rigidly so that the vibration resulting from the deposition of repair material shall not impair or displace them.

h) **Where Gunite /shotcrete to be done in more than one layer**

In such cases, the additional reinforcement should be so fixed that it is encased in succeeding layer. No additional reinforcement is required to be fixed in first layer of gunite.

Mesh reinforcement shall be fixed in the manner so that it is firmly held at least 12 mm away from the parent concrete surface as well as from the final finished surface. It shall be ensured that it is stiffened enough and cannot belly out during the guniting / jacketing / concrete overlays with consequent lack of cover. It shall be done by tying with parent concrete surface through shear key bars or depth gauges. GI-wire mesh fabric will add sacrificial "Zinc" coating & shall reduce corrosion process in the reinforcement. The wire mesh spacing shall be as specified in the drawings.

7.10 Alkaline Passivating bond coat over Reinforcement

a) **Purpose**

To protect steel reinforcement with a passivating alkaline layer provided all around its circumference along the length with strong adhesive to bond with applied repair concrete or mortar.

b) **Materials and T&P:**

Specified alkaline passivating & bonding materials e.g. CPCC material, epoxy, epoxy phenolic IPN-RB or specified polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, mechanical mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882.

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

Patented materials e.g. CPCC or epoxy-phenolic IPN-RB as per licensee's specifications

c) **Execution:**

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Full quantity shall be worked out as theoretically required for consumption in the whole work.

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Step-3: Prepare the surface for treatment.

Step-4: Thoroughly inspect all the concrete surfaces prior to applications of passivating/ bond coat and get approved from the Engineer-in-Charge.

Step-5: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-6: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),

Mechanical blender for mixing

Brush for application of specified and approved passivating/bond coat.

Step-7: Material Mixing: Components of the passivating/ bond coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-8: Material Application: The alkaline passivating & bonding material shall be applied to prepared reinforcement substrate after tying in new reinforcement wherever specified in the form of bars or welded wire fabric. It shall be applied to reinforcement surfaces by stiff nylon bristle brush. The coating material shall be worked well all round the periphery and along its exposed length using a stiff brush ensuring that no pinholes are remaining. The second coat, if required, the same shall be applied as per manufacturer's recommendation after the first coat is touch dry.

7.11 Bonding coat for hardened concrete with repair concrete/shotcrete/cement mortar

a) Purpose

To provide adequately strong adhesion of parent concrete with applied repair concrete or mortar.

b) Materials and T&P

Specified bonding materials e.g. epoxy or polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, spray gun, mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

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c) Execution

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer- in-Charge Full quantity shall be worked out as theoretically required for consumption in the whole work

Step-3: Prepare the surface for treatment.

Step-4: Saturate the surface with water but shall be free of excess surface water, debris and dust, where cementitious bond coat is to be applied. Otherwise, surface to remain dry and clean of debris and dust.

Step-5: Thoroughly inspect all the concrete surfaces prior to applications of adhesive and get approved from the Engineer-in-Charge.

Step-6: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-7: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing Spray equipment, brush for application of epoxy, polymer modified, bonding cement slurry.

Step-8 Bond Coat Mixing: Components of the bonding coat mix shall be weighed batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-9 Bond coat application for jacket concrete/ shotcrete/ Mortar placement: The specified adhesive shall be applied to concrete surface at atmospheric temperatures below 40°C for epoxy adhesive and below 30°C for polymer modified cement or cement-sand slurry adhesive. Bonding coat shall be applied by spray equipment or stiff nylon bristle brush as approved by Engineer-in-Charge. The bonding material shall be worked well into the surface of the parent body ensuring that no pinholes are visible.

Polymer modified bonding cement slurry shall be applied to a thickness not in excess of 2 mm.

If necessary, a second coat shall be applied at right angles to the first to ensure complete coverage and absence of pin holes.

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All concrete surface shall be well protected beyond limits of surface receiving adhesive against spillage.

Step-10 Repair Material Application: Fresh plastic concrete/ shotcrete/ mortar shall be applied while adhesive is still tacky and well within the pot-life/ setting period. If adhesive cures to the extent of losing its tack or has set before plastic concrete/shotcrete/mortar is placed, the same shall be removed or slightly abraded and second coat of adhesive applied. Freshly placed plastic concrete shall be thoroughly consolidated to ensure full bonding of new concrete with the substrate.

d) Bond of repair with parent concrete:

Evaluate bonding of fresh concrete/ shotcrete/ mortar to existing concrete after the fresh material has cured for not less than 7 days by sounding and tapping fresh concrete with a blunt metal instrument to the satisfaction of Engineer-in-charge. Suspect inadequate bonding, if a hollow sound is detected in any area. In case of conflicted location contractor shall extract one core from the repaired surface area at the end of 28 days.

Conduct one core test at random for checking the bond, for every 100 square metre or part thereof. The contractor shall core each area after 28 days of application of concreting/ shotcreting/ repair mortar application for determination of bonding adequacy.

Core drilling shall be done through applied repair material and into the existing concrete. Core diameter shall be not less than three times the nominal size of the coarse aggregate used in repair material or as required by the Engineer-in-Charge. Length of cylindrical cores shall preferably be twice the core diameter or twice the thickness of applied repair material or as instructed by Engineer-in-Charge but in any case not less than the dia of the core.

Cores shall be visually inspected by Engineer-in-Charge for evidence of poor workmanship.

Cores shall be tested in tension to evaluate the quality of bond between new concrete/shotcrete/mortar and the parent concrete. If the failure is in the parent concrete the bond of new repair material shall be deemed to be satisfactory.

Failure at the bond line or in the repair material shall be concluded as lack of proper bond or inadequate strength of repair mortar

Dismantle such areas of work failed in bond or repair material and re-prepare the surface after chipping off new concrete/mortar work and abrading the epoxy/polymer/cement slurry interface. Nothing for testing concrete for bond between old and new concrete shall be paid separately.

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7.12 Curing of RCC Surfaces etc

a) Purpose

To ensure satisfactory hydration of cement by retaining or replenishing the mixing water lost due to natural drying and evaporation process for a specified period through exposed cementitious surfaces of the freshly placed cement mortar/ concrete.

b) General

Importance of wet curing to all items of work involving use of cement can not be over emphasised. Any surface experiencing discontinuity of dampness of surface with any patch having dried out during the specified period of curing, it shall be prominently marked with lime or other suitable prominent colour.

c) Materials and T&P:

Curing compound, brush or hand operated spraying gun and all other related accessories for application on Concrete/Plastered Surface.

d) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified manufactured material shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out theoretically for consumption in the whole work.

Step-3

- Moist Curing:

Cover all exposed surface of concrete, when the concrete begins to harden i.e. two to three hours after compaction with moist gunny bags or any other material approved by the Owner.

Keep the exposed surfaces continuously damp after its final setting (i.e. after a maximum of 8 hours of concreting) by ponding with a sheet of water or by covering with a layer of sacks, canvass, hessian or similar water absorbent materials constantly kept wet by water sprinkling for at least 7 days, where ordinary portland cement is used and 10 days, where portland pozzolana cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as per manufacturer's recommendations or as directed by the Owner.

- Using Curing compound:

Testing of Materials:

It must be ensured that curing compound should neither affect the strength nor the surface of concrete. It shall not leave any undesirable stains on surface to

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affect the bond of plaster or other finishes to be applied later. It should be soluble in water, so that it can be removed by splashing or washing with water without scrubbing the surface.

Test for Efficacy:

The testing of curing compounds shall be done from each lot of curing compound received at site by casting two sets of 15 cm cubes with each set having 6 cubes. One set shall be moist cured by covering with damp gunny bags and subsequently by immersing under water and the other set by applying curing compound on top after 2 to 3 hours of casting and subsequently on de-moulding apply on the remaining faces all around. The cubes shall be kept in an environment similar to which the actual structure is exposed for a period of 7 days after its casting. Three concrete cubes each from both sets shall be tested after 7 days for their crushing strength as per standard test procedure. The average crushing strength of cubes cured with curing compound shall be not less than 95% of the crushing strength of cubes cured under damp or immersion curing.

Test for Staining:

The set of three sample cubes applied with curing compound, remaining after 7-day cube crushing strength test, shall be washed with water with soft brush scrubbing with nylon bristles and allowed to dry for a period of seven days in an atmosphere with relative humidity not exceeding 40% at ambient temperature. The other set of three cubes cured for seven days under damp or immersion conditions shall also be kept for another seven days under identical humidity and temperature conditions. The surface of the two sets of such cubes shall be compared by closely observing for any visible stain and texture that may detrimentally affect its bond with subsequently applied plain plaster or aesthetic appearance. Such observations shall be recorded in three categories as no effect, slight effect and moderate effect. The curing compound shall be considered as acceptable in the 'no effect' category and unacceptable in the 'moderate' category. The decision of Engineer-in-Charge, which shall be final and binding, based on the likely use of finished surface of concrete/plaster shall determine the acceptability of the 'slight effect' category.

Concrete curing compounds, after testing satisfactorily for efficacy, may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing within two to three hours of casting and well within an hour of removal of formwork.

7.13 Engineered Steel Tubular double Scaffolding System

a) Purpose

To provide a scaffolding system with adjustable working platforms on the exterior of the building for the workmen to work upon any part of the area to be

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accessed safely and with ease for surface preparation, application of repairs and construction activity.

b) **Materials**

The standard proprietary tubular double scaffolding system of repute with all accessories, working platforms etc.

c) **Design**

It shall be designed for all the incidental dead, live and wind loads as per IS: 875 in steel tubular sections as per general design considerations governed by IS:800. The design of the scaffolding system shall cater to the safety features for the workmen.

d) **Fabrication and Erection**

Fabrication and erection shall be done as per the design brief and installation instructions of the proprietary firm. It shall be maintained in functional condition for the work duration.

7.14 Temporary barricading using angle iron verticals and sheet panels

a) **Purpose**

To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work.

b) **Materials**

Available Corrugated G.I. Sheet minimum 24 G thick; Framing structural material at least MS Angle iron of size [40x40x5mm] or equivalent.

c) **Fabrication & Erection**

Size of framing panel shall be decided depending upon site conditions and these could be approximately 2.0 metres long with height as 1.8 metre.

It shall be made up at least of two verticals, each with additional length of about 600 mm for fixing in to ground firmly and two horizontals equal to the length of panel.

It shall be made up by cutting the structural sections to size, shear punching holes in verticals and horizontals for nuts and bolts or making other suitable provision for receiving CGI sheet or other specified panelling material and connection of panel with adjoining panels.

Fabrication of frame of an individual panel shall be by welding at corners, welding MS plate at base of verticals or any other acceptable practice approved by Engineer-in-charge.

G. I sheet or other specified panelling material shall be suitably fixed. It shall preferably be done by means of nuts and bolts at its ends spaced at about 300

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mm c/c transversely and at about 600 c/c longitudinally along corrugations. The corrugations of CGI sheet shall run along the shorter span of the panel.

In case of newly fabricated panels, these shall be painted with red oxide zinc chromate primer on steel work and approved primer on other material and at least one coat of paint of approved shade. In case of used panels, one coat of paint of approved shade shall be applied over the existing paint. The portion of verticals to be embedded in ground shall be suitably protected against rusting by painting it with bitumen or other suitable paint.

The fabricated panels shall be suitably fixed vertically and firmly in to the ground to the satisfaction of Engineer-in charge by maintaining a uniform height of about 1.8 metres above GL and connecting each panel with the adjoining panels with nut and bolts or other suitable means.

Suitable provision of frame/posts in the openings provided in barricading shall be made for receiving door shutter at locations as approved by Engineer-in-Charge.

7.15 Temporary protective fabric screens

a) Purpose

To protect passersby from falling debris and also to protect the workmen and structure being repaired against direct exposure to sun.

b) Materials:

For screening purpose jute cloth, woven PVC cloth, geo-textile or wire-mesh as specified and approved by Engineer-in-Charge shall be used, which shall conform to their relevant BIS Code. Screen materials shall be fixed by suitable means comprising of M.S.Flats/ J-bolts /nails/clamps, etc with washer or any other suitable means on frames of existing scaffolding etc.

c) Procedure

Scaffolding, if required, comprising of verticals, horizontals and diagonal bracings of steel tubes shall be fixed over ground which is payable separately.

One end of the screening material, brought to site in looms/rolls, shall be properly fixed over top horizontal member with suitable means and suspended so as to cover the required area.

The vertical fall of screen shall be suitably fixed/firmed up at intermediate levels so as to keep it in position during the work duration.

Next strip of the screening material shall be fixed with its sides stitched or suitably jointed or lapped with the previous ones as approved by Engineer-in-charge.

Spacing of frame member of scaffolding shall be so selected that the sagging of screen shall not hinder the repair process.

The contractor shall maintain the protective screens in acceptable conditions for the entire work duration as required by the Owner.

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8 CONCRETE RETROFITTING METHODS

In selecting the retrofitting method, the current status of the existing concrete structure as determined through inspection, the performance of the structure, the performance required of the structure after retrofitting, the conditions for retrofitting construction work, the ease of maintenance, economy and other factors shall be considered.

At the stage of selecting the retrofitting method, the current status of the existing structure and its performance shall be obtained, and the performance required for the structure after retrofitting and the conditions for retrofitting work shall be determined. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors.

Various retrofitting methods listed below shall be used for retrofitting objective:

8.1 Retrofitting of concrete members

a) **Continuous fiber reinforced plate bonding construction method:**

Bonding continuous fiber reinforced plates to the surface of the existing structure to restore or improve load-carrying capacity

b) **Continuous fiber reinforced plate jacketing construction method:**

Jacketing with continuous fiber reinforced plates around the periphery of the existing structure to restore or improve load-carrying capacity and deformation characteristics

c) **Prestressed concrete jacketing construction method:**

Placing pre-stressing wires and pre-stressing stranded steel wires in place of lateral ties around the periphery of existing member sections and using mortar and concrete to bond them in order to reinforce the structure. To increase the restraining effect of the inner concrete, the pre-stressing steel is generally stressed during placement.

d) **Pre-stressing introduction (internal cable) construction method:**

Using internal cables for the existing concrete members to provide pre-stressing and restore or improve the load-carrying capacity of the members.

e) **Repaving method:**

Replacing some or all of the existing concrete members with new members through the use of precast members or concreting on site to restore or improve load-carrying capacity.

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8.2 Retrofitting as a structural body

a) Beam (girder) addition method:

Adding beams between the main girders of the existing reinforced concrete deck to reduce the deck span and restore or improve the load-carrying capacity of the reinforced concrete deck.

b) Seismic wall addition method:

Placing new reinforced concrete walls between existing reinforced concrete rigid-frame bridge piers and bonding them to form a continuous unit in order to restore or improve the load-carrying capacity as a structural body.

c) Support point addition method:

Supporting the intermediate sections of the beams and other existing concrete members with new members to reduce the span of the members in order to restore or improve the load-carrying capacity as a structure.

d) Seismic isolation method:

Using seismic isolation bearings and the like to reduce the seismic energy applied to the structure in order to improve its various performance values during an earthquake.

8.3 Foundation retrofitting

a) Underground wall (beam) addition method:

Connecting the foundations with cast-in-site diaphragm walls and underground connecting beams to distribute stress and ensure the stability of the entire system.

b) Pile/footing addition construction method:

When pile foundations are damaged or there is residual displacement, adding piles or footings to increase the load-carrying capacity of the foundation.

c) Foundation improvement method:

Improving the ground around the foundation with cement improvement materials to improve the ground bearing capacity and horizontal foundation resistance. Also prevents excessive pore water pressure and liquefaction.

d) Steel sheet-pile coffering construction method:

Placing sheet-piles around the periphery of the footings and bonding them to the footings to improve bearing capacity and horizontal resistance.

e) Foundation compacting method:

When insufficient foundation bearing capacity is a concern due to scouring or the like, using concrete or the like to compact the ground around the foundation in order to restore bearing capacity.

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8.4 Repair of cracks and missing sections

a) **Cracks fill method:**

Forcing low viscosity resin and ultra-fine cement into the cracks in existing concrete members to seal the cracks.

b) **Fill method:**

Filling cracks, rock pockets, cavities, peeling and other small-scale missing sections in existing concrete members with resin and mortar to repair sections.

c) **Section repair method:**

Removing deteriorated or damaged portions of existing concrete members and then restoring these members to their original sectional status using materials with excellent bonding to existing concrete.

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9 SHORING AND UNDERPINNING

9.1 Material and Equipment

- a) The contractor shall furnish all materials, tools, equipment, facilities and services as required for providing the necessary shoring and underpinning work and facilities. Jack and jacking equipment shall be more than adequate for the imposed loads and shall be provided with calibrated gauges.
- b) Shoring and bracing materials
Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles, and accessories as required.
- c) Lagging and sheeting material
Provide heavy timber boards, planking or sheeting as required. Lagging board shall be secured in place by steel H-piles, with boards inserted between the H-flanges.
- d) Underpinning Pier
An excavation pit, provided generally by manual excavation, which is carried to a pre-selected bearing surface and then filled with concrete to provide supplementary foundation support for the underpinning structure.
- e) Concrete
Refer clause 4 of this specification for concrete requirements.
- f) Grout
Refer to Clause 5 of this specification for Non-Shrink Grout requirements.
- g) Structural Steel
Refer to Clause 9 of this specification for Structural steel requirements

9.2 Execution

- a) Detection of Movement
 - For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding improvements to be monitored. Settlement markers shall be capable of being read to an accuracy of 1.52mm.
 - Take and record readings not less than once per week during performance of the work until the permanent structures is complete to the ground level.
 - Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.

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- Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks or longer if movement persists, and report the results to the Engineer.
- The detection of movement shall be performed by a qualified licensed land surveyor or civil engineer.

9.3 Shoring and Underpinning

- Existing footings, foundations, pile caps, grade beams, retaining walls, or pavement which may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement.
- Provide soldier piling, lagging and sheeting, tie-backs, slurry diaphragm wall, and cementitious grouting, as required, to hold back earth at excavations and as required to prevent cave-ins and earth sloughs.
- Footings, foundations, pile caps, grade beams, retaining walls, or pavements which have been undermined by earthwork and pile-driving operations shall be filled and supported with concrete extended to undisturbed bearing earth or bedrock.
- Concrete may be placed as a stiff mix of minimum slump (dry pack), or concrete may be pneumatically placed (shotcrete), or concrete may be placed by conventional methods with concrete formed to hold it in proper position.

9.4 Concrete Piers, Walls and Pile caps

- Install concrete underpinning piers, walls, and pile caps as indicated, with the bottom at the indicated or bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed.
- Where earth forms are indicated, install waterproof building paper or board between the earth and concrete to prevent water loss from the fresh concrete.
- Do not remove support of existing structure until concrete piers, walls, or pile caps have attained design strength.

9.5 Piles and Caissons

- Install pipe pile shells or drilled shafts at locations indicated, and extend from underside of existing footings to indicated elevations, plus additional penetration if required to develop the design working load of the pile or caisson.
- Distribute jacking reactions over the existing structure in a manner that will not overstress or deflect the existing structure.

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- Weld splices where indicated. Provide watertight welds capable of developing the full strength of the pile or caisson. Align splices to ensure the straightness of the pile from top to tip. Use outside sleeves and backup rings as necessary.
- Where the pile tip is below the ground-water table, maintain the elevation of the water inside the shell at approximately the elevation of the ground-water table during installation of the shell.
- After installation of the shell, apply the full design-working load to the empty pile shell and maintain until there is no measurable settlement over a one hour period.
- Maintain the excavation within the pile shell approximately 12 inches above the tip during driving, and dewater pile shells prior to filling with concrete in a manner which will prevent loss of earth or soil at the tip. An earth plug may be left in the pile tip or a concrete plug may be placed and cured prior to dewatering pile shells.
- After load testing to the design load, dewatering, and inspection of the shell by the Engineer, fill accepted pile shells with concrete in the presence of the Engineer. Keep an accurate record of the volume of concrete deposited in each pile. Deficiencies revealed by comparing the volume of the inside of the pile with the volume of placed concrete will be cause for rejection of the pile or correction of the deficiency.
- Securely wedge in place with steel wedges those piles that have satisfied the load-testing requirements. Weld and encase in concrete all wedges, plates, wedging struts and piles, as indicated or required.
- Following completion of load transfer of underpinned structures, fill the underpinning pits with concrete as indicated. Provide reinforcement, shear keys, dowels, and water stops as indicated or required. Place concrete to within 3 inches of the underside of the existing foundation. After three days, dry pack the space between the foundation and concrete.

9.6 Load testing of piles and acceptance criteria

- After the concrete within the pile or shaft has set for at least 24 hours, test each pile or pier by jacking to a load equal to 150 percent of the design-working load of the pile. Maintain the load until there is no measurable settlement of the pile over a one-hour period.
- Load-test piles in sequences and groupings that will minimize or eliminate eccentric loadings on the existing foundation and piles.
- Piles will be rejected and shall be retested if, in the opinion of the Engineer, there is a danger of unequal loading.
- Should the existing structure fail to furnish sufficient reaction to installed underpinning piles to the test loads specified, provide additional reaction to prevent damage to, and movement of, the structure during installation of

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piles, and to obtain specified underpinning test loads. The additional reaction shall not detrimentally affect the structure.

- Maximum out-of-plumb tolerance for installed piles: two percent.
- Maximum offset of top of pile from the design center: 3 inches.

9.7 Fill and backfill

Provide engineered fill and backfill in accordance with Clause 3 of this specification, after acceptance of the underpinning by the Owner.

9.8 Temporary Supports

Install temporary supports where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work.

9.9 Restoration

Restore existing structures to conditions equivalent to those existing prior to the start of shoring and underpinning work, including repair of any settlement-related damage.

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10 STRUCTURAL STEEL WORK

Design of structural steel work shall include generally but not be limited to the steel constructions listed below:

- Steel building structure and open structures including beams, columns, bracings, supporting structures for floors, roof slabs, cladding etc.
- Hoist & monorail supporting beams etc.
- Platforms and walkways
- Ladders, staircases, handrails, etc.

10.1 Design

(a) General

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However where large cut outs are to be provided in the floor slabs horizontal floor bracing shall be provided. Grating / Chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support and horizontal bracing shall be provided as required in such cases.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimize vibration, avoid resonance and maintain alignment and level.

(b) Design of structure

The Design of steel structures shall be done by Working stress or Limit state method, in accordance with the provisions of IS: 800 and other relevant IS codes as applicable to specific structures. Basic consideration for structural framing shall be stability, rigidity, building usage, ease of fabrication / erection and overall economy. Additional bracings / moment connections shall be used to assure stability of structures. Structure shall be designed such that the surfaces of all parts shall be accessible for inspection, cleaning, painting and maintenance. Most of steel superstructure shall be designed as simple space frame structures. Simple space frame design utilizes single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Large span built-up girders shall be single web plate girders of welded construction with bearing and intermediate stiffeners. For lifting / monorails beams ISMB sections shall be preferred and the bottom flange of all beams shall be checked separately for distortion and reinforced suitably if required.

Columns shall be designed to support the load combination which results in maximum interaction ratio. Exterior columns shall be designed to resist moments

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due to wind & seismic. Columns shall also be designed to resist moments caused by discontinuous vertical bracing or non-concentric bracing work points. Column base can be fixed or pinned. Lateral forces shall be resisted by rigid jointed moment connections in rigid frame design. For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension, etc.) use 90 % of the column dead load and no live load. Uplift forces from vertical bracing and Wind uplift on the roof shall be included where applicable.

Permissible stresses for different members shall not be allowed to exceed by 33.33 % under wind and seismic conditions. However, members who shall be designed primarily to resist wind load such as bracing members, no increase in permissible stresses will be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. All anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself. No anchor pockets in foundation shall be allowed. Design of base plates shall be based on design pressure on foundation which shall not exceed the following:

Pedestal in concrete grade M30 7.50 N/mm²

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A coefficient of friction of 0.30 shall be used in conjunction with the minimum column load. If the horizontal shear force exceeds the frictional resistance force or if the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Anchor bolts are not assumed to resist any horizontal shear force. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Static analysis of overhead conveyor galleries upto a span of 24 m is allowed. However dynamic analysis shall be carried out for overhead conveyor galleries exceeding 24 m span.

For equipments, the bolt shall be either embedded or placed inside the pedestal and grouted with non-shrink grout.

The following criteria shall be followed for posting loads on the design drawings. For vertical beam reactions, the load shall be posted whenever the value exceeds the maximum allowable uniform distributed load. For axial loads in floor beams, the actual horizontal load which the beam end connection must resist shall be posted for each end of the beam. Note that this value may be different for opposite end of the same beam. For truss members, only one member force shall be noted for each member.

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(c) Permissible deflections

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

• **Vertical deflection**

a) For beams supporting dynamic equipment	Span / 500
b) For beams supporting floors / masonry	Span / 325
c) For beams supporting pipes (pipe racks)	Span / 400
d) For roofing and cladding components	Span / 250
e) For gratings and chequered plates	Span / 200 subject to a maximum of 6 mm

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

For manually operated cranes and monorails : Span / 500

For electric overhead cranes

- i) Up to 50 t capacity : Span / 750
- ii) Over 50 t capacity : Span / 1000

• **Horizontal deflections**

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	Height / 325
b)	Multistoried building (without crane load)	Height / 500
c)	Pipe rack columns	Height / 200
d)	Open Structures	Height / 200
e)	Crane gantry girder due to surge	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail due to action of crane surge load only	Height / 2500 limited to level maximum of 10 mm
g)	Open gantry columns at crane rail level due to action of crane surge load only	Height / 4000 limited to maximum of 10 mm

Provisions of IS: 800 and relevant latest IS Codes shall be followed for limiting deflections of structural elements not listed above.

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(d) Minimum thickness and size of steel elements

• **Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgement in each instance.

Trusses, purlins, girts and bracing	6 mm
Columns and beams	8 mm
Gussets	8 mm
Stiffeners	8 mm
Base plate	10 mm
Chequered plates	6 mm o/p
Grating flats	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc shall be 6 mm.

• **Minimum Sizes**

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

(e) Slenderness and depth ratios

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

Truss	1 / 10
Rolled beams and girders for Ordinary floors and rafters	1 / 24
Supporting floor beams for vibrating Machines / equipments	1 / 15
Roof purlins and girts	1 / 45

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(f) Design of Connections

Welding will be done in accordance with the recommendations of IS: 816 and IS: 9595.

Shear connections will be designed for 75 % of section strength for rolled sections and 80 % of section strength for built up section or rolled section with cover plates. Designed shear force shall be more than actual shear. Moment connections between beam and column will be designed for 100 % of moment capacity of the beam section.

All butt welds will be full penetration butt welds.

Size of fillet weld for flange to web connection for built up section will be as follows:

- i) Able to take full shear capacity or actual shear whichever is more for box section
- ii) Able to take 80 % of full shear capacity or actual shear (if indicated in drawings) or shall be 0.5 times of the web thickness whichever is more. For I-section Weld will be double fillet
- iii) All welds will be continuous. The minimum size of the fillet weld will be 6 mm as per relevant IS code

Connection of vertical bracings with connecting members will be designed for full tensile capacity of the bracings. The connection between top flange & web of built-up girder will be full penetration butt weld & for bottom flange, connection may be fillet weld.

Connection of base plate & gusset members with the columns will be done considering that total load gets transferred through weld.

Splicing

All splicing work will be full strength. Field splicing will be done with web / flange cover plates. For, exceptional cases the field splicing will be designed for 50 % of load carried by the cover plates and remaining 50 % load through full penetration butt weld. Shop splicing for all sections other than rolled will be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections will be carried out using web and flange cover plate. For design efficiency of site weld shall be considered as 80 %.

Insert plates

Insert plates shall be designed / checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall also be checked. Lugs using steel bars shall preferably be fillet welded to the plate to transfer full strength of the lug.

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10.2 Fabrication

(a) General

Fabrication drawings shall be prepared according to the provision of IS: 800, IS: 813, IS: 816, IS: 9595, IS: 1367 and IS: 9178.

The work to be provided by the Bidder, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following:

- i) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on design drawings submitted by the Bidder and approved by the Owner/Consultant.
- ii) To submit revised design with calculations and detailed fabrication (drawings in case any substitution of the designed sections are to be made.
- iii) To submit design calculations for joints and connections developed by the Bidder along with detailed fabrication drawings.
- iv) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding \ electrodes for field connections. The field connection materials supplied by the Bidder shall be to the extent of actual requirement plus 10 % (ten percent).
- v) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- vi) Suitably mark, bundle and pack for transport all fabricated materials.
- vii) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

(b) Conformity with Design

Except where the standard connection details are furnished, the Bidder shall design all connections, supply and fabricate all steelwork and furnish all connection materials, Shear connectors / shear lugs on the beams in accordance with the approved drawings and / or as instructed by the Owner/Consultant Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and / or as approved by the Owner/Consultant. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

(c) Quality control

The Bidder shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all

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work shall be performed in accordance with this specification. In addition to the Bidder's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Owner/Consultant. As far as possible, all inspection by the Owner/Consultant shall be made at the Bidder's fabrication shop whether located at Site or elsewhere. The Bidder shall co-operate with the Owner/Consultant in permitting access for inspection to all places where work shall be done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Bidder.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

- a) Steel Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
- b) Bolts, Nuts Manufacturer's certificate, dimension & Washers checks, material testing.
- c) Electrodes Manufacturer's certificate, thickness and quality of flux coating.
- d) Welders .Qualifying Tests
- e) Welding sets Performance Tests
- f) Welds Inspection, X-ray, Ultrasonic tests
- g) Paints Manufacturer's certificate, physical Inspection reports
- h) Galvanizing Tests in accordance with IS: 2633 and IS: 4759.

(d) Materials

If desired by the Owner/Consultant, Test Certificates of materials supplied by the Bidder in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Owner/Consultant, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

Materials for main and secondary members shall be selected in line with good engineering practice and shall be arranged within any structure with due regard for maintenance of the structure and Plant and Equipment supported or sheltered by the Structure and also with regard to corrosion.

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pitting, rusts, etc. that may impair their strength, durability and appearance.

All rolled steel shall conform to the requirements of the Indian Standards.

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- i) Structural Steel will conform to IS: 2062 Grade-A for rolled steel members or plates up to 20 mm thickness.
- ii) For plates above 20 mm thickness and welded construction, steel conforming to IS: 2062 Grade-B will be used.

(e) Workmanship

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of IS: 800 and other relevant Indian Standards or equivalent.

Straightening Material

Rollled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed as per IS:1852. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

Cutting

Cutting shall be affected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Owner/Consultant.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

Planning of Edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Owner/Consultant.

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Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end, but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

Bolted construction

All bolts and nuts shall conform to the requirements of IS: 1367.

Field connections shall preferably be bolted connections unless specified otherwise. Weld connections at site shall be avoided.

High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter unless designated otherwise. High strength bolts shall be installed as bearing type joint except where loads are reversible. Bearing Type connection (H.T. bolts Grade 8.8) shall be used for all removable type connections. Bolts will be tightened to develop the required pre-tension during their installation.

All erection bolts shall be of minimum 16 mm diameter of property class 4.6 conforming to IS: 1367 unless specified otherwise.

Holes for bolts shall not be more than 1.5 mm for bolt of diameter equal or lesser than 25 mm and shall not be more than 2 mm for bolt of diameter greater than 25 mm.

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

Assembly

Drifting to enlarge un-matching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the

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metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted nor damaged and shall be so prepared that the specified cambers, if any, are maintained.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Owner/Consultant.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or locknut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

Welded Construction

Welding shall be in accordance with relevant Indian Standards. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817. All shop connections shall be welded type.

Preparation of Material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears, Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than 20C.

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

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In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Owner/Consultant, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Consultant.

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding shall be started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

No welding shall normally be done on parent material at a temperature below (-) 50C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 50C and 00C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 200C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

Submerged arc welding process shall be used for welding longitudinal fillet welds (connecting flanges with web) and longitudinal / transverse butt joints for fabrication of columns, framing beams and all other built up members unless manual arc welding is specifically required. All electrodes, flux, bare wire etc will

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be procured from approved manufacturers. All butt welds in beams, girders & columns will be of full penetration. All butt welds will be radio-graphically or ultrasonically tested as per relevant IS codes and standard practice. The base wire electrodes for submerged arc welding will conform to IS: 7280. The combination of wire and flux will satisfy requirements of IS: 3613.

Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the Owner/Consultant.

Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-buttressed over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2 mm.

Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

Miscellaneous

- Lacing bars

The ends of lacing bars shall be neat and free from burrs.

- Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

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- **Bearing Plates**

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

- **Architectural Clearances**

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

- **Shop Connections**

- All shop connections shall be welded as specified on the Drawings.
- Certain connections, specified to be shop connections, may be changed to field connections if desired by the Owner/Consultant for convenience of erection and the Bidder will have to make the desired changes at no extra cost to the Owner.

- **Shop Erection**

The steelwork shall be temporarily shop-erected complete or as directed by the Owner/Consultant so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

(f) Shop Painting

All fabricated steel material, except those galvanized or to be embedded in concrete, shall receive paint coatings as specified below. All paints shall be of approved brand and shade as per the Owner's requirement.

Steel surface, which is to paint, shall thoroughly be cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by wire brush & if required by sand blasting prior to actual surface preparation. The surface shall be cleaned to grade ST-2.5 as per SIS05-5900 or as per IS: 1477 (Part -I).

All steel structures shall receive two primer coats and two finish coats of painting. After fabrication the first coat of primer shall be immediately given over the prepared steel surface. The second coat of primer shall be applied over the dried first primer coat. Two finish coats shall be applied over the primer coats before dispatch of structure at site.

Primer paint shall be red oxide zinc chromate conforming to IS: 2074. Dry film thickness of each coat shall be 50 microns. Adequate care should be taken such that the surface does not possess a slick finish to which paint may not adhere properly. Top coat shall consist of two coats of HB Synthetic enamel of approved shade and colour with glossy finish and DFT as 75 microns (total). Thus the total DFT of painting including that of primer coats shall not be less than 175 microns.

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Following care shall be taken while painting:

- i) Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.
- ii) Surfaces inaccessible after assembly shall receive two coats of primer prior to assembling.
- iii) Surfaces inaccessible after erection, including top surfaces of floor beams supporting gratings or chequered plate, shall receive one additional coat of finish paint over and above number of coats specified above before erection.
- iv) Portion of steel member embedded / to be encased in concrete shall not be painted.
- v) Areas / Surfaces subjected to chemical attacks shall be painted with acid resistant paint.
- vi) Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

(g) Inspection, testing and acceptance criteria

Unless specified otherwise, inspection to all work shall be made by the Owner/Consultant at the place of manufacture prior to delivery. The Owner / Consultant shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification. The Bidder shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Owner/Consultant to carry out inspection and / or tests in accordance with the Contract.

The Bidder shall guarantee compliance with the provisions of this Specification.

The Bidder shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Bidder shall get the specimens tested in a laboratory approved by the Owner/Consultant and submit to the Owner/Consultant the test results in triplicate within 3 (three) days after completion of the test.

Steel

All steel supplied by the Bidder shall conform to the relevant Indian Standards, except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to

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be used by the Owner/Consultant, random samples of materials will be taken from each unidentified lot of 50 ton or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be borne by the Bidder.

All material shall be free from all imperfections like mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

All raw steel plate of thickness more than 20 mm supplied by the Bidder shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Owner/Consultant:

- i) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.
- ii) If the results of the tests in (i) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (i) or as directed by the Owner/Consultant.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Owner/Consultant requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Bidder. If the plates in the fabricated item are found to be laminated, the component will be rejected.

Welding

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Owner may ask for at least one test-destructive or non-destructive including X-ray, ultrasonic test or similar, the cost of which shall be borne by the Bidder. In the event of further tests as may be desired by the Owner. The cost of such test shall be borne by the Bidder if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Owner / Consultant shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

Bolts, nuts and washers

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Owner/Consultant and shall conform to the relevant Indian Standards. If desired by the Owner/Consultant, representative samples of these materials may have

- i) Name of the Bidder

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- ii) Number and date of the Contract
- iii) Name of the office placing the contract
- iv) Nomenclature of stores
- v) A schedule of parts or pieces, giving the parts or piece number with
- vi) Tolerance

The tolerance on the dimension of the individual rolled steel components shall be as specified in IS: 1852. The tolerances on straightness, length etc. of various fabricated components (such as beams, girders, columns, etc) of the steel structures (other than steel railway and road bridges structure) subjected to dynamic loading (like wind, seismic etc.) and thin walled constructions (like box girders) shall be as specified in IS: 7215.

10.3 Erection

(a) General

The work to be provided for by the Bidder, unless otherwise specified in the Bid, shall include but not be limited to the following:

- i) The Bidder shall provide all transport equipment, lifting equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- ii) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Bidder shall pay all demurrage and / or wharfage charges etc. on account of default on his part.
- iii) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the Owner/Consultant. If necessary, suitable temporary approach roads to be built for transportation of fabricated steel structures.
- iv) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Owner/Consultant. The Bidder shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- v) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Owner/Consultant.
- vi) Touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Bidder free of cost to the Owner.

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vii) All minor modifications of the fabricated steel structures as directed by the Owner/Consultant including but not limited to the following:

- Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
- Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
- Reaming of holes for use of higher size bolt if required.
- Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Owner/Consultant.
- Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
- Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
- Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
- Carry out tests in accordance with this Specification if directed.

(b) Conformity with design

The Bidder will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and / or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and / or the instructions of the Owner/Consultant. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and / or the instructions of the Owner/Consultant.

(c) Storage of materials

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site.

(d) Yard

The Bidder will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access, trailers and other heavy equipments. The yard shall be fenced all round with security / arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access, trailers and

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other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

The Bidder should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. All of which shall be carried out by the Bidder at his own cost as directed by the Owner.

(e) Covered Store

All field connection materials, paints, etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Bidder.

(f) Workmanship

Erection Plant and equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Owner/Consultant.

Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Owner/Consultant. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

Temporary bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure Installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Bidder in respect of temporary bracings and guys shall cease when the structural steel is once located plumbed levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Owner/Consultant.

The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Bidder to take out the materials from 'the

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project site. The Owner may remove and return the materials in good condition to the Bidder without any charge if they have been left in place under other agreed arrangement.

Temporary floors for buildings

It shall be the responsibility of the Bidder to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and / or by-laws of state, Municipal or other local authorities.

Setting out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Owner/Consultant. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Bidder shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations.

He shall remain responsible for correct positioning. For heavy columns, etc. the Bidder shall set proper screed bars if desired by the Owner/Consultant, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

Drifting

Correction of minor misfits of bolts will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

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11 ARCHITECTURAL WORKS

The architectural design concept of buildings shall be evolved considering the functional, technical and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes. To achieve above objective Bidder shall employ a qualified architect / architectural firm to carry out all designs and hold all other architectural responsibilities for the project.

The Bidder shall obtain and be conversant with all laws, by-laws and regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The Bidder shall provide the drawings and documents for such statutory approvals.

11.1 General

The architectural services shall cover finishing work of new buildings and modernised existing buildings/structures, included under the specification starting from masonry work, partition walls, cladding walls, roof protection, finishing of walls, floors and ceilings, false ceiling as required potable water system, sanitation etc.

During execution of the contract, the Bidder shall take approval from the Owner, for all building materials and finish items (e.g. floor tiles, doors, and windows, paints etc.) to be used for the contract by submitting samples and/or product literature as appropriate.

Finishing works including material used for renovation/modernisation work shall be matched with the finishing of existing structures to make similarity in architectural view of new and existing structures.

11.2 Finishes

All exposed surfaces shall be clean and smooth and members shall be sized to give a pleasing appearance. The Finishes for all Structures and Buildings shall meet the functional requirements and shall be as per the approved Finishing Schedule. However, the finishing schedule shall be pre-approved by the Owner/Consultant.

11.3 Design Requirements

(a) Architectural Concepts

- All buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to all

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buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

- Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipments, exposed structural elements, piping, trestles, bus ducts and other service elements.
- Overall emphasis shall be on developing an eco-friendly architecture, merging with the nature with its own sustainable energy management systems.
- The scheme shall be conceptually finalized in totality including that of equipments so that the proper co-ordination with other agencies can be taken up at appropriate time.

(b) Architectural Design

- Natural light shall be used to the maximum extent. For adequate light and ventilation, National Building Code recommendation shall be followed.
- Entrance canopies, chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.
- All the buildings shall be architecturally designed to meet the National Building Code.
- Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect Statutory requirement and any clearances from local authority may be required to be met with, wherever essential. The Architect Consultant shall be of national - International repute having experience in similar kind of works. The consultant shall evolve the design philosophy and shall present it in the form of presentation drawings, prospective views, 3-D Models & detail drawings.
- A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving plant technology and architectural & civil engineering for a smooth control hierarchy and man machine interface.

The Bidder shall develop the architectural layout of all the buildings listed in this document as per the final approved equipment disposition and other layout considerations indicated elsewhere in this specification. These drawings shall need the approval of the Owner/Consultant before construction. The Bidder shall also have to submit perspective views if so desired by the Owner/Consultant at no expenditure to the Owner. Approval from statutory authorities, e.g. Factories Inspector, Explosives Inspector, Loss Prevention Association of India / Tariff

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Advisory Committee etc. shall be the responsibility of the Bidder without any obligation of the Owner.

The entire complex shall have an architectural character and style of its own and shall be visually and functionally integrated with the existing landscape. The Bidder must visit the site and have a feel of the overall environment, so that a harmonious as well as integrated architectural concept of the proposed phase of development is achieved. Special care must be taken to enhance the visual and technological quality of development by adopting updated technology, materials, finish etc.

11.4 Guideline for Architectural Works

11.4.1 Roof Insulation and Ventilation

Wherever required the roof of buildings shall be insulated with foam concrete. For ventilation requirements relevant section of the specification shall be referred.

11.4.2 Roof Waterproofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size 230x230x18 mm laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

11.4.3 Brick/stone masonry and parapet wall

All masonry works shall be designed in accordance with IS: 1597, IS: 1905, IS: 2212, IS: 4326 and other relevant IS codes as applicable. Structural design of load bearing and non-load bearing walls constructed with solid or perforated burnt clay bricks or concrete blocks shall be in accordance with criteria specified by National Building Code of India.

All walls shall be non-load bearing infill panel walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change rooms, first aid rooms and toilets, which may be half brick thick.

Minimum 50 kg/sq.cm compressive strength brick shall be used for non-load bearing super structure brickwork. Cement sand mortar 1:6 for one brick thick wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided to reinforce the wall where required.

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All brickwork shall be plastered as per specification.

Even where metal cladding is specified, for initial [3 m] height from the ground level, minimum one brick thick masonry wall shall be provided.

All up stands and parapet walls on roof shall be of RCC construction, minimum height of parapet walls shall be [1050 mm] and a minimum thickness of [125 mm].

11.4.4 Cement based polymer modified mortar

a) Purpose

To carry out structural repairs to prepared patches of spalled concrete with an alkaline impervious repair material comprised of polymer admixed cement-sand mortar.

b) Materials and T&P

Polymers in emulsion or powder forms as may be specified conforming to ASTM C1059, Ordinary Portland Cement of 43 grade conforming to relevant BIS code, Sand conforming to Zone-II or Zone-III grade of IS: 383, Mixing water conforming to IS: 456-2000, mortar mixer with mechanical water dozer, spatulas, trowels, etc.

c) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified polymers shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 Testing of Material: The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less). These are to be tested for conformance to the specified requirements before use on the work. Polymer modified cement mortar with cement: sand proportion by weight as (1:3) shall have the following properties

Minimum compressive strength -20N/sq.mm after 28 days at 27oC

Step-4: Identify and mark the area for Polymer modified mortar repair.

Step-5 Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

Prop & support the structural member to relieve it of stress and strains.

Removal of existing surface plaster/treatment shall be done.

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Chipping unsound/weak concrete material shall be done.

Removing concrete all around embedded rusted reinforcement shall be done.

Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done.

Sealing the cracked or honeycombed concrete with injection grouting shall be done.

Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate, which may also be used as depth measuring gauge.

Additional fresh reinforcement, if required, shall be tied with required overlaps or welded.

The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically.

Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done.

Step-6: Clean the dust and saturate the prepared surface of concrete and reinforcement with a clean oil free air blast and water fit for construction.

Step-7: Inspection of concrete surface prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-8: Alignment & thickness Control- Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-9: Apply Passivating & bonding coat over the cleaned existing and new reinforcement.

Step-10: Apply bond coat on the cleaned concrete substrate.

Step-11: Mix and Prepare Polymer Modified Mortar to have a uniform consistency and texture by adding cement sand and polymer as weigh batched ingredients of the design mix, a specified proportion of water through water dozer.

Use of prepacked ready to use components supplied by manufacturers in containers may be allowed subject to approval of Owner. In case where prepacked ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

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Plastering with cement based polymer modified mortar shall be done immediately after applying the bonding slurry to the prepared surfaces, preferably in coats of approximately 10mm thickness as greater thickness may lead to delamination/collapse. However, coats shall be applied in fairly rapid successions within 15 to 30 minutes. After applications of mortar the surface shall be finished using a wooden float.

Step-12: Moist cure the polymer modified mortar surface for 1-3 days followed by air curing at ambient temperature or as per manufacturer's specification, if specified otherwise. Use of flowing water or ponding of water shall not be done for curing. Steam curing shall not be permitted.

Step-13: Test the Surface of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

d) **Inspection & Quality control**

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing stoppage of work during low temperatures (minimum working temperature being 8°C in most of the polymer modified mortar or as per manufacturer direction) and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 28 days of mortar application. The cores shall be examined for evidence of poor workmanship by the Owner, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall dismantle such areas of work as required by the Owner and re-do the same after re-preparing the surface by chipping off mortar work and abrading the bonding slurry interface.

11.4.5 Partition Wall

All intermediate walls shall be full brick thick wall in 1:6 cement sand mortar. Half brick thick wall in 1:4 cement: sand mortar with [2 nos. 6 mm] diameter rod in every fourth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area.

11.4.6 Metal cladding

a) **Permanent colour coated sandwiched insulated metal cladding system**

Trough zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 180 gm / sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film

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Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanised M.S. sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanising shall not be less than 180 gm / sq. m.

The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanised steel sheet of grade 375 as per IS: 277. Inner sheet shall be fixed at the rate not more than 0.75 m centre to centre to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS: 8183, having a density of 32 kg / cu. m for glass wool & 48 kg / cu. m for rock wool.

b) Permanent colour coated (non-insulated) metal cladding system

Trough zinc-aluminium alloy coated not less than 180 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability.

c) Flashings, Cap, Trim Closures etc.

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

11.4.7 Plastering

On the exterior wall & rough side of interior brick wall [18 mm] thick minimum with cement-sand mortar in two layers shall be applied. Where external finish will require rich plastering for special finish plaster shall be of 1:4/1:3.

Interior wall: [12 mm] thick with 1:4 cement-sand mortars

Ceiling: [6 mm] thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

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11.4.8 Removal of plaster manually from masonry or concrete surface using chisel and hammer and disposal of debris etc

a) **Purpose**

For removal of all type of loose /delaminated /damaged/weak cement plaster from surface of masonry or concrete.

b) **Procedure**

Step-1: Safety shall be ensured in accordance with contract conditions and specifications.

Step-2: Provide double scaffolding, protective screens etc.

Step-3: Existing plaster to be to be identified for removal by tapping all areas and its boundary shall be marked with a colour marking (in an optimal rectangular shape), which shall be approved by Engineer-in-Charge.

Step-4: Make a cut normal to the surface all along the boundaries with power driven cutters. The depth of cut shall not exceed the thickness of plaster.

Step-5: Remove the plaster manually with the help of chisel and hammers to completely expose the parent masonry or concrete surface, so as not to have any traces of such plaster left behind.

11.4.9 False ceiling and under deck insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the under side of the roof / floor slab of the air-conditioned areas based on the functional requirement. Aluminium false ceiling system shall comprise of [84 mm] wide [12.5 mm] deep closed type plain panels of approved colour, roll formed out of [0.5 mm] thick corrosion resistant aluminium alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, AC ducts etc. Suitable M.S channel (minimum ISMC100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc.

Bidder shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire detectors, fire protection sprinklers etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the Owner approves the layout. Under deck insulation shall comprise of [50 mm] thick resin bonded mineral wool insulation mat conforming to IS:8183. This mat shall be backed with [0.05 mm] thick aluminium foil and [24 Gx25 mm] wire mesh netting. These shall be fixed to ceiling or wall as the case may be with [100x50x6 mm] slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at [600 mm c/c and 14 G] steel wire drawn through slots and fixed to wire netting.

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11.4.10 Doors

- Generally hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas.
- Solid core factory made wooden flush doors in hard wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.
- Special areas like control rooms and other special area shall be provided with minimum 15 micron pre-coated Le. colour anodised aluminium glazed partitions with air lock facilities having two sets of doors.
- Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard and also to all fire exists as per TAC requirement.
- Doors shall be provided at appropriate location to prevent dust ingress from outside.
- FRP Doors with FRP Frames shall be provided for all the toilet doors.
- Weather stripping shall be provided to all outside doors as well as air-conditioned areas and all other doors where dust-free environment is required.

11.4.11 Rolling shutters

Rolling steel shutters conforming to IS: 6248 will be used for large openings where frequent use is not envisaged. Unless noted otherwise, main entry doors of width and height to suit the requirements. Rolling shutters with area up to 8 m² shall be pull and push type hand operated, while above 8 m² shall be pull and push type with ball bearings (Electrically operated) as per IS specification.

11.4.12 Windows & Ventilators

In all buildings, full glazed windows and ventilators in minimum [15 micron] colour anodized aluminium window frame shall be provided with [4 to 6 mm] thick (depending on the size of panel) clear float glass and [6 mm] thick clear wired/laminated glass where required from safety point of view. Structural glazing may be considered as an important facade element.

The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Glass thickness and member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Bidder before execution.

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11.4.13 Plywood Covering Panels to Cover Windows etc. During repairs

a) Purpose

To protect the finished items against their spoiling/damage to finishes during the process of carrying out repairs in a building. The items could include finished windows, doors, glass curtain wall or other such items.

b) Materials:

Wooden Battens of size 50mm X 50mm (approximately) or as approved by Engineer-in-charge, free from warping, cracks etc. made from locally available timber.

Plywood of suitable thickness, preferably 6 mm thick, as approved by Engineer-in-Charge.

Nails, screws etc. as per requirement.

c) Fabrication:

Size of covering panels shall be more than the size of windows etc. to be shielded/ protected, enough to be fixed to the walls without damaging the windows etc.

Wooden battens shall be cut approximately to the size of panels of windows etc. to be protected. The joints of the wooden framework shall be lap joint or as approved by Engineer-in-Charge.

Where the panel size is more than 2 square metres or as specified by the Engineer-in-Charge, the stiffening shall be done with batten backing to impart stiffness enough to provide rigidity against undue deflection due to impact of falling debris, self load, etc.

Plywood shall be fixed with nails/screws over the batten frames. The spacing of nails/screws shall be about 300mm c/c or as may be required at site.

d) Fixing:

The plywood covering panel shall be suitably fixed without damaging the windows etc. being protected by such panels with nails/screws fixed in walls strong enough to resist the forces likely to be imparted during repair work. It shall be done in such a manner that it can be removed with ease without damaging the covered windows etc. after completion of repairs.

e) Removal:

After completion of work, the covering panels shall be removed carefully, so as not to cause any damage to windows etc. covered. The damages, if any, shall be made good.

11.4.14 Facilities in Buildings

Adequate toilet and drinking water facilities shall be provided for personnel working in each building. Each building shall have toilet facilities both for Gents

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and Ladies. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.

However minimum 1 Water Closet, 1 washbasin, 1 urinal shall be provided in each toilet.

Each floor shall have drinking water facility connected through water purification system like Aquaguard or similar approved make.

11.4.15 Glazing & Glazed Partition

- Glazing in Control room between AC. and non-AC. areas shall be insulating glass consisting of [two 6 mm] thick toughened float glass sheet hermetically sealed and separated by [12 mm] gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.
- [4 mm] thick ground glass shall be provided for toilets.
- Glazing between two AC. areas shall be with 6 mm thick clear float glass.
- All glazing shall be in aluminium frame.
- [6mm] thick Wired / laminated glass shall be used for windows / ventilators at higher level for safety.
- [24mm] thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with [12mm] air gap & hermetically sealed shall be mounted on [15 micron] coloured anodised aluminium frame suitable for structural glazing system.

11.4.16 Sealant

Silicon sealant or polyurethane sealant shall be used in all expansion joints exposed to weather. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water-lightness.

11.4.17 Damp Proof Course

[40 mm thick 1:1.5:3] concrete with waterproofing admixture. Water proofing compound shall be of Zydex, SIKA, or similar approved.

11.4.18 Plinth Protection

Minimum [1000 mm] wide and minimum [100 mm] thick M 15-grade concrete plinth protection along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be provided. The plinth protection shall be laid over prepared sub-grade and base formed with locally available broken laterite stone to thickness of [150 mm].

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11.4.19 Painting

- Exterior Masonry Surface : Buildings shall be finished with [Acrylic Emulsion pain] as per IS specification with approved colour and scheme.
- Exterior Steel Work : Anti-corrosive synthetic enamel paint over [anti corrosive primer].
- All Woodwork: [Synthetic paint over a coat of primer].
- All Internal Steel Work : [Synthetic enamel over a coat of primer].
- Interior Office Spaces Rooms, All AC Areas : Acrylic emulsion paint over [2 mm] control thick plaster of paris punning.
- Balance areas: As indicated in finish schedule in this document.
- Fire Door: Post Office red shade shall be provided.

11.4.20 Flooring

Unless and otherwise specified, the nominal total thickness of floor finish shall be [50 mm] including under bed and topping. The flooring shall be laid on already matured concrete base. The under bed for floors shall consist of minimum grade of M 15 with stone chips [12.5 mm] downgraded as coarse aggregates. The under bed shall be provided appropriate slope towards catch pit for floor drainage.

- **False Flooring System**

Removable type false flooring system shall be provided wherever required (computer rooms etc.). RCC floor slab will be sunk to a depth [800 mm], which shall be height of the false floor system. The flooring shall consist of fire resistant phenol formaldehyde bonded particle board panels [600x600x35 mm] size, mounted on steel pedestals of adjustable height and supporting steel grid system to provide under floor space. [2 mm] thick flexible anti-static PVC topping on top and PVC strip edging on sides of each panel shall be provided.

- **PVC Floor Finish**

Two mm thick PVC as per IS: 3462 and laid as per IS: 5318 over concrete under bed of [48 mm] shall be provided in electronic cubicle rooms, conference room, etc. PVC tiles shall ensure anti static surface.

- **Vitrified ceramic Tiles**

Heavy duty vitrified ceramic tiles of appropriate thickness and of minimum size [600 mm x 600 mm] of approved shade & colour shall be provided for control room as per relevant code and manufacturer's specification over concrete bedding to result in an overall thickness of [50 mm].

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- **IPS Flooring**

IPS (cement concrete flooring) with metallic floor hardener topping [12 mm] thick with a total thickness of [50 mm] shall be provided in maintenance and unloading area, ground floors, floor of pump house, permanent stores and other plant building areas where heavy duty flooring is required.

IPS flooring with non-metallic floor hardener shall be provided in all MCC and switchgear rooms, which are not air-conditioned.

IPS flooring shall also be provided in areas, which are not provided with any special finish. Areas which are likely to be subjected to oil spillage shall be provided with two coats of oil resistant painting over IPS floor finish. If required, Bidder has to use floor hardeners at appropriate locations.

- **Heavy Duty Ceramic Tiles**

Heavy duty vitrified ceramic tiles with suitable finish shall be used in toilets, pantry, dining hall of canteen, locker rooms etc. The tiles shall be minimum of [300 x 300 x 7 mm] of approved shade, brand and colour.

- **Acid / Alkali Resisting Tiles**

Battery rooms and other areas coming into contact with acid / alkali vapours or fumes shall be given acid / alkali resistant tiles 25 mm thick, jointed with acid / alkali resistant cement slurry. Bedding shall comprise of potassium silicate mortar conforming to IS: 4832 (Part-I) and resin based mortar like epoxy for jointing. Total thickness of flooring shall be 50 mm. Ceramic unglazed vitreous tiles conforming to IS: 4457 with minimum thickness of 20 mm may also be used as acid / alkali resistant tile. The above specification does not apply to D.M. Plant.

- **Acid / Alkali resistant Tiling / Brick lining in D.M Plant**

Bitumen primer followed by 12 mm thick bituminastic, 6 mm thick potassium silicate mortar bedding and 38 mm thick alkali / acid resistant bricks as per IS: 4860 shall be provided for CPU regeneration area, Chemical house floor, effluent drains, floors around equipment and chemical handling vessels, chemical storage area for the floor, curbs and sumps, all as per the acid / alkali proofing specialist Contractor's requirement.

For floor of neutralising pit, the finish shall be as follows. Bitumen primer followed by 18 mm thick bituminastic, 6 mm thick potassium silicate mortar bedding and 75 mm thick acid / alkali resistant brick as per IS: 4860.

For walls of neutralising pit, the same specification as above shall apply except that thickness of the brickwork shall be 115 mm with suitable pilasters at 2000 mm c/c.

Special instruction to be followed for acid resistant lining in neutralising pit shall be as follows.

- The structures shall be tested for water tightness.

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- ii. Surface on which lining is to be applied shall be prepared as per IS: 2395.
- iii. Joints between acid resistant bricks / tiles shall be filled with resin type mortar conforming to IS: 4832 (Part II). Seal coat of ready-made epoxy paint shall be provided at the joints to cover up any porosity.
- iv. Acid resistant bricks shall be laid with 6 mm wide and 20 mm deep pointing. Pointing shall be with epoxy / furane / CNSL as per the requirement of the agency guaranteeing the performance of lining.
- v. Under side of all precast slabs / steel covers over effluent drains shall be given two coats of epoxy coating, each coat of 150 microns thick.
- vi. Acid / alkali resistant treatment shall extend at least 1 metre on all sides from the outermost periphery of pedestals / saddles for indoor installations and 2 metres all round for outdoor installations.

- **Integral Floor Finish**

For cable vaults floor finish integral to the concrete base shall be provided as per IS: 2571.

- **Cast-in-situ Terrazzo**

Risers and treads of staircases shall be provided with cast in-situ terrazzo. This shall be laid as per IS: 2114, using white cement or cement with colouring pigment. Chequered finish shall be provided for treads. Total thickness of the finish shall be 25 mm.

11.4.21 Miscellaneous

PVC nosing shall be provided for edge protection of R.C.C. stair treads.

Angles [50x50x6 mm] (minimum) with lugs shall be provided for edge protection of cutouts / openings in floor slabs, edge of drains covering gratings, edge of R.C.C cable / pipe trenches of any other place where breakage of edges / corners is expected.

Floors of switchgear rooms shall have embedded steel channel suitable for easy movement of breaker panel.

11.4.22 Skirting/DADO

- [150] mm skirting matching with floor finish shall be provided in all areas unless specified otherwise elsewhere.
- Toilets and locker rooms shall be provided with dado of [2100] mm high with glazed tiles of minimum [5] mm thickness generally as per IS: 777.
- For Control room and control equipment room minimum 5 mm thick decorative coloured ceramic tiles shall be provided upto false ceiling level.
- For battery room and other areas coming in contact with acid / alkali spillage / fume, dado of acid / alkali resistant tiling as per IS: 4457 shall be provided

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to a height of [2100] mm set in potassium silicate mortar and joints pointed with resin bonded mortar

- Staircase wall shall be given dado of cast in-situ terrazzo to a height of [2100] mm or as per approved drawings.
- Before wall surfaces are covered with tiles, flags or mosaic to be set in normal mortar bedding, a sprayed coating of cement mortar shall be applied to the base unless otherwise specified. Where no adequately even surface is available for work involving thin beddings, special provisions shall be made to compensate for this, e.g., rendering coat, screed. The concrete surface to which tiles, flags, terrazzo, screed, etc are to be placed, shall be cleaned by wet sandblasting and washed with water under pressure, so as to produce the specified surface condition.
- The exterior brickwork walls shall consist of load bearing and non-load bearing type construction. Exterior surfaces shall be treated with approved chemical waterproofing over cement plaster. Bricks of minimum 75 kg/cm² crushing strength shall be provided. Brickwork shall be carried out in cement sand mortar conforming to IS: 1077. Cement sand mortar shall conform to IS: 2250.

11.4.23 Roof access

All roofs shall be provided with access thorough a staircase / cage ladder. Minimum [1000 mm] wide access path shall be provided with suitable tiles to approach equipment on roof.

11.4.24 Roof Drains

Roof drains design criteria

Minimum diameter of the pipe shall be [150 mm]. The roof drains shall be sized for the roof area runoff for a maximum rainfall per hour at site.

Detailed specification is mentioned elsewhere in this specification.

Roof Drainage and Water Proofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size [230x230x18 mm] laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

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12 GENERAL REQUIREMENTS

12.1 Roof

All the buildings having R.C.C slabs over structural steel framing are provided with troughed metal sheet decking which acts as permanent shuttering. These sheets shall meet the general requirements of IS: 14246 and shall conform to class 3 for durability. The sheeting shall be permanently colour coated galvanised M.S. troughed metal sheet decking of approved profile with minimum base metal thickness of 0.8 mm and minimum trough depth of 38 mm. Silicon modified polyester painting shall be used for permanent coating over galvanised surface with minimum rate of galvanising of 180 gm of zinc per sq. m. Dry film thickness of colour coating shall be at least 20 micron.

Roof of all buildings having R.C.C. framework shall have cast in-situ R.C.C. slab with conventional shuttering.

Structural steel roofing wherever required shall be of permanently colour coated galvanised M.S troughed metal sheet of approved profile. Minimum base metal thickness shall be 0.8 mm. The rate of zinc consumption for galvanising shall be 275 gm/sq. m. The external face shall have permanent colour coating of PVF 2 paint of minimum DFT of 20 microns and inner surface shall be coated with silicon modified polyester paint with DFT of 20 microns

12.2 Platforms and walkways

Platforms shall be provided to all major equipment, not directly accessible from the floors, for maintenance. Platforms and connecting walkways shall have a minimum width of 750 mm. Platforms in front of the entry shall be at least 900 mm wide. Platforms located close to each other shall be connected with walkways.

All steel platforms above grade level shall be constructed with kick plates at edge of the platform to prevent tools or materials from falling off. It shall consist of 8 mm thick steel plate projecting 100 mm above the platform surface. Kick plate shall be painted with the same type of coating as the material to which it is attached. Approach to EOT crane shall be ensured by Cage ladder or staircase.

12.3 Stairs and ladders

Steel Stairs

All steel staircases shall normally have minimum clear width (back to back of stringer) of 1000 mm and maximum inclination with horizontal of 35.75°. However, in case of space restriction, minimum clear width up to 750 mm and slope up to 45° may be provided. The vertical height between successive landings shall not exceed 5 m. Channels (minimum MC 200) shall be provided as stair stringers. Treads shall be minimum 250 mm wide of chequered

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plate/grating, with suitable nosing, and spaced equally so as to restrict the rise to maximum 180 mm (200 mm in exceptional cases).

Steel Ladders

Ladders shall be provided to platforms, walkways, instruments and equipments, which do not require frequent access. Ladders shall preferably be vertical and its angle with vertical shall not exceed 50. Ladders shall be of minimum 450 mm clear width with 20 mm diameter MS rungs spaced at 300 mm (maximum).

Ladders shall be provided with a safety cage of minimum 750 mm diameter clear when the top of ladder is more than 4.5 m above the landing level. However safety cages shall start at 2.5 m above the lower landing level.

RCC Stairs

All stairs shall have maximum riser of 180 mm and a minimum tread of 250 mm. However, for public buildings riser shall be limited to 150 mm and tread width of 300 mm. Minimum width of stairs shall be 1200 mm generally. All stairs normally shall not have more than 15 risers in one flight. Aluminium angle nosing with minimum 50X25X3 angle or PVC nosing shall be provided for edge protection of RCC stairs.

12.4 Handrails

Handrails shall be provided at appropriate places to ensure safety e.g. around all floors/roof openings, projections / balconies, walkways, platforms, steel stairs etc.

All handrails shall be of 32 mm nominal bore MS pipes (medium class) as per IS: 1161 galvanised using 900 gm/sq. m of zinc. Handrails for platforms, walkways and projections shall be a two-rail system with the top rail 1000 mm above the walkway surface and the intermediate rail 450 mm below the top rail. Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the protected horizontal opening. In such a case spacing shall not exceed 1850 mm centre to centre of posts. Handrails shall be shop fabricated for specific locations and field welded or bolted to the erected structural steel. For platforms at elevation more than 30 m, three rail system with top rail at 1500 mm shall be adopted.

For RCC stairs, handrails with 20 mm square MS bar balustrade with suitable MS flat & aluminium / Teakwood handrail shall be provided, unless specifically mentioned otherwise. All hand rails except stairways shall be provided with toe guard plate of 100x8mm thick.

12.5 Edge protection

Wherever possible around floor openings an RCC kerb of 100 mm wide 150 mm high shall be provided. All concrete edges, where breakage of concrete corner is expected, shall be provided with angles at least L 50x50x6 with lugs for edge protection e.g. all round the cut-outs/openings in floor slab, edges of drains

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supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers and supporting edges of precast covers etc.

12.6 Vertical Headroom

All accessible areas shall be provided with minimum clear headroom as follows, unless otherwise specified:

Table 2.9
Headroom

Description	Headroom, mm
Finished floors to ceiling (buildings)	3000
Doors, Walkways, Platforms, Stairs etc.	2100
False ceiling of office areas	3000
False ceiling walkway	1000
Safety cage for ladders	2500
Access for forklift trucks	2800
Main roads/Railway crossings & crane access	7000
Other plant roads and truck access	5000
Cable & Pipe rack (except road/rail crossings)	3000

12.7 Waterproofing of underground structures

All underground structures like basements, pump houses, water retaining structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sq.m (minimum) for water/ damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that waterproofing grouting can be injected later in case of leakage.

12.8 Anti-termite treatment/Anti-weed treatment

Pre-constructional anti termite treatment shall be given to all buildings as per IS: 6313 and other relevant Indian Standards.

Reservoirs shall be given an anti-weed treatment of approved quality and quantity as per the manufacturer's specification. Anti weed treatment shall be carried out before carrying out the lining work.

12.9 Plinth Level

The finished floor levels shall be 800 mm higher than the external finished ground level. Finished ground floor level (plinth level) of all buildings and pump houses shall be minimum 500 mm above the formation level/grade level.

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All cable vaults shall be located above ground level i.e. cable vaults shall not be provided as basements in the buildings.

12.10 Statutory Requirements

All the applicable statutory rules pertaining to Indian Factories act, Factory rules of state government, Fire safety rules of Tariff Advisory Committee, Water act of Pollution Control Boards, Explosives act etc. and stipulations of other relevant statutory authorities shall be taken into consideration at the time of design.

Provisions of safety, health and welfare according to Factories act shall be complied with design stage. These shall include provision of continuous walkway (minimum 500 mm wide) along crane-girder at crane girder level on both sides of the building, comfortable approach to EOT crane cabin, railings, fire escape, locker room for workmen, pantry, toilets, rest room etc.

Adequate number of fire escapes shall be provided in a building. Fireproof doors, number of staircases, fire separation walls, lath plastering on structural steel member (in fire prone areas) shall be made according to the recommendation of TAC. For fire safety requirements of buildings IS: 1641 and IS: 1642 shall be followed in addition to TAC requirements. All masonry firewalls shall be minimum 345 mm thick and RCC firewall shall be minimum 200 mm thick.

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13 GENERAL CIVIL WORKS AND CONSTRUCTION TOLERANCES

13.1 Basic requirements for all civil works

Design requirements

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Owner/Consultant.

- Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers (whichever is less).
- The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable nor troublesome to personnel and will not cause damage to the machine or structure.
- The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating plant.
- The differences between frequencies and the dynamic analysis of the superstructures and foundations shall be in accordance with the relevant design standard.
- The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.
- Throughout the works all floor slabs above rooms containing electrical equipment shall be watertight. No drainpipes or water pipes are permitted to pass through these rooms.
- All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Owner/Consultant and shall comply strictly with the tests prescribed hereinafter or, where tests are not laid down in this specification, with the requirements of the latest issue of the relevant Indian, American, British, German Standards or other Standards approved by the Owner/Consultant.
- Samples of all materials proposed to be used in the works may be called for at any time by the Owner/Consultant.

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- The work shall be carried out by competent personnel skilled in their various trades.
- Before commencing the works, the Bidder shall ascertain the locations and nature of all existing underground services and shall take every possible precaution against any damage occurring to them or interference therewith, during the execution of the works.
- Suitable access to the roofs of the buildings by means of steel stairs shall be provided for maintenance and repair of any installation.
- All rooms with fire hazard shall be provided with suitable emergency exists.
- Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles, which will be used (cars, forklifts, trucks/trailers etc) to reach up to the point of unloading of the equipment.
- Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms, at all levels using suitable stair wells and suitable electric hoists. The dimensions of rooms, stairwells, doors, etc shall be designed to suit the a.m. transport concept.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.

13.2 Basic requirements during construction

Basic Cleaning

Basic cleaning includes all floors, walls, ceilings, built-in fittings and equipment, including the furnishings. The basic cleaning operation must result in a degree of cleanness, which permits the fully equipped buildings and rooms and associated outdoor installations and secured surfaces to be taken over without complaint.

Advertising boards and stickers, temporary protective coatings and claddings, remains and splashes of paint, must be removed with water or suitable solvents. Dust and other dirt must be completely removed from all wall and floor surfaces, as well as from all furniture.

Windows and mirrors must be cleaned so that they are completely clear and without streaks.

Perlator gauges, showerheads, odour traps and floor drains of the sanitary installations must be cleaned and the fittings and bright pipe work must be spotlessly polished.

Petrol and oil separators must be emptied, cleaned and refilled if necessary during basic cleaning.

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Lamps, including dishes, lighting units and tubes, switches and sockets as well as bases and skirting boards, doors with frames and glazing, windows, window seats and other furniture and fittings must be included in the basic cleaning operation.

Initial Equipment

The specification is drawn up on the assumption that the scope of the initial equipment and consumption materials is to be provided complete in every respect; everything required for the use and care of the installations must be supplied, even if this is not expressly specified in the documentation.

Bidder shall ensure that during excavation ground water level shall be lowered by at least 0.50 m below the founding level adopting appropriate method of dewatering. Lean concrete below foundation shall be laid soon after excavation with minimum loss of time.

13.3 Technical Specification for renovation & modernisation of Chimney Accessories

This part of the specification deals with the supply, fabrication and renovation & modernization of load bearing insulation blocks, stainless steel, lead sheets and PTFE in bearings, thermal insulation, expansion compensator joints etc. complete.

Expansion Compensator

- a. The expansion compensator will be fabricated by a reputed Manufacturer. The name of manufacturer(s) will be indicated by the Bidder in his bid.
- b. The materials to be used will be suitable for the flue gas conditions specified at Part-1 and will be acid resisting. The expansion compensator will comprise of several layers of materials. The number of layers and materials should typically consist of the following which are given in order from the gas side.
 - i. Texturised glass cloth not less than 1.6 mm thick and not less than 1200 grams/square metre. The glass cloth will be suitably treated to prevent dust accumulation.
 - ii. Further layer of (i).
 - iii. Glass felt insulation not less than 10 mm thick and not less than 1500 grams/square metre.
 - iv. PTFE film not less than 0.2 mm thick and not less than 460 grams/ square metre.
 - v. Fluoroelastomer coated glass fabric not less than 0.4 mm thick and not less than 650 grams/square metre.

The space between the expansion joint material and the liner will be sealed by providing a bolster made up of glass felt of density 24 Kg/Cu.m. confined in texturised glass fabric not less than 0.25 mm thick and weight not less than 400 grammes/square metre and capable of withstanding a temperature of 300oC. The bolster will have a final covering of stainless steel wire mesh having

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a mesh size of not more than 16 mm x 16 mm made of wires of dia not less than 0.3 mm. The bolster will be secured in position by extending the glass fabric and the stainless steel wire mesh upto the end of the metal flange and bolting them along with the expansion joint material.

The gap between two parts of flue liner at the top of expansion joint (Refer tender drawing) will be provided with packed unbonded loose wool and 3 (three) numbers of 12 mm diameter asbestos cords which will be tightly fitted in the gap.

- c. The various layers of the expansion compensator will be manufactured to the specified thicknesses and unit weights within a manufacturing tolerance of $\pm 5\%$ of the absolute specified values.
- d. The materials chosen will be suitable for site handling and site installation. The Bidder will supply full details of the materials to be used, together with fabrication drawings of the expansion compensators. The Bidder will provide more specific details of the expansion compensators, as briefly specified herein, with his Tender to evaluate the various materials proposed to be used for assembling/fabricating the joint.
- e. The Bidder will provide an installation, dismantling and maintenance user-handbook for the expansion compensators. The material will be transported, handled, stored, etc. strictly in accordance with the Manufacturer's recommendations and the details of which should also be included in the handbook.
- f. Spare expansion compensators as specified will also be supplied by the Bidder, for the duty specified, capable to withstand up to 10 years in storage complete with fitting instructions, spare bolts, bars and any sealant in suitably provided packaging for transport.
- g. Each layer of the expansion compensator will be checked for thickness, unit weight, tensile strength and elongation. The composite expansion joint will be tested for temperature withstandability.

Load Bearing Insulation Blocks

- a. Load bearing insulation blocks, in the support bearing assembly and in the slide guide of the flues, will be rigid, non-combustible lime-silica board, reinforced with amosite asbestos fibres. The blocks will be fabricated from Sindanyo natural grade CS.51 asbestos boards as manufactured by TAC Construction Ltd., U.K., or from a material with equivalent physical properties as approved by the Owner/ Consultant.
- b. Typical thermal and physical properties of the blocks will be as follows:

Minimum specific heat at 200 deg.C	0.28
Maximum service temperature	320 deg. C
Maximum coefficient of linear expansion	2.7×10^{-6} per deg. C

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Maximum thermal conductivity (at 200 deg. C)	0.67 w/m/deg.
Minimum normal dry density	720 g/Cu.m
Minimum compressive strength to be sustained prior to onset of compression yield	12 /Sq.mm
Minimum shear strength when tested in accordance with BS:3497-1979	30 /Sq.mm

- c. The blocks will be insoluble in water and will not warp or swell under conditions of extreme humidity.
- d. The blocks which will be capable of being drilled, cut and machined will be submitted to the Owner/ Consultant for their approval.

Gaskets for Manholes and Ports

The joint between the metal flanges and the covers for manholes and ports provided in the liners and transition ducting will be sealed, to full width of the joint, with a woven metallic asbestos gasket. The material to be used will not be less than 6 mm thick and will be suitable to withstand a temperature of 300oC and will be acid resisting. The material will have graphite finish on both faces.

Installation of Expansion Compensators

- a) The Manufacturer's instructions for installation and site testing will form the basis of the Bidder's method statement which will be submitted to the Owner/Consultant for approval. Once approved it will be adhered to throughout the installation sequence.
- b) The expansion compensators will be prevented from distortion by more than the Manufacturer's specified tolerances during transportation, handling, erection and jointing.

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14 STANDARDS, CODES AND REFERENCES

14.1 General

The Design of the Steel Structural Works shall be prepared and presented in accordance with IS codes. In absence of guidelines of specific items in the IS codes, International codes viz., American, BS, DIN or Australian code shall be used. All the Indian Standards referred to shall be the latest revision (including all amendments issued thereto) on the date of opening of the price bid. The Standards adopted shall be clearly stated in the calculations.

The Design shall comply with the current Local Authority Building Regulations (National Building Code) where appropriate. Subject to the agreement of the Owner, other International / Foreign National Standards, and, International / Foreign National Standard Codes of Practice, may be used.

To the extent that the Design shall include materials, methods or workmanship to be incorporated into the works, they shall be selected and incorporated into the design in accordance with the recommendations and requirements of the following (as appropriate in order of precedence but not mutually exclusive):

Statutory requirements

The Contract provisions

Bureau of Indian Standard Codes of Practice

International / Foreign National Standards

Agreement Certification for Materials

Manufacturer's recommendations for materials

Competent Trade Association recommendation

Engineering judgment

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

Where British / American / DIN or other codes and standards are referred to in this document, equivalent Indian Standards may be substituted if available.

Materials supplied from India shall follow the Indian Standard Specifications.

Field and laboratory testing procedures for materials follow Indian Standard Specifications.

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14.2 Codes for Loads

- IS: 875 : Code of Practice for design loads (other than earthquake) for Buildings and structures (All parts)
- IS: 1911 : Schedule of unit weights of building materials
- IS: 1893 (Part 1) : Criteria for earthquake resistant design of structure – General provisions and buildings
- IS: 1893 (Part 4) : Criteria for earthquake resistant design of structure – Industrial structures including stack-like structures

14.3 Codes for RCC

- IS: 456 : Plain and reinforced concrete - Code of Practice
- IS: 2974 : Code of Practice for design and construction of machine foundations
- IS: 2911 : Code of Practice for design and construction of pile foundation
- IS: 4326 : Code of Practice for earthquake resistant design and construction of buildings
- IS: 4995 : Criteria for design of reinforced concrete bins for storage of granular (all parts) and powdery materials
- IS: 4998 : Criteria for design of reinforced concrete chimneys: (All parts)
- IS: 5525 : Recommendation for detailing of reinforced concrete works
- IS: 1786 : Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS: 11384 : Code of Practice for composite construction in structural steel and concrete
- IS: 11504 : Criteria for structural design of Reinforced concrete Natural Draft Cooling Tower
- IS: 11682 : Criteria for design of RCC staging for overhead water tanks
- IS: 13920 : Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces

14.4 Codes for Structural Steel

- IS: 800 : Code of Practice for general construction in steel
- IS: 801 : Code of practice for use of cold-formed light gauge steel structural members in general building construction
- IS: 806 : Code of Practice for use of steel tubes in general building construction
- IS: 808 : Dimensions for hot rolled steel beam, column channel and angle section

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IS: 812	: Glossary of terms relating to welding & cutting of metals
IS: 813	: Scheme of symbols for welding
IS: 814	: Covered electrodes for manual metal arc welding of carbon and carbon manganese steel - Specification
IS: 815	: Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel
IS: 816	: Code of Practice for use of metal arc welding for general construction in mild steel
IS: 817	: Training of welders - Code of practice (Part 1 & 2)
IS: 818	: Code of practice for safety and health requirements in electric and gas welding and cutting operation.
IS: 819	: Code of practice for resistance spot welding for light assemblies in mild welding
IS: 822	: Code of practice for inspection of welds.
IS: 1182	: Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
IS: 1200	: Method of measurement of building and civil engineering works
IS: 1161	: Steel tubes for structural purpose
IS: 1363	: Indian standard- Hexagonal head bolts, screws and nuts of product grade C
IS: 1367	: Technical supply condition for threaded fasteners
IS: 1477	: Code of practice for painting of ferrous metal in building
IS: 1852	: Specification for rolling and cutting tolerance for hot-rolled steel products
IS: 2062	: Structural steel (fusion welding quality)
IS: 2074	: Ready mixed paint, air drying, red oxide zinc-chrome, priming
IS: 2645	: Specification for integral cement waterproofing compound
IS: 2932	: Specification for enamel, synthetic exterior type –I
IS: 3613	: Acceptance tests for Wire flux combination of submerged arc welding
IS: 3757	: Specification for high strength structural bolts
IS: 4000	: Code of practice for High Strength bolts in steel structures
IS: 7205	: Safety code for erection of structural steel work
IS: 7215	: Specification for Tolerances for fabrication of steel structures
IS: 7280	: Specification for Bare wire electrodes for submerged arc

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Tender Document for R&M of Unit No. [..] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	--------------------------

- welding of structural steel
- IS: 8640 : Recommendations for dimensional parameters for industrial building
- IS: 9178 : Criteria for design of steel bins for storage of bulk material (All parts)
- IS: 9595 : For Metal arc welding of carbon and carbon manganese steel - Recommendation
- IS: 11592 : Conveyor galleries
- IS: 12843 : Tolerances for erection of steel structures

14.5 Miscellaneous Codes

- IS: 919 : ISO system of limits and fits
- IS: 1038 : Specification for steel doors, windows and ventilators
- IS: 1172 : Code of basic requirements for water supply, drainage and sanitation
- IS: 1346 : Code of Practice for water proofing of roofs with bitumen felts
- IS: 1742 : Code of Practice for building drainage
- IS: 1905 : Code of Practice for structural use of unreinforced masonry
- IS: 2210 : Criteria for design of reinforced concrete shell structures and folded plates
- IS: 2633 : Method for testing uniformity of coating on Zinc Coated Articles
- IS: 3067 : Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
- IS: 4759 : Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products
- IS: 10440 : Code of Practice for construction of reinforced brick and reinforced brick concrete floors and roofs
- IS: 13592 : Un-plasticized polyvinyl chloride (UPVC) Injection molded fittings for soil & waste discharge system for inside and outside buildings including ventilation and rail water system specification
- IS: 15658 : Precast concrete blocks for paving
- SP: 6 : Handbook for structural engineers - All parts
- SP: 7 : National Building Code of India
- SP: 16 : Design Aids for reinforced concrete to IS: 456-1978
- SP: 20 : Handbook on masonry design and construction
- SP: 22 : Explanatory handbooks on codes for earthquake

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- engineering (IS: 1893-1975 and IS: 4326-1976)
- SP: 24 : Explanatory handbooks on Indian Standard code of Practice for plain and reinforced concrete
- SP: 25 : Handbook on causes and prevention of cracks in buildings
- SP: 32 : Handbook on functional requirements of industrial buildings
- SP: 34 : Handbook of concrete reinforcement and detailing (SCIP)
- TAC : Traffic Advisory Committee
- : Indian Explosive Act
- : Indian Factory Act and State Factory Act
- : Indian Electricity Act

Any statutory codes / standards / regulations other than listed above, as may be applicable, shall be followed.

Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in this document, the latest editions of the codes and standards given below shall also apply:

- a) Japanese Industrial Standards (JIS).
- b) American National Standards Institute (ANSI).
- c) American Society of Testing and Materials (ASTM).
- d) American Society of Mechanical Engineers (ASME).
- e) International Organization for Standardization (ISO).
- f) American Welding Society (AWS).
- g) National Electrical Manufacturers Association (NEMA).
- h) National Fire Protection Association (NFPA).
- i) International Electro-Technical Commission (IEC).
- j) German national codes (DIN)
- k) Expansion Joint Manufacturers Association (EJMA)

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-II, Section-II, Part-D	[137]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-III
PART-A
TECHNICAL SCHEDULES-MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
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	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
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	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

Document Number	Rev No.	Description	Page No.	Date of Issue
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2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
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8. Performance Guarantees
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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[iv]	15.01.2016

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
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Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[v]	15.01.2016

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1. Raw water Intake Pumps

SL.NO	DESCRIPTION	DATA
A)	General	
1)	Name of manufacturer	
2)	Model Number	
3)	Total No. of pumps	
4)	Type	
5)	Fluid	
6	Type of Discharge	
7)	Location	
B)	Performance Requirement	
1)	Number of operating pumps	
2)	No. of standby pumps	
3)	Shut off head of the Pump (mwc)	
4)	Rated Speed, rpm	
5)	Maximum efficiency of the pump at discharge flange for design point to be considered for arriving at the guaranteed power consumption at motor terminals	
6)	Maximum efficiency of the pump motor at design point to be considered for arriving at the guaranteed power consumption at motor terminals	
7)	Rated Capacity, cum/hr	
8)	Head at the discharge flange for the Rated Flow, mwc	
9)	Range of operation	
10)	Location of the thrust bearing is at	
11)	Type of thrust bearing cooling	
12)	Medium for thrust bearing cooling	
13)	Qty of water required for thrust bearing cooling	
14)	Type of shaft sealing	
15)	Medium for shaft sealing	
16)	Qty of water required for shaft sealing	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[1]	15.01.2016

SL.NO	DESCRIPTION	DATA
17)	Qty of water required for lubrication of line shaft bearing	
18)	Maximum capacity up to which pump can be operated satisfactorily.	
19)	Minimum Capacity up to which pump can be operated satisfactorily	
20)	Run-away speed (reverse) rpm	
21)	Are pumps and motors capable of withstanding the reverse run-away speed continuously as specified?	
22)	Minimum Submergence required (minimum distance required from the minimum water level to the centre line of bowl (in mm) at	
	a)Minimum Capacity	
	b)Design Capacity	
	c)Maximum Capacity (run out)	
23)	Height from sump invert level to bottom of bowl	
24)	NPSH required (in milli metres) at	
	a)Minimum Capacity	
	b) Design Capacity	
	c) Maximum Capacity (run out)	
25)	NPSH available at minimum water level	
26)	Pump Specific Speed (Include calculation also)	
27)	System Suction Speed at design condition (based on NPSH available at minimum water level in sump) (Include calculation also)	
28)	Pump Suction Speed (based on NPSH required) at design condition (Include calculation also)	
29)	Pump & drive combined critical Speed (rpm)	
	a) 1st	
	b) 2nd	
30)	Rotor over speed (rpm)	
31)	Motor Rating (at 50 deg C)-in KW	
C)	Technical Particulars	
1)	Impeller type and design	
2)	Type of Thrust Bearings	
3)	Number of Bearings of the following & its location	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[2]	15.01.2016

SL.NO	DESCRIPTION	DATA
	a) Cutless rubber type	
	b) "Thorden" Type	
	c) Thrust Bearings (in pump)	
	d) Thrust Bearings (in motor)	
	e) Other types (Specify the type)	
4)	Whether required hoisting clearance over the motor top provided as per the requirement in Technical Specification?	
5)	Heaviest component to be handled by the crane during	
	a) Erection (kg)	
	b) During Maintenance (kg)	
D)	Pump Dimensions	
1)	Spacing between line shaft bearings, (mm)	
2)	Impeller shaft diameter, (mm)	
3)	Line Shaft diameter, (mm)	
4)	Impeller diameter at inlet, (mm)	
5)	Impeller diameter at outlet, (mm)	
6)	Size of pump discharge flange, (mm.)	
7)	Distance from Pump house floor to the Minimum water level	
8)	Diametrical clearance between casing and impeller at the wearing rings (mm)	
E)	Material of Construction	
1)	Impeller	
2)	Suction bell	
3)	Casing	
4)	Wearing rings or Equivalent part (Indicate the name	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[3]	15.01.2016

SL.NO	DESCRIPTION	DATA
	of the Part)	
5)	Pump shaft	
6)	Line shaft	
7)	Shaft coupling	
8)	Shaft sleeve	
9)	Line shaft bearing	
10)	Column pipe	
11)	Shaft enclosing tube	
12)	Discharge elbow	
13)	Distance piece	
14)	Matching flanges	
15)	Thrust pads	
16)	Bolts, nuts and lock washers	
17)	Base plate and Soleplate	
18)	Gaskets	
19)	Gland packing	
20)	Ladder, platform and related accessories.	

2. Traveling Water Screens

SL.NO	DESCRIPTION	DATA
A)	General	
1)	Name of Manufacturer	
2)	Model Number	
3)	Number of Screens	
4)	Type of Screens (Single Flow / Dual Flow)	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[4]	15.01.2016

SL.NO	DESCRIPTION	DATA
5)	Location	
B)	Performance Requirement	
1)	Flow Capacity per screen	
2)	Speed of Traveling Water Screen	
3)	Normal head loss through the screen	
4)	Maximum head loss through the screen	
5)	Maximum velocity through the screens at the lowest water level	
6)	Number of wash water pumps (working+ standby)	
C)	Technical Particulars	
1)	Width of Screen	
2)	Mesh Opening size of the screen	
3)	Size of the mesh wire	
4)	Height of the screen baskets	
5)	Depth of Screen from operating floor to sump floor	
6)	Depth of water from the sump floor a) At lowest water level b) At highest water level	
D)	Material of Construction	
1)	Baskets	
2)	Wire mesh	
3)	Sprockets	
4)	Chain Links	
5)	Wash Water Pump Impeller	
6)	Wash Water Pump Casing	
7)	Wash Water Pump Shaft	

3. Raw Water Pumps

SL.NO	DESCRIPTION	DATA
A)	General	
1)	Name of manufacturer	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[5]	15.01.2016

SL.NO	DESCRIPTION	DATA
2)	Model Number	
4)	Type	
B)	Performance Requirement	
1)	No. of working pumps	
2)	No. of standby pumps	
3)	Shut off head of the Pump (mwc)	
4)	Rated Speed, rpm	
5)	Maximum efficiency of the pump at design point	
6)	Rated Capacity, cum/hr	
7)	Head at the discharge flange for the Rated Flow, mwc	
8)	Range of operation	
9)	Location of the thrust bearing is at	
10)	Type of thrust bearing cooling	
11)	Medium for thrust bearing cooling	
12)	Qty of water required for thrust bearing cooling	
13)	Type of shaft sealing	
14)	Medium for shaft sealing	
15)	Qty of water required for shaft sealing	
16)	Qty of water required for lubrication of line shaft bearing	
17)	Maximum capacity up to which pump can be operated satisfactorily.	
18)	Minimum Capacity up to which pump can be operated satisfactorily	
19)	Run-away speed (reverse) rpm	
20)	Are pumps and motors capable of withstanding the reverse run-away speed continuously as specified?	
21)	Minimum Submergence required (minimum distance required from the minimum water level to the centre line of bowl (in mm) at	
	a)Minimum Capacity	
	b)Design Capacity	
	c)Maximum Capacity (run out)	
22)	Height from sump invert level to bottom of bowl	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[6]	15.01.2016

SL.NO	DESCRIPTION	DATA
23)	NPSH required (in milli metres) at	
	a)Minimum Capacity	
	b) Design Capacity	
	c) Maximum Capacity (run out)	
24)	NPSH available at minimum water level	
25)	Pump Specific Speed (Include calculation also)	
26)	System Suction Speed at design condition (based on NPSH available at minimum water level in sump) (Include calculation also)	
27)	Pump Suction Speed (based on NPSH required) at design condition (Include calculation also)	
28)	Pump & drive combined critical Speed (rpm)	
	a) 1st	
	b) 2nd	
29)	Rotor over speed (rpm)	
30)	Motor Rating (at 50 deg C)-in KW	
C)	Technical Particulars	
1)	Impeller type and design	
2)	Type of Thrust Bearings	
3)	Number of Bearings of the following & its location	
	b) Cutless rubber type	
	b) "Thorden" Type	
	c) Thrust Bearings (in pump)	
	d) Thrust Bearings (in motor)	
	e) Other types (Specify the type)	
4)	Whether required hoisting clearance over the motor top provided as per the requirement in Technical Specification?	
5)	Heaviest component to be handled by the crane during	
	a) Erection (kg)	

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SL.NO	DESCRIPTION	DATA
	b) During Maintenance (kg)	
D)	Pump Dimensions	
1)	Spacing between line shaft bearings, (mm)	
2)	Impeller shaft diameter, (mm)	
3)	Line Shaft diameter, (mm)	
4)	Impeller diameter at inlet, (mm)	
5)	Impeller diameter at outlet, (mm)	
6)	Size of pump discharge flange, (mm.)	
7)	Distance from Pump house floor to the Minimum water level	
8)	Diametrical clearance between casing and impeller at the wearing rings (mm)	
E)	Material of Construction	
1)	Impeller	
2)	Suction bell	
3)	Casing	
4)	Wearing rings or Equivalent part (Indicate the name of the Part)	
5)	Pump shaft	
6)	Line shaft	
7)	Shaft coupling	
8)	Shaft sleeve	
9)	Line shaft bearing	
10)	Column pipe	
11)	Shaft enclosing tube	
12)	Discharge elbow	
13)	Distance piece	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[8]	15.01.2016

SL.NO	DESCRIPTION	DATA
14)	Matching flanges	
15)	Thrust pads	
16)	Bolts, nuts and lock washers	
17)	Base plate and Soleplate	
18)	Gaskets	
19)	Gland packing	
20)	Ladder, platform and related accessories.	

4. Circulating Water Pumps

SL.NO	DESCRIPTION	DATA
A)	General	
1)	Name of manufacturer	
2)	Model Number	
3)	Country of Origin	
4)	Total No. of CW pumps	
5)	Type	
6)	Fluid	
7)	Location	
B)	Performance Requirement	
1)	Number of operating pumps	
2)	No. of standby pumps	
3)	Shut off head of the Pump (mWC)	
4)	Rated Speed, r.p.m	
5)	Maximum efficiency of the CW pump at discharge flange for design point to be considered for arriving at the guaranteed power consumption at motor terminals	
6)	Maximum efficiency of the CW pump motor at design point to be considered for arriving at the guaranteed power consumption at motor terminals	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[9]	15.01.2016

SL.NO	DESCRIPTION	DATA
7)	Rated Capacity, cum/hr	
8)	Total head at Rated Flow	
9)	Range of operation	
10)	Design lowest low water level at fore bay	
11)	Design highest high water level at forebay	
12)	Forebay equipment head loss at design(indicative)	
13)	Power Loss in Bearings (KW)	
	a) Line shaft Bearings	
	b) Thrust Bearing (if provided in pump)	
14)	Location of the thrust bearing is at	
15)	Power Loss in thrust bearing included in motor efficiency (KW) - if applicable	
16)	Maximum capacity upto which pump can be operated satisfactorily	
17)	Minimum Capacity upto which pump can be operated satisfactorily	
18)	Maximum power consumption at motor terminals in the pump operating range	
19)	Minimum Power Consumption at motor terminals in the operating range	
20)	Power consumption at motor terminals at shut off head (KW)	
21)	Pump input power at run-out flow (KW)	
22)	Run-away speed (reverse) r.p.m.	
23)	Are pumps and motors capable of withstanding the reverse run-away speed continuously as specified?	
24)	Minimum Submergence required (minimum distance required from the minimum water level to the centre line of Draft Tube (Formed suction) inlet (in Milli Metres)	
	a)Minimum Capacity	
	b)Design Capacity	
	c)Maximum Capacity (run out	
25)	Height from sump invert level to center line of Draft Tube (Formed suction) inlet	
26)	Height from centre line of Draft Tube inlet(Formed	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[10]	15.01.2016

SL.NO	DESCRIPTION	DATA
	suction) to Impeller eye	
27)	NPSH required (in Milli Metres) at	
	a) Minimum Capacity	
	b) Design Capacity	
	c) Maximum Capacity (run out)	
28)	NPSH available at minimum water level	
29)	Pump Specific Speed (Include calculation also)	
30)	System Suction Speed at design condition (based on NPSH available at minimum water level in sump) (Include calculation also)	
31)	Pump Suction Speed (based on NPSH required) at design condition (Include calculation also)	
32)	Pump & drive combined critical Speed (rpm)	
	a) 1st	
	b) 2nd	
33)	Rotor over speed (rpm)	
34)	Motor Rating (at 50 deg C)- in KW	
C)	Technical Particulars	
1)	Impeller type and design	
2)	Type of Thrust Bearings (Whether it is Mitchel or Kingsbury)	
3)	Number of Bearings of the following & its location	
	a) Cutless rubber type	
	b) "Thorden" Type	
	c) Thrust Bearings (in pump)	
	d) Thrust Bearings (in motor)	
	e) Other types (Specify the type)	
4)	Whether required hoisting clearance over the motor top provided as per the requirement in Technical Specification?	
5)	Heaviest component to be handled by the crane during	
	a) Erection (KG)	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[11]	15.01.2016

SL.NO	DESCRIPTION	DATA
	b) Maintenance (KG)	
6)	Capacity of EOT Crane (Tons) required for CW pump house	
D)	Pump Dimensions	
1)	Spacing between line shaft bearing, (mm)	
2)	Impeller shaft diameter, (mm)	
3)	Line Shaft diameter, (mm)	
4)	Diameter of Formed Suction (inlet to the impeller) in mm	
5)	Suction draft tube (Formed intake) dimensions (width x height) (mm)	
6)	Impeller diameter at inlet, (mm)	
7)	Impeller diameter at outlet, (mm)	
8)	Size of pump discharge flange, (mm.)	
9)	Distance from Pump house floor to the Minimum water level	
10)	Diametrical clearance between wearing rings (mm)	
E)	Thrust Bearing	
1)	Name of Manufacturer	
2)	Location & number	
3)	Type of thrust bearing	
F)	Material of Construction	
1)	Suction Bell & Volute Casing	
2)	Casing Liner	
3)	Lining (for suction draft tube & Volute)	
4)	Impeller	
5)	Wearing rings	
6)	Pump shaft	
7)	Line shaft	
8)	Shaft coupling	
9)	Shaft sleeve	
10)	Line shaft bearing	

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SL.NO	DESCRIPTION	DATA
11)	Discharge elbow	
12)	Matching flanges	
13)	Thrust pads	
14)	Bolts, nuts and lock washers	
15)	Base plate and Soleplate	
16)	Gaskets	
17)	Gland packing	
18)	Ladder, platform and related accessories.	
G)	Miscellaneous Data	
1)	Whether Transient analysis of complete CW System is included in the scope of supply as specified?	
2)	Name of the independent Institute/ Consultant for Transient Analysis	
3)	Whether sump model study of CW sump and forebay is included in the scope as specified?	
4)	Whether the model study of the CW pump is included in the scope as specified?	

5. Stop log gates

(Bidder shall furnish details for each size stop log gates provided for CW and RW system separately)

SL.NO	DESCRIPTION	DATA
A)	General	
1)	No. of Stop log gates	
2)	Stop log gate lifting beams for gates	
3)	Service	
4)	Type of gate	
5)	Location	
6)	Design standard	
7)	Gate sections	
8)	Minimum corrosion allowance to be Considered in gate assembly	
9)	Lifting beam	
10)	Channel width	
11)	No. of sections per set	

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SL.NO	DESCRIPTION	DATA
12)	Dimensions (LXWXH) in mm	
13)	Weight of Stop log gate a) Each segment weight b) Total weight	
B)	Material of Construction	
1)	Guide & Concrete Embedment	
2)	Frame with skin plate	
3)	Seal clamping strips	
4)	Side and top seal	
5)	Bottom seal	
6)	Middle seal	
7)	Lifting pin	
8)	Lifting eye bolt	
9)	Hardware (bolts, screws, nuts, washers etc.)	
10)	Lifting beam assembly	
11)	Channel width	
12)	No. of sections per set	
13)	Dimensions (LXWXH) in mm	
14)	Gate	
15)	Equalising valve	
16)	Channel material	

6. Coarse Screens

(Bidder shall furnish details for each size coarse screen provided for CW and RW system separately).

SL.NO	DESCRIPTION	DATA
A)	General	
1)	No. of racks	
2)	Service	
3)	Location	
B)	Technical Particulars	
1)	Design standard	

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SL.NO	DESCRIPTION	DATA
2)	Type of rack	
3)	Size of rack	
4)	Capacity	
5)	Dimension of rack	
6)	wire size	
7)	Spacing between wires	
8)	Design differential head	
C)	Material of construction	
1)	a)Guide and concrete embedment	
2)	b)Frame work	
3)	c) wire mesh screen assembly	
4)	d) Bolts, nuts and other hardware	
D)	Other Details	
1)	Weight of the coarse screen	
2)	Hoist for lifting the screen provided	
3)	Inspection & testing as specified	
4)	Manufacturer's catalogue / literature enclosed	

7. Trash Rack

SL.NO	DESCRIPTION	DATA
A)	General	
5)	No. of racks	
6)	Service	

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SL.NO	DESCRIPTION	DATA
7)	Location	
B)	Technical Particulars	
1)	Design standard	
2)	Type of rack	
3)	Size of rack	
4)	To match Capacity	
5)	Dimension of rack	
6)	bar thickness	
7)	Spacing between bars	
8)	Design differential head	
B)	Material of construction	
1)	Guide & Concrete embedment	
2)	Frame work	
3)	Bar screen assembly	
4)	Bolts, nuts and other hardware	
C)	Other Details	
1)	Weight of the coarse screen	
2)	Hoist for lifting the screen provided	
3)	Inspection & testing as specified	
4)	Manufacturer's catalogue / literature enclosed	

8. CW Pipe, Recirculation pipe line and make water pipe line

SL.NO	DESCRIPTION	DATA
A)	Pipe	
1)	Manufacturer	

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SL.NO	DESCRIPTION	DATA
2)	Manufacturing process	
3) /	Type of construction	
4)	Material of construction	
5)	Type of joints	
6)	Wall thickness	
7)	All the pipes under this group included	
B)	Fittings	
1)	Manufacturer	
2)	Manufacturing process	
3)	Type of joints	
4)	All the fittings under this group included	
C)	Flanges	
1)	Manufacturer	
2)	Material standard	
3)	Type	
4)	Standard	
D)	Hydrostatic test Pressure kg/sq.cm	
1)	At shop	
2)	At site	
F)	Out Side Wrapping & Coating (buried portion)	
	The Contractor to furnish a complete write-up on the proposed wrapping & coating including list of similar installations	

9. Rubber Expansion Joints
(Bidder shall furnish details for each size RE joints provided for CW and RW system separately)

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SL.NO	DESCRIPTION	DATA
A)	General	
1)	Manufacturer	
2)	Service	
3)	Design Standard	
4)	Number of Expansion Joints	
5)	Size (Diameter)	
6)	Type	
B)	Technical Details	
1)	Operating Temperature	
2)	Design temperature	
3)	Design Pressure	
4)	Test Pressure	
5)	Minimum cycle life	
6)	Flow m ³ /hr (Normal)	
7)	Pressure drop across expansion joint	
8)	Bursting Pressure	
9)	End connection	
10)	Installation position	
11)	Axial compression	
12)	Axial elongation	
13)	Lateral movement	
14)	Angular deflection	
15)	Torsional deflection	
16)	Stainless steel retaining ring thickness	
17)	Shore Hardness for inner cover	
18)	Shore Hardness for outer cover	

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SL.NO	DESCRIPTION	DATA
19	Flange drilling standard	
20	Companion flanges	
21	No. of control units	
C)	Material of construction	
1)	Bellow	
2)	Carcass	
3)	Bellow Exterior	
4)	Bellow Interior	
5)	Metal reinforcement	
6)	Control rod Assembly	
	i)Limit rods	
	ii)Stretcher Plate	
7)	Retaining ring segments	
8)	Fasteners	
9)	Stretcher bolt / nuts & washers	
10)	Gasket material	

10. Butterfly Valves for CW System / RW System
(Bidder shall furnish details for each size and type BFVs provided for CW and RW system separately)

SL.NO	DESCRIPTION	DATA
A)	GENERAL	
1)	Name of manufacturer	
2)	Model No	
3)	Fluid	
4)	Type	
5)	Size	

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SL.NO	DESCRIPTION	DATA
6	Type of operation	
	Number of valves	
B)	Technical Particulars	
1)	Valve Design Code & Design Rating	
2)	End Flange details (Refer standard also)	
3)	Type of actuator	
4)	Flow	
5)	Normal	
6)	Maximum	
7)	Sealing direction	
8)	Pressure	
	a) Design	
	b) Operating	
9)	Disc differential pressure	
C)	Material of construction	
1.	Body	
2.	Body linings	
3.	Shaft sealing	
4.	Shaft bearing	
5.	Stem material	
6.	Disc material	
7.	Seat on body/disc	
8.	Internal hardware	
9.	Hand wheel/lever	

11. Makeup water pipe (From RW pump discharge header to In plant Raw Water Reservoir)

SL.NO	DESCRIPTION	DATA
1.	Internal diameter	

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SL.NO	DESCRIPTION	DATA
2.	Thickness of pipe, mm	
3.	Pressure rating	
4.	Standard of manufacture	
5.	Test pressure	
6.	Material grade	
7.	Maximum service temperature	
8.	Type of jointing	
9.	Whether readymade fittings are available ?	

12. Sluice gate :

SL.NO	DESCRIPTION	DATA
1.	Frame, leaf(disc)	
2.	Stem	
3.	Wedges	
4.	Seat	
5.	Flush Bottom Seal	
6.	Thrust Nut	
7.	Hand Wheel	
8.	Stem Guide Bracket	
9.	Hand Crank & Yoke	
10.	Stem Coupling	

13. Aerator

SL.NO	DESCRIPTION	DATA
1	Number	
2	Type	

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SL.NO	DESCRIPTION	DATA
3	Material	
4	Design Flow (m ³ /h)	
5	Surface Flow Rate (m ² /m ³ /h)	

14. Stilling Chamber

SL.NO	DESCRIPTION	DATA
1.	Number	
2.	Purpose	
3.	Material	
4.	Capacity	
5.	Specialties	

15. Flash Mixer

SL.NO	DESCRIPTION	DATA
1.	Number	
2.	Type	
3.	Material of Construction	
4.	Agitator	
5.	Type	
6.	Number	
7.	Isolation gates along with hand wheels	
8.	Capacity, each	
9.	Draining	

16. Clariflocculator

SL.NO	DESCRIPTION	DATA
1.	Material of inlet from flash mixer to Flocculation tank	
2.	Number required	
3.	Type	

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SL.NO	DESCRIPTION	DATA
4.	Material of Construction	
5.	Rated net output capacity	
6.	Guaranteed output	
7.	Retention time (minimum)	

17. Common Sludge Pit

SL.NO	DESCRIPTION	DATA
1	Length (m)	
2	Width (m)	
3	Active Depth (m)	
4	Whether Outdoor/ Indoor	
5	Whether Covered/ Uncovered	
6	Whether hand rails provided for uncovered pit	

18. Sludge thickener feed Pumps

SL.NO	DESCRIPTION	DATA
1.	Number	
2.	Type	
3.	Location	
4.	Liquid to be pumped	
5.	Rated Capacity	
6.	Duty	
7.	Range of operation	
8.	Design standard	
9.	Material of Construction	
10.	Casing	
11.	Casing	
12.	Impeller	
13.	Shaft sleeve	

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SL.NO	DESCRIPTION	DATA
14.	Shaft bearing	
15.	Base plate	
16.	Stuffing box	
17.	Impeller shaft	
18.	Pump Motor Selection	
19.	Instrumentation	
20.	Pressure Gauge	
21.	Interlock required for Pump operation	

19. Sludge Thickener and Centrifuge

SL.NO	DESCRIPTION	DATA
1.	Thickener	
	Quantity	
	Capacity	
	Minimum Consistency at outlet	
2.	Centrifuge Feed Pumps	
	a) Number	
	b) Type	
	c) Materials	
	d) Capacity	
	e) Head	
	f) Fluid to be handled	
3.	Centrifuge	
	Type	
	Quantity	
	Capacity	
	MOC of centrifuge	

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SL.NO	DESCRIPTION	DATA
	Minimum Consistency at outlet	

20. Sludge Transfer Pumps

SL.NO	DESCRIPTION	DATA
1	Number of pumps provided	
2	Number of pumps working	
3	Number of pumps standby	
4	Type	
5	Rated Capacity	
6	Total Dynamic Head	
7	Range of operation	
8	Design Standard	
9	Efficiency	
10	Material of Construction	
	Casing	
	Impeller	
	Shaft	
	Shaft sleeve	
	Shaft bearing	
	Base plate	
	Stuffing box	
11	Pump Motor Rating	
12	Instrumentation Provided (pressure gauge, level switch, level transmitter etc)	
13	Interlock provided for pump operation	

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21. DM Neutralizing Pit Transfer Pumps

SL.NO	DESCRIPTION	DATA
1	Number of pumps provided	
2	Number of pumps working	
3	Number of pumps standby	
4	Type	
5	Orientation (Horizontal / Vertical)	
6	Rated Capacity	
7	Total Dynamic Head	
8	NPSHr	
9	Priming System in case of Horizontal pumps	
10	Range of operation	
11	Design Standard	
12	Efficiency	
13	Material of Construction	
	a) Casing	
	b) Impeller	
	c) Shaft	
	d) Shaft sleeve	
	e) Shaft bearing	
	f) Base plate	
	g) Stuffing box	
14	Pump Motor Rating	
15	Instrumentation Provided (pressure gauge, level switch, level transmitter etc)	
16	Interlock provided for pump operation	

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22. DM Plant supply pumps and Service Water Pumps

SL.NO	DESCRIPTION	DATA
A	DM Plant Supply Pump	
1.	No. of Pumps provided	
2.	No. of Pumps working	
3.	No. of Pumps Standby	
4.	Liquid handled	
5.	Design Water Temperature	
6.	Normal water level (M)	
7.	Minimum water level (M)	
8.	Maximum water level (M)	
9.	Pump performance requirements :	
10.	Performance Standard	
11.	Minimum Flow capacity, (Cu.M/Hr.)	
12.	Speed. RPM	
13.	Total dynamic head (MLC)	
14.	Range of operation	
15.	Design standard	
16.	Pump type	
17.	Impeller type	
18.	Reverse flow through pump to be considered for pump design	
19.	Type of gland lubrication and sealing	
20.	Type of coupling	
21.	Bearing cooling	
22.	MOC of Casing	
23.	MOC of Impeller	
24.	MOC of Shaft sleeve	
25.	MOC of Shaft bearing	
26.	MOC of Base plate	
27.	MOC of Stuffing box	

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SL.NO	DESCRIPTION	DATA
28.	MOC of Impeller shaft	
B	Service Water Pump	
1.	No. of Pumps required	
2.	No. of Pumps working	
3.	No. of Pumps Standby	
4.	Liquid handled	
5.	Design Water Temperature	
6.	Normal water level (M)	
7.	Minimum water level (M)	
8.	Maximum water level (M)	
9.	Pump performance requirements :	
10.	Performance Standard	
11.	Minimum Flow capacity, (Cu.M/Hr.)	
12.	Speed. RPM	
13.	Total dynamic head (MLC)	
14.	Range of operation	
15.	Design standard	
16.	Pump type	
17.	Impeller type	
18.	Reverse flow through pump to be considered for pump design	
19.	Type of gland lubrication and sealing	
20.	Type of coupling	
21.	Bearing cooling	
22.	MOC of Casing	
23.	MOC of Impeller	
24.	MOC of Shaft sleeve	
25.	MOC of Shaft bearing	
26.	MOC of Base plate	
27.	MOC of Stuffing box	

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SL.NO	DESCRIPTION	DATA
28.	MOC of Impeller shaft	

23. CT Make Up Pumps

SL.NO	DESCRIPTION	DATA
A	General	
1	Name of Manufacturer	
2	Model No.	
3	Type of Pumps	
	No. of Pumps provided	
	No. of Pumps working	
	No. of Pumps Standby	
	Liquid handled	
B	Technical Particulars	
1.	Design Water Temperature	
2.	Normal water level (M)	
3.	Minimum water level (M)	
4.	Maximum water level (M)	
5.	Performance Standard	
6.	Minimum Flow capacity, (Cu.M/Hr.)	
7.	Speed. RPM	
8.	Total dynamic head (MLC)	
9.	Range of operation	
10.	Design standard	
11.	Pump type	
12.	Impeller type	
13.	Reverse flow through pump considered for pump design	
14.	Type of gland lubrication and sealing	
15.	Type of coupling	
16.	Bearing cooling	
C	Materials of Construction	

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SL.NO	DESCRIPTION	DATA
	a) Casing	
	b) Impeller	
	c) Shaft	
	d) Shaft sleeve	
	e) Shaft bearing	
	f) Base plate	
	g) Stuffing box	

24. Chemical Storage & Dosing System

SL.NO	DESCRIPTION	DATA
A)	Bulk Coagulant Storage	
1.	Capacity (Number of days)	
2.	Chemical to be handled	
3.	Number of tanks/ bins	
4.	Form (Sold / Liquid)	
B)	Coagulant Handling & Preparation System	
1.	Monorail / Hoist provided (Yes/ No)	
2.	Capacity of Hoist (tons)	
3.	Design Dosage Rate	
4.	Capacity of each tank	
5.	Type of Tank	
6.	Material of Construction	
7.	Number of agitators	
8.	Shaft Material of Agitator	
9.	Impeller Material of Agitator	
10.	Accessories	
C)	Coagulant Dosing Pumps	
1.	Chemical to be dosed	
2.	Numbers of pumps (Working +Standby)	

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SL.NO	DESCRIPTION	DATA
3.	Duty	
4.	Design flow rate of each dosing pump	
5.	Head of dosing pump	
6.	Pump stroke speed per minute	
7.	Material of Construction	
	a) Liquid end (pump head valve, valve housing, etc), valve spring	
	b) Diaphragm	
	c) Packing	
	d) Shaft	
8.	Accessories	
D)	Bulk Coagulant Aid Storage & Preparation Tanks	
1.	Purpose	
2.	Chemical to handled	
3.	Method of storage / Preparation	
4.	Number of tanks	
5.	Design Dosage rate	
6.	Design Quantity of Water to be dosed	
7.	Design Storage Capacity to be considered	
8.	Type of Tank	
9.	Material of Construction	
10.	Agitator & Number	
11.	Agitator shaft Material	
12.	Agitator Impeller Material	
13.	Accessories	
E)	Coagulant Aid Dosing Pumps	
1.	Purpose	
2.	Chemical to be dosed	
3.	Type	
4.	Numbers required (Working +Standby)	

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SL.NO	DESCRIPTION	DATA
5.	Duty	
6.	Design Quantity of Water to be dosed	
7.	Design flow rate of each dosing pump	
8.	Head of dosing pump	
9.	Capacity control	
10.	Pump stroke speed per minute	
11.	Material of Construction	
	a) Liquid end (pump head valve, valve housing, etc), valve spring	
	b) Diaphragm	
	c) Packing	
	d) Shaft	
12.	Accessories	
F)	Bulk Acid Storage & Preparation Tanks	
1.	Purpose	
2.	Chemical to handled	
3.	Number of tanks	
4.	Design Storage Capacity to be considered	
5.	Type of Tank	
6.	Material of Construction	
G)	Acid Unloading and Transfer Pump	
1.	Purpose	
2.	Chemical to be dosed	
3.	Type	
4.	Numbers required (Working +Standby)	
5.	Head	
6.	Capacity	
H)	Bulk Alkali Storage & Preparation Tanks	
1.	Purpose	

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SL.NO	DESCRIPTION	DATA
2.	Chemical to handled	
3.	Number of tanks	
4.	Design Storage Capacity to be considered	
5.	Type of Tank	
6.	Material of Construction	
I)	Alkali Unloading and Transfer Pumps	
1.	Purpose	
2.	Chemical to be dosed	
3.	Type	
4.	Numbers required (Working +Standby)	
5.	Duty	
6.	Head	
7.	Capacity	
8.	Capacity control	
9.	Pump stroke speed per minute	

25. Lime Storage, Preparation and Dosing System for PT Plant

SL.NO	DESCRIPTION	DATA
A	Lime Storage	
1.	Location of Lime Storage	
2.	Storage capacity (number of days)	
B	Solution Preparation Tank	
1	Storage Capacity	
2	Number of Tanks	
3	Tank Type	
4	Length of Tank	
5	Width of Tank	
6	Free Board	

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SL.NO	DESCRIPTION	DATA
7	Height of Straight	
8	Effective Volume per tank	
9	Number of agitators per tank	
10	Material of Construction of Agitator	
11	Concentration of solution to be prepared	
12	Purity of Chemical Considered	
C	Lime Solution Pumps	
1	Type of Pumps	
2	Number of Pumps (Working+ Standby)	
3	Flow rate (m ³ /h)	
4	Pumping Head	
D	Lime Dosing Tanks	
1	Storage Capacity	
2	Number of Tanks	
3	Tank Type	
4	Length of Tank	
5	Width of Tank	
6	Free Board	
7	Height of Straight	
8	Effective Volume per tank	
9	Number of agitators per tank	
10	Material of Construction of Agitator	
E	Lime Dosing Pumps	
1	Type of Pumps	
2	Number of Pumps (Working+ Standby)	

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SL.NO	DESCRIPTION	DATA
3	Dosing rate (lph)	
4	Pumping Head	

26. Sulphuric Acid Bulk Storage and Dosing System

SL.NO	DESCRIPTION	DATA
A	Sulphuric Acid Storage	
1	Number of tanks	
2	Design Storage Capacity considered	
3	Type of Tank	
4	Material of Construction	
B	Acid Unloading and Transfer Pump	
1	Type	
2	Numbers required (Working +Standby)	
3	Head	
8	Capacity	
C	Sulphuric Acid Dosing System	
1	Acid Unloading Pumps i) Quantity ii) Capacity iii) Head	
2	Bulk Acid Tank i) Quantity ii) Capacity iii) Material of Construction	
3.	Acid Dosing Pumps	

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SL.NO	DESCRIPTION	DATA
	i) Quantity ii) Capacity iii) Head iv) Material of Construction v) Range of Stroke Length Adjustment vi) All Interconnecting piping between equipments with isolation valves, fittings and other accessories. a) Material specification of piping. b) Material specification of valves c) Valve Actuation.	
4	Dosage rate of each chemical (ppm)	
5	CW Make up rate (m ³ /h)	
6	Alkalinity of CW Make up water (mg/l CaCO ₃)	
7	pH of CW Make up water	
8	Cycles of Concentration	
9	Alkalinity of Circulating Water (mg/l CaCO ₃)	
10	pH of Circulating Water	

27. Pressure Sand Filters

SL.NO	DESCRIPTION	DATA
1.	No. of filters in the system	
2.	No. of filters working	
3.	Time between successive back washing	
4.	Filtering material	
5.	Design code	
6.	Feed Flow / module (Net output)	
7.	Design surface flow-rate at normal condition	

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SL.NO	DESCRIPTION	DATA
8.	Pressure indicator	
	i) Location	
	ii) Number	
9.	Flow indicator	
	i) Location	
	ii) Number	
10.	Type	
11.	Backwash water source	
12.	Inter connection of units	
13.	Material of Construction	
	i) Filter vessel	
	ii) Rubber lining	
	iii) Hardness	
	iv) Frontal piping	

28. Activated Carbon Filters

SL.NO	DESCRIPTION	DATA
1.	No. of filters in the system	
2.	No. of filters working	
3.	No. of standby filters	
4.	Time between successive back washing	
5.	Filtering material	
6.	Filtration speed	
7.	Design code	
8.	Net Flow	
9.	Design surface flow-rate at normal condition (Maximum)	
10.	Pressure indicator	
	i) Location	
	ii) Number	
11.	Flow indicator	

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SL.NO	DESCRIPTION	DATA
	i) Location	
	ii) Number	
	iii) Type	
12.	Backwash water source	
13.	Inter connection of units	
14.	Material of Construction	
	i) Filter body	
	ii) Rubber lining	
	iii) Hardness	
	iv) Frontal piping	

29. Potable Water tank

SL.NO	DESCRIPTION	DATA
1.	Service	
2.	Number	
3.	Effective capacity	
4.	Type	
5.	Design Code	
6.	Location	
7.	Free board, mm (minimum)	
8.	Bottom shape	
9.	Material of construction	
10.	Inside protection	
11.	External painting	
12.	Overflow, drain and sample connection	
13.	Manhole (Davit type)	
14.	Special Fittings	
	• Seal for overflow	
	• Additional nozzle connections	
	• Conservation vent valves	

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SL.NO	DESCRIPTION	DATA
	• Air breather with KoH seal	
	• Special feature	
15.	Instrumentation	
	• Level indicator	
	• Type	
	• Level switch	
	• Level integrator transmitter	

30. Potable Water Supply Pumps

SL.NO	DESCRIPTION	DATA
1.	Duty	
2.	Location	
3.	No. of Pumps required	
4.	No. of Pumps working	
5.	No. of Pumps Standby	
6.	No. of Pumps working parallel	
7.	Liquid handled	
8.	Design Water Temperature	
9.	Pump performance requirements :	
10.	Performance Standard	
11.	Min. Flow capacity, (Cu.M/Hr.)	
12.	Speed. RPM	
13.	Static head of pumping system (MLC)	
14.	Pump shut off head (MLC)	
15.	Range of operation	
16.	Design and constructional features :	
17.	Design standard	
18.	Pump type	
19.	Reverse flow through pump to be considered for pump design	

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SL.NO	DESCRIPTION	DATA
20.	Wearing rings	
21.	Material of construction :	
	i) Casing	
	ii) Impeller	
	iii) Shaft sleeve	
	iv) Thrust bearing	
	v) Base plate	
	vi) Stuffing box, glands, and lantern ring	
	vii) Pump Shaft	

31. Demineralization Plant

SL.NO	DESCRIPTION	DATA
A)	DM Plant	
1.	No. of DM Streams	
2.	No. of parallel streams	
3.	No. of working streams	
4.	No. of standby streams	
5.	Water source	
6.	Installation	
7.	Normal operation	
8.	Net permeate water output	
9.	Type and Make of Resins (Bidder to furnish the details for each type of resins to be used for SAC, WAC, SBA, WBA and MB Vessels)	
10.	Pressure Vessels Type	
11.	Number of Pressure Vessels (For Each type i.e. Strongly acidic cation exchanger (SAC), Weak Acid Cation exchanger (WAC), Strongly basic anion exchanger (SBA), Weak Base Anion exchanger (WBA), Mixed bed exchanger (MB))	<i>SAC, WAC - [....] SBA, WBA - [....] MB - [....]</i>
12.	Net outflow/unit	<i>SAC, WAC - [....]</i>

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SL.NO	DESCRIPTION	DATA
		<i>SBA, WBA - [....] MB - [....]</i>
13.	Design surface flow rate	<i>SAC, WAC - [....] SBA, WBA - [....] MB - [....]</i>
14.	Design Pressure	<i>SAC, WAC - [....] SBA, WBA - [....] MB - [....]</i>
15.	Design Temperature	<i>[....]</i>
16.	Material of Construction of Shell	<i>SAC, WAC - [....] SBA, WBA - [....] MB - [....]</i>
17.	Material of Construction of Dished End	<i>SAC, WAC - [....] SBA, WBA - [....] MB - [....]</i>
18.	Effective Bed Depth	<i>SAC, WAC - [....] SBA, WBA - [....] MB - [....]</i>
19.	Buffer Bed Depth	<i>SAC, WAC - [....] SBA, WBA - [....] MB - [....]</i>
20.	Inert bed Depth	<i>SAC, WAC - [....] SBA, WBA - [....]</i>
B)	Air Blowers for MB exchanger and Neutralization Pit	
1.	Numbers	
2.	Service	
3.	Type	

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SL.NO	DESCRIPTION	DATA
4.	Duty	
5.	Capacity of each blower for Mixed Bed	
6.	Head to be developed	
7.	Material of construction	
	Casing	
	Lobes / impeller	
	Shaft	
	Safety valve	
8.	Testing & inspection	
9.	Material test required	
10.	Code for testing	
C)	Degasser Tower (DGT)	
1.	Number required	
2.	Type	
3.	Normal flow rate per tower	
4.	Maximum & minimum capacity	
5.	Fill material	
6.	CO ₂ content in	
7.	Design Code	
8.	Location	
9.	Size (Diameter x height)	
10.	Distributors and Collectors	
11.	Manhole (Davit type)	

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SL.NO	DESCRIPTION	DATA
12.	Staircase, Platform and Hand Rails	
13.	Material of Construction (Shell, Distributors, collectors, Nozzles etc.)	
14.	External painting	
15.	Inside Protection	
	a) Shell	
	b) Distributors, Collectors	
16.	Degasser air discharge duct	
D)	Degassed Water Storage Tank (DGWT)	
1.	Number required	
2.	Design Code	
3.	Location	
4.	Type	
5.	Useful capacity	
6.	Free Board	
7.	Material	
8.	External Painting	
9.	Inlet, outlet, Vent, overflow, drain	
10.	Manhole (Davit type)	
11.	Staircase, platform and Handrails	
12.	Level Indicator-cum-Controller	
	Type	
	Number	
	Transmitter	

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SL.NO	DESCRIPTION	DATA
	Auto-manual	
	Control valve	
	Number	
	Body	
	Plug & Stem	
	Seat	
	Actuator	
	Inching	
E)	Degassed Water Pumps (DGP)	
1.	Number	
2.	Type	
3.	Location	
4.	Duty	
5.	Capacity	
6.	T.D.H.	
7.	Material of Construction	
	Casing	
	Impeller	
	Shaft & shaft sleeve	
	Packing seal	
	Common base plate	
	Casing & Impeller Type	
	Range of operation	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[44]	15.01.2016

SL.NO	DESCRIPTION	DATA
	Design standard	
	Rated Speed	
	Permissible Tolerance	
	Noise level for pump	
F)	Air Blowers	
1.	Numbers	
2.	Service	
3.	Type	
4.	Duty	
5.	Capacity, each for Pressure Sand Filter	
6.	Head to be developed	
7.	Material of construction	
	i) Casing	
	ii) Lobes / impeller	
	iii) Shaft	
	iv) Safety valve	
	v) Testing & inspection	
	vi) Material test required	
	vii) Code for testing	
	viii) Rotor balancing	
G)	DM Water Transfer Pumps	
1.	Duty	
2.	Location	

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SL.NO	DESCRIPTION	DATA
3.	No. of Pumps Required	
4.	No. of Pumps Working	
5.	No. of Pumps Stand-by	
6.	Suction Lift/Head Available (MLC)	
7.	Pump Performance Requirements	
	a) Flow Capacity (Cu.m/hr.)	
	b) Total Dynamic Head as per IS-5120 at Rated Capacity (MLC)	
	c) Rated Speed (rpm) (max.)	
	d) Range of Operation	
	e) Suction specific speed	
	Design standard	
	a) Type of Gland Lubrication and Sealing	
	b) Bearing Cooling (if required)	
	Shaft Sealing Arrangement	
	Type of Pump-motor Connection	
	Type of Coupling	
8.	Material of Construction	
	a) Casing	
	b) Casing Liner	
	c) Diffuser	
	d) Impeller	
	e) Wearing Rings	
	f) Shaft	

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SL.NO	DESCRIPTION	DATA
	g) Shaft Sleeve	
	h) Base Plate	
	l) Shaft bearings	
	j) Wetted Fastener	
H)	DM Water Storage Tank	
1.	Number required	
2.	Design code	
3.	Location	
4.	Capacity of each tank	
5.	Free Board (Minimum) mm	
6.	Type and pressure class	
7.	Material of construction and Thickness	
8.	Internal Painting	
9.	External Painting	
10.	Overflow, drain	
11.	Manhole (Davit type)	
12.	Staircase, platform, and Handrails	
13.	Level Indicator	
	Number	
	Type	
14.	Level Switch	
	Number	
	Centralized Panel	

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32. CW Chemical Dosing System Bidder to provide details for each chemical viz. A) Anti Scalant
B) Corrosion Inhibitor C) Non Oxidizing Biocide D) Dispersant

SL.NO	DESCRIPTION	A	B	C	D
1.	Type of chemical				
2.	Chemical Dosing Tank				
	a) Number				
	b) Capacity				
	c) Material of construction				
3.	Chemical Dosing Pumps				
	a) Number				
	b) Capacity/pump				
	c) Head				
	d) Material of construction (all wetted parts)				
	e) Stroke length adjustment				
4.	Accessories to be provided				
5.	All interconnecting piping between equipment with isolation valves, fittings and other accessories etc.				
6.	Safety shower and Eye Wash fountain.				
7.	Cooling water make up quality				
8.	Cooling water range				
9.	Cooling water flow				
10.	Cycle of concentration				
11.	Location of dosing system				

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33. Hypo Chlorite Dosing Pumps

SL.NO	DESCRIPTION	DATA
A)	For Continuous Dosing	
1.	Number	
2.	Description for each equipment	
	Location	
	Fluid to be handled	
	Duty	
3.	Type	
4.	Type of impeller	
5.	Design standard	
6.	Service temperature	
7.	Rated Capacity (cum. Per hr)	
8.	Range of operation	
9.	Permissible tolerance in rated capacity	
10.	Suction Condition	
11.	Head to be developed at rated capacity	
12.	Permissible tolerance in efficiency at rated capacity(%)	
13.	Material of Construction	
	Casing	
	Impeller	
	Shaft Seal	
B)	For Shock Dosing	
1.	Number	
2.	Description for each equipment	
	Location	
	Fluid to be handled	
	Duty	
3.	Type	
4.	Type of impeller	

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SL.NO	DESCRIPTION	DATA
5.	Design standard	
6.	Service temperature	
7.	Rated Capacity (cum. Per hr)	
8.	Range of operation	
9.	Permissible tolerance in rated capacity	
10.	Suction Condition	
11.	Head to be developed at rated capacity	
12.	Permissible tolerance in efficiency at rated capacity(%)	
13.	Material of Construction	
	Casing	
	Impeller	
	Shaft Seal	

34. Air Conditioning & Ventilation System

SL.NO	DESCRIPTION	DATA
A)	Split Air Conditioner (Ductable / Non Ductable) (Bidder to provide details Location wise)	
1.	Type	
2.	Make	
3.	Model No.	
4.	Capacity (TR)	
5.	Qty.	
6.	Power Consumption (kW)	
7.	Overall Dimension (L x B x D)	
8.	Gross Weight (kg)	
9.	Catalogue enclosed	
10.	Accessories provided	
11.	Mounting Frame	
12.	Drain pipe (6m. long)	
13.	Refrigerant Compressor	

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SL.NO	DESCRIPTION	DATA
	a) Manufacturer	
	b) No. of Units	
	c) Type	
	d) Refrigerant	
14.	Performance	
	Condensing Temp. (deg C)	
	Evaporating Temp. (deg C)	
	Capacity in Kcal/hr.	
	R.P.M.	
	B.H.P. required	
	Lubrication type	
	H.P. recommended	
	All operating/safety controls and interlocks as specified are provided. (Use separate sheets and furnish details)	
15.	Coil (Condenser and Evaporator)	
	a) Manufacturer	
	b) Type	
B)	Window Air Conditioners (Bidder to provide details Location wise)	
1	Type	
2	Capacity (TR)	
3	Manufacturer	
4	Application area	
5	Power Consumption (kW)	
6	Refrigerant	
7	Compressor Type	
8	Overall Dimensions (LxBxW)	
9	Weight (kg)	
10	Noise Level (at 1M distance)	
C	Water-Cooled Packaged Air Conditioners (Bidder to provide details Location wise)	

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SL.NO	DESCRIPTION	DATA
	General	
1	Type	
2	Make	
3	Model No.	
4	Capacity (TR)	
5	Condenser Water entering and leaving Temperature (deg C)	
6	Power Consumption (kW)	
7	Overall Dimension (L x B x D)	
8	Gross Weight (kg)	
9	Nos. Quoted	
10	Whether Microprocessor based control panel provided	
	Refrigerant Compressor	
1	Manufacturer	
2	No. of Units	
3	Type	
4	Refrigerant	
5	Condensing Temperature (deg C)	
6	Evaporating Temperature (deg C)	
7	Capacity (kCal/h)	
8	RPM	
9	BHP	
	Condenser (Water Cooled Type)	
1	Manufacturer	
2	Model No.	
3	Fluid Temp – Tube Side (deg C) Inlet/Outlet	
4	Fluid Temp – Shell Side (deg C) Inlet/Outlet	
5	Fluid Velocity (m/sec)	
6	No.of passes	
7	LMTD (deg C) (Including correction factor)	

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SL.NO	DESCRIPTION	DATA
8	Overall heat transfer co-efficient	
9	Fouling factor	
10	Surface area (Sq. m)	
11	Pressure drop (meters of water head)	
12	Material of tubes	
13	Inside/ outside diameter and thickness of tubes	
14	Material and thickness of tube sheet	
15	Thermo-wells	
16	Pressure gauges	
17	Vent. Connection with valves	
18	Drain connection with valves	
19	Relief valve	
20	Fusible plug	
	Evaporator Fan	
1	Total static pressure (mm WG)	
2	Outlet Velocity	
3	Rated Speed	
4	BHP	
5	Motor Rating	
6	Material of Impeller	
7	Material of Casing	
8	Material of shaft	
	Cooling Coil	
1	Cooling capacity (kCal/h)	
2	Air quantity (M3/h)	
3	Coil entering air temperature (deg C)	
4	Coil leaving air temperature (deg C)	
5	Pressure drop- air side (mmWG)	
6	Number of circuits	
7	Fouling Factor	

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SL.NO	DESCRIPTION	DATA
8	Overall Heat Transfer Coefficient	
	Water Pumps	
1	Make	
2	Type	
3	Model No.	
4	Nos. Provided	
5	Rated Capacity (M3/h)	
6	Total Head at rated capacity (MWC)	
7	Pump Efficiency at rated capacity (MWC)	
8	Permissible suction head	
9	Pump speed (rpm)	
10	Pump BHP (kW)	
11	Motor Rating (kW)	
12	Whether vibration isolation pads provided	
	Cooling Towers	
1	Make	
2	Type of Cooling Towers	
3	Model No.	
4	Nos. provided	
5	Total operating weight (including water)	
6	Overall dimensions	
7	Cooling Water Quantity (m3/h)	
8	Inlet water temperature (deg C)	
9	Outlet water temperature (deg C)	
10	Wet Bulb Temperature (deg C)	
11	Approach (deg C)	
12	Fan Capacity (M3/h)	
13	Velocity at fan outlet (m/sec)	
14	Total pressure (mm WG)	
15	Fan Power (kW)	

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SL.NO	DESCRIPTION	DATA
16	Motor Rating (kW)	
17	Number of nozzles	
18	Pressure at the nozzles	
D)	Centrifugal Fan (For each fan) (Bidder to provide details Location wise)	
1.	Manufacturer	
2.	Model No.	
3.	Type	
4.	Number quoted	
5.	Capacity (m ³ / h.)	
6.	Specific weight of air at temperature considered (kg/m ³)	
7.	Rated speed in rpm	
8.	Total head at above speed (mmw)	
9.	Static head at rated speed (mmw)	
10.	Critical speed of fan and shaft (rpm)	
11.	Fan power at rated speed (rpm)	
12.	Fan total efficiency at rated speed (%)	
13.	Wheel diameter (mm)	
14.	Overall Wheel width (mm)	
15.	Outlet velocity (m/s)	
16.	Material used in wheel and its thickness	
17.	Material used in shaft	
18.	Type of bearing	
19.	Type of fan drive	
20.	Drive manufacturer	
21.	Number of belts	
22.	Size of belts	
23.	Vibration Isolator Manufacturer	
24.	Vibration Isolator size and No.	
25.	Outlet damper size	

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SL.NO	DESCRIPTION	DATA
26.	Outlet damper type	
27.	Material and thickness of louver and casing	
28.	Inlet damper type	
29.	Inlet damper size	
30.	Material and thickness of plate used in the casing and flap on the damper	
31.	Rated volt of motor	
32.	Rated KW of motor offered	
33.	Type of insulation	
34.	Motor ambient temperature ($^{\circ}\text{C}$)	
35.	Type of enclosure	
36.	Overall dimension including fan & motor	
37.	Painting detail	
E)	Axial Flow Fans (For each Fan) / Roof Extractors (Bidder to provide details Location wise)	
1.	Manufacturer	
2.	Model No.:	
3.	Type	
4.	Number quoted	
5.	Specific weight of air at temperature considered (kg / m^3)	
6.	Capacity (m^3/h)	
7.	Static head at rated speed (mmw)	
8.	Total head at rated speed (mmw)	
9.	Rated speed (RPM)	
10.	Critical speed of fan (rpm)	
11.	Fan power at rated speed (BKW)	
12.	Fan efficiency at rated speed (%)	
13.	Wheel diameter (mm)	
14.	No. of blades in wheel	
15.	Outlet velocity in (m/s)	

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SL.NO	DESCRIPTION	DATA
16.	Material used in fan wheel	
17.	Material in other parts	
18.	Type of fan bearing	
19.	Type of drive	
20.	Rated volt of motor	
21.	KW of motor offered	
22.	Type of insulation	
23.	Motor ambient temperature ($^{\circ}\text{C}$)	
24.	Type of enclosure	
F)	Tube Axial Flow Fans (For each Fan) (Bidder to provide details Location wise)	
1.	Manufacturer	
2.	Model No	
3.	Type	
4.	Number quoted	
5.	Specific weight of air at temperature considered (kg / m^3)	
6.	Capacity (m^3/h)	
7.	Static head at rated speed (mmw)	
8.	Total head at rated speed (mmw)	
9.	Rated speed (rpm)	
10.	Critical speed of fan (rpm)	
11.	Fan power at rated speed (BKW)	
12.	Fan efficiency at rated speed (%)	
13.	Wheel diameter (mm)	
14.	No. of blades in wheel	
15.	Outlet velocity in (m/s)	
16.	Material used in fan wheel	
17.	Material in other parts	
18.	Type of fan bearing	
19.	Type of drive	

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SL.NO	DESCRIPTION	DATA
20.	Rated volt of motor	
21.	kW of motor offered	
22.	Type of insulation	
23.	Motor ambient temperature (Deg C)	
24.	Type of enclosure	

35. Fire Protection System

SL.NO	DESCRIPTION	DATA
A)	Hydrant System	
1.	Number of Internal Hydrant	
2.	Valves provided	
3.	Number of External Hydrant valves provided	
4.	No. of Water monitors provided	
5.	Type of Hydrant valves	
6.	Make of Hydrant valves	
7.	Material of body of Hydrant valves	
8.	Material of trim of Hydrant valves	
9.	Type of Hoses	
10.	Make of Hoses	
11.	Material of Hoses	
12.	Whether hose boxes and central hose house are provided with all branch pipes nozzles & accessories as specified?	
13.	Type of isolation Valves	
14.	Make of isolation valves	
15.	Material of body of isolation valves	
16.	Material of trim of isolation valves	
17.	Whether the design philosophy of Hydrant System is per Technical Specification	
B)	HVW & MVW Spray System	
1.	Areas Protected Under HVW Spray System are as per specification	

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SL.NO	DESCRIPTION	DATA
2.	Areas Protected Under MVW Spray are as per specification	
3.	Whether design criteria/philosophy is adopted as per Technical Specification?	
4.	Type of detection system(s) provided for various areas are as specified	
C)	Fire Extinguishers & Fire Station Equipments	
1.	Whether all the specified fire extinguishers fire station equipment & accessories are offered?	
2.	Whether all the extinguishers & fire station equipments conform to relevant IS standards?	
D)	Fire Detection Alarm Detection and Control System	
1.	Whether Fire alarm & detection system is as per specification.	
2.	Whether all the annunciation panels, fire alarm panels, central monitoring station, repeater panels, etc. are provided as specified	
3.	Whether all the type of fire detection system are provided in various areas as specified?	
4.	Whether complete design philosophy of the system conforms to specification requirements?	
5.	Make, type & model no. of	
	Fire detection and alarm system	
	Addressable multisensor type smoke detector	
	Addressable photo electric type smoke detector	
	Linear heat sensing cable detector	
	QB detector	
6.	Whether interface modules are provided for all process actuated switches and digital type detectors as specified	
7.	Whether complete system hardware software and other services as specified are offered?	
E)	Fire Water Pumps and Pump House	
1.	Hydrant system pumps & drive	
	i) Number & type of drive	
	ii) Type of pumps	
	iii) Make and model no.	

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SL.NO	DESCRIPTION	DATA
	iv) Capacity & Head	
2.	Spray system pumps & drive	
	i) Number & type of drive	
	ii) Type of pumps	
	iii) Make and model no.	
	iv) Capacity & Head	
3.	Jockey pumps & drive	
	i) Number & type of drive	
	ii) Type of pumps	
	iii) Make and model no.	
	iv) Capacity & Head	
4.	Diesel Engines	
	i) Number of type for each pump	
	ii) Type of engine	
	iii) Make & model no.	
	iv) Capacity & Head (of each rating)	
5.	Material of construction	
	Casing & Impeller of hydrant system pumps	
	Casing & Impeller of Spray system pumps	
	Casing & Impeller of jockey pumps	
6.	Whether standby pumps are provided as specified?	
7.	Whether battery and battery charges are provided for diesel engines as specified?	
8.	Whether pumps drives & all accessories are approved by TAC?	
9.	Whether required monorail hoist of adequate capacity provided in the pump house?	
F)	Control Room & Control Equipment Room Fire Extinguishing System	
1.	Type of agent gas employed for the inert gas extinguishing system by the bidder	
2.	Whether complete Design, manufacture and installation	

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SL.NO	DESCRIPTION	DATA
	of the extinguishing system conform to relevant NFPA standards	
3.	Whether design philosophy is as per specification requirement?	
4.	Whether all the areas as specified under above inert gas extinguishing system are being protected.	
5.	Capacity of each gas cylinders in liters.	
	Total quantity of Gas. Kg.	
	Total Number of Cylinders	
	Working	
	Standby	
G)	Fire Water Pumps	
1.	Hydrant Pump	
	Type	
	Capacity	
	Head	
2.	Spray Pump	
	Type	
	Capacity	
	Head	

36. Plant & Instrument Air System

SL.NO	DESCRIPTION	DATA
A.	Performance Data	
1.	Free Air Delivery	
2.	Discharge Pressure	
3.	Noise level near compressors	
4.	Vibration limit (measured at top and bottom of main bearing)	
B.	Construction Features	
1.	Location	
2.	No. of compressors (for 2 units)	

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SL.NO	DESCRIPTION	DATA
3.	Type	
4.	Service	
5.	Duty	
6.	Type of Drive	
7.	Design ambient for drive	
8.	Number of starts per hour	
9.	Type of transmission	
10.	Anti vibration arrangement required	
11.	Maximum temperature for any step during the cycle	
12.	Type of control	
13.	Type of Annunciation	
14.	Flange standard	
C.	Materials of Construction	
1.	Compressor chamber	
2.	Rotors	
3.	Bearing	
4.	Timing Gear	
5.	Base Plate	
6.	Inlet throttle valve & housing	
7.	Shaft seals	
8.	Safety valves	
9.	Water separator	
10.	Blow off valve	
11.	Unloading Cylinder header	
12.	Tube of oil cooler	
13.	Outer casing of coolers	
14.	Gear Box	
15.	Gears	
D.	Supply of Accessories & Services	
1.	Intake air filters with silencers	

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SL.NO	DESCRIPTION	DATA
2.	Intercoolers	
3.	After coolers with moisture separators	
4.	All instruments as specified, as shown in tender drawing and as required for safe and trouble- free operation of the system	
5.	Coupling guards	
6.	Air receivers	
7.	Base plates	
8.	Foundation bolts, nuts, sleeves, inserts etc.	
9.	All interconnecting air and cooling water piping, complete with valves, fittings as shown in relevant tender drawings and as required for reliable and smooth operation of the system	
10.	Eye bolts, lifting tackle, tools, etc.	
11.	Control panels complete with all accessories	
12.	Instrument gauge panels complete with all accessories	
E.	Auxiliary Cooling Water Data	
1.	Quality	
2.	Design inlet temperature	
3.	Design pressure	
4.	Normal inlet pressure	
5.	pH value	
6.	Maximum pressure drop allowable between inlet and outlet points	
F.	Testing and Inspection	
1.	Material Testing and identification	
2.	Dye Penetration test	
3.	Type of performance test to be conducted	
4.	Field performance test	
5.	MPI and UT tests	
6.	All other specific tests as specified in this section	
G.	Drive Motor	

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SL.NO	DESCRIPTION	DATA
1.	Drive motor for compressor shall comply with Electrical section of the Specification.	
H.	Intake Air Filter	
1.	Numbers required	
2.	Location	
3.	Type	
4.	Silencer	
5.	Air flow rate	
6.	Particle removing efficiency	
7.	Maximum allowable pressure drop at stated air flow rate in new condition of filter (viscosity of air at normal ambient temperature)	
8.	Test requirement	
I.	Air Receiver	
1.	Numbers required	
2.	Installation	
3.	Type	
4.	Design pressure	
5.	Hydraulic test Pressure	
6.	Design code	
7.	Capacity of each air receiver	
8.	Material of construction of shell	
9.	Material of construction of dished ends	
10.	Material of construction of flanges	
11.	Supply of Accessories & Services	
	Flanges with nuts, bolts and gaskets	
	Pressure gauge with snubber	
	Pressure switch	
	Temperature indicator	
	Relief valve	
	Trap station	

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SL.NO	DESCRIPTION	DATA
	Level gauge	
	Vent valve/plug	
	Supporting stand with necessary foundation bolts, nuts, sleeves, etc	
	Eye bolts, lifting tackle etc.	
12.	Painting	
	i) External	
	ii) Internal	
13.	Inspection and Testing	
	Material testing and identification	
	Bend test as per BS-5169	
	Field performance test	
	D.P. test where radiography cannot be done	
	Hydraulic Test	
	Other specific tests	
J.	Intercooler, Aftercooler, Moisture Separator, Piping, Valves etc.	
1.	Aftercooler	
	Installation	
	Type	
	Relief Valve	
	Moisture Separator	
	Trap Station	
	Temperature Indicator	
	Temperature Switch	
	Level Gauge	
2.	Intercooler	
	Installation	
	Type	
	Relief Valve	
	Trap Station	

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SL.NO	DESCRIPTION	DATA
	Pressure Gauge	
	Temperature Indicator	
	Temperature Switch	
3.	Supply of Accessories and Services	
	Supporting stands with bolts, nuts and gaskets	
	Eye bolts, lifting tackle etc with tools and tackle	
	Flanged connections for supply and return of cooling water	
4.	Material of Construction	
	Tube	
	Shell	
	Tube Sheet	
	Baffles	
	Flanges	
K.	Cooling Water Data	
L.	Piping, Valves and Fittings for Compressed Air System	
1.	Pipes for cooling water line	
2.	Pipes for compressed air line & interconnecting air line	
3.	Fittings	
4.	Fittings for cooling water line	
5.	Fittings for compressed air piping & interconnecting air piping	
6.	Valves for air line	
7.	Valves for cooling water line	
8.	Testing and inspection	
M.	Air Drying Plants	
1.	Quantity	
2.	Type	
3.	Design airflow, at plant inlet, Nm ³ /min.	
4.	Dew point of outlet air at atmospheric pressure	

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37. Fuel Oil System

SL.NO	DESCRIPTION	DATA
LIGHT DIESEL OIL (LDO) SYSTEM		
Unloading Pumps		
1	Number (Working and Standby)	
2	Type	
3	Capacity	
4	Pumping Head	
LDO Tanks		
1	Number	
2	Capacity (kilo Liters)	
Pressurizing and Forwarding Pumps		
1	Number (Working and Standby)	
2	Type	
3	Capacity	
4	Pumping Head	
5	Type of Simplex / Duplex Filters Provided	
Heavy Fuel Oil (HFO) System		
Unloading Pumps		
1	Number (Working and Standby)	
2	Type	
3	Capacity	
4	Pumping Head	
HFO Tanks		
1	Number	
2	Capacity (kilo Liters)	
Pressurizing and Forwarding Pumps		
1	Number (Working and Standby)	
2	Type	
3	Capacity	

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SL.NO	DESCRIPTION	DATA
4	Pumping Head	
5	Type of Simplex / Duplex Filters Provided	
6	Method of Heat Tracing	

38. Mill Reject Handling System

SL.NO	DESCRIPTION	DATA
1.	Quantity of rejects	
2.	Temperature Rejects	
3.	Make	
4.	Capacity	
5.	Conveying speed of rejects	
6.	Particle size considered for conveying	
7.	Pipe size	
8.	Motor name plate rating	
9.	Capacity of mill rejects storage hopper	
10.	Material of construction of parent material of rejects storage hopper	
11.	Thickness of liner of rejects storage hopper	
12.	Minimum valve angle of hopper	
13.	Clear head room available below hopper for truck movement	
14.	Type, number and capacity of hoist envisaged	
15.	Total weight of the system	

39. Cooling Towers

SL.NO	DESCRIPTION	DATA
Natural Draft Cooling Towers		
A	General	
1	Make	
2	Type of Towers (Cross Flow / Counter Flow)	
3	Number of Towers per unit	

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SL.NO	DESCRIPTION	DATA
4	Base Diameter and Height	
B	Technical Particulars	
1	Rated water flow per tower	
2	Design wet bulb temperature	
3	Approach	
4	Cooling range at rated flow	
5	Design ambient relative humidity (average)	
6	Height of top of tower above sill	
7	Height of throat above sill	
8	Height of top of air inlet above sill	
9	Depth of fill at periphery/centre	
10	Internal diameter of tower	
11	Evaporation Loss at Rated Condition	
12	Temperature of leaving air	
13	Total air area/tower (Fill area)	
14	Total louvered area/tower (Inlet area)	
15	Water flow area	
16	Water flow rate per m ³ of effective fill volume	
17	Plan area of fill	
18	Cooling water flow per unit fill area (L)	
19	Dry air flow per unit fill area (G)	
20	Ratio of water to air weight (L/G)	
21	Temperature of air at fill outlet (wet bulb/dry bulb)	
22	Total dry air flow per tower	
23	Inlet air enthalpy	

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SL.NO	DESCRIPTION	DATA
24	Exit air enthalpy	
25	Total heat exchange per hour	
26	Evaporation loss (maximum)	
27	Drift loss (maximum)	
28	Draft loss	
29	Performance Co-efficient	
30	Duty Co-efficient	
31	Frictional losses in inlet pipe up to distribution trough	
32	Static head from ground level to centre line of hot water header to Cooling Tower.	
C	Tower fill	
1	Make	
2	Model	
3	Material of fill	
4	Material of fill support	
5	Total wetted surface area m ² of fill per tower	
6	Thickness of fill member	
7	Total fill volume per tower	
8	Number of fill decks	
D	Main Inlet Pipe	
1	Nos.	
2	Diameter	
3	Thickness	
4	Material of construction	
5	Pressure class	

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SL.NO	DESCRIPTION	DATA
E	Distribution pipes	
1	Type	
2	Material of construction	
3	Diameter	
4	Pressure class of Distribution Pipe	
F	Nozzles	
1	Make of nozzle	
2	Type of nozzle	
3	Material of construction of Nozzle	
4	Nozzle spacing	
5	No. of nozzles per tower	
G	Measurements during operation	
1	Arrangement for flow measurement	
2	Arrangement for temperature measurement	
3	Arrangement for pressure measurement	
H	Cold Water Basin	
1	Basin dimensions	
2	Storage capacity between normal to minimum water level	
3	Difference between lowest water level and level at top of mud sill at the basin cold water outlet	
4	Free board in the basin	
5	Slope of basin floor towards sludge pit	
6	Number of sludge pits	
7	Number of cold water outlet channels	
8	Number of Sluice Gates per cold water outlet channel	

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SL.NO	DESCRIPTION	DATA
9	Number of screens per cold water outlet channel	
10	Maximum velocity through screens under minimum water level condition	
Induced Draft Cooling Towers		
A	General	
1	Make	
2	Type of Towers (Cross Flow/Counter Flow)	
3	Number of Towers per unit	
4	Overall Dimension of the Cooling Tower	
B	Technical Particulars	
1	Rated water flow per tower	
2	Design wet bulb temperature	
3	Approach	
4	Cooling range at rated flow	
5	No. of working cells	
6	No. of spare cells	
7	No. of fans per cell	
8	Length of each cell	
9	Width of each cell	
C	Tower fill	
1	Make	
2	Model	
3	Material of fill	
4	Material of fill support	
5	Total wetted surface area m ² of fill per tower	

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SL.NO	DESCRIPTION	DATA
6	Thickness of fill member	
7	Total fill volume per tower	
8	Number of fill decks	
D	Cold Water Basin	
1	Basin Dimensions	
2	Storage capacity between normal to minimum water level	
3	Difference between lowest water level and level at top of mud sill at the basin cold water outlet	
4	Free board in the basin	
5	Slope of basin floor towards sludge pit	
6	Number of sludge pits	
7	Number of cold water outlet channels	
8	Number of Sluice Gates per cold water outlet channel	
9	Number of screens per cold water outlet channel	
10	Maximum velocity through screens under minimum water level condition	
E	Fans	
1	Name of Manufacturer	
2	Capacity	
3	Design exit air temperature	
4	Density of exit air	
5	Speed	
6	No. of blades per fan	
7	Diameter at tip	
8	Tip velocity range	

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SL.NO	DESCRIPTION	DATA
9	Clearance between tip and diffuser	
10	Fan air flow rate per cell	
11	Static pressure at fan	
12	Total pressure at fan	
13	Fan HP @ fan shaft/motor shaft	
14	Fan total efficiency	
15	Whether fan blades have adjustable pitch	
F	Fan Motors	
1	Name of Manufacturer	
2	Type	
3	Speed	
4	Efficiency at full load	
5	Motor rating	
6	Starting torque	

40. Gas Chlorination

SL.NO	DESCRIPTION	CW System	Pre-Treatment Plant	Potable Water System
General				
1	Number of Streams (Working and Standby)			
2	Continuous Dosing Rate of Chlorine (mg/l)			
3	Shock Dosing Rate of Chlorine (mg/l)			
4	Material of Piping a) Raw Water b) Chlorine Solution			

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SL.NO	DESCRIPTION	CW System	Pre-Treatment Plant	Potable Water System
	c) Distributer			
5	Whether P&I D furnished with the bid. (Yes/ No).			
6.	Whether Layout of Chlorination Building furnished with the bid. (Yes/ No).			
Booster Pumps				
1	Manufacturer			
2	Numbers (Working and Standby)			
3	Capacity (m ³ /h)			
4	Head (MWC)			
Chlorine Ton Containers				
1	Manufacturer			
2	Number of ton containers			
3	Chlorine capacity, (kgs)			
4	Design code for container			
5	Material of Construction (Bidder to indicate Specification and Construction Standard) (a) Shell (b) Educator tubes (c) Isolation valves (d) Valve protection dome			
6	Hoisting Capacity			
7	Weighing Scale Provided (Yes/No)			
8	Capacity of Weighing Scale			

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SL.NO	DESCRIPTION	CW System	Pre-Treatment Plant	Potable Water System
Evaporator				
1	Manufacturer			
2	Type			
3	Max. capacity (kg/hr) of Chlorinne			
4	Electrical ratings (a) Voltage, phase & frequency (variations) (b) kW Rating			
5	Pressure drop in the evaporator circuit of max flow,kg/cm ²			
6	Temperature of chlorine gas at outlet (Deg C)			
7	Chlorine heating system (a) Type (b) Water requirement (m ³ /day) (c) Whether Cathodic Protection provided (Yes/No)			
8	Material of Construction (a) Evaporator casing (b) Evaporator tube (c) Evaporator chamber (d) Super heater (e) Water chamber (f) Electrical heater			
Chlorine Gas Filters				
1	Type			
2	Capacity, each, (kg/hr)			
3	Material of construction			

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SL.NO	DESCRIPTION	CW System	Pre-Treatment Plant	Potable Water System
	(a) Body (b) Screen, wire gauge & mesh size (c) Filtering medium			
4	Whether Provided with vent/drain connection (Yes/No)			
Chlorinators				
1	Manufacturer			
2	Type			
3	Capacity (kg/h)			
4	Provided with the following (Yes/No) (a) Inlet pressure reducing valve (b) Chlorine feed rate adjuster (c) Chlorine feed rate indicator (d) Automatic pressure vacuum relief valve (e) Vacuum regulating valve (f) Pressure & Vacuum gauges (g) Injector (h) Control panel for each chlorinator with necessary Instrumentation, whether provided? (yes/no)			
5	Material of Construction (a) Chlorinator body (b) Inlet pressure reducing valve (c) Chlorine feed rate adjuster (d) Chlorine feed rate indicator (e) Automatic pressure vacuum relief valve (f) Vacuum regulating valve (g) Injector			

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SL.NO	DESCRIPTION	CW System	Pre-Treatment Plant	Potable Water System
Safety Provisions				
1	Whether Chlorine Absorption System Provided (Yes/No)			
2	Whether capacity of the system is Equivalent to one tonner of gas(Yes/No)			
3	List of Safety Equipments included in Supply.			

41. Electro Chlorination

SL.NO	DESCRIPTION	DATA
General		
1	Number of Streams (Working and Standby)	
Electro Chlorination Plant Supply Pumps		
1	Number	
2	Fluid to be handled	
3	Duty	
4	Type	
5	Type of impeller	
6	Design standard	
7	Service temperature In deg C	
8	Rated Capacity (cum. per hr)	
9	Range of operation	
10	Permissible tolerance in rated capacity (%)	
11	Suction Condition	
12	Head to be developed at rated Capacity	
13	Efficiency at rated capacity (%)	

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14	Lubrication	
15	Material of Construction i) Casing ii) Impeller iii) Shaft seal	
16	Type of drive	
Strainer		
1	Number to be provided	
2	Description for each unit	
3	Type	
4	Fluid to be handled	
5	Rated capacity	
6	Mesh size of the screen in mm and free flow area of the screen	
7	Material of Construction a) Screen b) Casing	
Hypochlorite Generator		
1	Number provided	
2	Type	
3	Rated generation capacity of each unit as available chlorine in kg per hr	
4	Range of generation control	
5	Material of construction I) Anode ii) Cathode iii) Shell	
6.	Useful Chlorine Content in the stream (kg Chlorine / kg Hypochlorite Solution)	

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Rectifier – cum- Transformer		
1	Transformer Unit	
2	Numbers provided	
3	Description for each unit i) Type ii) Duty	
Hypo Chlorite Storage Tank		
1	Numbers provided	
2	Type of Tank	
3	Type of fluid to be handled	
4	Active Capacity in cu.m.(each tank)	
5	Design Code	
6	Material of Construction	
7	Level Indicator i) Number ii) Type	
8	Level Switch i) Number ii) Type iii) Alarm iv) Interlock	
Degassifier Blowers		
1	Number	
2	Location	
3	Service	
4	Duty	

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5	Type	
6	Rated Capacity in cum per hr	
7	Material of construction i) Casing ii) Impeller iii) Shaft	
8	Type of drive	
9	Pressure gauge i) Number ii) Location iii) Type	
10	Flow switch i) Number ii) Location iv) Alarm iv) Interlock	

Hypo Chlorite Dosing Pumps For Continuous Dosing

1	Number (Working and Standby)	
2	Type	
3	Type of impeller	
4	Design standard	
5	Service temperature	
6	Rated Capacity (cum. Per hr)	
7	Range of operation	
8	Suction Condition	
9	Head to be developed at rated capacity	
11	Efficiency at rated capacity(%)	
12	Material of Construction i) Casing ii) Impeller iii) Shaft iv) Shaft Seal	

Hypo Chlorite Dosing Pumps For Shock Dosing

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1	Number (Working and Standby)	
2	Duty	
3	Type	
4	Type of impeller	
5	Design standard	
6	Service temperature	
7	Rated Capacity (cum. per hr)	
8	Range of operation	
9	Suction Condition	
10	Head to be developed at rated capacity	
11	Efficiency at rated capacity (%)	
12	Material of Construction i) Casing ii) Impeller v) Shaft vi) Shaft Seal	

42. Effluent Treatment Plant and Zero Discharge System

SL.NO	DESCRIPTION	DATA
Influents to ETP		
1	Blow down from CW System (m ³ /h)	
2	Blow down from the Boiler including quenching water (m ³ /h)	
3	Flow from Neutralizing Pit of DM Plant (m ³ /day)	
4	Flow from floor wash drains of Boiler, Turbine Halls and other Buildings. (m ³ /day)	
5	Recycled water from the ash pond (to be used for ash handling only) (m ³ /h)	
6	Oil free water from oil/ water separator (m ³ /day)	
7	Clear Water from the settling tank of coal pile area	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[82]	15.01.2016

SL.NO	DESCRIPTION	DATA
	during rainy season (m ³ /day)	
8	Total maximum flow to the Effluent Treatment Plant (m ³ /h)	
Guard Pond		
1	Effective Volume of Guard Pond (in hrs) (Considering total maximum flow rate)	
2	Holding Capacity of Guard Pond (in hrs)	
3	pH Value to be obtained after chemical dosing	
Lamella Clarifier Feed Pumps		
1	Number of Pumps (Working and Standby)	
2	Type of Pump	
3	Capacity (m ³ /h)	
4	Total Pumping Head (MWC)	
5	kW Rating	
6	Type of Drive	
7	Material of Construction i) Casing ii) Impeller iii) Shaft iv) Shaft Seal	
Lamella Clarifier		
1	Numbers (Working and Standby)	
2	Inflow Flow Rating of Lamella Clarifier	
3	Turbidity at the inlet to the Clarifier	
4	Retention Time	
5	Outflow Flow Rating of Lamella Clarifier	
6	Turbidity at the outlet to the Clarifier	
7	Surface Flow Rate (m ³ /h/m ²)	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[83]	15.01.2016

SL.NO	DESCRIPTION	DATA
Pressure Filter		
1	Numbers (Working and Standby)	
2	Flow Rating of Pressure Filter	
3	Dimensions of the Pressure Filter	
4	Type of Filtering Media	
5	Depth of Filtering Media	
6	Turbidity at the outlet of Pressure Filter	
7	Design Surface flow velocity (m ³ /h/m ²)	
Ultra Filtration Unit		
1	Number of Streams (Working and Standby)	
2	Number of Feed Pumps(Working and Standby)	
3	Flow Rating of Ultra Filtration Unit (net output)	
4	Recovery from Ultra Filtration Unit (%)	
5	Provision of Dechlorination before entry to Ultra Filtration Unit	
6	Net Capacity of Suck back tank	
Reverse Osmosis Unit		
1	Number of Streams (Working and Standby)	
2	Number of Feed Pumps(Working and Standby)	
3	Flow Rating of RO System (net output)	
4	Recovery from Ultra Filtration Unit (%)	
5	Provision of Dechlorination before entry to RO Unit	
6.	Net Capacity of Suck back tank	
Achievement of Zero Discharge		
1	Vendor's proposal for Utilization of UF Reject, RO Reject and any other residual effluent to achieve zero discharge (Whether furnished or not-Yes/No)	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[84]	15.01.2016

SL.NO	DESCRIPTION	DATA
2	P&ID for Effluent Treatment Plant (Whether furnished or not -Yes/No)	
3	Mass balance for Effluent Treatment Plant (Whether furnished or not- Yes/No)	

43. Cranes & Hoists

SL.NO	DESCRIPTION	DATA WITH LOCATION
A)	EOT Cranes	
1.	Type of Cranes :	
2.	Design fabrication and testing of crane confirm to standard/code no (IS:3177 - Latest Edition & IS:807 - Latest	
3.	Quantity	
4.	Crane capacity (Tonne) Main hook Auxiliary hook	
5.	Manufacturer	
6.	Type	
7.	Location (Indoor/ Outdoor)	
8.	Height of lift (m) a. Main hook Above floor Below floor b. Aux hook Above floor Below floor	
9.	Duty Class Mechanical/electrical	
10.	Speeds (normal & Creep -10% of main speed) m/ min a. Main hoist & creep b. Aux. Hoist & creep c. Cross travel d. Long travel	
11.	Sheave material, type of guard a. Main hoist b. Aux hoist	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[85]	15.01.2016

SL.NO	DESCRIPTION	DATA WITH LOCATION
12.	Rope Drum Quantity, Material a. Main hoist b. Aux hoist	
13.	Gantry rail size / Hardness	
14.	Crab rail size/Hardness	
15.	Wheel Material	
16.	Hardness	
17.	Wheel diameter / Nos provided for LT wheel CT wheel	
18.	Operation: SPAN Safe Working Load	
19.	MOTORS : Hoist (Main) Micro Hoist (Main) Long Travel/Cross Travel	
20.	Speeds	
21.	Main Hoist Mtrs/Min. Cross Travel "	
22.	Long Travel "	
23.	Brakes (Type/Details) a. Cross travel b. Long travel	
24.	Power supply a. Power supply b. S.L.D: c. Electric equipment specification	
25.	Control voltage	
B)	U/S Crane	
1.	Hoist type	
2.	Capacity (t)	
3.	Quantity	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[86]	15.01.2016

SL.NO	DESCRIPTION	DATA WITH LOCATION
4.	Duty Class	
5.	Span	
6.	Material Specification Frame Hook Load Chain Hand Chain Hand Chain Wheel Load chain wheel Gears.	
7.	Type of brake provided	
8.	Geared Trolley	
9.	Material specification Frame Gears Hand Chain Hand Chain Wheel Trolley wheels	
10.	Wheel dia (mm) LT CT	
11.	Wheel material /hardness LT CT	
C)	Electric Hoist (For each of the hoist)	
1.	Quantity	
2.	Location	
3.	Capacity	
4.	Duty classification	
5.	Wire ropes a. Type of construction b. Size c. Number of falls d. Factor of safety e. Conforming to IS	
6.	Rope drum	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[87]	15.01.2016

SL.NO	DESCRIPTION	DATA WITH LOCATION
	<ul style="list-style-type: none"> a. Materials b. Diameter c. Conforming to IS 	
7.	Drives <ul style="list-style-type: none"> a. Type & material of gear box b. Gear & pinion c. Material & hardness 	
8.	Motors <ul style="list-style-type: none"> a. Type & number b. KW rating c. Synchronous speed d. Class of insulation e. Pull out torque f. Frame size 	
9.	Brakes <ul style="list-style-type: none"> a. Type b. Size c. Torque rating 	
10.	Lifting hook <ul style="list-style-type: none"> a. Type b. Material c. Type & details of control 	
11.	Wheels <ul style="list-style-type: none"> a. Numbers b. Diameter c. Material & hardness d. Max. wheel load e. Wheel base f. Wheel type g. Conforming to IS 	
12.	Rail: <ul style="list-style-type: none"> a. Size b. Length c. Radius of curvature d. Hardness of rail 	
C)	Manual Hoist (For each of the hoist)	
1.	Capacity	

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LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[88]	15.01.2016

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

SL.NO	DESCRIPTION	DATA WITH LOCATION
2.	Quantity	
3.	Height of Lift	
4.	Class of Duty	
5.	Conforming to IS	

Seal of Company

Signature : _____
 Name : _____
 Designation : _____
 Date : _____

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	03	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-A	[89]	15.01.2016



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-III
PART-B
TECHNICAL SCHEDULES-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[i]	25.09.2014

VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[ii]	25.09.2014

VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
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10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[iii]	25.09.2014

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[iv]	25.09.2014

MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

BALANCE OF PLANT (PACKAGE NUMBER: R&M-SP-03)

VOLUME-III, PART-B TECHNICAL SCHEDULES-ELECTRICAL (TO BE FILLED BY BIDDER)

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[v]	25.09.2014

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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*{Only the Applicable portion of the Data Sheet based on the scope of work as
firmed up in Section-I, Volume-II should be retained and the remaining portion
should be deleted. The scope of work in Section-I, Volume-II is based on Residual
Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA)}*

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[vii]	25.09.2014

1 MOTOR

SL. NO.	DESCRIPTION	UNIT	DATA
1.	Manufacturer		
2.	Type and frame size		
3.	Nos. required		
4.	Application		
5.	Specification & Codes		
6.	Capacity for specified climatic conditions [50°C]		
7.	Location for installation		
8.	Type of enclosure & ventilation		
9.	Degree of protection		
10.	Type of duty		
11.	No. of phases, frequency & voltage		
12.	Permissible variations in		
a)	Voltage		
b)	Frequency		
c)	Combined		
13.	At rated voltage & frequency		
a)	Full load current		
b)	Full load speed		
c)	No load current		
14.	Minimum permissible voltage during starting :		
15.	Maximum permissible time at minimum permissible voltage during running at full load.		
16.	Maximum permissible time at 75% of rated voltage during running at full load.		
17.	Whether motor stalls at 70% of rated voltage Efficiency & power factor.		
18.	Stator winding		
	Type & nos. of terminals Brought out		
	Resistance between terminals at 20°C		
	Resistance per phase at 20°C		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[1]	25.09.2014

SL. NO.	DESCRIPTION	UNIT	DATA
	Inductance per phase		
	Capacitance per phase		
	Starting current as % of full load current		
19.	Torque at full load in Kgm.		
a)	Break away torque in % of full load torque		
b)	Pull up torque in % of full load torque		
c)	Pull out torque in % of full load torque		
20.	Starting time in sec.		
a)	Without mechanism coupled		
b)	Mechanism coupled through hydraulic coupling when it may be presumed that load is transferred to motor shaft only after attaining almost full speed.		
	i. with rated voltage		
	ii. with 80% of rated voltage		
	iii. with 110% of rated voltage		
21.	Starting time in sec. With mechanism coupled through flexible coupling		
a)	with rated voltage		
b)	with 80% of rated voltage		
c)	with 110% of rated voltage		
22.	Safe stall time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
23.	Safe stall time (Cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
24.	Limiting motor temperature to determine safe stall time		
25.	Permissible maximum accelerating time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[2]	25.09.2014

SL. NO.	DESCRIPTION	UNIT	DATA
26.	Permissible maximum accelerating time (cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
27.	Class of Insulation And Material		
28.	Whether insulation is suitable for 415 V, 6.6kV system		
29.	Temperature rise under normal conditions over 50°C ambient temperature		
30.	By resistance method --- °C over cooling water temp. for CACW motors.		
31.	Degree centigrade over cooling air temp. for CACA motor.		
32.	By Thermometer method ---- Degree centigrade over cooling water temp. for CACW motor.		
33.	Degree centigrade over cooling air temp. for CACA motor.		
34.	Method of starting :		
35.	Permissible starting duty cycles :		
36.	Stator thermal time constant :		
37.	Method of cooling (If applicable)		
	Details of water cooling system		
a)	No. of cooler		
b)	Water requirement per cooler		
c)	Losses removed by cooler		
d)	Max. permissible temperature of cooling water at inlet		
e)	Max. permissible temperature of cooling water at outlet		
f)	Maximum permissible pressure at water outlet		
g)	Water pressure drop through the cooler		
h)	Temp. of cold air coming out & entering the machine For permissible cooling water temperature of [31°C]		
i)	Temp. rise of air passing through machine at full load.		
j)	Air pressure drop through The cooler		
k)	Temp. rise of water through cooler		
l)	Protection against leakage of water :		

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SL. NO.	DESCRIPTION	UNIT	DATA
m)	Arrangement to ensure the water flow		
38.	Bearings		
a)	Number :		
b)	Type :		
c)	Lubrication system :		
d)	Quantity of lubricant reqd. For both the bearings. Life in hours at rated speed :		
e)	Recommended lubricant :		
f)	Bearing end play :		
g)	Inlet oil pressure :		
h)	Temp. rise of oil :		
i)	Max. permissible temp. of bearing :		
j)	Max. Permissible temp. of Oil		
k)	Permissible running time without forced oil at full load & full speed :		
39.	Whether bearings are provided with 4 wire, platinum RTD having 100-ohm resistance at 0°C for remote temp. Indication.		
a)	Whether bearings are provided with local temperature indicator having two adjustable contacts rated for 5A at 240V AC or 0.5A at 220V DC. : Yes/No		
b)	If forced lube oil system provided : Yes / No		
c)	Qty of lubricant required for initial filling.		
d)	Recommended period after which lubricant should be replaced		
e)	Bearing cooling water requirement		
f)	Max. Permissible bearing cooling water inlet temp. (permissible)		
g)	Max. Permissible bearing cooling water outlet temp.		
h)	Terminal designation corresponds to direction of rotation (Facing driving end).		
i)	Terminal boxes with accessories separate terminal boxes provided.		
40.	Winding temp. detectors		
41.	Bearing temp. detectors		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[4]	25.09.2014

SL. NO.	DESCRIPTION	UNIT	DATA
42.	Moisture detectors		
43.	Neutral terminals		
44.	Main terminal box details		
a)	Type & Nos.		
b)	Fault level permissible for 0.25 sec.		
c)	Location		
d)	Cable gland size & no.		
e)	Direction of cable entry.		
45.	Space Heater		
a)	Number		
b)	Location		
c)	Capacity of each		
d)	Total power requirement		
e)	Voltage.		
46.	Details of 4 wire platinum RTD having 100 ohm resistance at 0°C for winding temp. detector.		
a)	Nos. provided		
b)	Location		
47.	Whether CTs for differential protection are provided : Yes / No		
a)	If Yes, no. of CTs supplied along with motors C.T. details		
	i. C.T. ratio		
	ii. Knee point voltage		
b)	S.C. withstand capacity		
c)	Type of mounting		
48.	Shaft orientation		
49.	Shaft extension		
50.	Grounding pads size nos. & location		
51.	Method of coupling to driven mechanism		
52.	Motor GD ² :		
53.	Lifting device		
54.	Weight		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[5]	25.09.2014

SL. NO.	DESCRIPTION	UNIT	DATA
a)	Weight of stator (wound)		
b)	Weight of rotor (wound)		
c)	Weight of base plate		
d)	Weight of cooler		
e)	Net weight of motor		
f)	Shipping dimensions & weight		
55.	Thermometer provided		
a)	In cold air path		
b)	In hot air path		
c)	For measurement of oil temp.		
56.	Characteristic curves furnished		
a)	Speed vs. current at rated voltage	Yes / No	
b)	Speed vs. torque at 110%, 100%, 90% and 80% of rated voltage:	Yes / No	
c)	Thermal withstand curve for hot & cold conditions.	Yes / No	
d)	Efficiency vs. load:	Yes / No	
e)	P.F. Vs. load:	Yes / No	
f)	Current vs. time:	Yes / No	
g)	Negative phase sequence curve:	Yes / No	
57.	Drawings furnished		
a)	General arrangement of motor	Yes / No	
b)	Main terminal box showing the method of terminating the incoming cables Yes/No	Yes / No	
c)	Instruction manuals	Yes / No	
	MOTOR (DC)		
1.	GENERAL		
a)	Manufacturer :		
b)	Equipment driven by Motor :		
c)	Motor type :		
d)	Country of origin :		
2.	DESIGN & PERFORMANCE		
a)	Frame Size :		

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SL. NO.	DESCRIPTION	UNIT	DATA
b)	Type of duty :		
c)	Type of enclosure & type of cooling :		
d)	Applicable standard to which motor generally confirms:		
e)	Type of mounting :		
f)	Direction of rotation :		
g)	KW rating at amb. Temp. 50 °C :		
h)	Rated power supply voltage		
	i. Armature circuit (V) :	V	
	ii. Field circuit (V) :	V	
i)	Permissible voltage variation :		
j)	Minimum permissible starting voltage :		
k)	Rated speed at rated voltage (RPM) :	RPM	
l)	At rated voltage		
	i. Full load current (A) :	A	
	ii. NO load current (A) :	A	
m)	Starting current (A) :		
	i. 100% voltage :		
	ii. 85% voltage :		
n)	Starting time (with pump coupled) :		
	i. 100% voltage (Sec) :		
	ii. 85 % voltage :		
	iii. 80 % voltage :		
o)	Efficiency at rated voltage at :		
	i. 100% load :		
	ii. 75% load:		
	iii. 50% load:		
p)	Safe stall time (sec) at 110% :		
	i. Hot condition :		
	ii. Cold condition :		
q)	Torque (Kg-m) :		
	i. Starting at min. permissible voltage:		
	ii. Rated:		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[7]	25.09.2014

SL. NO.	DESCRIPTION	UNIT	DATA
r)	Fly wheel moment (GD2) motor (Kg-m)		
3.	CONSTRUCTIONAL FEATURES		
a)	Winding insulation :		
	i. Class & type :		
	ii. Tropicalised (Yes/No) :		
	iii. Temp. rise over specified ambient of 50 °C. :		
	iv. Method of temp. measurement :		
b)	Degree of protection of terminal box for :		
	i. Main terminal box :		
	ii. Space heaters (AUX. TB) :		
c)	For main terminal box :		
	i. No. and type of cable gland :		
	ii. Recommended cable size (Armature/field) :		
d)	Fault level (KA, sec) :		
e)	Bearings :		
	i. Type (at DE/NDE):		
	ii. Make :		
	iii. Recommended lubricant :		
	iv. Life :		
f)	Weight of motor (Kg.) :		
g)	Field current at rated speed (A)		
h)	Field resistance (Ohm) at rated speed at 30 °C		
i)	Field trimmer rating (Ohm) for getting basic speed at 30 °C.		
j)	Resistance (Ohm) between terminals at 30°C.		
	i. Armature :		
	ii. Series winding :		
	iii. Inter pole winding :		
	iv. Shunt winding resistance:		
k)	1 st and 2 nd critical speed :		
l)	Overload that can be carried by motor without changing overall performance and period for which it is applicable		

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SL. NO.	DESCRIPTION	UNIT	DATA
m)	Grounding device :		
n)	Space heater :		
	i. No. & location :		
	ii. Volt & KW rating :		
4.	RESISTORS		
a)	Starting (external) resistance :		
	i. Type of resistor :		
	ii. Ohmic, current & power rating of resistor elements		
	iii. Max. permissible temp. of resistor elements :		
	iv. Connection diag. Of resistor elements		
	v. No. of startup stages/steps :		
	vi. Resistance values of stages :		
	-at 30 deg. C (Ohm) :		
	-at running condition (Ohm) :		
	vii. Expected temp of resistor at running condition		
	viii. Expected temp of box at running condition		
	ix. Mounting/stacking of resistor elements and G.A. of resistor box		
b)	Schematic connection diag. Of motor with starting resistor and field trimmer resistor.		
5.	CHARACTERISTIC CURVES		
a)	Starting current/times :		
b)	Thermal withstand curve for hot and cold condition		
c)	Torque/speed		
d)	Load/Efficiency		
e)	Speed/Time		

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2 MOTOR ACTUATORS

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		
2.	Application		
3.	Motor type		
	Supply voltage	V	
4.	Phase, frequency	Hz	
5.	Motor rated voltage	V	
6.	Control Voltage	V	
7.	Voltage and its variation	V	
8.	Frequency and its variation	Hz	
9.	Combined V & f variation	%	
10.	Degree of Protection		
11.	Winding Insulation		
12.	Temperature Rise (over ambient temperature)	°C	
13.	Painting		
14.	Motor Starting		
a)	Method		
b)	Starting Current		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[10]	25.09.2014

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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3 LT TRANSFORMER (OIL TYPE/DRY TYPE)

6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Make		
2.	Application		
3.	Location		
4.	Type		
5.	Reference standard		
6.	Rated power (indicative)		
7.	Rated winding voltage ratio (line to line)		
8.	Number of phases		
9.	Winding		
10.	Rated frequency		
11.	Type of cooling		
12.	Insulation Class		
13.	Temperature rise Over ambient temperature of 50°C		
a	For Winding by resistance method		
b	For Oil by Thermometer method		
14.	Insulation level (LI/AC)		
a	HV- (LI/AC)		
b	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
15.	Vector group		

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16.	Short-circuit impedance on principal tap				
17.	Parallel operation of transformer				
18.	Type of taps provided				
19.	Taps provided on				
20.	Range of taps				
21.	Method of Tap charge control-				
a	Manual local				
b	Electrical local				
c	Electrical remote				
d	Automatic				
22.	System earthing				
a	H.V.				
b	L.V.				
23.	Terminal arrangement				
a	H.V.				
b	L.V.				
24.	Neutral for earthing				
25.	Transformer bushing	HV	LV	LV - N	
26.	Voltage class KV(r.m.s.)				
27.	Creepage distance mm				
28.	Min. Ph-Ph/ Ph-E clearance mm				
29.	System fault Level				
a	HV Side				
b	LV Side				

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30.	Max. Noise level		
31.	Auxiliary supply		
32.	LV neutral side current transformer for standby earth fault protection		
33.	Guaranteed no load loss (kW)		
34.	Guaranteed load loss (kW)		
35.	Efficiency		
a	At full load		
b	At 75% load		
c	At 50% load		
36.	Accessories		
	Each transformer furnished With fittings and accessories as per specification.		
37.	Approximate overall dimensions		
a	Length		
b	Breadth		
c	Height		
38.	Crane lift for un taking core and coil assembly Approximate Weights		
a	Core and coil		
b	Enclosure and fittings		
c	Oil		
d	Total weight		
39.	Shipping Details:		
a	Weight of the heaviest package		
b	Dimension of the largest package : (LxBxH)		
40.	Tests		
	Routine test as per IS and other tests as per specification		

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4 LT PCC/MCC/DISTRIBUTION BOARD

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material	Cu/Al	
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Colour finish shade	Interior exterior	

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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Starters		
3.1	Type	DOL Rev / Star-Delta	
3.2	Contactor rated duty		
3.3	Single phasing preventer required.	Yes / no	
3.4	Thermal overload relay reset	Manual / Auto	
4.0	Circuit breakers		
4.1	Maker's name		
4.2	Voltage, frequency & no.of phases , poles		
4.3	Rated operating duty		
4.4	Circuit breakers type		
4.5	Short circuit withstand current for 1 sec. Duration	kA	
4.6	Rated making current	kAp	
4.7	Rated current at site reference ambient temp	A °C	
4.8	Type of operating mechanism		
4.9	Minimum no. of auxiliary Contacts for purchaser's use		
4.10	Control voltage		
a	For Spring charging motor	V AC/DC	
b	For closing/tripping	V AC/DC	
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	
b	Closing at normal voltage	%	
c	Trip coil	%	
4.12	Power required for closing at normal voltage	W	
4.13	Power required for tripping at normal voltage	W	

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[15]	25.09.2014

S. No.	DESCRIPTION	UNIT	DATA
4.14	Spring charging motor details:		
a	Rating	kW	
b	Rated voltage	V, AC/DC	
c	Spring charging	Sec.	
	Electrical and mechanical anti-pumping features been provided	Yes/No	
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		
5.2	Rated operating duty		
5.3	Rated breaking capacity	kA (rms)	
5.4	Rated making current	kA (Peak)	
5.5	On/Off operation		
5.6	Manual	Yes/No	
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	
5.8	Auxiliary contacts required	Yes/No	
6.0	Contactors		
6.1	Make		
6.2	Rated duty	AC3/AC4	
6.3	No of poles		
6.4	Utilization category		
6.5	Rated voltage of auxiliary contacts	V	
6.6	Rated voltage of coil	V	
6.7	Rated breaking capacity	Factor of rated current	
6.8	Rated making capacity	Factor of rated current	
6.9	Limits of operation		
a	Supply voltage variation		

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S. No.	DESCRIPTION	UNIT	DATA
b	Supply frequency variation for closing		
c	Drop out voltage		
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		
7.1	Voltage Ratio		
7.2	CT Ratio		
7.3	Measuring CTs		
7.4	Protection CTs		
7.5	Measuring VTs		
7.6	Protection VTs		
8.0	Control transformers		
8.1	Make		
8.2	Type		
8.3	Applicable standards		
8.4	Ratio		
8.5	Class of insulation		
8.6	Rated output	VA	
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		
10.2	Make		
10.3	Type designation		
10.4	Setting range		
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		
11.2	Make		
11.3	Type		
11.4	Current setting range		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[17]	25.09.2014

S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	
12.0	Under voltage relay		
12.1	Make		
12.2	Type		
12.3	Voltage rating	V	
12.4	Setting range	V	
13.0	Auxiliary relays and timers		
13.1	Make		
13.2	Type		
13.3	Coil voltage	V	
14.0	Control/selector switch		
14.1	Make		
14.2	Type designation		
15.0	Meters		
15.1	Applicable Standards		
15.3	Accuracy Class		
15.4	Make		
15.5	Type		
16.0	<u>Voltmeter</u>		
16.1	Make		
16.2	Type		
16.3	Applicable standards		
16.4	Accuracy class		
17.0	<u>Ammeter</u>		
17.1	Make		
17.2	Type		
17.3	Applicable standards		
17.4	Accuracy class		

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S. No.	DESCRIPTION	UNIT	DATA
18.0	<u>Indicating lamps</u>		
18.1	Make		
18.2	Type		
18.3	Voltage	V	
18.4	Wattage of lamp	W	
19.0	<u>Push buttons</u>		
19.1	Make		
19.2	Type designation		
19.3	Contact rating	A	
20.0	<u>Space heater</u>		
20.1	Make		
20.2	Type		
20.3	Rated voltage	V	
21.0	<u>Wiring and terminal blocks</u>		
21.1	Voltage grade		
21.2	Insulation		
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	
b	Control wiring	Sq.mm	
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		
	II) For Fixed Type		
21.5	Minimum current rating of terminal blocks	A	

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5 415V NON SEGREGATED PHASE BUS DUCT

S. No.	DESCRIPTION	UNIT	DATA
1.	Make/ Name of Manufacturer		
2.	Type of Busduct	Segregated /non segregated	
3.	Type of cooling	Natural/Forced	
4.	Reference Standard		
5.	Rated Voltage	V	
6.	No of phase and Frequency	Hz	
7.	Insulation level a) Min Power frequency Voltage b) Impulse withstand voltage	kVrms kVp	
8.	Rated Continuous current	Amp	
9.	Short time withstand capability a) Symmetrical for 1 sec b) Momentary	kA kAp	
10.	Maximum temperature rise over 50 degree design ambient temperature a) Bus bar b) Enclosure	Degree	
11.	Degree of protection of enclosure		
12.	Bus bar a) Material & Grade b) Conductivity c) Size		
13.	Enclosure a) Material & Grade b) Thickness c) Ph- ph spacing d) Over all dimension		
14.	Dc resistance in micro ohm/metre/phase a) At 20 degree		

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S. No.	DESCRIPTION	UNIT	DATA
	b) At 85 degree		
15.	Reactance in ohm/meter/phase		
16.	Capacitance to ground		
17.	Losses in watt/meter/phase		
18.	Insulators		
	a) Make		
	b) Material		
	c) No per support		
	d) Voltage Glass		
	e) Compression strength		
	f) Cantilever strength		
19.	Size and material of ground bus		
20.	Support steel structure		
21.	Whether the following has been provided		
	a) Thermostat controlled space heater		
	b) Silica gel breather		
	c) Drain plug		
	d) Neoprene rubber gaskets at joints		
	e) Disconnecting links		
22.	Painting shade		
	a) Interior		
	b) Exterior		

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6 220V DC System

SL. NO.	DESCRIPTION	UNIT	DATA
A.	DC SYSTEM		
	BATTERY		
	General		
	• Make		
	• Catalogue No.		
	• Type		
	• Reference Standard		
	Rating		
	• Rated Voltage	Volt	
	• 10-hour rating at 27 Deg.C to end cell voltage	AH	
	• 2-hour discharge rate to end cell voltage	Amp	
	• 1 –hour discharge rate to end cell voltage	Amp	
	• 1 -minute discharge rate to end cell voltage	Amp	
	Performance		
	• Battery duty cycle curve furnished	Yes/No	
	• Cell voltage characteristics during duty cycle furnished	Yes/No	
	• Minimum cell voltage during duty cycle	Volt	
	• AH efficiency at 10-hour discharge rate	%	
	• Expected life of Battery	Yr	
	Battery Characteristics		
	• Recommended charging rate for		
	i) Float charging	Amp	
	ii) Equalising Charge	Amp	
	iii) Boost charging in 10 hrs.		
	• Start	Amp	
	• Finish	Amp	
	• Recommend specific gravity at 27 Deg.C		
	i) For first filling		
	ii) At full charge		

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SL. NO.	DESCRIPTION	UNIT	DATA
	iii) At end of 10-hour discharge		
	• Short-circuit current for a dead-short across battery terminals, when		
	i) Float charge at 2.15 V/Cell	kA	
	ii) Boost charge at 2.75 V/Cell	kA	
	• Battery internal resistance	Ohm	
1	Cells		
	• Number of cells per battery	Nos.	
	• Nominal Cell voltage	V	
	• Cell voltage at the end of duty cycle	V	
	• Cell voltage at the end of full discharge at 10-hour rate	V	
	• Type of the cell		
	• Cell designation as per relevant Standard		
	• Material of the container		
	• Overall dimension of each cell (LxDxH)	mm	
	• Weight of complete cell		
	i) Without electrolyte	kg	
	ii) With electrolyte	Kg	
	• Internal resistance of cell	Ohm	
2	Intercell Connector		
	• Intercell connector furnished	Yes/No	
	• Type of intercell connector	bolted/burned	
	• Material of intercell connector		
3	Plates		
	• Number of positive plates per cell	Nos.	
	• Type of positive plate		
	• Type of negative plate		
4	Separator		
	• Type		
	• Material		
	• Thickness	mm	

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SL. NO.	DESCRIPTION	UNIT	DATA
5	Electrolyte		
	• Amount of electrolyte for first filling		
	i) Per cell	litre	
	ii) Per set	litre	
	• First filling with 10% extra furnished	Yes/No	
	• Electrolyte conforms to		
6	Racks		
	• Number of racks per battery	Nos.	
	• Number of cells per rack	Nos.	
	• Type of racks	Rows/Tiers	
	• Material of rack		
	• Racks provided with		
	i) Numbering tags for cells	Yes/No	
	ii) Clamps for cables	Yes/No	
	• Insulator furnished for		
	i) Cell	Yes/No	
	ii) Stand	Yes/No	
	• Inter-row, Miter-tier connectors and end take-off furnished	Yes/No	
	• Connector hardwares furnished	Yes/No	
7	Dimension & Weight		
	• Overall dimension (LxDxH)	mm	
	• Approx. Weight	Kg	
	• Battery layout drawing furnished	Yes/No	
8	Ventilation requirement furnished	Yes/No	
9	List of accessories furnished	Yes/No	
10	Technical leaflets furnished	Yes/No	
	BATTERY CHARGER		
i)	GENERAL		
	a. Make		

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SL. NO.	DESCRIPTION	UNIT	DATA
	b. Catalogue No.		
	c. Type		
	d. Reference Standard		
ii)	A.C. Input		
	a. Voltage \pm % variation	Volt, %	
	b. Phase	No.	
	c. Frequency \pm % variation	Hz., %	
	d. Input current	Amp	
iii)	D.C. Output		
	a. Voltage	Volt/Cell	
	b. Current	Amp.	
	Type of Cooling		
iv)	Max. Temp rise within cubicle above site ambient		
	a. Rectifier transformer	°C	
	b. SCR	°C	
v)	Performance		
	a. Regulation for 0-100% rated load with \pm 10% Input voltage and \pm 5% input frequency variation	%	
	b. Ripple content in O.C. output		
	i) With battery	%	
	ii) Without battery	%	
	c. Guaranteed efficiency at rated load	%	
	d. Power factor at rated load	%	
vi)	Miscellaneous		
	a. Charger provided with following features		
	i) Automatic voltage regulation	Yes/No	
	ii) Current limiting circuitry	Yes/No	
	iii) Smoothing filter circuit	Yes/No	
	iv) Soft-start feature	Yes/No	
	v) Automatic load sharing during parallel operation	Yes/No	
	b. SCR elements provided with		

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SL. NO.	DESCRIPTION	UNIT	DATA
	i) Surge protection	Yes/No	
	ii) Fast acting HRC fuse	Yes/No	
vii)	A. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
viii)	A. C. Fuse / MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
ix)	A.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rated Current	Amp	
	e. Utilization category		
	f. Thermal overload with In-built single-phase preventer provided	Yes/No	
x)	Rectifier Transformer		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating		
	i) KVA	KVA	
	ii) Voltage	V	

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SL. NO.	DESCRIPTION	UNIT	DATA
	iii) % reactance	%	
	e. Class of insulation		
	f. Method of cooling		
xi)	Controlled Rectifier (SCR)		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. RMS Current rating	Amp	
	e. Surge Current		
	i) One-cycle	Amp	
	ii) Repetitive Cycle	Amp	
	f. Peak inverse voltage		
	i) Continuous	Volt	
	ii) Surge	Volt	
xii)	D.C. Fuse/MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating		
	i) Continuous	Amp	
	ii) Interrupting	KA	
xiii)	D.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating	Amp	
	e. Utilization category		
xiv)	Blocking Diodes		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		

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SL. NO.	DESCRIPTION	UNIT	DATA
	d. Current Rating		
	i) One – minute	Amp	
	ii) One-hour	Amp	
	e. Peak inverse voltage	Volt	
xv)	Indication Lamps		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Wattage	Watt	
	e. Series resistor	Ohm	
xvi)	Meters		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Size	mm	
	e. Accuracy		
xvii)	Alarm Facia		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. No. of window per facia	Nos.	
xviii)	D. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating	Amp	
	e. No. of poles	Nos.	
xix)	Charger Panel		
	a. Make		
	b. Type		
	c. Reference Standard		

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SL. NO.	DESCRIPTION	UNIT	DATA
	d. Enclosure		
	i) Degree of protection		
	ii) Sheet steel thickness	mm	
	e. Panel provided with		
	i) Internal lamp with door-switch	Yes/No	
	ii) Space heater with thermostat	Yes/No	
	iii) 5A, 3-pin receptacle with plug	Yes/No	
	f. Internal Wiring		
	i) Insulation		
	ii) Voltage grade	V	
	iii) Minimum conductor size	mm ²	
	g. Power Terminals		
	i) Make		
	ii) Size/Cat. No.		
	h. Control Terminals		
	i) Make		
	ii) Size/Cat. No.		
	iii) 20% spare terminal furnished	Yes/No	
	i. Ground Terminal furnished	Yes/No	
	j. Overall dimension (LxDxH)	mm	
	k. Weight	Kg	
	l. General Arrangement drawings furnished	Yes/No	

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7 HV CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.1.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
a)	In air	A	
b)	In ground	A	
c)	In duct	A	
d)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
a)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
b)	Grad and Shape of conductor		
c)	Nominal cross section area	mm ²	
d)	Number of wires		
e)	Diameter of wire	mm	
f)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
i.	Between cores	mm	
ii.	Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.20	Inner sheath		
a)	Material, confirming standard / type		
b)	Extruded	Yes/No	
c)	Calculated diameter over laid up cores		
d)	Thickness (min)	mm	
e)	Diameter of cable over inner sheath	mm	
f)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
g)	Filler Material details		
1.21	Armouring		
a)	Material		
b)	Type of armouring		

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S. No.	DESCRIPTION	UNIT	DATA
c)	No. and size of strip/wire		
d)	Whether galvanized	Yes/No	
e)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
a)	Material confirming standard/ type		
b)	Extruded	Yes/No	
c)	Minimum Thickness of sheath	mm	
d)	Tolerance on thickness of sheath	mm	
e)	Min. tensile strength	N/sq mm	
f)	Min. elongation percentage at rupture		
g)	Colour of Outer sheath		
h)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification and standards	Yes/No	
1.23	Overall diameter of cable and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous current		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/km	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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8 LT POWER & CONTROL CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.2.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
e)	In air	A	
f)	In ground	A	
g)	In duct	A	
h)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		

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S. No.	DESCRIPTION	UNIT	DATA
g)	Material reference standard for conductor		
h)	Grad and Shape of conductor		
i)	Nominal cross section area	mm ²	
j)	Number of wires		
k)	Diameter of wire	mm	
l)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	iii. Between cores	mm	
	iv. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.20	Inner sheath		
h)	Material, confirming standard / type		
i)	Extruded	Yes/No	
j)	Calculated diameter over laid up cores		
k)	Thickness (min)	mm	
l)	Diameter of cable over inner sheath	mm	
m)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
n)	Filler Material details		
1.21	Armouring		
f)	Material		

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S. No.	DESCRIPTION	UNIT	DATA
g)	Type of armouring		
h)	No. and size of strip/wire		
i)	Whether galvanized	Yes/No	
j)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
i)	Material confirming standard/ type		
j)	Extruded	Yes/No	
k)	Minimum Thickness of sheath	mm	
l)	Tolerance on thickness of sheath	mm	
m)	Min. tensile strength	N/sq mm	
n)	Min. elongation percentage at rupture		
o)	Colour of Outer sheath		
p)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification	Yes/No	
1.23	Overall diameter of cable and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous currents		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/km	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated		

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S. No.	DESCRIPTION	UNIT	DATA
	temperature		
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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9 ILLUMINATION System

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC	
1.2	Variation in Supply		
	a) Voltage	%	
	b) Frequency	%	
	c) Combined voltage & frequency	%	
1.3	Design Ambient Air Temperature	°C	
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	
	b) At 220V DC (For DC LP)	kA(DC)	
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		
b	Conductor size	SWG	
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		
2.2	Rated Voltage, phase and Frequency	AC	
2.3	One Minute Withstand Voltage	V	
2.4	Mounting Type		
	a) LDBs		
	b) Single Phase LP		
2.5	Type and no of circuits & feeder rating		
2.6	Colour shade		
2.7	Lighting Transformer		
	a) Type		
	b) Voltage Ratio	V	
	c) Taps	%	
	d) Vector Group		
	e) Impedance	%	
	f) Rating	KVA	
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		
3.2	Luminaries		
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		

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S. No.	DESCRIPTION	UNIT	DATA
	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		
	a) Luminaires		
	b) Accessories		
4.0	Schedule of fitting and Accessories		
5.0	Technical details of luminaries		
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumens	
	ii) After 1000 burning hours	Lumens	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		
a	Power factor		
5.4	Luminaires		
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		
	ii) Suitable upto conductor size	SWG	
c	Internal wiring size	Sq.mm	
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	

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S. No.	DESCRIPTION	UNIT	DATA
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		
8.1	Make		
8.2	Type		
8.3	Output	VA	
8.4	Accuracy Class		
8.5	Literature enclosed	Yes/No	
9.0	Meters		
9.1	Make		
9.2	Type		
9.3	Accuracy Class		
9.4	Literature enclosed	Yes/No	
10.0	Relays (if any provided)		
10.1	Make		
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a) Normally open		
	b) Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		
11.2	Suitable for use in hazardous area		
	a) Area classification		
	b) Gases/Vapor group		
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	

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S. No.	DESCRIPTION	UNIT	DATA
12.0	Lighting Control Switches		
12.1	Make		
12.2	Decorative		
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	
14.0	Lighting wires		
14.1	Make		
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	CONDUITS		
15.1	Make		
15.2	Rigid Steel		
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	Lighting poles/towers		
17.1	Make		
17.2	Type of Poles/Towers		
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S. No.	DESCRIPTION	UNIT	DATA
18.0	Ceiling fans		
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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10 CABLE CARRIER SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		
2.	Size of Tray	mm	
3.	Material		
4.	Application		
5.	Type of Tray		
6.	Thickness of Tray	mm	
7.	Thickness of Galvanization	mm	
8.	Tray Cover Size	mm	
9.	Cable Tray Accessories		
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[43]	25.09.2014

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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11 EARTHING & LIGHTNING PROTECTION SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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12 6.6kV Switchgear

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material		
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Color finish shade	Interior Exterior	

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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		
3.3	Rated operating duty		
3.4	Circuit breakers type		
3.5	Short circuit withstand current for 1 sec. Duration	kA	
3.6	Rated making current	kAp	
3.7	Rated current at site reference ambient temp	A	
3.8	Type of operating mechanism		
3.9	Minimum no. of auxiliary Contacts for purchaser's use		
3.10	Control voltage		
	Spring charging motor	V AC/DC	
3.11	Closing Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.12	Opening Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.13	Operating time		
	Opening time	ms	
	Breaking time	ms	
	Total tripping time	ms	
	Total Closing time	ms	
3.14	Number of breaks per pole		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Contactor		
	Voltage class	kV	
	Short time Rating		
	Duty		
5.0	Fuse		
	Voltage class	kV	
	Rupturing capacity	kAp	
6.0	Current Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Basic Insulation level	kV	
6.1	CT for differential protection		
	Class		
	Secondary resistance at 75 ° C		
	Knee Point Voltage		
	Excitation Current		
6.2	CT for Metering		
	Class		
	Secondary resistance at 75 ° C		
6.3	CT for Protection		
	Class		
7.0	Voltage Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Voltage ration		
8.0	Meters		
a	Make		
b	Type		

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S. No.	DESCRIPTION	UNIT	DATA
8.1	Voltmeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
8.2	Ammeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
9.0	Indicating lamps		
a	Make		
b	Type		
c	Voltage	V	
d	Wattage of lamp	W	
10.0	Push buttons		
a	Make		
b	Type		
c	Contact rating	A	
11.0	Space heater		
a	Make		
b	Type		
c	Rated voltage	V	
d	Power rating	W	
12.0	Wiring and terminal blocks		
a	Voltage grade		
b	Insulation		
c	Minimum size of conductor for:		
d	Power wiring	Sq.mm	
e	Control wiring	Sq.mm	
f	Type of terminal blocks:		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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S. No.	DESCRIPTION	UNIT	DATA
g	I) For Withdraw able Type		
h	II) For Fixed Type		
i	Minimum current rating of terminal blocks	A	
13.0	ABT Panel		
a	Make		
b	Type		
c	Panel thickness	mm	
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		

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13 VARIABLE FREQUENCY DRIVE

S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
1	Manufacturer Name		
2	Model No.		
3	Application		
4	Quantity		
5	Enclosure Protection Rating		
6	Output Current Rating at ambient temperature		
7	% derating considered for specific ambient		
8	Rated Voltage (volts) Input		
9	Output Frequency Range (Hz)		
10	Number of Phases and Frequency (Hz)		
a.	Short time current rating		
b.	Dynamic rating		
11	Rectifier type & Design		
12	Inverter type & Design		
13	Min/Recommended / Max switching frequencies (kHz)		
14	Filters		
a.	Line Side		
b.	Load Side		
15	Drive Input		
16	Output Modulation Method		
17	Speed Accuracy (+ / - %)		
18	Response time (speed)		
19	Response time (Torque)		
20	Type of cooling		
21	Whether VVFD is suitable for outdoor installation		
22	Drive Control Capabilities		
a.	Start/Stop Push button		
b.	Modbus control		
23	Permissible % variation		
a.	Voltage		
b.	Frequency		
24	Load parameters at rated voltage & frequency		
a.	Output Frequency (Hz)		
b.	Full Load current (Amp)		
c.	VVF Heat dissipation (w)		
25	VVF Efficiency		
a.	At Full rated Torque		
b.	At 75% of full load torque		
c.	At 50% of full load torque		
26	Drive Power factor range		
	At rated speed, Torque		
27	DC Voltage		
28	Fundamental power factor		
29	Switching Frequency		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
a.	Drive Dimensions		
b.	Length		
c.	Height		
d.	Depth		
e.	Weight		
30	Metering		
a.	Applicable Standards		
b.	Accuracy Class		
c.	Make		
d.	Type		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[51]	25.09.2014

14 6.6KV SEGREGATED PHASE BUSDUCT

S. No.	Technical Particulars	Unit	Bidder Data	Remarks
1.0	General			
1.1	System nominal voltage	kV		
1.2	System maximum voltage	kV		
1.3	Number of phases			
1.4	Rated Frequency	Hz		
1.5	Neutral Grounding			
1.6	Insulation level			
a	1 min power frequency withstand voltage	kV		
b	Impulse withstand voltage	kVp		
1.7	Short Circuit Level			
a	Symmetrical short circuit capacity	kA		
b	Dynamic capacity	kAp		
1.8	Space heating voltage	V		
1.9	Reference standard			
2.0	Busduct			
2.1	Make			
2.2	Type of bus duct			
2.3	Service			
2.4	Type of cooling			
2.5	Nominal service voltage/rated frequency			
2.6	Busduct length			
2.7	Rated voltage class			
2.8	Continuous current rating of bus duct under site conditions between			
	a) UT and associated 6.6kV unit switchgear	Amps		
	b) ST and associated 6.6kV station switchgear	Amps		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[52]	25.09.2014

S. No.	Technical Particulars	Unit	Bidder Data	Remarks
	c) Tie between Station and Unit switchgear	Amps		
2.9	Basic impulse withstand level (1.2 x 50 micro sec wave)	kVp		
2.10	One minute power frequency dry withstand voltage	kV		
2.11	Short time current for one second /Dynamic withstand current	KA /KA _p		
2.12	Maximum temperature rise of conductor over 50°C ambient	°C		
2.13	Maximum temperature rise of enclosure over 50°C ambient	°C		
2.14	Maximum temperature rise of conductor over 50° C ambient when carrying short circuit current for 1 sec	°C		
3.0	Bus conductor			
3.1	Bus conductor Material			
3.2	Bus conductor size for			
	a) Between UT and 6.6kV Unit Switchgear	mmx mm		
	b) Between ST and 6.6 kV Station switchgear	mmx mm		
3.3	Bus conductor shape			
3.4	Busbar Section			
4.0	Bus enclosure			
4.1	Bus Enclosure Material			
4.2	Shape of Enclosure			
4.3	Cross section of enclosure	mmx mm		

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-B	[53]	25.09.2014

S. No.	Technical Particulars	Unit	Bidder Data	Remarks
4.4	Phase barriers			
a	Material of Phase Barriers			
b	Phase Clearance (Minimum) Phase to Phase Phase to Earth	mm x mm		
5.0	Parameters of busduct			
5.1	Resistance/meter/Phase at 20°C of conductor for			
5.2	Inductive reactance/meter/phase at 20°C for			
5.3	Capacitive reactance/metre/phase at 20°C			
5.4	Heat loss in the bus duct at full rated current			
5.5	Weight of 3-phase duct	kg		
5.6	Standard section length	m		
5.7	Minimum required clearances from the periphery of the bus duct			
	i) To structural steel work parallel to the duct	mm		
	ii) To structural steel work perpendicular to the duct	mm		
5.8	Type of Joints between Adjacent Sections of Bus Conductor Welded/Bolted			
9.0	Insulators and seal off bushings			
9.1	Make			
9.2	Rated Voltage	kV		
9.3	One minute Power Frequency Withstand Voltage	kVrms		
9.4	Impulse Withstand Voltage (1.2 x 50 micro-second Wave)	kVp		
9.5	Minimum Creepage Distance	mm/kV		

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S. No.	Technical Particulars	Unit	Bidder Data	Remarks
9.6	Insulators			
	a) Material of Insulators			
	b) Cantilever strength			
	c) Weight of insulator	kg		
	d) No of supports and insulator span			
10.0	Seal-off bushings			
a	Current rating of Seal of Bushings	Amps		
b	Material of Seal Off Bushings			
c	Type			
d	Mechanical Strength			
e	e) Weight of each bushing	kg		
11	Earthing Material			
12	Finish of Bus Enclosure			
13	Rain hood required Yes/No			
14	Degree of protection for enclosure			

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15 EMERGENCY DIESEL GENERATOR

SL No.	DESCRIPTION	UNIT	BIDDER DATA
1.	EMERGENCY DIESEL GENERATOR		
1.1	Engine	-	
1.1.1	Manufacturer	-	
1.1.2	Type/model	-	
1.1.3	Country of manufacture	-	
1.1.4	Number and arrangement of cylinders	-	
1.1.5	Bore	mm	
1.1.6	Stroke	mm	
1.1.7	Speed of diesel engine	rpm	
1.1.8	Rated output according to ISO 3046 – Part 1	kW	
1.1.9	Rated output according to site conditions and 26°C ambient temperature	kW	
1.1.10	Mean piston speed	ms	
1.1.11	Direction of rotation (viewed from coupling end)	-	
1.1.12	Max. cylinder pressure	bar g	
1.1.13	Max. compression pressure	bar g	
1.1.14	Critical speed	rpm	
1.1.15	Inertia constant H of complete diesel/generator set	s	
1.1.16	Starting facilities sufficient for consecutive start-ups	no.	
1.1.17	Fuel consumption at rated voltage:		
	a. 100% rated load	l/kWh	
	b. 75% rated load	l/kWh	
	c. 50% rated load	l/kWh	

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SL No.	DESCRIPTION	UNIT	BIDDER DATA
1.1.18	Exhaust gas temperature at 100% site rating:		
	a. at cylinder outlet	°C	
	b. upstream turbo charger	°C	
	c. downstream turbo charger	°C	
1.1.19	Cooling water temperature:		
	a. inlet	°C	
	b. outlet (at 37°C ambient temperature)	°C	
1.1.20	Volume of fuel oil day tank	m ³	
1.1.21	Dimensions of fuel oil day tank	m x m x m	
1.2	Engine and Generator		
1.2.1	Overall length	mm	
1.2.2	Overall width	mm	
1.2.3	Overall height	mm	
1.2.4	Total weight of generator	kg	
1.2.5	Total weight of engine	kg	
1.3	Generator		
1.3.1	Manufacturer	-	
1.3.2	Type/model	-	
1.3.3	Country of manufacture	-	
1.3.4	Protection class	-	
1.3.5	Rated apparent power	kVA	
1.3.6	Rated power factor	cos phi	
1.3.7	Rated active power	kW	
1.3.8	Rated voltage	kV	

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SL No.	DESCRIPTION	UNIT	BIDDER DATA
1.3.9	Voltage variation range		
	a. static	± %	
	b. dynamic/transient	± %	
1.3.10	Rated current	A	
1.3.11	Rated frequency	Hz	
1.3.12	Rated frequency variation range		
	a. static	± %	
	b. dynamic/transient	± %	
1.3.13	Rated speed	rpm	
1.3.14	Direct axis sub-transient reactance (saturated)	X"d	
1.3.15	Maximum asymmetric 3-phase short circuit current	kA peak	
1.3.16	Test voltage	kV	
1.3.17	Insulation class	-	
1.3.18	Number of bushings	-	
1.4	Excitation system		
	Type of excitation system (rotating diodes required)		
	At no load:		
	a. exciter current	A	
	b. exciter voltage	V	
	At rated load:		
	a. exciter current	A	
	b. exciter voltage	V	
	Exciter machine:		
	a. manufacturer	-	
	b. type/model	-	

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SL No.	DESCRIPTION	UNIT	BIDDER DATA
	Rated power	kW	
	Insulation class	-	
	Voltage regulation (electronic)		
	Manufacturer	-	
	Type/model	-	
	Country of manufacture	-	
	Voltage regulation range	%	
1.5	Generator protection system		
1.3.1	Manufacturer of protection system	-	
1.3.2	Country of manufacture	-	
1.3.3	Number of cabinets	-	
1.3.4	Auxiliary voltage	V	
1.3.5	Differential protection		
	Relay type	-	
1.3.6	Voltage controlled inverse time over current		
	Relay type	-	
1.3.7	Reverse power protection		
	Relay type	-	
1.3.8	Stator earth fault protection		
	Relay type	-	
1.3.9	Overvoltage protection		
	Relay type	-	
1.3.10	Rotor earth fault protection		
	Relay type	-	
1.3.11	Diode failure relay		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of *[Name of the Power Plant]*

[Logo of Utility]

SL No.	DESCRIPTION	UNIT	BIDDER DATA
	Relay type	-	
1.3.12	Excitation loss protection		
	Relay type	-	
1.3.13	Negative phase sequence protection		
	Relay type	-	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**BALANCE OF PLANT
(PACKAGE NUMBER: R&M-SP-03)
VOLUME-III
PART-C
TECHNICAL SCHEDULES-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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* * * * *

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

BALANCE OF PLANT (PACKAGE NUMBER: R&M-SP-03)

VOLUME-III, PART-C TECHNICAL SCHEDULES-I&C (TO BE FILLED BY BIDDER)

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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LII-GETS12021-G-00129-003	01	Tender Document for Selection of R&M Contractors – Balance of Plant Volume-III, Part-C	[v]	25.09.2014

1 PROGRAMMABLE LOGIC CONTROLLER (PLC)

Table 1.1
Data Sheet for PLC

S.N	Feature	To be Filled by Bidder
1	Type of the system offered and Model No.	
2	Make	
3	Year of launching of the system	
4	Is the system offered, the latest system available/ being marketed in the international market by the vendor	
5	Place of Manufacturing	
6	Is the offered system confirms to the Specification provided in the tender document with regard to Spare Capacity, Expandability, Redundancy,	
7	Is the System offered is with open system architecture to enable integration of third party hardware/ software applications	
8	Support direct connectivity to Ethernet based LAN	
9	Deterministic and secure architecture	
10	On-line removal/replacement of I/O modules/ drive control modules possible without switching off power supply to the corresponding rack & without affecting controller operation	
11	Total I/O handling capacity of Controller	
12	No. of Tags handling capacity of Controller	
13	Total Power requirement for the offered system	
14	Total Heat Load of all cabinets	
15	Scanning rate for	
a	Analog Signal	
b	T/C Signal	

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S.N	Feature	To be Filled by Bidder
c	RTD Signal	
d	Binary Signal	
16	Loop Execution Time for	
a	Interlocks	
b	Close loops	
17	Auto switchover to backup redundancy Level	
a	Controller Level	
b	Power supply Level	
c	Communication Level	
18	Output Status on Controller Failure	
19	Battery back-up duration for control processor	
20	Non-volatile memory capacity to store programs, standard software to perform control, DAS & Diagnostic functions	
21	Maximum no. of Channels for	
a	Analog Input module	
b	T/C Input module	
c	RTD Input module	
d	Analog Output module	
e	Binary Input Module	
f	Binary Output module	
22	Optical Isolation for Binary Input/Output provided.	
23	Galvanic isolation for Analog Input/Output provided	
24	Can the analog and binary controls be implemented at different execution speeds, in the multi-function controllers.	
25	Simulation of Analog/Digital Input/Output possible.	
26	Data Transmission speed for	
a	Ethernet LAN	

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S.N	Feature	To be Filled by Bidder
b	Data Highway	
c	I/O Bus	

Table 1.2
Data Sheet for High Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	No. of Inputs/Module	
2	Types of Input (Linear)	
3	Accuracy	
4	A/D Converter	
5	Temperature Effect	
6	CMRR	
7	NMRR	
8	MTBF	
9	Stability	
10	Diagnostic	
11	Isolation	

Table 1.3
Data Sheet for Low Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input (Grounded/ Ungrounded)	
4	Cold junction compensation	
5	Accuracy	
6	A/D Converter	
7	Temperature Effect	
8	CMRR	
9	NMRR	

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S.N	Feature	To be Filled by Bidder
10	MTBF	
11	Stability	
13	Diagnostic	
14	Isolation	

Table 1.4
Data Sheet for Binary Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Contact Bounce Filtering Provided	

Table 1.5
Data Sheet for SOE Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	

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S.N	Feature	To be Filled by Bidder
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Time stamping provided	
14	Time Resolution	
15	Filter Delay Time	

Table 1.6

Data Sheet for Smart Transmitter Interface Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Protocol	
6	Accuracy	
7	Function	
8	Diagnostic	
9	Isolation	

Table 1.7

Data Sheet for Pulse Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	

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S.N	Feature	To be Filled by Bidder
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Minimum Pulse Width	

Table 1.8

Data Sheet for Analog Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Isolation	
6	Accuracy	
7	Load	
8	Diagnostic	
9	Isolation	
10	Power supply	
11	Short circuit Protection	

Table 1.9

Data Sheet for Binary Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	

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S.N	Feature	To be Filled by Bidder
4	MTBF & MTTR	
5	Contact rating	
6	Contact Voltage	
7	Switching Frequency	
8	Contact Life	
9	Power supply	
10	Isolation	

Table 1.10
Data Sheet for Controller

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	Processor make	
3	Type of Processor/minimum word length	
4	Memory Size	
5	No. of Loops	
6	No. of I/O	
7	Configuration	
8	Battery Backup Available	
9	Duration of Battery backup	
10	Redundancy	
11	Change Over Time	
12	Failure of any one of the processor not to affect system operation	
13	What could be the maximum loading of the Controller CPU with the configuration offered	
14	Cycle Time	
15	Expansion facility available	
16	Data Transfer mode	

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S.N	Feature	To be Filled by Bidder
17	MTBF & MTTR	

Table 1.11
Data Sheet for Engineering Station

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Processor	
3	Cache Memory	
4	RAM	
5	Hard disk Drive	
6	CD Drive	
7	Video card	
8	Operating System	
9	Interfacing Ports	
10	Monitor	
a	Type	
b	Size	
c	Resolution	
d	Colors	
e	Sync	
f	Dot per inch	
g	Glare Filter	
h	Make & Model no.	
11	keyboard	
a	Type	
b	Make & Model No.	
c	Key lock control	
12	Mouse	
a	Type	

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S.N	Feature	To be Filled by Bidder
b	Make & Model no.	
13	Is on line program modification (Control algorithms, logic, sequence programs etc.) and loading possible from Engineering console through data highway without taking the controller in 'standby' mode? Specify limitation, if any	
14	Is it possible to access the control configurations (both regulatory and discrete) along with dynamic updating of process variables (analog values and binary status) from the Engineering station.	
15	Can the system configuration modified and loaded into controller from engineering station	
16	Programming language used for implementing logics / control schemes	

Table 1.12
Data Sheet for Laser Printer

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Printer memory	
4	Speed	
5	Resolution	
6	Colors	
7	Duty Cycle	
8	Power Supply	
9	Paper Size	
10	Cartridge Life	
11	Diagnostic	
12	Interfaces	

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Table 1.13
Data Sheet for Interposing Relays

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Coil Voltage	
4	Contact	
5	Contact Rating	
6	Coil Insulation Class	
7	Mechanical Life	
8	Coil Protection	
9	Connection	
10	Mounting	

Table 1.14
Data Sheet for Operator Work Stations

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	Monitor Support	
5	CD Drive	
6	Power Supply	
7	Keyboard	
8	Pointing Device	
9	Monitor	

Table 1.15
Data Sheet for Servers

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	

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S.N	Features	To be filled by bidder
4	RAID	
5	Monitor Support	
6	CD Drive	
7	Power Supply	
8	Keyboard	
9	Pointing Device	
10	Monitor	

Table 1.16
Data Sheet for LCD

S.N	Features	Minimum Requirements
1	Viewable Picture Area	
2	Resolution	
3	Aspect Ratio	
4	Display Colors	
5	LCD Panel	
6	Contrast Ratio	
7	Brightness	
8	Viewing Angle	
9	Computer Interface	
10	Cabinet Material	
11	Finish	
12	Mounting	
13	Power supply	
14	Accessories	

Table 1.17
Data Sheet for Engineering Laptop

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	CD Drive	

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S.N	Features	To be filled by bidder
5	Power Supply	
6	Communication Ports	
7	Screen size	
8	Battery	

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2 UN-INTERRUPTED POWER SUPPLY (UPS)

Table 2.1
Data Sheet for UPS

Sr. no	Description	To be Filled by Bidder
1	Make	
2	Type	
3	Nominal output power for PF = 0.8 Lag	
4	Audible noise level	
5	Protection degree	
6	Standards	
7	Internal protection	
8	Installation	
9	Service access	
10	External cable connections	
11	Earthing	
12	Cooling	
13	Bypass & Interfacing	
14	Input connection	
15	Primary components	
16	Overload on bypass	
17	Voltage limits for inverter/bypass Load Transfers	
18	Programmable signaling	
19	Metering	
20	Dimension & Weights	
a)	Number of cabinets	
b)	Dimension of Inverter cabinet (W x H x D) mm	
c)	Dimension of static switch cabinet (W x H x D) mm	
d)	Dimension of A.C. distribution board (W x H X D) mm	

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e)	Dimension of transformer and stabilizer panel (WxHxD) mm	
f)	Dimension of any other UPS cabinet, if furnished (WxHxD)mm	
g)	Overall dimension (LxHxD) mm	
16	Heat load for Ventilation/Air Conditioning requirement	
a)	Inverter and static switch at 100% load	
b)	Inverter and static switch at 50% load	
c)	Inverter and static switch at 33% load	

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3 FIELD INSTRUMENTS

TABLE 3.1
Data Sheet for Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	Turn Down ratio	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Operating Voltage	
13	Output Signal	

TABLE 3.2
Data Sheet for RTD

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	No. of Elements	
4	Wire Gauge	
5	Protection tube OD/ Material/ Filling	
6	Response time	
7	Accuracy	
8	Characteristics	

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S.N	Features	To be Filled by Bidder
9	MOC Head/ protection class	
10	Cable connection	

TABLE 3.3

Data Sheet for Thermowell

S.N	Features	To be Filled by Bidder
1	Make	
2	MOC	
3	Process Connection	
4	Immersion Length	

TABLE 3.4

Data Sheet for Pressure Gauge/DP Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Sensing Element Material	
4	Movement Material	
3	Case Material / Protection Class	
5	Dial Size	
6	Scale	
7	Over range Protection	
8	Adjustment	
9	Element Connection	
10	Process Connection	
11	Accuracy	
12	Repeatability	
13	Response time	
14	Chemical Seal Unit	

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TABLE 3.5

Data Sheet for Temperature Gauge

S.N	Feature	To be Filled by Bidder
1	Make/Model No.	
2	Type	
3	Stem	
4	Movement Materials	
5	Case Material/Protection class	
6	Dial Size	
7	Scale	
8	Adjustment	
9	Range Selection	
10	Over range Protection	
11	Instrument Connection	
12	Process Connection	
13	Accuracy	
14	Repeatability	
15	Response Time	

TABLE 3.6

Data Sheet for Level Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing Element & material	
4	Body Material	
5	End Connection	
6	Accuracy	
7	Housing	
8	Zero / Span adjustment	
9	Packing material	

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TABLE 3.7
Data Sheet for Temperature Switch

S.No	Feature	To Be Filled By Bidder
1	Switching Range	
2	Display Type	
3	Display Resolution	
4	Indicator	
5	Accuracy	
6	Sensor Element	
7	Housing and Probe Material	
8	Electrical Data Power	
9	Switch Type	
10	Switch Rating	
11	Switch Logic	
12	Response Time	
13	Dampening	
14	Electrical Connection	
15	Electrical Protection	
16	Other Functions	

TABLE 3.8
Data Sheet for Pressure/DP Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing Element material	
4	Wetted Parts material	
5	Case Material	

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S.N	Feature	To be Filled by Bidder
6	Over range for Pressure/Vacuum Switch	
7	Process Connection	
8	Switch Configuration	
9	Switch Rating	
10	Cable Connection	
11	Enclosure Class	
12	Accuracy	
13	Repeatability	

TABLE 3.9

Data Sheet for Capacitance Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Sensing elements	
3	Probe Material	
4	Repeatability	
5	Accuracy	
6	Probe length	
7	End connection	
8	Rating of contacts	
9	Enclosure class	
10	Housing material	
11	Electrical Connection	

TABLE 3.10

Data Sheet for Displacer Type Level Switch

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	

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S.N	Features	To be Filled by Bidder
4	MOC of Float/Stem	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Electrical Connection	
13	Output Signal	

TABLE 3.11

Data Sheet for Displacer Type Level Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	MOC of Float/Stem	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Electrical Connection	
13	Output Signal	

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TABLE 3.12
Specification for Ultrasonic Level Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	
10	Mounting	
11	Transmitter housing material/enclosure	

TABLE 3.13
Data Sheet for Radar Type Level Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	
10	Mounting	
11	Transmitter housing material/enclosure	

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TABLE 3.14

Data Sheet for RF Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Particle size	
3	Insertion length	
4	Mounting	
5	Process connection	
6	Protection Class	
7	Cable connection	

TABLE 3.15

Data Sheet for Flow Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Insertion length	
3	Mounting	
4	Process connection	
5	Protection Class	
6	Cable connection	

TABLE 3.16

Data Sheet for Rotameters

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Fluid media	
4	Float Material	
5	Accuracy	
6	Process connection	
7	Enclosure material & protection class	

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TABLE 3.17
Data Sheet for Flow Glass

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Size	
4	Body Material	
5	Glass material	
6	Pressure Rating	
7	Temperature Rating	
8	Protection class	
9	Connection	

TABLE 3.18
Data Sheet for Pneumatic Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Diaphragm Material	
4	Spring Material	
5	Body Material	
6	Stem material	
7	Coupling type & material	
8	Pneumatic Connection	
9	Action on Air Failure	
10	Angle of operation	
11	Signal Range	
12	Manual Operation	

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TABLE 3.19
Data Sheet for Electrical Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Motor rating	
4	Power supply	
5	Control Supply	
6	Electrical Connection	
7	Body Material & Protection Class	
8	Gear Train Material	
9	Input Signal	
10	Output Signal	
11	Manual Operation	

TABLE 3.20
Data Sheet for I-to-P Converter

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Air Supply	
3	Input Signal	
4	Output Signal	
5	Linearity	
6	Hysteresis	
7	Mounting	
8	Protection class	
9	Enclosure	
10	Drift	
11	Direct/Reverse action Facility	

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TABLE 3.21

Data Sheet for Smart Positioner

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Input	
3	Power Supply	
4	Type of Electronics	
5	Valve position sensing	
6	Enclosure Type/Material	
7	Operating Range	
8	Modes of operation	
9	Flow characteristics	
10	Fail safe/Freeze feature	
11	Air supply pressure	
12	Process Connection	

TABLE 3.22

Data Sheet for Air Filter Regulator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Inlet Pressure	
4	Output	
5	Filter Element size	
6	Filter Element Material	
7	Drain	
8	Bowl Material	
9	Enclosure Protection class/ Material	
10	Process connection	

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TABLE 3.23

Data Sheet for Position Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Power Supply	
3	Type	
4	Output	
5	Accuracy	
6	Enclosure Protection class/ Material	
7	Cable Entry	

TABLE 3.24

Data Sheet for Limit Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Sensing Element	
3	Material	
4	Repeatability	
5	No. of Contacts	
6	Contact Ratings	
7	Enclosure type/material	
8	Electrical Connection	
9	Set point	
10	Mounting	

TABLE 3.25

Data Sheet for Solenoid Valve

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Operating Principle	
3	Coil Voltage Rating	

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S.N	Feature	To be Filled by Bidder
4	Body	
5	Trim	
6	Manual Operation	
7	Duty	
8	Sealing	
9	Coil enclosure	
10	Coil Insulation Class	
11	Cable Connection	

TABLE 3.25
Data Sheet for pH Analyzer

S.No	Feature	To be Filled by Bidder
1	Type	
2	Sensor	
3	Range	
4	Temperature compensation	
5	No. of stream	
6	Measuring Error	
7	Stability	
8	Error	
9	Measuring cycle	
10	Reproducibility	
11	Output signal	
12	Linearly	
13	Calibration	
14	Zero Adjustment	
15	Slop Adjustment	

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S.No	Feature	To be Filled by Bidder
16	Storage of measured valves	
17	Indication	
18	Data Input	
19	Protection	

TABLE 3.26
Data Sheet for Conductivity Analyzer

S.No	Feature	To Be Filled By Bidder
1	Type	
2	Range	
3	No. of stream	
4	Temperature compensation	
5	Temperature coefficient	
6	Reference temperature	
7	Error of Measurement	
8	Response Time	
9	Measuring cycle	
10	Signal Output	
11	Indication	
12	Calibration	
13	Programming	
14	Enclosure Material	
15	Protection	
16	Other	

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TABLE 3.27
Data Sheet for Silica Analyzer

S.No	Feature	To Be Filled By Bidder
1	Type	
2	No. of Steam	
3	Order of steam selection	
4	Range	
5	Error of measurement	
6	Reproducibility	
7	Response Time	
8	Calibration	
9	Transmitter	
10	Display	
11	Output	
12	Material	
13	Serial Interface	
14	Requirement:	

TABLE 3.28
Data Sheet for Sodium Analyzer

S.No	Feature	To Be Filled By Bidder
1	Type	
2	No. of stream	
3	Measuring range	
4	Error of measurement	
5	Response Time	

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S.No	Feature	To Be Filled By Bidder
	(90% of full scale)	
6	Transmitter	
7	Serial Interface	
8	Error Report	

TABLE 3.29
Data Sheet for Turbidity Analyzer

S.No	Feature	Minimum/Maximum Requirement
1	Type	light reflection principle
2	Accuracy	</- +/- 2% low range </- +/- 5% high range
3	Response Time	</- 5 minutes
4	Range	0-100 NTU
5	No. of Stream	Single

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4 PROCESS CONNECTION PIPING & ACCESSORIES

Table 4.1
Data Sheet for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	

Table 4.2
Data Sheet for Impulse Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	

Table 4.3
Data Sheet for Copper Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	
6	PVC Coating thickness	

Table 4.4
Data Sheet for Fittings for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	

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S.N	Feature	To be Filled by Bidder
2	Type of Fitting	
3	Material	
4	Size	
5	Pressure Rating	
6	Temperature Rating	

Table 4.5

Data Sheet for Compression Fittings for Impulse Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Fitting	
3	Material	
4	Size	
5	Ferrule	
6	Pressure Rating	
7	Temperature Rating	

Table 4.6

Data Sheet for CS Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	
6	Type of threading	
7	Thickness of galvanization	

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Table 4.7
Data Sheet for Ball Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	
9	Ball Material	
10	Seat Material	
11	Stem material	

Table 4.8
Data Sheet for Globe Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	
9	Ball Material	
10	Seat Material	
11	Stem material	

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Table 4.9
Data Sheet for Air Header

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Thickness	
5	Test Pressure	
6	Inlet Connection	
7	Outlet Connection	
8	Drain Connection	
9	Inlet Valve type/size	
10	Drain Valve type/size	
11	Distribution Valve type/size	

Table 4.10
Data Sheet for Instrument Manifolds

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Type	
5	Ports	
6	Rating	
7	Connection	

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5 INSTRUMENTATION CABLES & ACCESSORIES

Table 5.1
Data Sheet for RTD Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Triads	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Triad Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 5.2
Data Sheet for Instrumentation Signal Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	

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S.N	Feature	To be Filled by Bidder
3	No. of Pairs	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Pair Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 5.3
Data Sheet for Fibre Optic Cable (Single Mode)

S.N	Feature	To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@1310 nm
		@1550 nm
2	Mode field Diameter	@1310 nm
		@1550 nm
3	Maximum Cable Cut-off Wavelength	

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S.N	Feature		To be Filled by Bidder
4	Maximum Zero Dispersion Wavelength		
5	Minimum Zero Dispersion Wavelength		
6	Maximum Zero Dispersion Slope		
7	Maximum Polarization Mode Dispersion		
8	Gigabit Ethernet Length 1000BASE-LX		
9	Ten Gigabit Ethernet Length	10GBASE-LX	
		10GBASE-LX4	
10	Maximum Core/cladding Concentricity Error		
11	Cladding Diameter		
12	Cladding Non-circularity		
13	Coating Diameter		
14	Maximum Coating Concentricity Error		
15	Temperature Dependence (-60 to + 85C)		
16	Temperature & Humidity Cycling (-10 to + 85C, 4 to 90% RH)		
17	Minimum Proof Test		
18	Bending Induced Attenuation (100 turns, 75mm diameter)		

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Table 5.4
Data Sheet for Fibre Optic Cable (Multi Mode)

S.N	Feature	To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@850 nm
		@1300 nm
2	Overfilled Launch Bandwidth	@850 nm
		@1300 nm
3	Gigabit Ethernet Length	1000BASE-SX
		1000BASE-LX
4	Ten Gigabit Ethernet Length	10GBASE-SR
		10GBASE-LX4
5	Numerical Aperture	
6	Core Diameter	
7	Maximum Core Non-circularity	
8	Maximum Core/cladding Concentricity Error	
9	Cladding Diameter	
10	Cladding Non-circularity	
11	Coating Diameter	
12	Maximum Coating Concentricity Error	
13	Temperature Dependence (-60 to +85C)	
14	Temperature & Humidity Cycling (-10	

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S.N	Feature	To be Filled by Bidder
	to + 85C, 4 to 90% RH)	
15	Minimum Proof Test	
16	Bending Induced Attenuation (100 turns, 75mm diameter)	

Table 5.5
Data Sheet for Cable Tray

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size (Width/Height)	
4	Perforation	
5	Length	
6	Thickness	
7	Coating of Hot dip Galvanizing	
8	Accessories	
9	Code/Standard	

Table 5.6
Data Sheet for Cable Glands

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Protection	
3	Compression	
4	Threading Type	
5	Material	
6	Check Nut	

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6 SYSTEM CABINETS & JUNCTION BOX

Table 6.1
Data Sheet for Cabinets

S.N	Feature	To be Filled by Bidder
1	Make	
2	Cabinet Dimension	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Anti vibration pad	
8	Painting	
9	Gland Plate thickness	
10	Grounding	
11	Ventilation	
12	Lighting	
13	Lifting arrangement	
14	Tag Plates	

Table 6.2
Data Sheet for Junction Box

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Dimension	
3	Mounting	
4	Protection class	
5	Material & Thickness	
6	Doors	
7	Cable entry	
8	Gasket	
9	Painting	

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S.N	Feature	To be Filled by Bidder
10	Gland Plate thickness	
11	Grounding	
12	Tag Plates	
16		

Table 6.3
Data Sheet for LIE/LIR

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Mounting	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Gland Plate thickness	
8	Air Connection	
9	Sample line Entry	
10	Drain Pipe	
11	Painting	
12	Anti Vibration Pad	
13	Grounding	
14	Tag Plates	
15	Dimension	

Signature : _____

Name : _____

Designation : _____

Seal of Company

Date : _____

Document Number	Rev No.	Description	Page No.	Date of Issue
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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-I
COMMERCIAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

Document Number	Rev No	Description	Page No.	Date of Issue
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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

Document Number	Rev No	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors– Coal Handling Plant Volume-I	[ii]	25.09.2014

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SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

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2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

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VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

COAL HANDLING PLANT (PACKAGE NUMBER: R&M-SP-04)

VOLUME-I COMMERCIAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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List of Acronym

CIF	:	Cost Insurance Freight
CIP	:	Carriage insurance paid
CPBG	:	Contract Performance BankGuarantee
DCB	:	Domestic Competitive Bidding
EDI	:	Electronic Data Interchange
FOB	:	Freight on Board
GCC	:	General Condition of Contract
GOI	:	Government of India
GST	:	Goods & Service tax
INR	:	Indian Rupee
I&C	:	Instrumentation & Control
ITB	:	Instruction to Bidder
LOA	:	Letter of Award
LOI	:	Letter of Intent
MoEF	:	Ministry of Environment and Forests
PERT	:	Program evaluation and review technique
RBI	:	Reserve Bank of India
R & M	:	Renovation and Modernization
SCC	:	Special Condition of Contract
VAT	:	Value added Tax

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1.0 INVITATION FOR BID

Tender No : [-----]

1.1 Introduction

[Give brief introduction about the name, ownership, business & Power Projects of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of Coal Handling Plant of Unit no.-XX - -----of the Power Plant]

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, invites sealed Tenders in English language from Prequalified Bidders for the Renovation & Modernization of Coal Handling Plant package of Unit No.[XXX] of the [XXX] Power Plant on Domestic Competitive Bidding (DCB) basis as per the scope of work given in Technical Specification Volume-II.

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly of existing equipment / systems, replacement of specified Equipment / systems by supplying new Equipment/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing and forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, all associated civil works including supply of cement, steel etc., testing & commissioning, successful completion of trial operation and guarantee tests for [Coal Handling Plant] package of Unit no. [XXX] of [XXX] Power Plant. The detailed scope of work is given in Technical Specification Vol. II.

The brief scope of work is given below: -

[-----]
[-----]
[-----]
]

For detailed Scope of Work & Services, refer Section-I of Volume-II of this Specification.

1.4 Tender Details

(a)	Cost of Tender Documents	:	INR [---]
(b)	Bid Guarantee Amount	:	INR [-----]
(c)	Date of issuance of Tender Document	:	[-----]
(d)	Date & Time of pre-Bid Conference	:	[-----]

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(e)	Last Date & Time of Receipt of Bid (Both Part I & Part II)	:	[-----]
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of facilities and performance guarantee test shall be as per SCC.

1.6 Bid Submission

- (a) The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.
- (b) The Bid proposals are to be submitted in two parts in separate sealed covers as follows:
 - Part I** : Bid Guarantee and Technical & Commercial Proposal without prices
 - Part II** : Price Schedule and Schedule of Functional Guarantee parameters with values.
- (c) All other terms and conditions along with the Technical Specifications, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- (d) Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:
[Designation, Address and Contact details.....]
.....]
- (e) Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- (f) The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the respective quoted Foreign Currencies.
- (g) Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- (h) The Tender Documents are meant for the exclusive purpose of bidding against the subject package and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Owner, intends to carry out the Renovation & Modernization of [Unit no.-XX ----- of the XXXX Power Plant].

Under the subject Tender, [Utility] invites bid for Renovation & Modernization of Coal Handling Plant package of the said Renovation & Modernization work to be carried out as per the accompanying Technical Specifications. The Bidder shall submit the offer for complete scope of work indicated in the Technical Specification.

2.2 Address and Contact Details of Owner

[Designation, Address and Contact details

-----]

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Owner's Consultant

[-----], hereinafter referred to as "Consultant" is the Consulting Engineer for the project, appointed by the Owner, [-----], to provide project consultancy services.

2.5 Sources of Fund

[Utility] intends to finance the subject Package of the said renovation & modernization work, through Internal and other sources & External/ Domestic Commercial/ Borrowing from international development funding agencies. [Utility] has tied up the required fund for this package.

2.6 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Owner will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.7 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.8 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents. It shall include the following:

- Disassembly of existing equipment/ systems as required.
- Detailed design of the systems/equipment covering all Mechanical, Electrical, Control & Instrumentation, Civil and Structural works.
- Complete manufacture, including shop inspection and testing.
- Providing engineering drawings, data, operational & maintenance manuals, etc., for the Owner's review/ approval.

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- (e) Packing, forwarding and transportation including insurance from the manufacturer's works to plant site and transportation from storage yard to erection site.
- (f) Receipt, storage, preservation and conservation of system/equipment at site including construction of storage facility viz. covered, semi-covered, air-conditioned, open yard at the space allocated at site by Owner including storage-cum-erection and all other specified & statutorily required insurance.
- (g) Pre-assembly, if any, erection, testing, commissioning, completion of plant and equipment/ system, conducting trial operation, performance guarantee test and handing over of all the plant and equipment/ system covered under this specification.
- (h) Carrying out all related civil and structural works at site including construction of foundations, buildings, structures etc. Including supply of cement and steel and all other required materials.
- (i) Supply of mandatory spares and tools & tackles.
- (j) Training of Owner's personnel.

Detailed scope is provided in Volume-II of the Technical Specifications.

Bids not covering the entire scope mentioned hereinabove may be treated as incomplete and hence are liable for rejection.

2.9 Time Schedule

The completion Time Schedule for Completion of R&M work and Performance Guarantee Tests shall be as given in the SCC.

2.10 Tender Documents

The scope of contract, technical specification, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following volumes:

Volume – I	:	Commercial
Volume – I Chapter-1	:	Invitation for Bid
Volume – I Chapter-2	:	Instructions To Bidders
Volume – I Chapter-3	:	General Project Information
Volume – I Chapter-4	:	General Condition of Contract (GCC)
Volume – I Chapter-5	:	Special Condition of Contract (SCC)
Volume – I Chapter-6	:	Forms & Schedules
Volume – II	:	Technical Specifications
Volume – II Section-I	:	Project Technical Specification
Volume – II	:	Detailed Technical Specification-Mechanical

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors–Coal Handling Plant Volume-I	-4-	25.09.2014

Section-II, Part-A		
Volume – II Section-II, Part-B	:	Detailed Technical Specification-Electrical
Volume – II Section-II, Part-C	:	Detailed Technical Specification-I&C
Volume – II Section-II, Part-D	:	Detailed Technical Specification-Civil
Volume – III	:	Technical Schedules
Volume – III, Part-A	:	Technical Schedule-Mechanical
Volume – III, Part-B	:	Technical Schedule-Electrical
Volume – III, Part-C	:	Technical Schedule-I&C

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Owner.

The Bidder is expected to examine all instructions, forms, terms, conditions, specifications and other information in the bidding documents. Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Owner in writing by post or by e-mail followed by postal confirmation at the Owner's address indicated in ITB. The Owner will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than twenty-one (21) days prior to the deadline for submission of bids prescribed by the Owner. Owner's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Owner will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operation and does not in any way adversely impact the interest of the Owner. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Owner may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the bidding documents.

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The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.11 Preparation of Bids

2.11.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.11.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

The bidders are required to submit, the bids for the Renovation and Modernization work in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical Data Sheets, List of Tools & Tackles, Deviations to Technical and Commercial Specifications/Conditions, Overall Completion Time Period & L-1 Network Schedule, Resource Deployment Schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part-II Bid will comprise Quoted Price and Quoted Performance Guarantee Parameters. Initially, only the Part-I Bid will be opened and Part-II Bid is kept in safe custody.

After evaluation of the Techno-Commercial (Part-I) Bids, each Bidder who has submitted a broadly responsive Part-I Bid, will be invited for Techno-Commercial Discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a memorandum. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions. The date & time for opening of Price Bid will be intimated separately.

Techno-Commercial Bid should not contain any price data.

Price Bid should not contain any matter in respect of Technical and / or Commercial aspects other than the details specifically sought by the Owner.

2.11.3 Bid Submission

- (1) Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2) All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered. All bids shall be prepared in the English language only, by typing or printing.

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- (3) *[One original and 9 (nine) identical copies of the original]* with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., "Original", "Copy No. 1", "Copy No. 2" etc.).
- (4) All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (5) The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (6) The Bidder's Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (7) In the event of discrepancy between "Original" and any copy of the bids, the hard copy of Original shall prevail.
- (8) The Bid shall be submitted to [-----]. Bid submitted to any other office of Owner is liable for rejection. Bids submitted by Telefax or e-mail will be rejected
- (9) Owner will receive Bids in respect of all the equipment/systems and scope of work as set forth in the accompanying Technical Specifications. All bids shall be prepared and submitted in accordance with the Tender Documents.
- (10) Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Technical Specifications in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11) A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Owner's rights or the successful Bidder's obligations under the contract.
- (12) Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13) Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Contractor under the Contract.
- (14) Either the agent or the Principal manufacturer directly could bid in a tender, but not both. In case both submit the tenders, the tender of the manufacture will alone be considered.
- (15) An agent representing one manufacturer in a tender will not be allowed to quote on behalf of another manufacturer along with previous manufacturer in a subsequent / parallel tender for the same item.

2.11.4 Bid Guarantee

- (1) The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of "[-----]" payable at "[-----]".

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- (2) The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank.
- (3) Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Owner at ([-----]). In the event of any deviation in this regard, the decision of Owner as to whether the same could be accepted or not, will be final and binding on the Bidder.
- (4) The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Owner.
- (5) No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified herein above or from banks not specified hereinabove will be liable for rejection.
- (6) Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7) The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Owner or fails to submit Contract Performance Guarantee.
- (8) The Bid Guarantee of all unsuccessful Bidders shall be returned after price cover opening and price evaluation. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Owner and acceptance thereof.

2.11.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part– I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part–I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Owner, at its discretion, may consider appropriate, shall be read out. The Part – II (Price Bid) will be lodged and opening date of the same will be intimated separately to those Bidders whose Part-I Bid will be determined to be substantially responsive to Tender Conditions and Technical specifications in all respects.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.
3. Owner takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

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2.12 Composition of Techno Commercial Bid (Part-1 Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 9 (nine) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B of this Volume).
- (ii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iii). Deleted
- (iv). Bid Guarantee- as per Annexure A.
- (v). Schedule of Prices as per Schedule – F1 (Table 1 to Table-7) with the word "Quoted" in lieu of Price data and all other details except price data.
- (vi). Mandatory spares as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (vii). Recommended spares (with the word "Quoted" in lieu of Price data)
- (viii). Tools & Tackles as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (ix). Schedule of Performance Guarantees- as per Schedule – F1 (Table-8) with the word "Quoted" in lieu of Performance Guarantee parameters
- (x). Signed copy of all the corrigendum's/amendments/clarifications, if any issued for the tender
- (xi). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (xii). Deviations to the Commercial specification, if any, as per Schedule – F3.
- (xiii). Deviations to Technical Specifications, if any, as per Schedule – F4.
- (xiv). Requirements of the Contractor at site, as per Schedule – F5.
- (xv). Resource deployment schedule as per Schedule – F6
- (xvi). Details of the present commitments of the Bidder, details of contracts in hand
- (xvii). Details of Sub-Contractors/Sub-Suppliers/Sub-Vendors, if any
- (xviii). Quality Assurance Programme
- (xix). Technical Details to be furnished with the Bid as called for in the Technical Specification Vol-II and Technical Bid Data Sheet Vol-III.
- (xx). Schedule of weights and dimensions
- (xxi). Coefficients and indices for price variation formula

The Part-I Bid shall not contain any Price data.

2.13 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices and the Performance Guarantee parameters only in the specified format. Price given in Part-II should cover the entire scope of work as given in Part-I of the offer including list of mandatory spares and Tools & tackles with itemized price and should be as per Schedule of Price enclosed. **[One original and 9 (Nine) identical]** copies shall be submitted.

1. The Price Bid shall contain the following :

- (i). Duly filled in Form of bid as per Annexure-C
- (ii). Completely filled in Schedule of Prices Schedule – F1 (Table 1 to Table-7)

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- (iii). Completely filled in Schedule of Performance Guarantees Schedule – F1 (Table-8).
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed formats. The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Owner shall be final. All entries shall be in English language only.
4. The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the quoted Foreign Currencies.
5. Prices in Indian supply shall be quoted on Ex-works supply of plant & equipment basis including Packing & forwarding. Inland transportation, Insurance charges, etc. shall be indicated separately.
6. Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation.

2.14 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the Contractor's obligations mentioned in tender document specification or to be reasonably inferred from the tender documents/ specification in respect of the disassembly/ dismantling of existing equipment facility as specified, design, manufacture, including procurement and subcontracting (if any), delivery, construction, installation, commissioning, completion of the facilities and conductance of Performance Guarantee tests for the facilities including supply of mandatory spares, recommended spare & tools/ tackles (if any). This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the facilities, conducting Guarantee tests and, where so required by the tender documents, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the tender documents, all in accordance with the requirements of the Conditions of Contract and Technical Specifications.

Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the tender documents.

Prices quoted by the Bidder shall be subject to adjustment during performance of the Contract to reflect changes in the cost of labour, material, etc. A bid submitted with a fixed price quotation will not be rejected, but the price adjustment will be treated as zero. The price adjustment provision will not be taken into consideration in bid evaluation.

2.15 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if

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any shall be signed by the person signing the Bid. Printed literature, it enclosed need not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.16 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Owner may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Specifications by amendment.
2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Specifications, which will be notified. Amendments will be hosted in Owner's website. Bidders are requested to visit Owner's website and note amendments, if any, before submission of bid. Owner shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.17 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

2.18 Information to be Furnished with the Bid

1. The Bid (Part-I) must clearly indicate the name of the manufacturer, the type or model of each principal item of equipment proposed to be supplied and erected. The Bid should also contain drawings and descriptive materials indicating general dimensions, material from which the parts are manufactured, principles of operation and the extent of pre-assembly involved, major erection equipment required to be deployed, method of erection and the proposed erection Organization structure.
2. The above information shall be provided by the Bidder in the form of separate sheets, drawings, catalogues, etc.
3. Any Bid not containing sufficient descriptive material to describe accurately the system / equipment proposed may be treated as incomplete and hence rejected. Such descriptive materials and drawings submitted by the Bidder will be retained by the Owner. Any major departure from these 'drawings and descriptive material submitted will not be permitted during the execution of the Contract' without specific written permission of the Owner.
4. Oral statements made by the Bidder at any time regarding quality, quantity or arrangement of the equipment or any other matter will not be considered.
5. Standard catalogue pages and other documents of the Bidder may be used in the Bid to provide additional information and data as deemed necessary by the Bidder.
6. In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy of all data sheets, Schedule, List of Mandatory spares, tools & tackles and Bar Chart/PERT as well as deviation tables in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation. Bidder shall submit all the filled in datasheet also in soft copy. Bidder shall also furnish soft copies and hard copies of Data Sheet with filled in details wherever details are required to be indicated by the Bidder.

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2.19 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other interested parties are advised to refrain from contacting by any means, the Owner and/or his employees/ representatives on matters related to the Bids under consideration. The Owner, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

2.20 Validity of Bid

1. The Bid shall be kept valid for acceptance for **[180 days]** from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Owner from participating in any of the Owner's tenders.

2.21 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully informs himself as to all the conditions and matters which may in any way affect the 'Renovation and Modernization work to be carried out or the cost thereof. Bidders are required to visit the plant to get familiarized with local conditions. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Owner.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Owner at least **[7 (seven) days]** before the date stipulated for pre-bid meeting. The Owner then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till **[21 days]** prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Owner. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.
3. Pre-Bid Conference will be organized and outcomes of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Owner to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.
5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

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2.22 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Owner not later than [-----] Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

2.23 Single Bidder Responsibility

1. The scope of supply and services shall be under single Bidder responsibility.
2. The successful Bidder should not sub contract the entire work on back to back basis or otherwise.

2.24 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Owner for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Owner, even though the Owner may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

2.25 Deputation of Representatives for Discussion

After opening of the Bid, if the Owner desires to have techno-commercial discussion on the Bid, the Bidder shall be in a position to depute his competent representatives of various disciplines at short notice with full authority for finalising technical parameters as well as Commercial Terms and Conditions of the Tender.

2.26 Evaluation of Bid

1. For evaluation and comparison of price bid, the prices indicated at [-----] summary of Prices as per Schedule [-----] will be considered. The Bids received will be evaluated by the Owner to ascertain the lowest evaluated substantially responsive Bid vis-à-vis the Tender Specifications. The Bidder has to satisfy himself that full information is furnished as required in the specifications. Lack of particulars or incomplete information furnished will run the risk of rejection of the bid. The following major procedures would be followed for evaluation of bids.
2. All the Bidders would be brought on par with reference to Technical Specification, Commercial Condition, Instructions to Bidders and subsequent techno-commercial discussions/ clarifications.
3. After the evaluation of Part-I bids (techno-commercial bids) and before opening of Part-II bids (Price Bids), in case the bidders are asked to make changes to their techno commercial offer that may have price implications, Owner may give the bidders opportunity to submit addendum to price bid covering the price implication only against such changes before the opening of Part-II bids (Price Bids). All the bidders will be notified, at least 15 days before the Price Bid opening date, about such changes against which they can submit addendum to Price Bid.
4. Commercial loading would be done for non-compliance of commercial terms and conditions of the Tender Specifications other than the vital clauses, as the case may be.

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5. To facilitate evaluation and comparison, the Owner will convert all bid prices expressed in foreign currencies into Indian Rupee at State Bank of India Bills Selling exchange rates prevailing on the date of opening of the price bid.
6. The Bidder is eligible for a price variation as per Tender Condition. However Price variation shall not be considered for Bid evaluation.
7. Technical loading will be done for omission of price data in respect of equipment/facilities, spares, tools & tackles, etc. The highest quoted corresponding price will be loaded against such omission. If no quoted price is available, the loading will be done as per the corresponding price as estimated by the Owner.
8. The quoted values for Performance Guaranteed Parameters given in Table below would be evaluated using evaluation factors specified. The evaluation factors shall be applicable to the differential values calculated from among the Bidders of corresponding item with appropriate highest or lowest value (i.e., the best quoted value) as the base. The evaluation will be based on the guarantee parameters inclusive of all tolerance furnished at the Guaranteed Condition. Bidders to note that the values indicated in the Schedule of Performance Guarantees shall be inclusive of all tolerances including measurement uncertainty.

Table-Bid Evaluation Factors

Sl. No.	Functional Performance Parameter	Evaluation Factor Rate
1.	Auxiliary Power	[-----]INR per kW increase

The evaluation factors rate shall be prorated for any fractions of the specified value.

- (1). Arithmetical errors will be rectified on the following basis:
 - If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.
 - If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
 - If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.
- (2). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder shall not charge any amount separately for that item from the Owner. If the terms, such as 'not applicable' "-----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.27 Local Conditions

1. The Bidder shall inspect the site and shall satisfy himself of the site conditions and shall apprise himself of the procedure for engagement of agencies/labour and shall collect any other information, which may be required before submitting the Bid.

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2. Wages not less than Minimum wages for Contract labour shall be paid as applicable in this region from time to time. Claims and objections due to ignorance of site conditions will not be considered after submission of Bid.
 - (i). The Bidder is required to carefully examine the Technical & General Specification, commercial Terms and Conditions, drawings and other details relating to work given in the Tender Specification and get fully acquainted as to all conditions and matters which may in any way affect the work or the cost thereof.
 - (ii). The Bidder shall be deemed to have exhaustively examined the Tender Specifications including the Form of Contract, to have obtained all information and clarifications on all matters whatsoever that might affect the carrying out of the work and to have satisfied himself as to the adequacy of his Bid. He is deemed to have known the scope, nature and magnitude of the work and the requirements of materials and labour involved etc. and as to all work he has to complete in accordance with the Contract for the adequacy of his Bid.
 - (iii). The Bidder shall be deemed to have visited and carefully examined the plant/ site and surroundings, to have satisfied himself about the nature and details of all existing structures, if any, and also as to the nature and conditions of the railways, roads, bridges and culverts, means of transport and communications, whether by land, water or air and as to possible interruptions thereto and the access to and from the site, to have made independent enquiries, examined and satisfied himself as to the sources for obtaining earth, gravel, sand, stones, bricks and all other construction materials, the site for disposal of surplus earth and debris, the available accommodation, underground existing services, sub-soil water conditions, storms, prevailing winds, climatic conditions and all other similar matters which may affect the work.
 - (iv). The Bidder shall be deemed to have acquainted himself with the Indian Income tax Act, 1961, Indian Companies Act, 1956, Indian Customs Act, 1962, Indian Central Excise Act, Value Added Tax, Indian Sales Tax Act, Indian Electricity Act, Central Electricity Authority Regulations, Indian Boiler Regulations, Factories Act, Pollution Control Regulations and other related Acts & Laws prevalent in the State of [-----] and in India and as amended from time to time. The Owner shall not entertain any request for clarifications from the Bidders regarding such local conditions.
 - (v). Any neglect or omission or failure on the part of the bidder in obtaining necessary and reliable information as stated above or on any other matter affecting the Bidder shall not relieve him from any risk or liabilities or the entire responsibility for completion of the work in accordance with the Tender Specifications.

2.28 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and technical specification. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with “Original” of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily rejected and ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.

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2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Owner at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Owner towards Owner's cost, loss and damage to Owner.

2.29 Blacklisting/Debarring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Owner.

2.30 Award of Contract

1. Award Criteria

- The Owner will award the contract to the successful Bidder whose Techno-commercial bid has been determined to be substantially responsive and Price Bid to be the lowest evaluated bid, provided that the Bidder is determined to be qualified to perform the contract satisfactorily.

The Owner reserves the right to vary the quantity of any of the Items / Spares and / or delete any Item / Spares altogether at the time of Award of Contract.

2. Owner's Right to Accept Any Bid and to Reject Any or All Bids

The Owner reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Owner's action.

3. Notification of Award

Prior to the expiration of the period of bid validity, the Owner will notify the successful Bidder in writing by registered letter (Letter of Award or LOA) or by email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Owner will promptly notify each unsuccessful Bidder and will discharge its bid security.

4. Signing the Contract Agreement

At the same time as the Owner notifies the successful Bidder that its bid has been accepted, the Owner will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

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Within *[twenty-eight (28)]* days of receipt of the Contract Agreement, the successful Bidder shall sign and date the Contract Agreement and return it to the Owner.

5. Corrupt or Fraudulent Practices

The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, *[Name of Utility]* requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. The Employer may reject a Bid Proposal of a successful Bidder if it emerges that the Bidder recommended for award has engaged in Corrupt or Fraudulent practices in competing for the subject contract. The Employer may declare a Bidding firm ineligible for participation in future tenders of the Employer, either indefinitely or for a stated period of time, if it at any time it emerges that the firm has engaged in Corrupt or Fraudulent practices in competing for or in executing a contract of the Owner. Corrupt Practice means the offering, giving, receiving or soliciting of anything of value to influence the procurement process or contract execution. Fraudulent practice means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition.

2.31 Agency Commission

No Agency commission shall be payable under the Contract.

2.32 Contract Performance Bank Guarantee (CPBG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period. If the contract price is in more than one currency, CPBG shall be 10% of respective currency.

2.33 Contract Quality Assurance

1. The Bidder shall include in his Bid a detailed Quality Assurance Programme containing the overall quality, management and procedures which he proposes to follow in the performance of the 'Works' during various phases.
2. After Letter of Award (LOA) the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall form a part of the 'Contract'.

2.34 Codes & Standards

Specifications give reference to Indian or internationally accepted Standards. However, equipment or materials meeting other recognized National or International Standards, which ensure an equal or superior quality than Standards specified, will also be accepted. For details of codes and standards refer Technical specification, Volume-II.

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2.35 Vital Clauses

The following clauses in the Tender Specification & Draft Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Warranty
- Liquidated Damages
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Owner / Purchaser : [-----]
- Consultant : [-----]
- Project Title : [-----]
- Location : [-----]
- Latitude : [-----]
- Longitude : [-----]
- Elevation above MSL : [-----]
- Nearest Railway Station : [-----]
- Nearest Sea Port : [-----]
- Nearest Airport : [-----]
- Road Access/Approach to Site : [-----]

For Project & Site related detailed information, refer Clause No. 2 of Section-I of Volume-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Works, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract.
- iv. **"Contract"** means the Agreement entered into between Owner and Contractor as per the 'Contract Agreement' signed by the parties, including contract documents, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Contractor's Equipment"** means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities.
- vii. **"Contractor"** means the person(s), Firm or a Company whose bid to perform the Contract has been accepted by the Owner and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Contractor.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Owner for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.
- ix. **"Contractor's Representative"** means any person nominated by the Contractor & approved by the Owner hereof to perform the duties delegated by the Contractor.
- x. **"Consulting Engineer"** means Owner's Engineer appointed by the Owner. Also refers to any other firm(s) or person(s) as may be appointed by the Owner from time to time.

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- xi. **“Commissioning”** means the construction of plant and equipment for operation of the Facility at rated capacity are complete and the plant and equipment achieves the designated full load/full capacity, at designated fuel/input.
- xii. **“Completion”** means that the Facilities (or a specific part thereof where specific parts are agreed) have been completed operationally and structurally and put in a tight and clean condition, and that all work in respect of pre-commissioning of the Facilities or such specific part thereof has been completed and commissioning has been attained as per Technical Specifications.
- xiii. **“Competent Authority”** means any agency, authority, department, inspectorate, ministry or statutory person (whether autonomous or not) of GOI, [Name of the State], Ministry of Environment and Forests (MoEF) any other State of the Republic of India or any local authority.
- xiv. **“Day”** means calendar day of the Gregorian calendar.
- xv. **“Defect Liability Period”** means the period of validity of the warranties given by the Contractor, commencing at completion of the Facilities or a part thereof, during which the Contractor is responsible for defects with respect to the Facilities.
- xvi. **“Effective Date”** means the date from which the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor shall be determined.
- xvii. **“Erection Services”** means those entire services ancillary to the supply of the plant and equipment for the Facilities, to be provided by the Contractor under the Contract. e.g. transportation and provision of marine or other similar insurance, inspection, expediting, site preparation works (including the provision and use of Contractor’s Equipment and the supply of all construction materials required), installation, testing, Pre-commissioning, commissioning, operations, maintenance, the provision of operations and maintenance manuals, training of Employer’s Personnel etc.
- xviii. **“Facilities”** means the plant and equipment to be supplied and installed, as well as all the Erection Services to be carried out by the Contractor under the Contract.
- xix. **“Force Majeure”** means mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- xx. **“GCC”** means the General Conditions of Contract hereof.
- xxi. **“Good Industry Practice”** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Contractor, equipment manufacturer or operator applying the standards generally adopted by global Contractors, global equipment manufacturers and operators in the construction or operation of power generation facilities or the manufacture of equipment therefore, except in so far as inconsistent with any applicable Indian law or directive.
- xxii. **“Guarantee Test(s)”** means the test(s) specified in the Technical Specifications to be carried out to ascertain whether the Facilities or a

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- specified part thereof is able to attain the Functional/Performance Guarantees specified in the Technical.
- xxiii. **"Incoterms"** means International rules for interpreting trade terms published by the International Chamber of Commerce (latest edition), Paris (France). Unless inconsistent with any provisions of the contract, the meaning of any trade term and the rights and obligations of the parties there under shall be as prescribed by Incoterms.
 - xxiv. **"Inspector/Inspecting Engineer"** means the Owner or any person nominated by the Owner from time to time, to inspect the equipment of works under the contract and/or the duly authorized representative of the Owner.
 - xxv. **"Latent Defect"** means the defects inherent in the material or arising out of design deficiency which does not manifest itself during the Warranty Period/Defect Liability Period, as described in this GCC.
 - xxvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Owner notifying the Contractor that its Bid Proposal has been accepted.
 - xxvii. **"Month"** means calendar month of the Gregorian calendar.
 - xxviii. **"Manufacturer's Works" or "Contractor's Works"** means the place used by the Contractor, its manufacturer, supplier, collaborators or sub-contractors/vendors/sub-vendors for the performance of the works.
 - xxix. **"Operational Acceptance"** means the acceptance by the Owner of the Facilities (or any part of the Facilities where the Contract provides for acceptance of the Facilities in parts), which certifies the Contractor's fulfillment of the Contract in respect of performance guarantees of the Facilities.
 - xxx. **"Owner" or "Purchaser"** shall means the [Name of the Utility], , and includes its legal successors or permitted assignees.
 - xxxi. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
 - xxxii. **"Pre-commissioning"** means the testing, checking and other requirements specified in the Technical specifications that are to be carried out by the Contractor in preparation for commissioning.
 - xxxiii. **"Project"** means the Owner's [-----] in respect of which the Contract has been signed.
 - xxxiv. **"Project Consultant" or "Owner's Consultant"** means the engineering firm or person(s) appointed by the Owner to render engineering project consultancy services for the project.
 - xxxv. **"Project Manager"** means the person appointed by the Owner thereof and named as such, to perform the duties delegated by the Owner.
 - xxxvi. **"Plant and Equipment"** means permanent plant, equipment, systems, machinery, apparatus, articles and things of all kinds to be provided and incorporated in the Facilities by the Contractor under the Contract (including the spare parts to be supplied by the Contractor under the Contract Agreement), but does not include Contractor's Equipment.
 - xxxvii. **"SCC"** means the Special Conditions of Contract hereof.

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- xxxviii. **“Site”** means the land and other places upon which the Facilities are to be installed, and such other lands or places as may be specified in the Contract as forming part of the Site.
- xxxix. **“Sub Contractor”, including “Vendors/Sub-Vendors”**, means any firm or person to whom execution of any part of the Facilities, including preparation of any design or supply of any plant and equipment is subcontracted directly or indirectly by the Contractor, and includes its legal successors or permitted assignees.
- xl. **“Technical Specification / “Tender Documents”** means the document, setting out a description and specification of the Works and statement of the technical and other standards to which the Works are to be performed including any modifications thereto made in accordance with the Conditions. This includes the technical & commercial specifications and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xli. **“Tenderer”/“Bidder”** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Owner, for the Project.
- xl. **“Time for Completion”** means the time within which completion of the Facilities as a whole (or of a part of the Facilities where a separate time for completion of such part has been specified) is to be attained in accordance with the stipulations and provisions of the Contract.
- xl. **“Warranty Period” or “Defect Liability Period”** means the period during which the Contractor shall remain liable for repair or replacement of any defective part of the works performed under the contract, free of cost.
- xl. **“Work(s)”** means and includes the tasks of furnishing of equipment, labour & services, transport, handling, unloading and storage at site, civil construction and complete erection, testing, commissioning putting into satisfactory operation and completion of successful performance tests, reliability tests and any other guaranteed parameters as defined in the Contract, replacement, modification, repair of defective parts or equipment during warranty period and rectification of latent defects during latent defect period.
- xl. **“Writing” or “Written”** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Owner. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

Terms and expressions not herein defined shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

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4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Owner.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing.
- vi. The bid & schedules/ attachment submitted by the contractor

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Construction of the Contract

The Contracts to be entered between the Owner and the Contractor shall be as under:

First Contract: For Ex-Works Supply of all Plant & Equipment including Mandatory Spares and technological and miscellaneous structures with all accessories.

Second Contract : For providing all services i.e. Inland Transportation for Delivery at Site, Inland Transit Insurance, Unloading, Storage, Handling at Site, Erection, Insurance Covers other than inland transit insurance, Testing, Commissioning and Conducting Guarantee Tests in respect of all the Equipment supplied under the First Contract, Civil works including supplies such as cement & reinforcement steel and all other services as specified in the Contract Documents.

The above two Contracts will contain a cross-fall breach clause specifying that breach of one Contract will constitute breach of the other Contracts which will confer a right on the Owner to terminate the other Contract also at the risk and the cost of the Contractor.

The award of the separate Contracts shall not in any way dilute the responsibility of the Contractor for the successful completion of the Facilities as per Contract Documents and a breach in one Contract shall automatically be construed as a breach of the other Contract which will confer a right on the Owner to terminate the other Contract also at the risk and the cost of the Contractor.

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4.6 Independent Contractor

The Contractor shall be an independent contractor performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Contractor shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or Subcontractors engaged by the Contractor in connection with the performance of the Contract shall be under the complete control of the Contractor and shall not be deemed to be employees of the Owner, and nothing contained in the Contract or in any subcontract awarded by the Contractor shall be construed to create any contractual relationship between any such employees, representatives or Subcontractors and the Owner.

4.7 Joint Venture or Consortium

Not Used.

4.8 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.9 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.10 Origin

"Origin" means the place where the materials, Equipment and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.11 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or E-mail to the address of the relevant party indicated in the Contract.

Either party may change its postal address, telefax number, or E-mail ID or addressee for receipt of such notices by ten (10) days' notice to the other party in writing.

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

4.12 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [.....] shall have exclusive jurisdiction in all matters arising under the Contract.

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4.13 Settlement of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Owner and the Contractor in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Owner & Contractor shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

Either Owner or the Contractor may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities.

Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Owner and the Contractor shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within [twenty eight (28)] days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by the Appointing Authority for arbitrator is given below.

Appointing Authority for Arbitrator:

- President, Institution of Engineers in case of an Indian Contractor.

If one party fails to appoint its arbitrator within [forty-two (42)] days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Arbitration proceedings as follows:-

- In case of an Indian Contractor Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996.

The Place for Arbitration shall be: [New Delhi], India.

The language of arbitration shall be English.

The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- The parties shall continue to perform their respective obligations under the Contract unless they otherwise agree.

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- The Owner shall pay the Contractor consideration due to the Contractor.

4.14 Scope of Facilities

- Unless otherwise expressly limited in the Technical Specifications, Facilities the Contractor's obligations cover the provision of all Plant and Equipment including spares and the performance of all Services required for design, manufacture (including procurement, quality assurance, construction, installation, associated civil works, Structural and others construction works, precommissioning and delivery) of the Plant and Equipment and the installation, commissioning, completion of facilities and performance testing of the Facilities in accordance with the plans, procedures, specifications, drawings, codes and any other documents as specified in the Technical Specifications. Such specifications include, but are not limited to, the provision of supervision and engineering services; the supply of labour, materials, equipment, spare parts and accessories; Contractor's Equipment; construction utilities and supplies; temporary materials, structures and facilities; transportation loading & unloading.
- The Contractor shall, unless specifically excluded in the Contract, perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for attaining Completion of the Facilities.

4.15 Time for Commencement and Completion

- The Contractor shall commence work on the scope of work under this Tender from the date of Letter of Award. Contractor shall thereafter proceed with the Facilities in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- The Contractor shall attain Completion of the Facilities (or of a part where a separate time for Completion of such part is specified in the Contract) within the time stated in the SCC subject to time extensions, the contractor is entitled under the contract conditions or time extension expressly grouted by the Owner.

4.16 Spare Parts

In addition to the supply of Mandatory Spare Parts included in the Contract, the Contractor agrees to supply other spare parts (recommended spares) required for the operation and maintenance of the Facilities for 3 years. However, the identity, specifications and quantities of such spare parts and the terms and conditions relating to the supply thereof are to be agreed between the Owner and the Contractor, and the price of such spare parts shall be that given in Price Schedule for recommended spares. The price of such spare parts shall include the purchase price thereof and other costs and expenses (including the Contractor's fees) relating to the supply of spare parts. The prices of recommended spares covered in price schedule shall be valid for a period of six months after the date of Notification of Award of Main Equipment and Mandatory Spares.

- The Contractor shall supply the recommended spares at the same terms and conditions as are otherwise applicable to this Contract.
- All the spares for the equipment under the Contract will strictly conform to the Specification and other relevant documents and will be identical to the corresponding main equipment/components supplied under the Contract and shall be fully interchangeable.
- All the Mandatory Spares covered under the Contract shall be manufactured along with the main Equipment as a continuous operation and the delivery of

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the spares will be affected along with the main Equipment in a phased manner and the delivery would be completed by the respective dates for the various categories of equipment as per the agreed schedule. If order for the Recommended Spares has been placed with the Contractor prior to commencement of manufacture of the main equipment this shall be applicable for manufacturer of recommended spares as well.

- The Contractor will provide the Owner with the manufacturing drawings, catalogues, assembly drawings and any other document required by the Owner for the recommended spares. Such details will be furnished to the Owner as soon as they are prepared but in any case not later than six months prior to commencement of manufacture of the corresponding main equipment.
- In addition to the spares recommended by the Contractor, if the Owner further identifies certain particular items of spares, the Contractor will submit the prices and delivery quotation for such spares within [30] days of receipt of such request with a validity period of 6 months for consideration by the Owner and placement of order for additional spares, if the Owner so desires.
- The quality plan and the inspection requirement finalised for the main equipment will also be applicable to the corresponding spares.
- The Contractor will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/components/equipment covered under the Contract and will further ensure with his vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.
- The Contractor shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered under the Contract. The same provision will also be applicable to spares supplied by Sub-contractors.
- For the first 6 years from the schedule date of completion of facilities the prices will be derived from the corresponding Ex-Works Price at which the order for such spares have been placed by Owner as a part of Mandatory Spares or Recommended Spares, or from the rates of Mandatory Spares or Recommended Spares as quoted by/negotiated with the Contractor. Ex-Works order price of future spares shall be computed in accordance with the price adjustment provisions covered under the main Contract excepting that the base indices will be counted from the scheduled date of Commissioning of the last equipment under the main project. The Contractor will indicate in advance the delivery period of the items of spares, which the Owner may procure in accordance with this clause. In case of emergent requirements of spares, the Contractor would make every effort to expedite the manufacture and delivery of such spares on the basis of mutually agreed time schedule.
- In case the Contractor fails to supply the mandatory or recommended spares in the terms stipulated above, the Owner shall be entitled to purchase the same from the alternate sources at the risk and the cost of the Contractor and recover from the Contractor, the excess amount paid by the Owner over the rates worked on the above basis. In the event of such risk purchase by the Owner, the purchases will be as per the Works and Procurement Policy of the Owner prevalent at the time of such purchases and the Owner at his option may include a representative from the Contractor in finalising the purchases.

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- It is expressly understood that the final settlement between the parties in terms of relevant clauses of the Contract Documents shall not relieve the Contractor of any of his obligations under the provision of long term availability of spares and such provisions shall continue to be enforced till the expiry of 6 years period reckoned from the scheduled date of Commissioning of the Plant and Equipment unless otherwise discharged expressly in writing by the Owner.
- The Contractor shall warrant that all spares supplied will be new and in accordance with the Contract Documents and will be free from defects in design, material and workmanship. The defects liability period for spares shall be 12 months from the date it is put to use. In case of failure of any spare part due to fault in design material or workmanship the same part will be replaced by the contractor without any extra cost of the Owner.

In case of any failure in the original component/equipment due to faulty designs, materials and workmanship, the corresponding spare parts, if any, supplied will be replaced without any extra cost to the Owner unless a joint examination and analysis by the Owner and the Contractor of such spare parts prove that the defect found in the original part that failed, can safely be assumed not to be present in spare parts. Any replaced spare parts will have the Defects Liability period of 12 months from the date it is put in use. The discarded spare parts will become the property of the Contractor as soon as they have been replaced by the Contractor. In any case the defect liability of spares will expire at the end of 48 months from the date of their receipt at site

The Defects Liability of spares that are not used within 18 months from the respective date of the delivery at Site will, be subject to condition that all such spares are stored in accordance with Contractor's standard recommended practice, if any, and the same has been furnished to the Owner.

4.17 Contractor's Responsibilities

- a) The Contractor shall design, manufacture (including associated purchases and/or subcontracting), disassemble/dismantle wherever required, install, commission and complete the Facilities and carryout the Guarantee tests with due care and diligence in accordance with the Contract.
- b) Before entering into this contract the Contractor is responsible to have examined the data relating to the Facilities provided by the Owner, and on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve contractor of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.
- c) The Contractor shall acquire in its name all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Contractor's and Subcontractor's personnel and entry permits for all imported Contractor's Equipment.
- d) The Contractor shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any and all liabilities, damages, claims, fines, penalties and expenses of

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whatever nature arising or resulting from the violation of such laws by the Contractor.

4.18 Owner's Responsibilities

- a) The Owner shall be responsible for acquiring and providing legal and physical possession of the Site and access thereto, and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract, including all requisite rights of way.
- b) The Owner shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Owner to obtain them in the Owner's name, are necessary for the execution of the Contract.
- c) If requested by the Contractor, the Owner shall use its best endeavours to assist the Contractor in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Contractor or Subcontractors or the personnel of the Contractor or Subcontractors, as the case may be, to obtain.
- d) The Owner shall be responsible for the continued operation of the Facilities after Completion.

4.19 Taxes & Duties

- a) Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation. The reimbursement of these taxes shall be on actual subject to the quoted value of these taxes as ceiling corresponding to the base price. Additional liability of taxes and duties arising out of price variation shall be reimbursed against documentary evidence over and above the ceiling (quoted value). Statutory variation in Indian taxes and duties will be dealt with as per the relevant stipulations of the specification..
- b) Except as otherwise specifically provided in the Contract, the Contractor shall bear and pay all Taxes, Duties, Levies and Charges including Entry Tax, Service Tax, if applicable in connection with the Facilities in India and outside India. All taxes, duties & levies on works contract, if any, shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- c) All taxes, duties and levies including entry tax/octroi (if any) in respect of all components, Equipment and material to be dispatched directly from the sub-vendor's works to site shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- d) In case there is introduction of GST or any other tax in lieu of existing Excise Duty/Service Tax and VAT/ Sales Tax, the contract price will be adjusted for the impact of any differential tax liability subject to documentary evidence. This will be restricted to direct transaction between the owner and contractor, and bought out items directly dispatched from sub-vendor's works to project site.
- e) Further all taxes, duties and levies including sales tax on works contract, Entry Tax, if any, in respect of civil construction works, erection & commissioning if any and custom duty/sales tax as applicable on the materials used for such construction works shall be to the contractor's account and no separate claim in this regard will be entertained by the Owner. Incidence of Service Tax & cess on any component

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of the Bid Price shall be to the Contractor's account and bidders shall include Service Tax as applicable at the date seven (7) days prior to the date of bid submission in the bid price. The Contract Price will be adjusted for impact of any change in the rate of service tax or cess on service tax subsequent to this date for direct transactions between the Owner and the Contractor.

- f) If any tax exemptions, reductions, allowances or privileges may be available to the Contractor, the Owner shall use its best endeavours to enable the Contractor to benefit from any such tax savings to the maximum allowable extent.

4.20 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Owner by the Contractor herein shall remain vested in the Contractor or, if they are furnished to the Owner directly or through the Contractor by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Owner shall however be free to reproduce all drawings, documents and other material furnished to the Owner for the purpose of the contract including, if required, for operation and maintenance.

4.21 Confidential Information

- a) The Owner and the Contractor shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Contractor may furnish to its Subcontractor(s) such documents, data and other information it receives from the Owner to the extent required for the Subcontractor(s) to perform its work under the Contract, in which event the Contractor shall obtain from such Subcontractor(s) an undertaking of confidentiality similar to that imposed on the Contractor.
- b) The Owner shall not use such documents, data and other information received from the Contractor for any purpose other than the operation and maintenance of the Facilities. Similarly, the Contractor shall not use such documents, data and other information received from the Owner for any purpose other than the design, procurement of Plant and Equipment, construction or such other work and services as are required for the performance of the Contract.
- c) The obligation of a party, shall not apply to that information which
- now or hereafter enters the public domain through no fault of that party
 - can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto
 - Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

4.22 Representatives

- a) Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Owner shall appoint and notify the Contractor in writing of the name of the Project Manager. The Owner may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Contractor without delay.

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The Owner shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Owner at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

All notices, instructions, information and other communications given by the Contractor to the Owner under the Contract shall be given to the Project Manager, except as herein otherwise provided.

b) Contractor's Representative & Construction Manager

- If the Contractor's Representative is not named in the Contract, then within *[fourteen (14) days]* of the Effective Date, the Contractor shall appoint the Contractor's Representative and shall request the Owner in writing to approve the person so appointed. If the Owner makes no objection to the appointment within *[fourteen (14)]* days, the Contractor's Representative shall be deemed to have been approved. If the Owner objects to the appointment within *[fourteen (14)]* days giving the reason there for, then the Contractor shall appoint a replacement within *[fourteen (14) days]* of such objection.
- The Contractor's Representative shall represent and act for the Contractor at all times during the currency of the Contract and shall give to the Project Manager all the Contractor's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Owner or the Project Manager to the Contractor under the Contract shall be given to the Contractor's Representative or, in its absence, its deputy, except as herein otherwise provided. The Contractor shall not revoke the appointment of the Contractor's Representative without the Owner's prior written consent, which shall not be unreasonably withheld. If the Owner consents thereto, the Contractor shall appoint some other person as the Contractor's Representative.
- The Contractor's Representative may, subject to the approval of the Owner (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Contractor's Representative, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Owner and the Project Manager.
- From the commencement of installation of the Facilities at the Site until Operational Acceptance, the Contractor's Representative shall appoint a suitable person as the construction manager (hereinafter referred to as "the Construction Manager"). The Construction Manager shall supervise all work done at the Site by the Contractor and shall be present at the Site throughout normal working hours except when on leave, sick or absent for reasons connected with the proper performance of the Contract. Whenever the Construction Manager is absent from the Site, a suitable person shall be appointed to act as his or her deputy.
- The Owner may by notice to the Contractor object to any representative or person employed by the Contractor in the execution of the Contract who, in the reasonable opinion of the Owner, may behave inappropriately, may be

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incompetent or negligent, or may commit a serious breach of the Site regulations.

- If any representative or person employed by the Contractor is removed.

4.23 Work Program

a) Contractor's Organization

The Contractor shall supply to the Owner and the Project Manager a chart showing the proposed organization to be established by the Contractor for carrying out work on the Facilities. The chart shall include the identities of the key personnel together with the curricula vitae of such key personnel to be employed within *[twenty one (21)]* days of the Effective Date. The Contractor shall promptly inform the Owner and the Project Manager in writing of any revision or alteration of such an organization chart.

b) Program of Performance

Within *[twenty-eight (28)]* days after the date of Notification of Award of Contract, the Contractor shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply, transport, assemble, install and precommissioning the Facilities, as well as the date by which the Contractor reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Contractor to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Contractor shall accord with the Time Schedule included in Contract Schedule 3 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Contractor shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Contractor's actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Contractor shall, at the request of the Owner or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

e) Work Procedures

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Owner and the Contractor, the Contractor may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

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4.24 Subcontractors and Subvendors

- a) The Contract Agreement specifies major items of supply or services and a list of approved Subcontractors against each item, including vendors. Insofar as no Subcontractors are listed against any such item, the Contractor shall prepare a list of Subcontractors for such item for inclusion in such list. The Contractor may from time to time propose any addition to or deletion from any such list. The Contractor shall submit any such list or any modification thereto to the Owner for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Owner for any of the Subcontractors shall not relieve the Contractor from any of its obligations, duties or responsibilities under the Contract.
- b) The Contractor shall select and employ its Subcontractors/Subvendors for such major items from those listed.

4.25 Design and Engineering

- a) Specifications and Drawings

The Contractor shall execute the basic and detailed design and the engineering work in compliance with the provisions of the Contract, or where not so specified, in accordance with good engineering practice. The Contractor shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents that it has prepared, whether such specifications, drawings and other documents have been approved by the Project Manager or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Contractor by or on behalf of the Owner.

- b) Codes and Standards

Wherever references are made in the Contract to codes and standards in accordance with which the Contract shall be executed, the edition or the revised version of such codes and standards current at the date *[twenty eight (28)]* days prior to date of bid submission shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

- c) Approval/Review of Technical Documents by Project Manager

The Contractor shall prepare (or cause its Subcontractors to prepare) and furnish to the Project Manager the documents for its approval Any part of the Facilities covered by or related to the documents to be approved by the Project Manager shall be executed only after the Project Manager's approval thereof.

Project Manager shall either return one copy thereof to the Contractor with its approval endorsed thereon or shall notify the Contractor in writing of its disapproval thereof and the reasons there for and the modifications that the Project Manager proposes. The Project Manager shall not disapprove any document, except on the grounds that the document does not comply with some specified provision of the Contract or that it is contrary to good engineering practice. The procedure for submission of the documents by the Contractor and their approval by the Project Manager shall be discussed and finalised with the Contractor.

If any dispute or difference occurs between the Owner and the Contractor in connection with or arising out of the disapproval by the Project Manager of any document and/or any modification(s) thereto that cannot be settled between the parties within a reasonable period, then such dispute or difference may be referred to an Adjudicator. If such dispute or difference is referred to an Adjudicator, the Project Manager shall give instructions as to whether and if so, how, performance of the

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Contract is to proceed. The Contractor shall proceed with the Contract in accordance with the Project Manager's instructions, provided that if the Adjudicator upholds the Contractor's view on the dispute, then the Contractor shall be reimbursed by the Owner for any additional costs incurred by reason of such instructions and shall be relieved of such responsibility or liability in connection with the dispute and the execution of the instructions as the Adjudicator shall decide, and the Time for Completion shall be extended accordingly.

The Project Manager's approval, with or without modification of the document furnished by the Contractor, shall not relieve the Contractor of any responsibility or liability imposed upon it by any provisions of the Contract except to the extent that any subsequent failure results from modifications required by the Project Manager.

4.26 Procurement

a) Plant and Equipment

The Contractor shall manufacture or procure and transport all the Plant and Equipment in an expeditious and orderly manner to the Site.

b) Transportation

The Contractor shall at its own risk and expense transport all the Plant and Equipment and the Contractor's Equipment to the Site by the mode of transport that the Contractor judges most suitable under all the circumstances. Unless otherwise provided in the Contract, the Contractor shall be entitled to select any safe mode of transport operated by any person to carry the Plant and Equipment and the Contractor's Equipment. Upon dispatch of each shipment of the Plant and Equipment and the Contractor's Equipment, the Contractor shall notify the Owner by telex, cable, telefax, facsimile or Electronic Data Interchange (EDI) of the description of the Plant and Equipment and of the Contractor's Equipment, the point and means of dispatch, and the estimated time and point of arrival in the country where the Site is located, if applicable, and at the Site. The Contractor shall furnish the Owner with relevant shipping documents to be agreed upon between the parties.

The Contractor shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Plant and Equipment and the Contractor's Equipment to the Site. The Owner shall use its best endeavours in a timely and expeditious manner to assist the Contractor in obtaining such approvals, if requested by the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any claim for damage to roads, bridges or any other traffic facilities that may be caused by the transport of the Plant and Equipment and the Contractor's Equipment to the Site.

4.27 Installation

a) Setting Out/Supervision/Labour

Bench Mark: The Contractor shall be responsible for the true and proper setting-out of the Facilities in relation to bench marks, reference marks and lines provided to it in writing by or on behalf of the Owner.

If, at any time during the progress of installation of the Facilities, any error shall appear in the position, level or alignment of the Facilities, the Contractor shall forthwith notify the Project Manager of such error and, at its own expense, immediately rectify such error to the reasonable satisfaction of the Project Manager.

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If such error is based on incorrect data provided in writing by or on behalf of the Owner, the expense of rectifying the same shall be borne by the Owner.

Contractor's Supervision: The Contractor shall give or provide all necessary superintendence during the installation of the Facilities, and the Construction Manager or its deputy shall be constantly on the Site to provide full time superintendence of the installation. The Contractor shall provide and employ only technical personnel who are skilled and experienced in their respective callings and supervisory staff who are competent to adequately supervise the work at hand.

The Contractor shall provide and employ on the Site in the installation of the Facilities such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the Contract. The Contractor is encouraged to use local labour that has the necessary skills. Unless otherwise provided in the Contract, the Contractor shall be responsible for the recruitment, transportation, accommodation and catering of all labour, local or expatriate, required for the execution of the Contract and for all payments in connection therewith.

The Contractor shall at its own expense provide the means of repatriation to all of its and its Subcontractor's personnel employed on the Contract at the Site to their various home countries. It shall also provide suitable temporary maintenance of all such persons from the cessation of their employment on the Contract to the date programmed for their departure. In the event that the Contractor defaults in providing such means of transportation and temporary maintenance, the Owner may provide the same to such personnel and recover the cost of doing so from the Contractor.

The Contractor shall, in all dealings with its labour and the labour of its Subcontractors currently employed on or connected with the Contract, pay due regard to all recognized festivals, official holidays, religious or other customs and all local laws and regulations pertaining to the employment of labour.

b) Contractor's Equipment

All Contractors' Equipment brought by the Contractor onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Contractor shall not remove the same from the Site without the Project Manager's consent that such Contractor's Equipment are no longer required for the execution of the Contract. Unless otherwise specified in the Contract, upon completion of the Facilities, the Contractor shall remove from the Site all Equipment brought by the Contractor onto the Site and any surplus materials remaining thereon.

The Owner will, if requested, use its best endeavours to assist the Contractor in obtaining any local, state or national government permission required by the Contractor for the export of the Contractor's Equipment imported by the Contractor for use in the execution of the Contract that is no longer required for the execution of the Contract.

c) Site Regulations and Safety

The Owner and the Contractor shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. The Contractor shall prepare and submit to the Owner, with a copy to the Project Manager, proposed Site regulations for the Owner's approval, which approval shall not be unreasonably withheld.

Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Facilities, gate control, sanitation, medical care, and fire prevention.

d) Opportunities for Other Contractors

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The Contractor shall, upon written request from the Owner or the Project Manager, give all reasonable opportunities for carrying out the work to any other contractors employed by the Owner on or near the Site. If the Contractor, upon written request from the Owner or the Project Manager, makes available to other contractors any roads or ways the maintenance for which the Contractor is responsible, permits the use by such other contractors of the Contractor's Equipment, or provides any other service of whatsoever nature for such other contractors, the Owner shall fully compensate the Contractor for any loss or damage caused or occasioned by such other contractors in respect of any such use or service, and shall pay to the Contractor reasonable remuneration for the use of such Equipment or the provision of such services.

The Contractor shall also so arrange to perform its work as to minimize, to the extent possible, interference with the work of other contractors. The Project Manager shall determine the resolution of any difference or conflict that may arise between the Contractor and other contractors and the workers of the Owner in regard to their work.

The Contractor shall notify the Project Manager promptly of any defects in the other Contractors' work that come to its notice, and that could affect the Contractor's work. The Project Manager shall determine the corrective measures, if any, required to rectify the situation after inspection of the Facilities. Decisions made by the Project Manager shall be binding on the Contractor.

e) Emergency Work

If, by reason of an emergency arising in connection with and during the execution of the Contract, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Facilities, the Contractor shall immediately carry out such work.

If the Contractor is unable or unwilling to do such work immediately, the Owner may do or cause such work to be done as the Owner may determine is necessary in order to prevent damage to the Facilities. In such event the Owner shall, as soon as practicable after the occurrence of any such emergency, notify the Contractor in writing of such emergency, the work done and the reasons there for. If the work done or caused to be done by the Owner is work that the Contractor was liable to do at its own expense under the Contract, the reasonable costs incurred by the Owner in connection therewith shall be paid by the Contractor to the Owner. Otherwise, the cost of such remedial work shall be borne by the Owner.

f) Site Clearance

Site Clearance in Course of Performance: In the course of carrying out the Contract, the Contractor shall keep the Site reasonably free from all unnecessary obstruction, store or remove any surplus materials, clear away any wreckage, rubbish or temporary works from the Site, and remove any Contractor's Equipment no longer required for execution of the Contract. **Clearance of Site after Completion:** After Completion of all parts of the Facilities, the Contractor shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site and Facilities clean and safe.

g) Watching and Lighting

The Contractor shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper execution and the protection of the Facilities, or for the safety of the owners and occupiers of adjacent property and for the safety of the public as per specification.

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4.28 Testing & Inspections

- a) The Contractor shall at its own expense carry out at the place of manufacture and/or on the Site all such tests and/or inspections of the Plant and Equipment and any part of the Facilities as are specified in the Contract.
- b) The Owner and the Project Manager or their designated representatives shall be entitled to attend the aforesaid test and/ or inspection, provided that the Owner shall bear all costs and expenses incurred in connection with such attendance including, but not limited to, all travelling and board and lodging expenses.
- c) Whenever the Contractor is ready to carry out any such test and/or inspection, the Contractor shall give a reasonable advance notice of such test and/or inspection and of the place and time thereof to the Project Manager. The Contractor shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Owner and the Project Manager (or their designated representatives) to attend the test and/or inspection.
- d) The Contractor shall provide the Project Manager with a certified report of the results of any such test and/or inspection. If the Owner or Project Manager (or their designated representatives) fails to attend the test and/or inspection, or if it is agreed between the parties that such persons shall not do so, then the Contractor may proceed with the test and/or inspection in the absence of such persons, and may provide the Project Manager with a certified report of the results thereof.
- e) The Project Manager may require the Contractor to carry out any test and/or inspection not required by the Contract, provided that the Contractor's reasonable costs and expenses incurred in the carrying out of such test and/or inspection shall be added to the Contract Price. Further, if such test and/or inspection impede the progress of work on the Facilities and/or the Contractor's performance of its other obligations under the Contract, due allowance will be made in respect of the Time for Completion and the other obligations so affected.
- f) If any Plant and Equipment or any part of the Facilities fails to pass any test and/or inspection, the Contractor shall either rectify or replace such Plant and Equipment or part of the Facilities and shall repeat the test and/or inspection upon giving a notice.
- g) If any dispute or difference of opinion shall arise between the parties in connection with or arising out of the test and/or inspection of the Plant and Equipment or part of the Facilities that cannot be settled between the parties within a reasonable period of time, it may be referred to the Adjudicator.
- h) The Contractor shall afford the Owner and the Project Manager, at the Owner's expense, access at any reasonable time to any place where the Plant and Equipment are being manufactured or the Facilities are being installed, in order to inspect the progress and the manner of manufacture or installation, provided that the Project Manager shall give the Contractor a reasonable prior notice.
- i) The Contractor agrees that neither the execution of a test and/ or inspection of Plant and Equipment or any part of the Facilities, nor the witnessing of any test by the Owner, nor the issuance of any test certificate shall relieve the Contractor of any obligation under this Contract.
- j) No part of the Facilities or foundations shall be covered up on the Site without the Contractor carrying out any test and/or inspection required under the Contract. The Contractor shall give a reasonable notice to the Project Manager whenever any such part of the Facilities or foundations is ready or about to be ready for test and/or inspection; such test and/or inspection and notice thereof shall be subject to the requirements of the Contract.

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- k) The Contractor shall uncover any part of the Facilities or foundations, or shall make openings in or through the same as the Project Manager may from time to time require at the Site, and shall reinstate and make good such part or parts.

4.29 Completion of the Facilities

- a) As soon as the Facilities or any part thereof has, in the opinion of the Contractor, been completed operationally and structurally and put in a tight and clean condition as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Contractor shall so notify the Owner in writing.
- b) The Owner shall supply the operating and maintenance personnel as specified in the Form of Contract Agreement for Pre-commissioning of the Facilities or any part thereof.
- c) As soon as all works in respect of Pre-commissioning are completed and, in the opinion of the Contractor, the Facilities or any part thereof is ready for Commissioning, the Contractor shall commence Commissioning as per procedures stipulated in Technical Specifications, and as soon as Commissioning is satisfactorily completed, the Contractor shall so notify the Project Manager in writing.
- d) If the Project Manager notifies the Contractor of any defects and/ or deficiencies, the Contractor shall then correct such defects and/or deficiencies.
If the Project Manager is satisfied that the Facilities or that part thereof have reached Completion, the Project Manager shall, within **[seven (7)]** days after receipt of the Contractor's notice, issue a Completion Certificate stating that the Facilities or that part thereof have reached Completion as at the date of the Contractor's notice.
If the Project Manager is not so satisfied, then it shall notify the Contractor in writing of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's repeated notice, and the above procedure shall be repeated.
- e) If the Project Manager fails to issue the Completion Certificate and fails to inform the Contractor of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's notice, or if the Owner makes use of the Facilities or part thereof, then the Facilities or that part thereof shall be deemed to have reached Completion as of the date of the Contractor's notice, or as of the Owner's use of the Facilities, as the case may be.
- f) As soon as possible after Completion, the Contractor shall complete all outstanding minor items so that the Facilities are fully in accordance with the requirements of the Contract, failing which the Owner will undertake such completion and deduct the costs thereof from any monies owing to the Contractor.
- g) Upon Completion, the Owner shall be responsible for the care and custody of the Facilities or the relevant part thereof, together with the risk of loss or damage thereto, and shall thereafter take over the Facilities or the relevant part thereof.

4.30 Commissioning & Operation Acceptance

- a) Commissioning
Commissioning of the Facilities or any part thereof Acceptance shall be completed by the Contractor as per procedures detailed in the Technical Specifications. The Contractor shall, unless otherwise specified in Contract/ Tender Specifications, supply the , utilities, lubricants, chemicals, catalysts, facilities, services and other matters required for Commissioning.
- b) Guarantee Test

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The Guarantee Tests (and repeats thereof) shall be conducted by the Contractor after Commissioning of the Facilities or the relevant part thereof to ascertain whether the Facilities or the relevant part can attain the Functional Guarantees specified in the Contract Documents. The Contractor's and Project Manager's advisory personnel shall attend the Guarantee Test. The Owner shall promptly provide the Contractor with such information as the Contractor may reasonably require in relation to the conduct and results of the Guarantee Tests (and any repeats thereof). If for reasons not attributable to the Contractor, the Guarantee Tests of the Facilities or the relevant part thereof cannot be successfully completed within the period from the date of Completion, specified in the SCC or any other period agreed upon by the Owner and the Contractor, the Contractor shall be deemed to have fulfilled its obligations with respect to the Functional Guarantees.

c) **Operational Acceptance**

Operational Acceptance shall occur in respect of the Facilities or any part thereof when

- the Guarantee Tests have been successfully completed and the Functional Guarantees are met; or
- The Guarantee Tests have not been successfully completed or has not been carried out for reasons not attributable to the Contractor within the period from the date of Completion specified in the SCC or any other agreed upon period as specified in GCC.
- The Contractor may give a notice to the Project Manager requesting the issue of an Operational Acceptance in respect of the Facilities or the part thereof specified in such notice as at the date of such notice.
- The Project Manager shall, after consultation with the Owner, and within forty five (45) days after receipt of the Contractor's notice, issue an Operational Acceptance Certificate. If within *[forty five (45)]* days after receipt of the Contractor's notice, the Project Manager fails to issue the Operational Acceptance Certificate or fails to inform the Contractor in writing of the justifiable reasons why the Project Manager has not issued the Operational Acceptance Certificate, the Facilities or the relevant part thereof shall be deemed to have been accepted as at the date of the Contractor's said notice.

d) **Partial Acceptance**

If the Contract specifies that Completion, Commissioning and Guarantee Tests shall be carried out in respect of parts of the Facilities, the provisions relating to Completion and Commissioning including the Guarantee Tests shall apply to each such part of the Facilities individually, and the Operational Acceptance Certificate shall be issued accordingly for each such part of the Facilities. If a part of the Facilities comprises facilities such as buildings, for which no Commissioning or Guarantee Tests are required, then the Project Manager shall issue the Operational Acceptance Certificate for such facility when it attains Completion, provided that the Contractor shall thereafter complete any outstanding minor items that are listed in the Operational Acceptance Certificate.

4.31 Completion Time and Liquidated Damage

a) **Completion Time Period**

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The Contractor guarantees that it shall attain Completion of the Facilities (or a part for which a separate time for completion is specified in the SCC) within the Time for Completion specified in the SCC.

- b) If the Contractor fails to attain Completion of the Facilities or any part thereof within the Time for Completion, the Contractor shall pay to the Owner liquidated damages in the amount computed at the rates specified in the SCC. The aggregate amount of such liquidated damages shall in no event exceed the amount specified as "Maximum" in the SCC.

However, the payment of liquidated damages shall not in any way relieve the Contractor from any of its obligations to complete the Facilities or from any other obligations and liabilities of the Contractor under the Contract.

- c) No bonus will be given for earlier completion of the facilities or part thereof.

4.32 Defects Liability

- a) The Contractor warrants that the Facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the Plant and Equipment supplied and of the work executed.
- b) The Defects Liability Period shall be *[eighteen (18)]* months from the date of Completion of the Facilities (or any part thereof) or *[twelve (12)]* months from the date of Operational Acceptance of the Facilities (or any part thereof).

If during the Defects Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipment supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect. The Contractor shall not be responsible for the repair, replacement or making good of any defect or of any damage to the Facilities arising out of or resulting from any of the following causes:

- improper operation or maintenance of the Facilities by the Owner
 - operation of the Facilities outside specifications provided in the Contract
 - Normal wear and tear.
- c) The Owner shall give the Contractor a notice stating the nature of any such defect together with all available evidence thereof, promptly following the discovery thereof. The Owner shall afford all reasonable opportunity for the Contractor to inspect any such defect.
- d) The Owner shall afford the Contractor all necessary access to the Facilities and the Site to enable the Contractor to perform its obligations.
- e) If the repair, replacement or making good is of such a character that it may affect the efficiency of the Facilities or any part thereof, the Owner may give to the Contractor a notice requiring that tests of the defective part of the Facilities shall be made by the Contractor immediately upon completion of such remedial work, whereupon the Contractor shall carry out such tests.
- f) If the Contractor fails to commence the work necessary to remedy such defect or any damage to the Facilities caused by such defect within a reasonable time (which shall in no event be considered to be less than fifteen (15) days), the Owner may, following notice to the Contractor, proceed to do such work, and the reasonable costs incurred by the Owner in connection therewith shall be paid to the Owner by

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the Contractor or may be deducted by the Owner from any monies due to the Contractor or claimed under the Performance Security.

If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defects Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the Defects Liability Period extended by a period of *[twelve (12) month]* from the time such replacement/repair of the Facilities or any part thereof.

4.33 Functional Guarantees

The Contractor guarantees that during the Guarantee Tests, the Facilities and all parts thereof shall attain the Functional Guarantees as per the Contract. If, for reasons attributable to the Contractor, Functional Guarantees are not met either in whole or in part, the Contractor shall, within a mutually agreed time, at its cost and expense make such changes, modifications and/or additions to the Plant or any part thereof as may be necessary to meet such Guarantees. The Contractor shall notify the Owner upon completion of the necessary changes, modifications and/or additions, and shall seek the Owner's consent to repeat the Guarantee Test. If the specified Functional Guarantees are not established even during the repeat of the Guarantee Tests, the Owner may at its option, either reject the plant and equipment and recover from the Contractor payments already made or Accept the equipment/system/plant after levying Liquidated Damages as specified.

4.34 Patents Indemnity

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Owner may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Contractor or the use of the such Facilities.

4.35 Limitation of liability

Except in cases of criminal negligence or wilful misconduct by the Contractor, the aggregate liability of the Contractor to the Owner, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Contractor to indemnify the Owner with respect to patent infringement.

Except in cases of criminal negligence or wilful misconduct by the Contractor, the Contractor shall not be liable to the Owner, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs, provided that this exclusion shall not apply to any obligation of the Contractor to pay liquidated damages to the Owner.

4.36 Transfer of Ownership

Ownership of the Plant and Equipment (including spare parts) to be imported into India shall be transferred to the Owner upon loading on to the mode of transport to be used to convey the Plant and Equipment from the country of origin to that country.

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Ownership of the Plant and Equipment (including spare parts) procured from within India shall be transferred to the Owner when the Plant and Equipment including spares are loaded on to the mode of transport to be used to convey the Plant and Equipment including spares from the works to the site and upon endorsement of the despatch documents in favour of the Owner. Ownership of the Contractor's Equipment used by the Contractor and its Subcontractors in connection with the Contract shall remain with the Contractor or its Subcontractors. Ownership of any Plant and Equipment in excess of the requirements for the Facilities shall revert to the Contractor upon Completion of the Facilities or at such earlier time when the Owner and the Contractor agree that the Plant and Equipment in question are no longer required for the Facilities, provided quantity of any Plant and Equipment specifically stipulated in the Contract shall be the property of the Owner whether or not incorporated in the Facilities. Notwithstanding the transfer of ownership of the Plant and Equipment, the responsibility for care and custody thereof together with the risk of loss or damage shall remain with the Contractor until Completion of the Facilities.

4.37 Care of Facilities

The Contractor shall be responsible for the care and custody of the Facilities or any part thereof until the date of Completion of the Facilities, where the Contract provides for Completion of the Facilities in parts, until the date of Completion of the relevant part, and shall make good at its own cost any loss or damage that may occur to the Facilities or the relevant part thereof from any cause whatsoever during such period. The Contractor shall also be responsible for any loss or damage to the Facilities caused by the Contractor or its Subcontractors in the course of any work carried out.

4.38 Loss of or Damage to Property; Accident or Injury; Indemnification

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with the supply and installation of the Facilities and by reason of the negligence of the Contractor or its Subcontractors, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Owner, its contractors, employees, officers or agents.

4.39 Insurance

- a) The Contractor shall at its expense take out and maintain in effect, or cause to be taken out and maintained in effect, during the performance of the Contract, the insurances set forth below in the sums and with the deductibles and other conditions as specified. The identity of the insurers and the form of the policies shall be subject to the approval of the Owner, who should not unreasonably withhold such approval.
 - Cargo Insurance during Transport:-Covering loss or damage occurring while in transit from the Contractor's or Subcontractor's works or stores until arrival at the Site, to the Plant and Equipment (including spare parts thereof) and to the Contractor's Equipment.
 - Installation All Risks Insurance:-Covering physical loss or damage to the Facilities at the Site, occurring prior to Completion of the Facilities, with an extended maintenance coverage for the Contractor's liability in respect of any loss or damage occurring during the Defects Liability Period while the

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Contractor is on the Site for the purpose of performing its obligations during the Defects Liability Period.

- Third Party Liability Insurance: - Covering bodily injury or death suffered by third parties (including the Owner's personnel) and loss of or damage to property occurring in connection with the supply and installation of the Facilities.
 - Automobile Liability Insurance:-Covering use of all vehicles used by the Contractor or its Subcontractors (whether or not owned by them) in connection with the execution of the Contract.
 - Workers' Compensation:-In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Other Insurances Such other insurances as may be specifically agreed upon by the parties.
- b) The Owner shall be named as co-insured under all insurance policies taken out by the Contractor pursuant except for the Third Party Liability, Workers' Compensation and Owner's Liability Insurances, and the Contractor's Subcontractors shall be named as co-insured's under all insurance policies taken out by the Contractor except for the Cargo Insurance During Transport, Workers' Compensation and Owner's Liability Insurances. All insurers' rights of subrogation against such co-insured's for losses or claims arising out of the performance of the Contract shall be waived under such policies.
 - c) The Form of Contract Agreement, deliver to the Owner certificates of insurance (or copies of the insurance policies) as evidence that the required policies are in full force and effect. The certificates shall provide that no less than twenty one (21) days' notice shall be given to the Owner by insurers prior to cancellation or material modification of a policy.
 - d) The Contractor shall ensure that, where applicable, its Subcontractor(s) shall take out and maintain in effect adequate insurance policies for their personnel and vehicles and for work executed by them under the Contract, unless such Subcontractors are covered by the policies taken out by the Contractor.
 - e) The Owner shall at its expense take out and maintain in effect during the performance of the Contract those insurances specified.
 - f) the Owner may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Contractor under the Contract any premium that the Owner shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Contractor. If the Owner fails to take out and/or maintain in effect the insurances the Contractor may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Owner under the Contract any premium that the Contractor shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Owner. If the Contractor fails to or is unable to take out and maintain in effect any such insurances, the Contractor shall nevertheless have no liability or responsibility towards the Owner, and the Contractor shall have full recourse against the Owner for any and all liabilities of the Owner herein.
 - g) The Owner shall give to the Contractor all such reasonable assistance as may be required by the Contractor. With respect to insurance claims in which the Owner's interest is involved, the Contractor shall not give any release or make any compromise with the insurer without the prior written consent of the Owner. With respect to insurance claims in which the Contractor's interest is involved, the Owner shall not give any release or make any compromise with the insurer without the prior written consent of the Contractor.

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- h) Wherever total damages/loss of Equipment/materials, would occur, the Contractor will be entitled to payment of all payments received from the underwriters except the following amounts:
- The amount paid to the Contractor under the Contract in respect of Equipment/materials damaged/lost (excluding the pro-rata initial advance) but including the entire amount of escalation, if any, already paid to the Contractor.
 - Custom Duties and taxes which have already been paid by the Owner.
 - In case of damage to any Equipment/materials during any stage, the Contractor upon rectification of the damaged equipment to the satisfaction of the Owner shall be paid to the extent of full claims settled by the underwriters.
- i) All the Plants & Equipment being supplied by the Owner free of cost for installation of the equipment, cabling, earthing and lightning protection etc. by the Contractor, covered by this specification shall be kept insured by the Contractor against loss, damage, theft, pilferage, fire etc. from the point of unloading at Site up to the time of taking over by the Owner including handling, in plant transportation, storage, installation, testing and commissioning, etc. and the Contractor shall be fully responsible for making good of any loss or damage at his own cost within a reasonable time as mutually agreed upon by the Owner and the Contractor. Any loss/damage shall be brought to the Owner's notice immediately. The premium paid by the Contractor to the Insurance Company for such insurance shall be reimbursed by the Owner to the Contractor at actual against documentary proof to be furnished by the Contractor. The Contractor shall obtain competitive quotation for such insurance and shall take prior approval from the Owner before taking the insurance. The insurable value of the equipment being procured by the Owner will be intimated to the Contractor for the purpose of insurance.
- It will be the responsibility of the Contractor to lodge, pursue and settle all claims with the Insurance Company in case of any damage, loss, theft, pilferage, fire, etc. and the Owner shall be kept informed about it. The losses, if any, will have to be borne by the Contractor, if the claims are not lodged and pursued properly or in the time or if the same are not settled by the Insurance Company.

4.40 Change in Laws & Regulation

- a) If, after the date [seven (7)] days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Contractor and/or the Time for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Contractor has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Owner and the Contractor and not on procurement of raw materials, intermediary components etc. by the Contractor. Notwithstanding the foregoing, such additional or reduced costs shall not be separately paid or credited if the same has already been accounted for in the price adjustment provisions wherever applicable.

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4.41 Force Majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected. Force Majeure events include Acts of God, Acts of Government, war, sabotage, riots, civil commotion, revolution, flood, earthquake, cyclone, fire, epidemic etc.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within **[fourteen (14)]** days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfil its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
 - constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby
 if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.
- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than **[sixty (60)]** days or an aggregate period of more than one hundred and **[twenty (120)]** days on account of one or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.
- (g) Force Majeure shall not apply to any obligation of the Owner to make payments to the Contractor herein.
- (a)

4.42 Change in the Facilities

(a) Introducing a Change

- The Owner shall have the right to propose, and subsequently require, the Contractor during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Facilities (hereinafter called "Change"), provided that such Change falls within the general scope of the Facilities and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the Facilities and the technical compatibility of the Change envisaged with the nature of the Facilities as specified in the Contract.
- The Contractor may from time to time during its performance of the Contract propose to the Owner (with a copy to the Project Manager) any Change that the Contractor considers necessary or desirable to improve the quality, efficiency or safety of the Facilities. This includes any additional scope of work that the contractor thinks is essential for achieving the minimum

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performance level specified in the SCC or the Contract. The Owner may at its discretion approve or reject any Change proposed by the Contractor.

- No change made necessary because of any default of the Contractor in the performance of its obligations under the Contract shall be deemed to be a Change, and such change shall not result in any adjustment of the Contract Price or the Time for Completion.

(b) Changes Originating from Owner

- If the Owner proposes a Change, it shall send to the Contractor a "Request for Change Proposal," requiring the Contractor to prepare and furnish to the Project Manager as soon as reasonably practicable a "Change Proposal," which shall include the following:
 - ✓ brief description of the Change
 - ✓ effect on the Time for Completion
 - ✓ estimated Cost of the Change
 - ✓ effect on Functional Guarantees (if any)
 - ✓ effect on any other provisions of the Contract.
- The pricing of any Change shall, as far as practicable, be calculated in accordance with the rates and prices included in the Contract. If the rates and prices of any change are not available in the Contract, the parties thereto shall agree on specific rates for the valuation of the Change.
- If before or during the preparation of the Change Proposal it becomes apparent that the aggregate effect of compliance therewith and with all other Change Orders that have already become binding upon the Contractor to increase or decrease the Contract Price as originally set forth in the Contract Agreement by more than fifteen (15) percent, the Contractor may give a written notice of objection thereto prior to furnishing the Change Proposal as aforesaid. If the Owner accepts the Contractor's objection, the Owner and the Contractor shall agree on specific rates for valuation of the change.
- Upon receipt of the Change Proposal, the Owner and the Contractor shall mutually agree upon all matters therein contained including agreement on rates if such rates are not available in the Contract or if the limit of 15% set forth has been exceeded. Within *fourteen (14)* days after such agreement, the Owner shall, if it intends to proceed with the Change, issue the Contractor with a Change Order.
- If the Owner is unable to reach a decision within *fourteen (14)* days, it shall notify the Contractor with details of when the Contractor can expect a decision.
- If the Owner decides not to proceed with the Change for whatever reason, it shall, within the said period of *fourteen (14)* days, notify the Contractor accordingly.
- If the Owner and the Contractor cannot reach agreement on the price for the Change, an equitable adjustment to the Time for Completion, or any other matters identified in the Change Proposal, the Owner may nevertheless instruct the Contractor to proceed with the Change by issue of a "Pending Agreement Change Order."

Upon receipt of a Pending Agreement Change Order, the Contractor shall immediately proceed with effecting the Changes covered by such Order. The

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parties shall thereafter attempt to reach agreement on the outstanding issues under the Change Proposal.

(c) Changes Originating from Contractor

- The Contractor shall submit to the Project Manager a written “Application for Change Proposal,” giving reasons for the proposed Change and including the information. Upon receipt of the Application for Change Proposal, the parties shall follow the procedures indicated above for “Request for Change Proposal.”

4.43 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Contractor is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:
- Any Change in the Facilities or
 - any occurrence of Force Majeure or
 - any suspension order given by the Owner or reduction in the rate of progress or
 - any changes in laws and regulations or
 - any default or breach of the Contract by the Owner, or any activity, act or omission of any other contractors employed by the Owner or
 - any other matter specifically mentioned in the Contract;
- By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Contractor.
- (b) Except where otherwise specifically provided in the Contract, the Contractor shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Owner and the Contractor shall agree upon the period of such extension.
- (c) The Contractor shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.44 Suspension

- (a) The Owner/ Project Manager may, by notice to the Contractor, order the Contractor to suspend performance of any or all of its obligations under the Contract. Such notice shall specify the obligation of which performance is to be suspended, the effective date of the suspension and the reasons thereof. The Contractor shall thereupon suspend performance of such obligation (except those obligations necessary for the care or preservation of the Facilities) until ordered in writing to resume such performance by the Project Manager/ Owner.
- If, by virtue of a suspension order given by the Project Manager/ Owner, other than by reason of the Contractor’s default or breach of the Contract, the Contractor’s performance of any of its obligations is suspended for an aggregate period of more than *[ninety (90)]* days, then at any time thereafter and provided that at that time such performance is still suspended, the Contractor may give a notice to the Project Manager requiring that the Owner shall, within *[twenty eight (28)]* days of receipt of the notice, order the resumption of such performance or

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request and subsequently order a change, excluding the performance of the suspended obligations from the Contract.

- (b) If the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas;

Then the Contractor may by *[fourteen (14)]* days' notice to the Owner suspend performance of all or any of its obligations under the Contract, or reduce the rate of progress. If the Contractor's performance of its obligations is suspended or the rate of progress is reduced, then the Time for Completion shall be extended, and any and all additional costs or expenses incurred by the Contractor as a result of such suspension or reduction shall be paid by the Owner to the Contractor in addition to the Contract Price, except in the case of suspension order or reduction in the rate of progress by reason of the Contractor's default or breach of the Contract.

- (c) During the period of suspension, the Contractor shall not remove from the Site any Plant and Equipment, any part of the Facilities or any Contractor's Equipment, without the prior written consent of the Owner.

4.45 Termination

(a) Termination for Owner's Convenience

The Owner may at any time terminate the Contract for any reason by giving the Contractor a notice of termination. Upon receipt of the notice of termination, the Contractor shall either immediately or upon the date specified in the notice of termination

- (i) cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition.
- (ii) terminate all subcontracts, except those to be assigned
- (iii) remove all Contractor's Equipment from the Site, repatriate the Contractor's and its Subcontractors' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Contractor, subject to the payment, shall

- ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- ✓ Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Contractor the following amounts

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- ✓ the Contract Price, attributable to the parts of the Facilities executed by the Contractor as on the date of termination
- ✓ the costs reasonably incurred by the Contractor in the removal of the Contractor's Equipment from the Site and in the repatriation of the Contractor's and its Subcontractors' personnel
- ✓ any amounts to be paid by the Contractor to its Subcontractors in connection with the termination of any subcontracts, including any cancellation charges
- ✓ costs incurred by the Contractor in protecting the Facilities and leaving the Site in a clean and safe condition
- ✓ the additional cost of satisfying other obligations, commitments and claims that the Contractor may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Contractor's Default

- (i) The Owner, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons thereof to the Contractor:

If the Contractor becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Contractor is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Contractor takes or suffers any other analogous action in consequence of debt

If the Contractor assigns or transfers the Contract or any right or interest therein in violation of the provision.

If the Contractor, in the judgement of the Owner has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

- (ii) If the Contractor
- has abandoned or repudiated the Contract
 - has without valid reason failed to commence work on the Facilities promptly the progress of Contract performance for more than *[twenty eight (28)]* days after receiving a written instruction from the Owner to proceed

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- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient materials, services or labor to execute and complete the Facilities in the manner specified in the program at rates of progress that give reasonable assurance to the Owner that the Contractor can attain Completion of the Facilities by the Time for Completion as extended

then the Owner may, without prejudice to any other rights it may possess under the Contract, give a notice to the Contractor stating the nature of the default and requiring the Contractor to remedy the same. If the Contractor fails to remedy or to take steps to remedy the same within *[fourteen (14)]* days of its receipt of such notice, then the Owner may terminate the Contract forthwith by giving a notice of termination to the Contractor.

(iii) The Contractor shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d) below
- deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Works and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

(iv) The Owner may enter upon the Site, expel the Contractor, and complete the Facilities itself or by employing any third party. The Owner may, to the exclusion of any right of the Contractor over the same, take over and use with the payment of a fair rental rate to the Contractor, with all the maintenance costs to the account of the Owner and with an indemnification by the Owner for all liability including damage or injury to persons arising out of the Owner's use of such equipment, any Contractor's Equipment owned by the Contractor and on the Site in connection with the Facilities for such reasonable period as the Owner considers expedient for the supply and installation of the Facilities.

Upon completion of the Facilities or at such earlier date as the Owner thinks appropriate, the Owner shall give notice to the Contractor that such Contractor's Equipment will be returned to the Contractor at or near the Site and shall return such Contractor's Equipment to the Contractor in accordance with such notice. The Contractor shall thereafter without delay and at its cost remove or arrange removal of the same from the Site.

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- (v) The Contractor shall be entitled to be paid the Contract Price attributable to the Facilities executed as at the date of termination, the value of any unused or partially used Plant and Equipment on the Site, and the costs, if any, incurred in protecting the Facilities and in leaving the Site in a clean and safe condition. Any sums due to the Owner from the Contractor accruing prior to the date of termination shall be deducted from the amount to be paid to the Contractor under this Contract.
- (vi) If the Owner completes the Facilities, the cost of completing the Facilities by the Owner shall be determined.

If the sum that the Contractor is entitled to be paid, plus the reasonable costs incurred by the Owner in completing the Facilities, exceeds the Contract Price, the Contractor shall be liable for such excess.

The Owner and the Contractor shall agree, in writing, on the computation described above and the manner in which any sums shall be paid.

(c) Termination by Contractor

- i. If
 - the Owner has failed to pay the Contractor any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Contractor may give a notice to the Owner that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Owner to remedy the same, as the case may be. If the Owner fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within *[fourteen (14) days]* after receipt of the Contractor's notice, or
 - the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas or failure to obtain any governmental permit necessary for the execution and/or completion of the Facilities which the Owner is required to obtain as per provision of the Contract or as per relevant applicable laws of the country,

then the Contractor may give a notice to the Owner thereof, and if the Owner has failed to pay the outstanding sum, to approve the invoice or supporting documents, to give its reasons for withholding such approval, or to remedy the breach within *[twenty eight (28) days]* of such notice, or if the Contractor is still unable to carry out any of its obligations under the Contract for any reason attributable to the Owner within *[twenty eight (28) days]* of the said notice, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.
- ii. If the Owner becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a

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receiver is appointed over any part of its undertaking or assets, or if the Owner takes or suffers any other analogous action in consequence of debt, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.

- iii. If the Contract is terminated, then the Contractor shall immediately
 - cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
 - terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d)(ii)
 - remove all Contractor's Equipment from the Site and repatriate the Contractor's and its Subcontractor's personnel from the Site.
 - In addition, the Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipment as of the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
 - ✓ Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as of the date of termination in connection with the Facilities.
- iv. If the Contract is terminated, the Owner shall pay to the Contractor all payments, and reasonable compensation for all loss or damage sustained by the Contractor arising out of, in connection with or in consequence of such termination.
- (d) The expression "Facilities executed" shall include all work executed, Erection Services provided, any all Plant and Equipment acquired (or subject to a legally binding obligation to purchase) by the Contractor and used or intended to be used for the purpose of the Facilities, up to and including the date of termination.
- (e) In calculating any payment due from the Owner to the Contractor, account shall be taken of any sum previously paid by the Owner to the Contractor under the Contract, including any advance payment paid.

4.46 Assignment

The Contractor shall not, without the express prior written consent of the Owner, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Contractor shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Renovation & Modernization of Coal Handling Plant-CHP) Package for [-----]
- **Bid Document No. :** [-----]
- **The Owner is:**
 - Name of Owner: [-----]
 - Address of Owner: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]
- **The Project Manager is:**
 - Name of Project Manager: [-----]
 - Address of Project Manager: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]

5.2 Effective Date

The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor.

The following three activities will be completed within *[two (2)]* months from the date of Letter of Acceptance:

- (a) The contract agreement will be executed by the Owner and the Contractor.
- (b) The Contractor will submit to the Owner the Contract Performance Bank Guarantee and the Advance Payment Bank Guarantee.
- (c) The Owner will pay the Contractor the Advance Payment as per the Terms of Payment.

The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Owner shall be as follows:

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1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Owner) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Owner may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

5.4 Liquidated Damage for Delay

5.5 Rate of Liquidated Damage for Delay

If the Contractor fails to successfully achieve completion of R&M activities and commissioning of the retrofitted facilities as per the scope of work within the time period specified in SCC, the Contractor shall pay to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

1.	Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	Liquidated Damage payable at the rate Rs.[.....] for each week of delay
2.	Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	Liquidated Damage payable at the rate Rs [.....] for each day of delay

The Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender are independent and shall be applied separately.

5.6 Liquidated Damage for Non-fulfillment of Functional Guarantees

If the Contractor fails to successfully achieve the Functional Guarantees during Performance Guarantee Test as per the Tender Specification, the Contractor shall pay

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to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

Sl. No.	Functional Guarantee Parameter	Rate of Liquidated Damage
1	Auxiliary Power	[.....] INR per kW increase

The reference condition for Performance Guarantee Parameters shall be as per Volume-II Technical Specification.

The Liquidated Damage for non-fulfillment of the different Functional Guarantee Parameters are independent of one another and shall be applied separately.

{Note: The rate of LD for any functional guarantee parameter shall be at least 1.5 times the corresponding Bid Evaluation Factor}

5.7 Maximum Leviable Liquidated Damages

The amount of Liquidated Damage for delay shall be limited to a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares. This limit is applicable for the Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender taken together.

The aggregate amount **of Liquidated Damage for non-fulfilment of functional guarantee shall be limited to** a maximum of 10 % of the total contracts price (i.e. sum of Ist and IInd contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The limit on maximum leviable Liquidated Damage for Delay and maximum leviable Liquidated Damage for non-fulfillment of functional guarantee are independent of each other and shall apply separately.

5.8 Payment of Liquidated Damages

Contractor shall pay to the owner any Liquidated Damages that are payable as per the provisions of the Contract within thirty (30) days of receipt of Owner's invoice setting forth amount of Liquidated Damages that are then due and payable. If Contractor delays payment of Liquidated Damages that are payable under the provisions of the Contract beyond thirty (30) days, Owner, at its discretion, shall be entitled to recover such amounts by either setting off the relevant unpaid amount against any payment(s) due to the Contractor or by making a demand under Contract Performance Bank Guarantee.

5.9 Contract Price

- The Contract Price shall be as (Contract Price and Terms of Payment) of the Form of Contract Agreement.

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- b) The Contractor shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

5.10 Terms of Payment

- a) The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement. The procedures to be followed in making application.
- b) No payment made by the Owner herein shall be deemed to constitute acceptance by the Owner of the Facilities or any part(s) thereof.
- c) The currency or currencies in which payments are made to the Contractor under this Contract to the Form of Contract Agreement, subject to the general principle that payments will be made in the currency or currencies in which the Contract Price has been stated in the Contractor's bid.

5.11 Bank Guarantees

- a) The Contractor shall provide the Bank Guarantees specified below in favour of the Owner at the times, and in the amount, manner and form specified below.
- b) Advance Payment Bank Guarantees
- The Contractor shall, within *[thirty (30)]* days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to *[ninety (90)]* days beyond the date of Completion of Facilities.
 - The security shall be in the form of an Unconditional Bank Guarantee. The Advance payment Bank Guarantees shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of equipment/facilities received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Facilities supplied and received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of those Facilities. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Contractor's responsibility and liabilities under the Contract including in respect of the Facilities for which the reduction in the value of security is allowed.
- c) Contract Performance Bank Guarantees
- The Contractor shall, within *[twenty-eight (28)]* days of the notification of award, provide a Bank Guarantees for the due performance of the Contract for ten percent (10%) of the Contract Price with an initial validity up to *[ninety (90)]* days beyond the Defects Liability Period. The performance Bank Guarantees shall be denominated in the currency or currencies of the Contract, or in a freely convertible currency acceptable to the Owner.

5.12 Sequential Supply

The Contractor is required to supply the material and equipment under the Contract in a sequential manner as per the requirement at site for erection. If Contractor supplies any material/equipment ahead of the requirement as per the agreed Detailed Time Schedule, the Owner, at its discretion, may withhold progressive payment for such material/equipment till the time it is due for supply as per the agreed Detailed Time Schedule.

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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	NOT USED
Annexure-E	NOT USED
Schedule F1 Table-1	Summary of Price Schedule
Schedule F1 Table-2	Price Schedule for Supply of Plant and Equipment Including Packing and Forwarding Charges
Schedule F1 Table-3A	Price Schedule for Mandatory Spares
Schedule F1 Table-3B	Price Schedule for Recommended Spares
Schedule F1 Table-4	Price Schedule for Tools & Tackles
Schedule F1 Table-5	Price Schedule for Erection Services Including Dismantling / Disassembly, Unloading, Handling, Storage, Preservation at Site, Erection, Testing, Commissioning and Performance Guarantee Tests of Plant and Equipment
Schedule F1 Table-6	Price Schedule For Civil works
Schedule F1 Table-7	Price Schedule For Training Charges
Schedule F1 Table-8	Schedule of Performance Guarantee Parameters
Schedule F2	Overall Time Schedule
Schedule F3	Deviation Schedule to Tender Document Vol-I Commercial
Schedule F4	Deviation Schedule to Technical Specification
Schedule F5	Requirements of the Contractor at Site
Schedule F6	Contractor's Resource Deployment Schedule

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Schedule F7	Coefficients and Indices for Price Variation Formula
II	Forms and Appendices to form part of Contract
Annexure-F	Form of Contract Agreement
Contract Schedule-1	Terms of Payment
Contract Schedule-2	Price Adjustment
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Approved Subcontractors
Contract Schedule-5	Scope of Works and Supply by the Owner
Contract Schedule-6	Functional Guarantees
Contract Schedule-7	Quality Assurance
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Bank Guarantee

ANNEXURES & SCHEDULES

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.: _____ Bank Guarantee No: _____
Date _____ :

To:
[Details of Designated Official]
[-Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [.....] dated [.....] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [.....] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [Name of package and R&M project], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [.....] (in words and figures) valid for 300 days from [.....] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [.....] Bank at (local address) [.....] having our Head Office at [.....] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of [.....] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

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This Guarantee shall be irrevocable and shall remain valid up to [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorized officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
 Name :
 Designation :
 Staff Code No. :

Banker's Seal :
 Date :

Witness:

1. Signature :
 Full name in block letters :
 Designation :
 Address :

2. Signature :
 Full name in block letters :
 Designation :
 Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[-Name of Utility] [.....]

Sub : ____ (Name of Package) [.....]

Tender

No.

[.....]

Having carefully examined the Tender Specifications issued to us for your Tender No. [.....] dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the 'works' in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification. The plant, equipment and systems offered are of the best and latest technology and of international standards.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR (Indian Rupees [.....] only)/ _____ in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of [180 (One Hundred and Eighty)] days from the date of opening of bids by Owner and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to [Name of Utility], assignees or authorized nominees such sums of money as are stipulated in conditions contained in Tender Specification and agree to furnish Bank Guarantee for Contract Performance as per the proforma prescribed by Owner and for

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the sum equal to 10% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Owner is not bound to accept the lowest or any Bids received and Owner has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Owner and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From:

Dated:

[-----]
[-----]
[-----]

To :

[-----]
[-----]
[-----]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire works as described in the specifications in conformity with the specifications and Tender Specifications, as per prices quoted by us in the Schedule of Prices and Schedule of Performance Guarantees [Schedule] enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Employer [Name of Utility] and for the sum equal to 10% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Employer is received and accepted by the Employer

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

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1. Signature
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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ANNEXURE – D

NOT USED

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**ANNEXURE – E
NOT USED**

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SCHEDULE – F1: TABLE - 1

SUMMARY OF PRICE SCHEDULE

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.1	NOT USED		
1.2	NOT USED		
1.3	NOT USED		
1.4	NOT USED		
2.	NOT USED		
3.	Supply of Plant & Equipment including Technological and misc. structures with all accessories (Ex-Works) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum price basis.		
4.	Sales Tax Payable on Indigenous equipment - on Ceiling basis. (a) VAT (b) Central Sales Tax (CST)		
5.	(a) Inland transport of imported plant & equipment on lumpsum and firm price basis.		
	(b) Inland transport of Indigenous plant & equipment on lumpsum and firm price basis		
6.	Lumpsum price for Civil Works including, supplies such as cement, reinforcement steel etc.at site cost, including Design & Engineering and Construction of entire Civil works.		
7.	Erection services including dismantling/disassembly, unloading, handling, storage and preservation at site, Erection, testing, commissioning and PG tests of plant & equipment on lumpsum price basis		
8.	Marine cum erection insurance on lumpsum and firm price basis		
9.	NOT USED		
10.	Training charges on firm price basis with ceiling.		
11.	VAT on Works Contract on ceiling basis		
12.	Service Tax including Education Cess on Ceiling basis		

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(In Figures and Words)

S.No.	Description	Foreign Currency	INR
13.	Others, if any (Please specify),		
14.	Total price of package (excluding mandatory spares and Tools & Tackles. (Total of SI.Nos.1.4 + 2 to 13).		
15.	Mandatory Spares on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-3)		
16.	Tools & Tackles on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-4)		
17.	Grand total price of package including Mandatory Spares and Tools & Tackles. (Total of SI Nos 14+15+16).		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 2

**PRICE SCHEDULE FOR SUPPLY OF PLANT AND EQUIPMENT INCLUDING
PACKING AND FORWARDING CHARGES**

S.No.	Description	
		Supply Ex-works price including packing and forwarding
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		

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S.No.	Description	Supply Ex-works price including packing and forwarding

	Sub Total (3)	
4	Total (1 + 2 + 3)	

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3A
PRICE SCHEDULE FOR MANDATORY SPARES

S. No.	Description	Price
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2	NOT USED	
3	Supply (Ex-works) of Mandatory Spares including Packing and Forwarding on lumpsum and Firm Price	
4.	a) NOT USED.	
	b) Inland transport on lumpsum and firm price basis.	
5	Insurance (Lumpsum and firm price basis)	
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7	Total price of Mandatory Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3B
PRICE SCHEDULE FOR RECOMMENDED SPARES

S. No.	Description	Price
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2	NOT USED	
3	Supply (Ex-works) of Recommended Spares including Packing and Forwarding on lumpsum and Firm Price	
4.	a) NOT USED.	
	b) Inland transport on lumpsum and firm price basis.	
5	Insurance (Lumpsum and firm price basis)	
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7	Total price of Recommended Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

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SCHEDULE – F1: TABLE-4
PRICE SCHEDULE FOR TOOLS & TACKLES

S. No	Description	Indigenous Price in INR
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2.	NOT USED	
3.	Supply (Ex-works) of Tools and Tackles including Packing and Forwarding on Lumpsum and firm Price	
4.	a) NOT USED.	
	b) Inland transport for indigenous items on lumpsum and firm price basis.	
5.	Insurance (lumpsum and firm price basis)	
6.	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7.	Total price of Tools and Tackles (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :

Name :

Designation :

Company :

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SCHEDULE – F1: TABLE-5

**PRICE SCHEDULE FOR ERECTION SERVICES INCLUDING
DISMANTLING/DISASSEMBLY, UNLOADING, HANDLING, STORAGE,
PRESERVATION AT SITE, ERECTION, TESTING, COMMISSIONING AND
PERFORMANCE GUARANTEE TESTS OF PLANT AND EQUIPMENT**

(In Figures and Words)

S.No.	Description	Total Price for complete work at Site
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		
	Sub Total (3)	
4	Total (1 + 2 + 3)	

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Signature :

Name :

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SCHEDULE – F1: TABLE - 6

PRICE SCHEDULE FOR CIVIL WORKS

S.No.	Description	PRICE
1.		
2		
3		
4		
5		
.....		
.....		
	Total	

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 7

PRICE SCHEDULE FOR TRAINING CHARGES

S.No.	Description	PRICE
1.		
2		
3		
4		
5		
.....		
.....		
	Total	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 8

SCHEDULE OF PERFORMANCE GUARANTEE PARAMETERS

The Bidder shall furnish performance guarantee of the Package in respect of all items listed below.

Category – I: Performance Guarantees under Liquidated Damages [L.D]

S. No	Particulars	Unit	Value inclusive of design, manufacture and all other Tolerances including measurement uncertainty
1			
2			
3			
.....			
.....			

Category – II: Mandatory Performance Guarantees

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			

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S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
3			
.....			
.....			

Category -III: Requirement under Demonstration Category

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			
3			
....			
.....			
.....			

Signature :

Name :

Designation :

Company :

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SCHEDULE – F2
OVER ALL TIME SCHEDULE
(Bidder to fill-in and submit with its Bid)

S.No	Work Description	Days from Effective Date	
		Start	Finish
1	Design & Engineering		
2	Manufacture of Plant/Equipment		
	(a)		
	(b)		
	(c)		
		
		
3	Delivery of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
4	Dismantling/Disassembly of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
5	Civil work at Site		
6	Erection of of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
7	Trial Operation & Provisional Take Over		
8	Performance Guarantee tests Completion and Final Take Over		

Signature :

Name :

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Designation :

Company :

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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I). The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I), then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F4

DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Owner's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Owner's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F5
REQUIREMENTS OF THE CONTRACTOR AT SITE
(Bidder to fill-in and return with its Bid)

The Bidder shall state his requirements against each of the following including the basis of requirements:

A.	Requirements Description	Quantity

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE - F6
CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE

A) Construction Equipment

The Bidder shall indicate the schedule of construction equipment, proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
1									
2									
3									
...									
...									

B) Resource Deployment Schedule

The Bidder shall indicate the schedule of manpower resources proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
2.	Human Resources								
2.1	Engineering Category								
2.1.1	Project Engineers								
2.1.2	Mechanical Engineers								
2.1.3	Electrical Engineers								
2.1.4	Civil Engineers								
2.1.5	C&I Engineers								
2.1.6	Commissioning Engineers								
2.1.7	Structural Engineers								
2.1.8	Others (bidder shall indicate) as applicable for the work								
2.2	Supervisory Category								
2.2.1	Const. Manager								
2.2.2	Electrical Supervisors								
2.2.3	Mechanical Supervisors								
2.2.4	C&I Supervisors								
2.2.5	Civil Supervisors								
2.2.6	Purchase Officer (s)								
2.2.7	Finance/Site Office								
2.2.8	Inspection/Quality Control								
2.2.9	Others (Bidder shall indicate) as applicable for the work								

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S. No.	Type of Resource	Months						
2.3	Labour Category							
2.3.1	Welder							
2.3.2	Fitter							
2.3.3	Rigger							
2.3.4	Un-skilled labour							
2.3.5	Others (Bidder shall indicate) as applicable for the work							

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F7
COEFFICIENTS AND INDICES FOR PRICE ADJUSTMENT FORMULA

Ex-Works price component of Plant and Equipment excluding mandatory spares				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Erection Services Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Civil Works Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

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Note: Bidder to fill up value of all Coefficients, names of indices and value of indices on the base date for Price Adjustment as per Contract Schedule-2. This schedule must be submitted along with Part-I Bid (Techno Commercial Bid) Bidders to use continuation sheets if required.

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Form of Contract Agreement

Document Number	Rev No	Description	Page No.	Date of Issue
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Form of Contract Agreement

THIS CONTRACT AGREEMENT is made the _____day of _____, 20_____.
 BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of [country of Employer] and having its principal place of business at [address of Employer] (hereinafter called “the Employer”), and (2) [name of Contractor], a corporation incorporated under the laws of [country of Contractor] and having its principal place of business at [address of Contractor] (hereinafter called “the Contractor”)

WHEREAS the Employer desires to engage the Contractor to dismantle/disassemble, design, manufacture, test, deliver, install, complete and commission certain Facilities, viz.

[.....]
 [.....]
 [.....]

(“the Facilities”) and the Contractor have agreed to such engagement upon and subject to the terms and conditions hereinafter appearing.

NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

- a) Contract Documents means this signed Contract agreement and its annexure/appendices, and the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. The following will constitute the Contract Documents:
 - i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
 - ii. Letter of award.
 - iii. Special Condition of Contract
 - iv. General Condition of Contract
 - v. Technical specification & Tender Drawing.
 - vi. The bid & its schedules/ attachment submitted by the contractor.
- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender.
- vi. The bid & schedules/ attachment Drawing submitted by the contractor.

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1.3 Definitions

The Definitions of terms and expressions shall be as per GCC clause 4.1. Terms and expressions not defined in GCC shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder:
The Contract Price shall be the aggregate of: [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Employer shall be as follows:

1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Employer) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Employer may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

The detailed Time Schedule shall be as per Contract Schedule 2.

Contract Schedules

The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

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Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]

-----[Title]

In the presence of -----

Signed by for and on behalf of the Contractor

-----[Signature]

-----[Title]

In the presence of -----

CONTRACT AGREEMENT

dated the -----day of-----, 20_-----

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

- Contract Schedule 1 : Terms of Payment
- Contract Schedule 2 : Price Adjustment
- Contract Schedule 3 : Time Schedule
- Contract Schedule 4 : List of Approved Subcontractors
- Contract Schedule 5 : Scope of Works and Supply by the Employer
- Contract Schedule 6 : Functional Guarantees
- Contract Schedule 7: Quality Assurance

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Contract Schedule-1

Terms of Payment

The Employer shall pay the Contractor in the following manner and at the following times, on the basis of the Price Break down given in the Section on Price Schedules. Payments will be made in the currencies quoted by the Bidder unless otherwise agreed between the parties. Application for payment in respect of part deliveries may be made by the Contractor as work proceeds.

I. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares):

1	10% of the total Ex-Works price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	50% of Ex-Works price for each identified equipment as progressive payment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of Ex-Works price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer
4	20% of the total Ex-Works price	On Completion of Facilities
5	5% of the total Ex-Works price	Successful completion of Performance Guarantee Test

II. Terms of Payment for Supply of Mandatory Spares and Recommended Spares

1	70% of the Ex-Works Price of each Spare	Upon dispatch of the identified Spare after dispatch clearance by employer on raising of invoice by the Contractor and submission of evidence of shipment
2	30% of the Ex-Works Price of each Spare from within India	On receipt of Spare at site and physical verification and certification by the Employer

III. Terms of Payment for Local Transportation, Inland Transit Insurance

For Plant & Equipment except Spares		
1	100% of Local Transportation, Inland Transit Insurance pro-rata to value of the equipment	On receipt of Equipment at site and upon raising of Invoice by the Contractor
For Spares		
2	100% of Local Transportation, Inland Transit Insurance pro-rata to value of	On receipt of Spare at site and upon raising of Invoice by the Contractor

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	Spare	
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IV. Terms of Payment for Erection of Plant & Equipment

1	10% of Total Price for Erection of Plant & Equipment	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Erection of Plant & Equipment as progressive payment pro-rata to value of plant & equipment erected	On certification by Employer of successful erection of plant & equipment and successfully passing of quality checks
3	10% of Total Price for Erection of Plant & Equipment	On Completion of Facilities
4	5% of Total Price for Erection of Plant & Equipment	Successful completion of Performance Guarantee Test

V. Terms of Payment for Civil Works

1	10% of Total Price for Civil Works	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Civil Works as progressive payment	On certification by Employer regarding value of work completed & successfully passing of quality checks
3	10% of Total Price for Civil Works	On Completion of Facilities
4	5% of Total Price for Civil Works	Successful completion of Performance Guarantee Test

VI. Terms of Payment for Price Adjustment Amount

Any increase in the Price of any component Contract shall be paid as per the Terms of Payment for base price. The initial 10% advance payment pertaining to increase in price shall be paid along with progressive payment of that equipment. Reduction to the Contract Price, if any, due to price adjustment provisions, shall be effected by recovering 100% of the reduction amount (including advance) from any of the Contractor's bills falling immediately due for payment.

VII. Terms of Payment for Taxes & Duties

Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other Tax or Duty payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon receipt of corresponding Plant &

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Equipment or Spare at site and submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such Taxes & Duties.

VIII.

Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such variation.

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Contract Schedule-2

PRICE ADJUSTMENT

- (i) The Contract Price shall be subject to price adjustment during performance of the Contract to reflect changes in the cost of labour and material in accordance with the provisions described below.
- (ii) Only following components of the Contract Price will be subject to Price adjustment :
 - (a) Ex-Works (India) price of plant and equipment excluding Mandatory Spares. The price adjustment amounts towards these price components shall be without any ceiling.
 - (b) Erection Services component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
 - (c) Civil Works component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
- (iii) Price adjustment amounts towards aforesaid components of Contract Price shall be paid in the respective currencies of Contract.
- (iv) The indices for price adjustment shall necessarily be of India and shall be well established and nationally recognized in India. Preferably Government indices shall be used.
- (v) The price adjustment formula for the components of the Contract Price above shall be as stipulated hereinafter.
- (vi) **Ex-Works price component of Plant and Equipment excluding mandatory spares**

The price component of the equipment for any shipment/ dispatch comprises of a fixed portion (designated as 'F' and the value of which is specified hereunder) and a variable portion linked with the indices for various materials and labour.

The amount of price adjustment towards variable portion payable/recoverable on each shipment/dispatch shall be computed as under :

$$ES = ES_1 - ES_0$$

ES₁ will be computed as follows:

$$ES_1 = ES_0 \left\{ F + a \times \frac{A_1}{A_0} + b \times \frac{B_1}{B_0} + c \times \frac{C_1}{C_0} + Lb \times \frac{L_1}{L_0} \right\}$$

Where

ES = Adjustment to Ex-Works component expressed in the currency of the Contract payable to the contractor for each shipment/dispatch

ES₁ = Adjusted amount of Ex-works price component expressed in the currency of the Contract payable to the Contractor for each shipment/dispatch

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- ES₀ = Ex-works for the plant and equipment in the currency of the Contract, shipment/dispatch wise.
- The fixed portion of the ex-works component of the Contract Price (F) shall be 0.15.
 - a, b,c etc. shall be co-efficient of major materials/items involved in the ex-works component of the Contract Price. The sum of these co-efficient shall be between 0.50 to 0.60.
 - A, B, C etc. shall be published price indices of corresponding major materials/items. Such indices shall necessarily be of India.
 - 'Lb" shall be co-efficient for labour component in the ex-works of the Contract Price which shall be between 0.25 to 0.35.
 - 'L' shall be labour index.
 - Sum of all the material co-efficient and the labour co-efficient shall be 0.85.

For the indices(A, B, C etc.), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid.

Subscript '1' refers to indices/exchange rates as of:

(a) three months prior to the date of shipment/dispatch for labour, and

(b) six months prior to the date of shipment/dispatch for material.

In case of shipments/dispatches which are delayed beyond the schedule date of shipment/dispatch for reasons attributable to the Contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of shipment/dispatch and the actual date of shipment/dispatch.

(vii) Erection Services Component

The price component for erection services comprises of a fixed portion and a variable portion linked with the index of labour.

$$ER = ER_1 - ER_0$$

ER₁ will be computed as follows:

$$ER_1 = ER_0 (0.15 + 0.85 \frac{FL_1}{FL_0})$$

Where:

ER	=	Adjustment to erection services component of contract price payable to the contractor for each billing.
----	---	---

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ER ₁	=	Adjusted amount of erection services component of Contract Price payable to the Contractor.
ER ₀	=	Value of the Erection work done in the billing period (month)
FL	=	Indian field labour index namely, All India Consumer Price Index for Industrial Workers (All India Monthly Average) as published by Labour Bureau, Simla, Government of India.

For the indices, subscript 'o' refers to indices as on 30 days prior to date set for opening of Part-I bids. .

For the indices, subscript '1' refers to the indices as applicable for the month of execution of the erection work. For the exchange rates, subscript '1' refers to the exchange rates as applicable on the last day of the month of execution of the erection work.

In case of erection activities which are delayed beyond the schedule date for reasons attributable to the contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of completion and actual date of completion of the respective erection activity.

(viii) The following components of the contract price shall not be subject to price adjustment and shall remain firm during the execution of the contract :

- (1) Ocean Freight and Marine Insurance for Plant and Equipment, mandatory spares and recommended spares.
- (2) Price for Mandatory spares & Recommended Spares.
- (3) Inland Transportation charges (including Inland Transit Insurance, port clearance, port handling & port charges) for plant & equipment and Spare Parts.

(ix) Civil Works Component

The Price of Civil Works for any month comprises a fixed part designated as 'F' and variable parts linked to indices for labour, steel, cement, other commodities and Fuel & Power. The monthly price adjustment amount for the civil works component of the Contract Price will be computed as per the formula given below:

$$EC = EC_1 - EC_0$$

EC₁ will be computed as follows:

$$EC_1 = EC_0 \left\{ F + a \times \frac{MI_1}{MI_0} + b \times \frac{LI_1}{LI_0} + c \times \frac{FI_1}{FI_0} + d \times \frac{SI_1}{SI_0} + e \times \frac{CI_1}{CI_0} \right\}$$

Where

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- EC = Adjustment to Civil Works price component expressed in the currency of the Contract payable to the contractor for each month
- EC₁ = Adjusted amount of Civil Works price component expressed in the currency of the Contract payable to the Contractor for each month
- EC₀ = Value of Civil Works done expressed in the currency of the Contract for the billing period (month).
- The fixed portion (F) of the Civil Works component of the Contract Price shall be 0.15.
 - 'a' is the coefficient for material cost other than cement and steel involved in the Civil Works component of the Contract Price and it shall be 0.15.
'b' is the coefficient for labour cost involved in the Civil Works component of the Contract Price and it shall be 0.3.
'c' is the coefficient for Fuel & Power cost involved in the Civil Works component of the Contract Price and it shall be 0.05.
'd' is the coefficient for steel cost involved in the Civil Works component of the Contract Price and it shall be 0.25.
'e' is the coefficient for cement cost involved in the Civil Works component of the Contract Price and it shall be 0.10.
 - MI shall be All India Whole Sale Price Index for all commodities as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry.
LI shall be All India Consumer Price Index for industrial labour as published by Labour Bureau, Government of India
FI shall Index Number of Wholesale Price for group Fuel & Power as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry
SI shall Index Number of Wholesale Price for Steel as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry
CI shall Index Number of Wholesale Price for Cement as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

For the indices(MI, LI,FI, SI and CI), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid. Subscript '1' refers to indices as of one prior to the month for which Civil Works is being billed.

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Contract Schedule-4
LIST OF SUB-CONTRACTORS
[List of approved subcontractors shall be placed]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Contract Schedule-5

SCOPE OF WORKS AND SUPPLY BY THE OWNER

[Scope of Works and Supply by the Employer shall be placed]

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Contract Schedule-6
FUNCTIONAL GUARANTEES
[Functional Guarantees shall be placed]

Contract Schedule-7
QUALITY ASSURANCE

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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[After Letter of Award (LOA), the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall]

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Contractor]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:	Bank Guarantee No:	Date:
--------	--------------------	-------

To:

[Name & Address of Owner (Utility)]

.....
]

Dear Sirs,

1 In consideration of the [.....] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Contractor's Name] having its registered office at.....hereinafter referred to as the 'CONTRACTOR', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures] and the same having been unequivocally accepted by the CONTRACTOR and the CONTRACTOR having agreed to provide a **Contract Performance Bank Guarantee** for the faithful performance of the entire CONTRACT including the Warranty Obligations /Liabilities under the CONTRACT equivalent to 10% (ten percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONTRACTOR by reason of any breach of the said CONTRACTOR of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to Rs.....(Rupees.....only). Any

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such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONTRACTOR or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The Bank further irrevocably guarantees and undertakes to pay any amount due and payable by the CONTRACTOR by reasons of non-fulfilment of any of the following obligations of the Contractor:
 - (a) Successful and satisfactory operation of the plant & equipment supplied and erected under the said Contract as per the Technical Specifications and other Tender/Contract documents.
 - (b) That the equipment installed under the said Contract shall be new and in accordance with Contract Documents and be free from all defects in design, engineering, material workmanship and performance for a period of 12 calendar months after final takeover of the equipment by the OWNER and that upon written notice from the OWNER, the CONTRACTOR shall remedy free of any expense to the OWNER, such defects as noticed and developed under the normal use of the said plant & equipment, within the said guarantee period.
- 4 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONTRACTOR. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 5 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONTRACTOR and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONTRACTOR or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 6 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONTRACTOR to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 7 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Contractor or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 8 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONTRACTOR's liabilities.

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- 9 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONTRACTOR(S).
- 10 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended from time to time for such period as may be desired by [Name of Contractor.....] on whose behalf this guarantee has been given.
- 11 Signed at.....this.....day of.....20.....

Signature :
Name :
Designation :
Staff Code No :

Bank Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
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	---	Part-D	Not Used

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
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6. Forms and Schedules

* * * * *

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2. Site & Project Specific Information
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4. Scope of Supply & Services
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* * * * *

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

* * * * *

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

**VOLUME-II,
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

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ABBREVIATIONS TO BE USED

{The utilities are advised to use the following standard abbreviations while preparing Model Tender Document for their power plant.}

AAQ	Ambient Air Quality
AC	Air Condition
ACG	Automatic Control Gear
ASME	American Society of Mechanical Engineers
BC	Belt Conveyor
BW	Belt Weigher
CCTV	Closed Circuit Television
CEA	Central Electricity Authority
CEMS	Continuous Emission Monitoring System
CERC	Central Electricity Regulatory Commission
CHP	Coal Handling Plant
CLCS	Closed Loop Control System
CV	Control Valve
DS	Dust Suppression
DE	Dust Extraction
EOT	Electrically Operated Travelling Crane
ESV	Emergency Stop Valve
ETP	Effluent Treatment Plant
EWS	Engineer's Work Station

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HMI	Human Machine Interface
I/O	Input / Output
IPR	Inter Posing Relay
ILMS	In line Magnetic Separator
ISMB	Indian Standard Medium Beam
LE	Life Extension
LPA	Loss Prevention Association of India
LVS	Large Video Screen
MCCB	Module Case Circuit Breaker
MD	Metal Detector
MoEF	Ministry of Environment & Forest
OPC	Object linked embedded Process Control
OWS	Operator Working Station
PF	Paddle Feeder
PLC	Programmable Logic Controller
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RSO	Recurrent Surge Oscillograph
RTD	Resistance Temperature Detector
SADC	Secondary Air Damper Control
SM	Suspended Magnet

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S/R	Stacker cum Reclaimer
TMCR	Turbine Maximum Continuous Rating
TC	Thermocouple
TP	Transfer Point
TPS	Thermal Power Station
TR	Tons of Refrigeration
TT	Traveling Tripper
VS	Ventilation System
WT	Wagon Tippler

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1 INTENT OF SPECIFICATION

1.1 The intent of this specification is to Renovate and Modernize various equipment & systems of Coal Handling Plant (CHP) including but not limited to [Coal Unloading, Conveying, Crushing, Stacking & Reclaiming, Bunker Filling System and all associated Electrical system, Control & Instrumentation systems and Civil & Structural work]. The renovated Coal Handling Plant shall be capable of operating with the following parameters to feed the coal to Boiler Bunkers of [No. of Units], each of the Boiler is designed for a steaming capacity of [...] TPH at [...] °C & [...] kg/cm² (a) pressure to generate rated unit output of [210/215/220/250] MW:

Description	Units	Design Parameters
Number of shifts of operation per day	.....	[...]
No. of Units to be catered by the designated CHP	.....	[...]
Number of rakes to be unloaded per day in Track Hopper	.....	[...]
Number of rakes to be unloaded per day in Wagon Tippler	.....	[...]
Rated & Design Tippling rate per hour	.....	[...]
Rated & Design Capacity of Paddle Feeder	TPH	[...]
Conveying Capacity from Track Hooper to Crusher House	TPH	[...]
Conveying Capacity from Wagon Tippler to Crusher House	TPH	[...]
Rated & Design Capacity of Screen	TPH	[...]
Rated & Design Capacity of Crusher	TPH	[...]
Conveying Capacity from Crusher House to Boiler Bunker	TPH	[...]
Rated & Design Stacking Capacity	TPH	[...]
Rated & Design Reclaiming Capacity	TPH	[...]
Rated & Design Capacity of Traveling Tripper	TPH	[...]

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1.2 The Bidder shall carry out the required replacement / refurbishment / retrofitting of the various equipment/systems of Coal Handling Plant package as per the requirements of his design so as to make the same capable of operating for an extended life of [20/25] years and giving the output specified in the subsequent clauses of this specification in order to be compatible with the requirement of Main Plant package. The scope of replacement / refurbishment / retrofitting shall include but shall not be limited to the scope of work mentioned in clause 4.6 which is based on the recommendation of RLA/CA and EA studies conducted during [.....]. However, any other items/systems which have not been specifically mentioned but are considered necessary by the Bidder for giving the intended performance of various equipment/systems of CHP package, shall also be included in the scope of Bidder and shall be separately highlighted by the Bidder in his proposal.

1.3 Bidders are required to quote the performance guarantee value for Auxiliary power consumption as per Table 1.2 below:

Table: 1.2

S.No.	Parameter	Performance Guarantee Values
1	Maximum Auxiliary Power Consumption (kW)	[.....]

For Auxiliary power consumption, the best quoted value shall be considered as base parameter and other bids shall be cost loaded as per difference between base parameter and respective quoted guaranteed parameter multiplied by evaluation factors specified in the Commercial Volume (Volume-I).

1.4 The modified/replaced/retrofitted equipment shall conform to the requirement of the specification prescribed in Section-II of Volume-II. The relevant technical details like OEM's Specifications and Drawings for the existing equipment required to be modified / replaced / retrofitted have also been provided in Volume-II, Section-II for the reference of the Bidders.

1.5 Bidders are required to carry out necessary modifications / replacement in the existing mechanical / electrical equipment or systems including related

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civil/structural works as per specification requirement and also based on their own assessment.

- 1.6 The scope of work for R&M shall include designing / re-designing, basic and detailed engineering, re-engineering, refurbishing / retrofitting, supply, inspection and testing at supplier's works, packing, forwarding to site, forwarding from site to Bidder's facilities, unloading and storage at site, pre-assembly, machining if required, site fabrication, erection, replacing of various equipment and systems, application of paints and thermal insulation, carrying out all pre-commissioning checks/ tests and any other work required to complete the system, commissioning and trial operation, performance tests of various equipment and systems covered under this Specification. Bidder's scope shall also include dismantling of the existing equipment/ facilities, including unloading & transportation to designated storage / disposal yard, wherever required as a result of augmentation of existing mechanical, electrical, I&C and civil/structural/ architectural works. The Bidder shall restore the equipment/ facilities, whenever applicable, after carrying out necessary renovations/modifications under the scope of R&M works.

All the tools & tackles, labour and other facilities required for dismantling and restoration shall also be in the scope of the Bidder.

Bidder shall also put back into service all the systems/equipment of the units after completion of R&M works, whether any modification is carried out on the same or not. All necessary tools, tackles, labour, instruments, spares, consumables etc. required for putting back into operation shall also be provided by the Bidder.

- 1.7 It is not the intent to specify completely herein all aspects of services and equipment to be provided by the Bidder who in any case shall be responsible for fulfillment of the intent of Specification. Irrespective of whether specifically mentioned or not, the services, equipment and systems to be provided in accordance with this Specification shall also form a part of the scope of work and shall conform in all respects to the highest standard of engineering, design, quality and workmanship so that after completion of R&M work by the Bidder, the plant shall be capable of performing completely in a safe, reliable and sustained manner as acceptable to the Owner.
- 1.8 Unless otherwise specifically clarified by the Owner, interpretation by the Owner in respect of scope of supplies & services and the meaning of the Specifications, drawings, requirements of operation, maintenance,

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redundancy etc., shall be final and binding on the Bidder. Owner shall have the right to reject or accept any work or material which in his assessment is not technically complete and proven to meet the requirements of this Specifications and/or applicable National and International Codes & Standards mentioned elsewhere in this Specification.

- 1.9 The requirements, conditions, appendices etc, given in various parts/ sections of technical Specifications shall form integral part of this Specification. Bidder is required to carefully examine and understand the Specifications and seek clarifications, if required, to ensure that he has understood the Specifications as intended by the Owner. In the absence of any specific clarifications made to the Owner during Bidding stage, the interpretation of Owner shall be final. The Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. All such points are required to be clarified & resolved during Bidding stage.
- 1.10 Any deviation or variation from the scope of supply and services or the intent of the Specification shall be clearly brought out under the schedule of Technical / Commercial deviations, irrespective of the fact that such deviation / variation may be standard practice or possible interpretation of the Specifications by the Bidder. In case, no clear and specific deviation is taken by the Bidder in the relevant schedule of Bid Proposal Sheet while making his Bid proposal, it will be construed that the Bidder shall comply with the stipulations of the Specification fully with regard to scope of services and supplies to be provided by him to achieve the objective of R&M. Further, unless otherwise specifically clarified by the Owner, the interpretation by the Owner in respect of scope of supplies and services to be performed by the Bidder shall be final and binding.
- 1.11 If the Bidder feels that, in his opinion certain features brought out in his offer are superior to what has been specified, these may be highlighted separately in the Bid. The Bidder at his own discretion may also make Alternate offers, which in his opinion are of superior technology, material etc. to the specified requirements leading to better performance like efficiency / output etc. of the units after renovation. In such case, the Bidder shall carry out a comprehensive study and clearly identify the scope of offer in his alternate proposal. The Bidder shall furnish that detailed study to Owner along with the Bid where the Bidder shall bring out in detail the scope of modifications required to be carried out by him in the various systems and equipment including but not limited to *[Coal Unloading, Conveying, Crushing, Stacking*

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& Reclaiming, Bunker Filling System and all associated Electrical system, Control & Instrumentation systems and Civil & Structural work].

Such Alternate proposals shall be supplemented with sufficient amount of information like specified design standards and performance requirements, Bidder's experience, operating feedback, provenness, etc. for justifying such proposals. Implications of such Alternate offers on the performance, output, efficiency, auxiliary power consumption, etc. shall be clearly brought out in the Bid to enable the Owner to determine the advantages, superiority and acceptability of the proposals.

However the Bidder's Base offer shall necessarily be in line with the Specification requirements.

The Base offers will be evaluated as per procedure outlined in the Bid documents and the Alternate Offers of the lowest evaluated Bidder will only be considered for acceptance or otherwise. Owner may reject alternative proposals submitted by the Bidder at his sole discretion, without assigning any reason what so ever.

- 1.12 In the event of conflict between requirements of any two clauses of the Specification documents or requirements of different Codes/ Standards specified, the more stringent requirement as per the interpretation of the Owner shall apply, unless confirmed otherwise by the Owner in writing.
- 1.13 The General technical conditions pursuant to the Contract, placed separately in this Specification, shall form an integral part of the Specification. These conditions shall supplement all the detailed technical Specification and requirement identified in this Specification.
- 1.14 Out of complete unit comprising of mechanical, electrical, C&I systems and equipment, some components/systems are envisaged to be replaced with new ones having better design features while some of the other components are to be refurbished / upgraded by the Bidder under present R&M Work. It shall be the responsibility of the Bidder to ensure that components/ equipment/ systems being supplied new OR components/ equipment/ systems being refurbished / upgraded by him are fully compatible and integrated with the existing equipment / systems so as to give safe, reliable and sustained operation of the complete unit. Modifications needed on the assembled equipment to ensure complete integration are to be brought out by the Bidder in the Bid and such modifications, if any, after Owner's approval shall be carried out by the Bidder to the satisfaction of the Owner.

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- 1.15 The systems shall operate without any restriction over the entire range of operating conditions as envisaged in the subsequent section of the Specification. The Bidder shall ensure that after R&M there are no restrictions/ alterations in modes of operations of the system, as per the original/existing operation philosophy.
- 1.16 As the various equipment/ systems/ components are to be fitted in the existing plant, Bidder is advised to visit the plant site to get fully conversant with the job, site conditions, and constraints, and collect all the information as required and as available before quoting against this Specification.
- 1.17 A brief extract of the existing plant, the original design details/ performance parameters along with plant details, operating history and known problem areas; wherever possible are brought out in the successive section of this Specification. Relevant plant layout drawings and certain key schematic drawings, as available, have also been provided in Annexure-I of this section of the specification for the purpose of familiarization & guidance only. The successful Bidder shall prepare and provide the additional drawings and documents describing the design and engineering details and the manuals for carrying out erection, commissioning and operation of the renovated unit.

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2 SITE & PROJECT SPECIFIC INFORMATION

2.1 Project Name

Project Title: [...]

Existing Capacity: [X xMW]

2.2 Project Location

The proposed project site is located at [...], in District [...] in the state of [...].
The location details of the project site are as indicated below:

Table: 2.1

Particulars	
Latitude	[... ° ...' ..."] N
Longitude	[... ° ...' ..."] E
Height above mean sea level	[...] m
Seismic Zone	Zone - [...]
Distance from [...] town	[...] km
Distance from national highway No. [...]	[...] km
Distance from state highway No. [...]	[...] km
Distance of nearest airport [...]	[...] km
Distance of nearest seaport [...]	[...] km

2.3 Climatological Data

Table: 2.2

Particulars	
Highest monthly mean of daily maximum temperature	[...] °C
Lowest monthly mean of daily maximum temperature	[...] °C

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Particulars	
Highest monthly mean of daily minimum temperature	[...] °C
Lowest monthly mean of daily minimum temperature	[...] °C
Annual mean of daily maximum temperature	[...] °C
Annual mean of daily minimum temperature	[...] °C
Extreme highest temperature	[...] °C
Extreme lowest temperature	[...] °C
Design ambient temperature (unless specified otherwise)	{50} °C
Relative Humidity: Maximum Minimum	[...] % [...] %
Average annual rainfall	[...] cm
Heaviest rainfall in 24 hours so far	[...] cm
Number of rainy days in a year	[...]
Highest monthly mean of wind speed	[...] km/h
Lowest monthly mean of wind speed	[...] km/h
Maximum wind speed	[...] km/h

Table: 2.3

Season	Dry bulb temperature	Wet bulb temperature
Summer	[...] °C	[...] °C
Monsoon	[...] °C	[...] °C
Winter	[...] °C	[...] °C

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2.4 Fuel

At present the power station is sourcing coal from [...] coal mines. The coal is being transported to the project site by [Indian Railways/ MGR system/ cross country conveyor]. Proximity of Railway line to site from Railway Station is about [...] km. The railway link shall also be used for transportation of heavy equipment to site during construction phase and to bring main and secondary fuel to the power plant during operation of plant.

2.5 Coal Analysis

- a. Proximate and ultimate analysis of coal (on as received basis)

Table: 2.4

Sl. No.	Particulars	Unit	Performance Coal	Worst Coal	Best Coal
(i)	Proximate Analysis				
1	Moisture	%	[...]	[...]	[...]
2	Ash	%	[...]	[...]	[...]
3	Volatile Matter	%	[...]	[...]	[...]
4	Fixed Carbon	%	[...]	[...]	[...]
	Total	%	100	100	100
(ii)	Gross calorific value	kCal/kg	[...]	[...]	[...]
(iii)	Grindability index	HGI	[...]	[...]	[...]
(iv)	Ultimate analysis				
1	Carbon	%	[...]	[...]	[...]
2	Hydrogen	%	[...]	[...]	[...]
3	Sulphur	%	[...]	[...]	[...]
4	Nitrogen	%	[...]	[...]	[...]
5	Oxygen (by	%	[...]	[...]	[...]

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Sl. No.	Particulars	Unit	Performance Coal	Worst Coal	Best Coal
	difference)				
6	Moisture	%	[...]	[...]	[...]
7	Ash	%	[...]	[...]	[...]
	Total	%	100	100	100

2.6

Water Analysis

[Describe the source of consumptive and / or cooling water (name of river or sea or bore well) and the type of condenser cooling system being adopted for the unit.]

Chemical analysis of water which is used for this project is indicated as below:

Table: 2.5

Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
A	Raw Water Analysis		
1	Calcium	mg/l	[...]
2	Magnesium	mg/l	[...]
3	Sodium	mg/l	[...]
4	Potassium	mg/l	[...]
5	Total Cations	meq/l	[...]
6	Bicarbonates	mg/l	[...]
7	Carbonates	mg/l	[...]
8	Nitrate	mg/l	[...]
9	Chloride	mg/l	[...]
10	Sulphate	mg/l	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
11	Total Anions	meq/l	[...]
12	Silica	mg/l	[...]
13	Iron Fe	mg/l	[...]
14	pH value	.....	[...]
15	Turbidity	NTU	[...]
16	Total Dissolved Solids	mg/l	[...]
17	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[...]
18	BOD	mg/l	[...]
19	COD	mg/l	[...]
B	Clarified Water Analysis		
1	Calcium	mg/l	[...]
2	Magnesium	mg/l	[...]
3	Sodium	mg/l	[...]
4	Potassium	mg/l	[...]
5	Total Cations	meq/l	[...]
6	Bicarbonates	mg/l	[...]
7	Carbonates	mg/l	[...]
8	Nitrate	mg/l	[...]
9	Chloride	mg/l	[...]

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Sl. No.	Constituents/Parameters	Units	Concentration (Range/Value)
10	Sulphate	mg/l	[...]
11	Total Anions	meq/l	[...]
12	Silica	mg/l	[...]
13	Iron Fe	mg/l	[...]
14	pH value	.....	[...]
15	Turbidity	NTU	[...]
16	Total Dissolved Solids	mg/l	[...]
17	Organic Matter (Oxygen absorbed from Acid Permanganate in 4 hr)	mg/l	[...]

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3 EXISTING PLANT DETAILS

The Power Plant, is of the configuration of [...x...MW]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The boiler for the unit is of [PF/CFBC] design. The boiler is provided with [front & rear/ corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. The Coal Handling Plant was supplied by M/s [...] and designed for rated conveying capacity of [...] TPH. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [...] substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...] coal mines. The consumptive water for the power plant is being sourced from [...river /...sea].

3.1 Operational Background

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The deterioration experienced over the years in Plant's Average Performance Parameters is shown in Table 3.1.

3.1.1 Average Performance Parameters of CHP over the Life

Table: 3.1
CHP Equipment's Average Performance Parameters over the Life

Years after Installation	Name of the Equipment	Availability (%)	Output (Capacity)	Aux. Power Consumption (%)	Total Consumptive water requirement	Hours of operation per day (24 hrs)
5	[...]	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]	[...]

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3.1.2 CHP Equipment's Average Performance Parameters during the last five years

Table 3.2 indicated below, illustrates variations over the last five years in the performance parameters.

{Furnish in the Table 3.2 below, the Average Values for the last five years. However, for the Parameters in respect of 'One Year back' and 'Current Year', furnish the Maximum, the Minimum and the Average Values.}

Table: 3.2

CHP Equipment's Average Performance Parameters during the Last Five Years

Equipment Name	Period	Availability (%)	Output (Capacity)	Efficiency (%)	Aux. Power Consumption (%)	Forced Outages (Nos.)
[.....]	Four Years back	[...]	[...]		[...]	[...]
	Three Years back	[...]	[...]		[...]	[...]
	Two Years back	[...]	[...]		[...]	[...]
	One Year back	[...]	[...]		[...]	[...]
	Current year	[...]	[...]		[...]	[...]
[.....]	Four Years back	[...]	[...]		[...]	[...]
	Three Years back	[...]	[...]		[...]	[...]
	Two Years back	[...]	[...]		[...]	[...]
	One Year back	[...]	[...]		[...]	[...]
	Current year	[...]	[...]		[...]	[...]

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3.1.3 Auxiliary Power Consumption of Coal Handling Systems (for running stream)

Table-3.3

Sl. No.	Equipment/System	Units	Power Consumption
A	Stream –I : Unloading & Direct feeding to bunker		
i.	Unloading & Feeding equipments under Track Hopper complex.		
ii.	Unloading & Feeding equipments under Wagon Tippler complex.		
iii.	Conveying Stream (Belt conveyors) to Crusher House		
iv.	Screening , Crushing and dust extraction equipments in crusher house.		
v.	Conveying stream (conveyors) from crusher house to coal bunker.		
vi.	Bunker filling equipment and dust extraction system for bunker.		
vii.	Inline Magnetic Separator		
viii.	Dust Suppression System		
ix.	Dust Extraction System		
x.	Scoop Coupling		
xi.	Sampling System		
xii.	Travelling Tripper		
xiii.	Vibrating Feeder (if any)		
B.	Stream II : Unloading & stacking to stockyard		
i.	Unloading & Feeding equipments under Track Hopper complex.		
ii.	Unloading & Feeding equipments under Wagon Tippler complex.		
iii.	Conveying Stream (Belt conveyors) to Crusher House		

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Sl. No.	Equipment/System	Units	Power Consumption
iv.	Screening, Crushing and dust extraction equipments in crusher house.		
v.	Yard Conveyors		
vi.	Stacker cum reclaimer		
vii.	Inline Magnetic Separator		
viii.	Dust Suppression System		
ix.	Dust Extraction System		
x.	Scoop Coupling		
xi.	Sampling System		
xii.	Travelling Tripper		
xiii.	Vibrating Feeder (if any)		
C	Stream III: Reclaiming from stockyard & conveying to Boiler bunker		
i.	Conveying stream (conveyors) from crusher house to coal bunker.		
ii.	Bunker filling equipment and dust extraction system for bunker.		
iii.	Stacker cum reclaimer		
iv.	Yard Conveyer		
v.	Inline Magnetic Separator		
vi.	Dust Suppression System		
vii.	Dust Extraction System		
viii.	Scoop Coupling		
ix.	Sampling System		

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Sl. No.	Equipment/System	Units	Power Consumption
x.	Travelling Tripper		
xi.	Vibrating Feeder (if any)		

3.2 Salient Technical Feature of Existing Coal Handling Plant

{Describe in this sub-section, the Design Parameters and Salient Features of all the important Equipment and Systems of Coal Handling Plant as mentioned below}.

3.2.1 Existing Plant/Equipment Details

The Coal for the Power plant is be sourced from the [...] block, which is approx. [...] km from the project site. The coal is being unloaded using Wagon tippler or track hopper arrangement at the Power plant unloading area.

[The details of the system are mentioned in the table below:]

Table: 3.4

Description	Units	Design Parameters
A. Wagon Tipplers		
Type	[...]
Max. weight of wagons to be handled	[...]
Nos. of Tippling /Hr. considering inhaul & outhaul operation	Tips/h	[...]
Duty	[...]
Drive Details		
• Brake	[...]
• Clamping Arrangement of Wagons	[...]
• Cradle	[...]

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Description	Units	Design Parameters
B. Side Arm Charger		
Type	[...]
Travel of Trolley	[...]
Capacity	.....	[...]
C. Apron Feeder		
Type	.....	[...]
Capacity	TPH	[...]
Location	.....	[...]
Quantity	.....	[...]
No of starts/min. for drive	.....	[...]
Length of Apron feeder	mm	[...]
Width of pan	mm	[...]
Material of Construction		
• Chain Link	.....	[...]
• Apron Pan	.....	[...]
• Rollers	.....	[...]
D. Dribble Feeder		
Belt Width	[...]
Belt Speed	[...]
Capacity of conveyor	TPH	[...]
Centre to Centre distance	[...]

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Description	Units	Design Parameters
Hours of Operation	hrs	[...]
Bulk Density of material	T/m3	[...]
Lump size of material	mm	[...]
Angle of surcharge	Deg	[...]
Troughing angle	.....	[...]
Type of fabric	.....	[...]
No. of Ply	.....	[...]
Grade	.....	[...]
Designation of belt	.....	[...]
Cover thickness (min)	mm	[...]
Cover thickness (min)	mm	[...]
Breaker ply required	.....	[...]
Type of Joint	.....	[...]
Tensioning arrangement	.....	[...]
E. Track Hopper		
Length of the track hopper	.....	[...]
Depth of track hopper	.....	[...]
Width of track hopper	.....	[...]
Holding Capacity of the hopper	[...]
Material of Construction	[...]
F. Paddle feeders		

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Description	Units	Design Parameters
Type	[...]
Location	[...]
No of starts/min. for drive	[...]
Capacity	TPH	[...]
Spacing of carrying idlers in the loading zone of Paddle feeder.	mm	[...]
Duty	hrs/Day	[...]
No of equipment working / stream	[...]
Drive arrangement	[...]
Feeder Carriage	[...]
Paddle Wheel Speeds	[...]
Paddle Feeder Rails		
• Size	[...]
• Support arrangement	[...]
Feeder Carriage Wheel		
• Type.	[...]
• Bearing	[...]
Material of Construction		
• Paddle Carriage.	[...]
• Shafts	[...]
• Paddle Wheel	[...]

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Description	Units	Design Parameters
• Feeder carriage wheels.	[...]
• Vanes		
Others		
• Anti-collision Device	.....	[...]
• Control	.....	[...]
• Location of control panel	.....	[...]
• Dust Suppression water Tank	.....	[...]
G. Belt Conveyor [Details shall be provided for all belt Conveyors]		
Belt Details	.....	[...]
Horizontal length	.....	[...]
Slope	Deg	[...]
Belt width	m	[...]
Belt speed	m/sec	[...]
Material to be handled	.....	[...]
Lump size	.....	[...]
Horizontal length	[...]
Slope	Deg	[...]
Belt width	m	[...]
Belt speed	m/sec	[...]
(i) Pulley		
Pulley Width	[...]

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Description	Units	Design Parameters
Lagging Material & thickness	mm	[...]
Lagging Pattern	[...]
Hardness of lagging material	.....	[...]
Construction Features	.....	[...]
Type of Construction	.....	[...]
Pulley Diameter	.....	[...]
Shell thickness	mm	[...]
Angle of Wrap for drive pulley.	deg	[...]
Type of Plumber Block	.....	[...]
Type of bearing	.....	[...]
Bearing life (hours)	hrs	[...]
Shaft material	.....	[...]
Type of sealing	.....	[...]
Lubrication	.....	[...]
(ii) Idlers	.....	[...]
Roller material	.....	[...]
Min. shell thickness (mm)	mm	[...]
Type of bearing	[...]
Type of idler lubrication	[...]
Bearing Lubrication	[...]
Bearing life		[...]

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Description	Units	Design Parameters
	hrs	
Type of Sealing	[...]
Frame Material	[...]
No of Rolls	.....	[...]
Idler Spacing	.....	[...]
(iii) Gear Box		
Location	.....	[...]
Duty	hrs/day	[...]
Frequency of Start	.....	[...]
Reducer Base Frame	.....	[...]
Gear Box service factor	.....	[...]
Type of cooling	.....	[...]
Input Motor Speed (Sync.)	rpm	
Material of Construction		
• Casing/Housing	[...]
• Gear & Pinion	[...]
• Shaft	[...]
(iv) Bearing	[...]
Make	[...]
Type of Bearing	hrs	
Life	[...]

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Description	Units	Design Parameters
Method of Lubrication	[...]
Lubricating medium	[...]
Type of enclosure	.....	[...]
(v) Fluid Coupling	.....	[...]
Location	.....	[...]
Type of Service	hrs/day	
Type of coupling	.....	[...]
Maximum allowable slip	.....	[...]
Rated input speed	rpm	[...]
Type of Cooling	.....	[...]
Direction of rotation	.....	[...]
Starting Torque	kg.m	[...]
Balancing	.....	[...]
(vi) Geared Coupling		
Type of Coupling	.....	[...]
Type of Service	h/day	
Equipment connected	[...]
Material of Construction	[...]
Hub & Flanges	[...]
Gear	[...]
Retainer disc.	[...]

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Description	Units	Design Parameters
Permissible misalignment (Approx.)	[...]
Parallel.	mm	[...]
Angular	Deg	[...]
(vii) Pin Bush Coupling		
Type of Coupling	.....	[...]
Type of Service	.....	[...]
Equipment connected	.....	[...]
Material of Construction	.....	[...]
Hub	.....	[...]
Flanges	.....	[...]
Permissible misalignment (Approx.)	.....	[...]
Parallel.	mm	[...]
Angular	Deg	[...]
(viii) Belt Protection Switches		
Spacing of Belt Sway switch	.....	[...]
Spacing of Pull cord switch	[...]
(ix) External Scraper		
Type	[...]
Location	[...]
Material of Construction		
• Frame	[...]

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Description	Units	Design Parameters
• Lever (if any)	[...]
• Scraper Blades	[...]
(x) V-Plough Internal Scraper		
Type	[...]
Location	[...]
Material of construction	[...]
Frame	[...]
Scraper blade	[...]
(xi) Brakes for Conveyors		
Type of Brake	[...]
Type of Service	[...]
Type of Coupling	[...]
Max. no. of stopping/tripping required per hour	[...]
Adjustments	[...]
Material of construction		
• Base	[...]
• Brake drum	[...]
• Brake arm	[...]
• Shoes	[...]
• Springs	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[26]	25.09.2014

Description	Units	Design Parameters
H. Transfer Towers [Details shall be provided for all Transfer Towers]		
No of transfer towers	no. s	[...]
Dimension(LxWxH)	mm	[...]
No of floors	no. s	[...]
Type of Construction	....	[...]
I. Flap Gates [Details shall be provided for all Flap Gate]		
Type	....	[...]
Location	....	[...]
Required numbers	....	[...]
Material handled	....	[...]
Material size	mm	[...]
Chute valley angle and gate position	....	[...]
No of ways	....	[...]
Hours of operation/day	....	[...]
Travel range	....	[...]
Actuator type	....	[...]
Speed of Travel	mm/s	[...]
Minimum thrust	kg	[...]
Minimum Stroke Length	mm	[...]
Material of Construction	[...]
• Gate	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[27]	25.09.2014

Description	Units	Design Parameters
• Shaft	[...]
• Chute Plate	[...]
• Liner	[...]
• Liner Type	[...]
Bearing		
• Type	[...]
• Life	[...]
• Type of sealing	[...]
• Method of lubrication	[...]
Miscellaneous Requirement		
Type of protection	[...]
Type of limit switches	[...]
J. Stacker-Cum- Reclaimer		
Type	[...]
Stacking capacity		
• Rated	TPH	[...]
• Design	TPH	[...]
Reclaim capacity	[...]
Total travel	[...]
Height of the stockpile	mm	[...]
Top & bottom Width of stockpile		

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Description	Units	Design Parameters
Length of the stockpile at base		
Boom Length		
Duty	h/Day	
Lump Size	.....	[...]
Moisture content	.....	[...]
Structural Design Data	.....	[...]
For operating condition with maximum operating wind factor	.....	[...]
For non-operating condition with maximum wind velocity	.....	[...]
Seismic Co-efficient	.....	[...]
Live load for walk-ways, Service platforms, Machinery floors.	.....	[...]
Anchoring arrangement for over-turning protection due to storm	.....	[...]
Track rail gauge		
Bucket wheel	.....	[...]
Type.	.....	[...]
Drive	.....	[...]
Material of construction of wheel & bucket	[...]
Holding brakes to be provided	[...]
Bucket Liners material	[...]
Carriage	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[29]	25.09.2014

Description	Units	Design Parameters
Travel Speed	[...]
Material of construction	[...]
Luffing mechanism of boom.	[...]
Slewing drive	[...]
Slewing Range	[...]
Overturning protection Details	[...]
Operator's Cabin	[...]
K. Vibrating Grizzly Feeders		
Location	[...]
Quantity	[...]
Size of coal to be handled	mm	
Type of feeder	[...]
Design Capacity of coal to be handled	[...]
Design for operating hours	hrs	
Constructional Features		
• Vibrator tray	[...]
• Down slope of the tray	Deg	
• Type of mounting	[...]
• Type of discharge rate controller	[...]
L. Roller screen [if applicable]		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[30]	25.09.2014

Description	Units	Design Parameters
Type	[...]
Nos. required	[...]
Capacity (Rated)	TPH	[...]
Capacity (Design)	TPH	[...]
Material to be handled	[...]
Maximum Lump Size	[...]
Disc rolls / Spacer Discs	[...]
Disc Roll Shafts	[...]
Bevel Gears	[...]
Longitudinal drive shaft	[...]
Liner plates material and thickness.	[...]
Structural	[...]
Motor	[...]
• Type of Motor	[...]
• Insulation class	[...]
• Enclosure	[...]
Coupling Guards	[...]
Control Cabinet	[...]
M. Primary Coal Crusher (Rotary Breaker) if applicable		
Type of crusher	[...]
Quantity	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[31]	25.09.2014

Description	Units	Design Parameters
Location	.....	[...]
Maximum Moisture Content	%	[...]
Input size	mm	[...]
Maximum percentage of oversized lumps (Capacity Guaranteed)	%	[...]
Capacity Design	TPH	[...]
Crusher & Motor	.....	[...]
Design moisture content	%	[...]
Hours of operation/day	Hours	[...]
Allowable crusher vibration	micron	[...]
Noise Level at a distance of 1 m horizontally and 1.5 m above the ground level	dBA	
N. Secondary Coal Crusher - Ring Granulator		
Quantity		[...]
Location	.....	[...]
Material to be crushed	.....	[...]
Capacity	.....	[...]
Crusher RPM	RPM	
Coal Hard groove index	[...]
Input size	mm	[...]
Guaranteed output size	mm	[...]
Hours of operation/day	Hrs	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[32]	25.09.2014

Description	Units	Design Parameters
Material of Construction		
• Shaft	[...]
• Casing	[...]
• Suspension Bar/Ring/Roller/ Hammer	[...]
• Frame	[...]
• Breaker Plate	[...]
• Cage assembly		
Internal parts in contact with coal	[...]
Type of hydraulic coupling	[...]
Crusher Bearing		
Bearing type	[...]
Life	[...]
Lubrication	[...]
Cooling arrangement	[...]
Enclosure	[...]
Type of bearing seal	[...]
Tramp iron trap or pocket to be provided	[...]
Allowable crusher vibration	[...]
Installation of Crusher	[...]
O. Travelling Tripper and Bunker		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[33]	25.09.2014

Description	Units	Design Parameters
Sealing Arrangement		
Location	[...]
Hours. of operation/day	Hours	[...]
Belt fabric	[...]
Belt width	m	[...]
Speed of belt	[...]
No. required	[...]
Capacity	[...]
Max. moisture of handling material	[...]
Construction material of frame	[...]
Type of lubrication	[...]
Wheel material	[...]
Bearing life.	[...]
Gear Box Arrangement	[...]
Drive	[...]
Motor margin for tripper bogie on design power at the motor shaft.	[...]
Minimum no of starts.	[...]
Brake type	[...]
Travel limit switches required.	[...]
P. Chutes , Hopper & Skirt Boards		
(i) Chute & Hopper Details		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[34]	25.09.2014

Description	Units	Design Parameters
Chute material	.....	[...]
Chute thickness	mm	[...]
Hopper material	.....	[...]
Hopper thickness	mm	[...]
Minimum valley angle	Deg	[...]
(ii) Skirt Boards		
Length	mm	[...]
Height	mm	[...]
Width	mm	[...]
Plate thickness(Side Top cover)	mm	[...]
Material flow rate handled (Rated Designed)	TPH	[...]
Moisture in coal	%	[...]
Q. Metal Detector		
Type	.....	[...]
Location	.....	[...]
Numbers Required	[...]
Duty	hours	[...]
Conveyor Capacity	TPH	[...]
Belt Width	m	[...]
Belt Speed	m/sec	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[35]	25.09.2014

Description	Units	Design Parameters
Troughing Angle	deg	[...]
Belt	.....	[...]
Type of Metal to be detected	.....	[...]
Min. size of metal to be detected	.....	[...]
Power Supply	.....	[...]
Suppressor Coil		[...]
Type of Marking device		[...]
Protective device provided		[...]
Local control panel provided		[...]
Special Features		[...]
R. Inline Magnetic Separator		
Quantity	.....	[...]
Location	.....	[...]
Conveyor Capacity (TPH)	.....	[...]
Material to be Conveyed	.....	[...]
Main Belt Fabric	.....	[...]
Main Belt Width	.....	[...]
Hours of Operation/day	.....	[...]
Tramp Iron Lifting Capacity		[...]
Operating Gap	mm	[...]
Tramp Iron Lifting Capacity	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[36]	25.09.2014

Description	Units	Design Parameters
S. Belt Weigher		
Type	[...]
Nos. required	[...]
Location	[...]
Belt width	m	
Weighing capacity (max.)	[...]
Weighing capacity (min.)	[...]
Accuracy	[...]
Type of Speed sensor	[...]
Type of load sensor	[...]
Type of calibration device	[...]
Guaranteed Min. accuracy (%)	[...]
Type of totalising unit	[...]
Rate indication	[...]
Protection class	[...]
T. Coal Sampling Unit		
Name of manufacturer	[...]
Experience & Details	[...]
Quantity & Capacity Of Coal samplers	[...]
Coal sampler parameters	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[37]	25.09.2014

Description	Units	Design Parameters
• Lump size of coal	[...]
• Suitable for belt width	[...]
• belt capacity (TPH)	[...]
Certificate from client Enclosed	[...]
Standard /Code to which sampling system conforms	[...]
U. Plain Water Dust Suppression System		
(i) Wagon Tippler Dust Suppression System(Plain Water Type)		
Capacity of each nozzle	[...]
Nozzle Spacing	mm	
No of nozzles installed	[...]
No of nozzles operating simultaneously	[...]
(ii) Dust Suppression System foe wagon Tippler (Dry Fog Type) if applicable		
Operation	[...]
Location of spray	[...]
Capacity and pressure at inlet of spray head	[...]
(iii) Dust Suppression For Track Hopper		
Operation	[...]
Pumps	[...]
Mini no of nozzles per spray head	[...]
Trolley Mounted Arrangement for	[...]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[38]	25.09.2014

Description	Units	Design Parameters
paddle feeders		
Ring Header	NB	[...]
Hose Tapping	[...]
Trolley tank capacity	[...]
Nozzle spacing for track hopper	mm	[...]
Nozzles	[...]
Flow from each nozzle	[...]
(iv) Dust Suppression For Coal Stack Yard		
Pump	[...]
Spray Head Type	[...]
Throw of Sprinklers	[...]
V. Dry Fog System for Transfer Point & Crusher House		
Spray Bar Assembly		
• No. of spray bar assemblies per transfer point	[...]
• Material of spray bar assemblies	[...]
• No. of nozzles per assembly	[...]
• Type of nozzles with flow ratings (Air / Water	[...]
• Material of nozzles	[...]
Pressure Regulating Units		
• No. of PRUs	[...]

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Description	Units	Design Parameters
• Type of regulation	[...]
• Regulation ranges	[...]
Flow Activation Stations		
• No. of Flow Activation Stations	[...]
• Type	[...]
Compressor with accessories		
• Make	[...]
• Model	[...]
• Type	[...]
• Capacity	[...]
Sump Pumps		
Location	[...]
Nos	[...]
Type	[...]
Capacity	m3/hr	[...]
Size of each drain pit	[...]
Material of Sump pump	[...]
• Casing & rotor housing	[...]
• Rotor	[...]
• Shaft	[...]

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Description	Units	Design Parameters
<ul style="list-style-type: none"> Shaft sleeve 	[...]
W. Ventilation and Air Conditioning		
Type of Ventilation	[...]
Area Description – Location	[...]
Fans	[...]
<ul style="list-style-type: none"> Type 	[...]
<ul style="list-style-type: none"> Supply 	[...]
<ul style="list-style-type: none"> Exhaust 	[...]
Filters	[...]
Type	[...]
Pressurized Ventilation		
Area Description - Location	[...]
Type of Ventilation	[...]
Fans	[...]
<ul style="list-style-type: none"> Type 	[...]
<ul style="list-style-type: none"> Supply 	[...]
<ul style="list-style-type: none"> Exhaust 	[...]
Filters	[...]
Type	[...]
X. Dust Extraction System in Crusher House at VSF & Belt Feeder Floor:		
Type of DE System	[...]

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Description	Units	Design Parameters
Dust Collection method	[...]
Dust disposal arrangement upto Coal Settling Pond	[...]
Y. Elevator		
Load Carrying Capacity	T	[...]
Location	.....	[...]
Type of elevator	.....	[...]
Speed (M/Min.)	.....	[...]
Z. Hoists and Chain Pulley Blocks {Details for each hoist shall be provided}		
Type of Hoist	.....	[...]
Capacity	T	[...]
Location	.....	[...]
Travel	m	[...]
Lift	m	[...]

3.2.2

Electrical System

[Electrical System for Coal handling package of R&M of Unit No. [...] of [Name of the Power Plant] is described as below:

Two numbers of 100% rated 6.6 kV feeders are provided by Owner at 6.6kV Station switchgear for feeding power to the complete Coal Handling Plant. Required number of adequately rated service Transformers of 6.6/0.433kV near load centers and associated 415V switchgear for feeding the auxiliaries of the complete Coal handling plant and all other associated equipments and system of like Cable Carrier, Lighting and Earthing & Lightning system are provided in CHP package. Dedicated DC system is provided for CHP package.

Brief write-up on the existing Electrical Equipment and Systems of Coal Handling System package describing the original design details is given below. Relevant plant layout drawings and certain key schematic drawings have also been

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furnished in Annexure-I of this section of the specification for the purpose of familiarization and modification if required].

A. Medium Voltage Switchgear

[Medium Voltage Switchgear is provided for feeding Conveyor motor load of CHP system at {6.6} kV level and for supplying service transformer for LT auxiliary loads. These CHP MV Board and Station MV board are connected through 6.6kV cables. The design parameters of MV Boards are furnished below:].

Table: 3.5

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Rated voltage, phases & frequency	V, Hz	[.....]
System neutral earthing		[.....]
Maximum system voltage	V	[.....]
One minute power frequency Voltage	kV (rms)	[.....]
Impulse withstand voltage	kV (peak)	[.....]
Continuous current rating of bus bars		[.....]
Short Circuit rating of Bus bar with duration	kA & sec	[.....]
Bus bar Material	Al/Cu	[.....]
Type- Fully Draw out/Fixed		[.....]
Maximum temperature of Bus Bars, dropper, connectors & contacts at		[.....]

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Description	Units	Design Parameters
continuous current rating under site reference ambient temperature		
Cable Entry		[.....]
Degree of Protection		[.....]
i) Bus bar		[.....]
ii) Others		
Thickness of steel		
i) Load bearing members		[.....]
ii) Non load bearing members		[.....]
Paint Shade		[.....]

B. Service Transformer

[The Service transformer of Oil/Dry type is provided to cater 100% of Coal Handling System LT load with 2 x100% configuration. The design parameters of the Service Transformer are furnished below:]

Table: 3.6

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type		[Oil/Dry.....]
Transformer application		[..Service]{Application Wise to be indicated}
Installation		[...Indoor/Outdoor.]

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Description	Units	Design Parameters
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Rated frequency	Hz	[.....]
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap		[.....]
Winding connection and vector group		[.....]
System fault level	kA	[HV.....]; [LV.....]
Insulation Level: a) One minute Power frequency withstand voltage b) Impulse withstand voltage	kV KV(peak)	[.....] [.....]
System earthing (a) HV (b) LV		[.....] [.....Solidly earthed.....]
Type of tap changer a) Range of Taps b) No of Steps		[.....Off Circuit.....] [.....] [.....]

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Description	Units	Design Parameters
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at a) Full load b) 75% load	%	[.....]

C. LV Switchgear (PMCC/MCC)

[The LV Switchgear is provided with two incomers and bus coupler or single bus with one incomer with outgoing feeders intend for CHP loads. The design parameters of the LV Switchgear /MCC are furnished below:

Table: 3.7

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Rated voltage, phases & frequency	V, Hz	[.....]
System neutral earthing		[.....]
Maximum system voltage	V	[.....]
One minute power frequency Voltage		[.....]
Continuous current rating of bus bars		[.....]
Short Circuit rating of Bus bar with duration	kA & sec	[.....]
Bus bar Material	Al/Cu	[.....]
Type- Fully Draw out/Fixed		[.....]

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Description	Units	Design Parameters
Type of Panel	Single/double Front	[.....]

D. Non Segregated Phase Bus Duct (NSPBD)

[The Non Segregated Phase Bus Duct (NSPBD) connects Service Transformer to Low Voltage Switchgear. The design parameters of the NSPBD are furnished below]: **Table: 3.8**

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type of bus duct		[.....]
Rated voltage and No. of phase	V	[.....]
Material of Bus bar and Enclosure		[.....]
Rated Current	A	[.....]
Designation (From and To)		[.....]
Type of cooling (NSPBD)		[.....]
Maximum temperature rise of conductor over 50oC ambient	oC	[.....]
Maximum temperature rise of enclosure over 50°C ambient	°C	[.....]
One minute power frequency voltage	KV (RMS)	[.....]

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withstand		
Continuous current rating at 50°C design ambient air temperature	A	[.....]
One second short circuit withstand rating	KA (RMS)	[.....]
Momentary short circuit withstand current	KA (Peak)	[.....]

[The DC system required for CHP is provided with 2 x100% battery with Battery Charger. The design parameters of the DC system comprising of Battery and Battery Charger are furnished below: However DC system for Main plant BTG package is covered under TG Package.]

Table: 3.9

Description	Units	Design Parameters
BATTERY		
Make/Manufacturer		[.....]
DC System Voltage	V	[220V.....]
Battery Type		[.....]
AH Rating/Rated Capacity	AH	[.....]
Number of cells		[.....]
End Cell Voltage	V	[.....]
Expected fault level at bus due to battery	kVA	[.....]

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Description	Units	Design Parameters
AH Efficiency at Rated load	%	[.....]
BATTERY CHARGER		
Make/Manufacturer		[.....]
Type of Battery Charger		[...Float & boost/Float cum Boost.....]
Battery Charger Rating	Amp	[.....]
AC Input Voltage , Phase , Frequency	V, Hz	[.....]
Short Circuit Level	kA/Sec	[.....]
Efficiency of Charger	%	[.....]
Guaranteed Efficiency		
a) At 50% load	%	[.....]
b)At rated load	%	[.....]
Power Factor		
a) At 50% load		[.....]
b)At rated load		[.....]

F. MV Cables

[The MV cables of 6.6kV UE Voltage grade is used for Tie connection between Station MV board and MV board of CHP and also for feeding service transformers for CHP package loads and Conveyor loads. The design parameters of the MV Cables are furnished below:]

Table: 3.10

Description	Units	Design Parameters
-------------	-------	-------------------

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Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

G. LV Cables

[The LV cables of 1.1kV Voltage grade are used for feeding LV motors of CHP package as well as for sub distribution system boards. The design parameters of the LV Cables are furnished below:]

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Table: 3.11

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

H. Control (Core) Cables

[The Control cables of 1.1kV Voltage grade are used for Protection, CT, VT connection and feedback/interlock signals. The design parameters of the Control (Core) Cables are furnished below:]

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Table: 3.12

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

I. MV/LV Motor

[The design parameters of MV)/LV motors used for CHP package are furnished below]:

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Table: 3.13

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Application		[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Frame Size		[.....]
Type of Cooling		[.....]
Installation		[.....]
Duty Type		[.....]
Load Factor		[.....]
Full load current		[.....]
Starting current & Starting PF	Times Normal current	[.....]
Winding connection	Star/Delta	[.....]
Full load speed		[.....]
Power factor and Efficiency		[.....]
Class of insulation		[.....]
Method of starting: :		[.....]
Main terminal box details		[.....]
Space Heater Details		[.....]

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Description	Units	Design Parameters
CT details if provided with differential protection		[.....]
RTD/BTD Details		[.....]

J. Actuator

[The design parameters of Electrical Actuators used for Coal Handling System package are furnished below]:

Table: 3.14

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Application		[.....](For each application)
Rating	kW	[.....]
Rated Voltage, Phase, Frequency	kV, Hz	[.....]
Installation		[.....]
Duty Type		[.....]
Load Factor		[.....]
Type		[... Integral/Non Integral.....]
Class of Insulation		[.....]

K. Cable Carrier System

[The Cable Carrier system for Coal handling package is described as below: Indoor Buildings are provided with Cable cellar/Trench and outdoor areas are provided with Pipe cum cable rack/Duct bank/Trench. Separate Tray is provided for MV cables. LV cables, Control cables and Instrumentation cables in the order that MV cables Tray at the top followed by LV, Control and Instrumentation Tray. Ladder

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type tray is used for MV, LV and Control cables, however Perforated Tray is used for Instrumentation cables. The Design parameters of Cable Carrier System are furnished below].

{Note: The Cable carrier system of Boiler, TG, AHP, eBOP and Mechanical BOP are covered in respective package itself. }:

Table: 3.15

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Size of Tray	mm	[.....]
Material		[.....]
Application		[.....] (I.e. MV/LV/Control/Inst.)
Type of Tray		[.....] (i.e.Ladder/Perforated)
Thickness of Tray	mm	[.....]
Thickness of Galvanization	mm	[.....]
Tray Cover Size	mm	[.....]
Cable Tray Accessories		
Tee	mm	[.....] {List out all size}
Cross	mm	[.....]{List out all size}
Bends	Deg	[.....]{List out all size}
Reducer	mm	[.....] to [.....]{List out all

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Description	Units	Design Parameters
		size}
Steel Supports		
a) ISMC	mm	[.....]{List out all size}
b) ISA		[.....]{List out all size}

L. Illumination System

[The illumination system is categorized mainly as Normal & DC lighting. Lighting System of CHP covers CHP Switchgear room, Conveyor lighting Crusher house, Junction Tower, Peripheral Lighting and roads which are in the boundary of CHP package. DC lighting are provided at strategic location which gets supply from DCDB. Lighting Distribution Board (LDB) is getting normally supply from 415V PMCC. Each LDB is provided with lighting transformer for isolation of lighting circuit from power circuit and also for limiting short time current rating. Outgoing circuits of LDB feeds Lighting panels which is placed local to fixtures. Separate LDB for indoor as well as for outdoor area is provided. The Design parameters of Illumination System and its major components comprising of LDB with transformer, Lighting Panel, Lighting Fixtures, Lighting wires and Lighting Poles are furnished below]:

{Lighting system for Boiler, TG, AHP, Mechanical BOP and eBOP are covered in respective package itself.}

Table: 3.16

Description	Units	Design Parameters
Lighting System:		
Voltage		
a)AC system		

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Description	Units	Design Parameters
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
b)DC system		
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
One Minute Withstand Voltage	V	[.....]
System Short-Circuit Level		
a) 415V AC	kA(rms)	[.....]
b) 220V DC	kA(DC)	[.....]
LDB/LP:		
Manufacturer Name		[.....]
Mounting		
a)LDB		[...Floor.....]
b) LP		[... Wall.....]
Installation		[.....](For each application ie for Indoor/Outdoor and area)
Type, No of Circuits/Feeder rating		[.....]
Lighting Transformer:		
Make of Transformer		[.....]
Type of Transformer		[...Dry.....]

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Description	Units	Design Parameters
Rating	KVA	[.....]
Voltage Ratio		[.....]
Impedance	%	[.....]
Lighting Wires:		
Make		[.....]
Voltage Grade	V	[.....]
Conductor Material	Cu/Al	[.....]
Size	Sq.mm	[.....]
Lighting Fixtures:		
Make		[.....]
Type of Luminaries		[.....]
Ballast Type		[.....]
Lighting Poles:		
Make		
Type of Poles		

M. Earthing and Lightning System

[The Earthing & Lightning System for Coal Handling package is described as below: Complete Equipment earthing with riser from main grid, peripheral building earthing and connecting to main grid with treated electrode with test link within the battery limit of CHP is covered in CHP package. Above ground earthing for CHP is covered in this package. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system for CHP battery limit of outdoor and building are covered in CHP Contractor scope of work and same shall be in line with

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earthing system. The Design parameters of Earthing and Lightning System are furnished below]:

{ Peripheral underground earthing as well as main earth grid below ground will be provided by others. }

Table: 3.17

Description	Units	Design Parameters
Earthing System:		
Make/Manufacturer		[.....]
Main Earthing Conductor		
a) Material		[.....]
b) Dia		[.....]
Treated Earth Pit/Earth Rod(Dia and Length)	mm & m	[.....]
Size of Earth Conductor		[.....]
a) MV Switchgear		{List out size of Flat Earth conductor used for different equipments of Power plant and no of points }
b) LV Switchgear		
c) MV Motors		
d) LV Motors {List out KW rating wise}	mm x mm	
e) Control panel, LPBS Etc.		
f) Transformer Body		
g) Transformer Neutral List out Transformer wise}		

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Description	Units	Design Parameters
h) Any other panel/Equipments		
Lightning System:		
Air Termination Rod		[.....]
a) Dia & Length		[.....]
b) Material		
Down comer		[.....]
a) Material		[.....]
b) Size		
Lightning Electrode with test link		[.....]
a) Material		
b) Dimension(Length and Dia)		[.....]

3.2.3 Control & Instrumentation

[The existing control and instrumentation system generally is an old control system and requires large scale replacement owing to obsolescence of the existing equipment. Coal handling plant control system is envisaged with the relay based hardwired logic which requires replacement with new Control System for coal handling plant which shall be Programmable Logic Controller (PLC) based or shall be implemented through micro-processor based distributed control system (DCS) covering total functional requirements of sequence control, interlock & protection, monitoring, alarm and data logging. Remote I/O cabinets shall be provided wherever required depending upon distance/location Integrated microprocessor based open loop control, sequential control and data acquisition system for Coal Handling System in hierarchical levels with integrated unit monitoring systems in the upper level are therefore to be envisaged for the plant.]

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3.2.4 Civil Works

Bidder shall go through the details of the existing Buildings / Structures / Foundations / Facilities mentioned hereunder (but not limited to) for thorough understanding of conditions of the same. In order to assess the quantum of Civil / Structural / Architectural R&M work within the package, Bidder shall also carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions at site and identification of modification requirements in any other structure or foundation not included here. Conditional details of important buildings / structures / foundations / facilities which require major modifications have been described below:

{Details of the existing buildings / structures and their foundations in the Coal Handling Plant area like wagon tippler structure, track hopper structure, stockpile, stacker-reclaimer foundations, conveyor galleries and trestles, crusher house, junction houses, tunnels, pent houses, transfer towers, compressor house, switchgear cum control room building, dust suppression/extraction/ventilation system structures etc. shall be indicated in this section. Also the available GA/Construction Drawing including Load Data should also be provided.}

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4 SCOPE OF SUPPLY & SERVICES

4.1 The scope of supply and services to be provided by the Bidder shall include all such activities as required to meet the target and intent of this specification. The scope for each unit shall generally cover, but will not be limited to the following:

- (i) Replacement of some of the existing components with new components of improved and better design.
- (ii) Incorporation of new systems / components wherever required in line with the Specification.
- (iii) Refurbishing / Retrofitting of some of the components in the existing equipment/system.
- (iv) All types of civil/structural works like modification and strengthening of foundation of existing and upgraded equipment, making new structures or foundations (if applicable), dismantling, restoration, supply and erection of any temporary supports or any other construction work required for implementation of renovation work.

All structural modifications/strengthening of existing structure of building, equipment foundation, etc. including supply, fabrication and erection of any new structure and provision of any additional platform if required for access to new equipment or existing equipment as specified.

Supply of all materials, equipments, machinery and manpower required for civil/structural R&M works.

Site enabling works as per the requirements to support civil/structural R&M works.

- (v) Design, engineering, submission of design calculations for review and approval, manufacturing, inspection and testing at suppliers' works, packing, forwarding to site, unloading, erection, supervision, pre-commissioning, testing and commissioning and performance testing of the equipment / systems and works indicated in clause No. 4.5 of this technical Specification.
- (vi) Mandatory spares, start-up and commissioning spares. The general requirements in respect of various types of spares are given in Clause 9 of this section of Technical Specification.
- (vii) Packing, transportation and transit insurance of all materials required for renovation / replacement work as per this Specification from the supplier's/sub supplier's works to [Name of the Plant], unloading, preservation and storage at site. Packing, transportation, transit insurance, clearance from all concerned agencies etc. of all components/materials

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required to be forwarded from [Name of the Plant] to Bidder's facilities and back to [Name of the Plant].

- (viii) Dismantling of the systems, handling and storage of dismantled equipment, reassembly and re-erection / reinstallation along with associated inspection, testing, commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.
- (ix) Materials which are removed from the existing machines but are not re-used during the re-assembly of the machines as well as those components which are found to be beyond refurbishment shall be the property of Owner and shall be deposited at Owner's designated stores. Bidder shall prepare a record of all such dismantled material and hand it over to the Owner.
- (x) Loading, transportation, unloading and disposal of scrap to the designated storage/disposal yard.
- (xi) It shall be responsibility of the Bidder to obtain on behalf of the Owner the necessary approvals of Inspection Authority as may be required for design and design calculations, manufacturing, erection procedure renovation. Bidder shall also be responsible for obtaining approval from the other statutory authorities in India, as may be required, for other plants and systems supplied by him. All such documentation submitted to statutory authorities shall also be submitted to the Owner for his review.

Handling of materials at site including handling / transportation as required to take equipment components to the workshop for carrying out the modification work and to bring it back for installation. All arrangement for such activities is to be done by the Bidder.
- (xii) Erection of all material supplied new for renovation (including erection of components, replacing old components). Re-erection of any component / equipment removed for modification so as to make complete unit consisting of Coal Handling Plant including electrical & control and instrumentation equipment /system ready for commissioning.
- (xiii) All gas cutting / dismantling, edge preparation, welding, bolting etc. and conductance of all NDTs like radiography, ultrasonic testing, MPI, die penetration testing etc. Any new matching pieces, piping, hangers & supports etc. required for assembly of equipment/ systems, as per system requirements shall also be included in the scope of the Bidder.
- (xiv) All Pre-commissioning activities as may be required such as hydraulic testing, air & gas tightness test, steam blowing for steam piping under fuel oil system, floating of safety valves, oil flushing etc. including erection and dismantling of all temporary systems like piping / tanks etc. and Conductance of all demonstration tests including performance test.

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- (xv) Assisting and coordinating with Owner in tuning various control loops finalizing protection and control requirements of all Systems under Coal Handling package.
- (xvi) Insurance for all items / activities in line with the provisions of General Condition of Contract of Volume-I.
- (xvii) Making arrangement for proper electrical grounding of all systems, supplied by him as required by the system design. All required accessories including grounding cables are also included in Bidder's scope.
- (xviii) Installation, Interconnection laying and termination of all Bidder supplied cables, testing and commissioning of all equipment/systems furnished by the Bidder.
- (xix) Civil / Mechanical work (such as grouting, cutting, welding etc.) related to mounting of New Cabinets, CRT / Keyboards, laying & termination of associated Cables.
- (xx) Supply of all necessary tools, tackles, commissioning spares, test instruments and deputing of experienced personnel for completion of the above erection, testing and commissioning work.
- (xxi) Dismantling of existing C&I cabinets along with associated cabling, for various systems under Coal handling package for retrofitting the new C&I systems, based on requirement as described in clause No. 4.6.
- (xxii) Providing all site execution and supervision by qualified and experienced engineering personnel during execution of all works under the scope of Bidder. Also providing all facilities and qualified personnel for implementing the approved quality assurance programme.
- (xxiii) Dismantling of the existing Instrumentation Cables and relaying of new cables as may be required.
- (xxiv) The Bidder shall conduct all shop and site tests as per the requirements of this Specification and Owner approved "Quality Assurance Program" to be finalized before the award of this Contract. Facilitating inspection, witness of shop and site tests by the representatives of Owner shall be in the scope of the Bidder.
- (xxv) Performance Guarantee tests after successful completion of initial operation.
- (xxvi) Construction Water

[Construction water shall be made available to Bidder at a single point in a suitable location. The Bidder shall arrange at his own cost the required pumps, distribution pipe line network for further distribution as required to carry out construction work.]

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(xxvii) Construction Power

[Construction power shall be made available to bidder at single point at [...] kV level. Further distribution as required to carry out the construction work shall be carried out by Bidder at his own cost.]

(xxviii) Providing all other services necessary for meeting the intent and requirement of this Specification. This shall include but not limited to system engineering, furnishing drawings, data, and information for Owner's review, participation in meeting & reviews, System warranty, revision of O&M Manuals etc.

4.2 Tools & Tackles

One (1) set of special tools and tackles required for the maintenance of equipment/systems have to be supplied by the Bidder. These tools and tackles shall be separately packed and brought to site. These shall not be used for erection/commissioning purposes and shall be in an unused and new condition, when they are handed over to the Owner. A list of all such special tools and tackles shall be submitted along with the offer.

For C&I system, Bidder shall supply one set for each unit of special non standard tools, module testing kit, cables, and any other equipment required for erection commissioning, testing, trouble shooting, calibration, maintenance and inspection of all systems / equipment provided. Any tools required to make changes (DIP shunt cutter, soldering irons, tips, wire wrap guns and bit unwrapping tools, strippers, terminal guard, connector repair tool, dies etc.) shall also be supplied.

Bidder's scope shall also include supply of all Cranes, welding sets and NDT testing equipment, scaffolding, special tools and tackles, jigs and fixtures as may be required during modification / erection and commissioning. Those items specifically brought to site solely for erection / modification purpose and if no more needed for regular maintenance of the equipment, can however, be taken back by the Bidder after completion of the work at site, subject to the approval of Owner.

4.3 Safety

The design of the equipment shall incorporate every reasonable precaution and provision for the safety of all personnel and for the safety and security of all persons and property. The design shall comply with all appropriate statutory regulations relating to safety.

Newly constructed structures and equipment shall be designed and constructed to withstand every foreseeable static and dynamic loading condition, including loading under earthquake conditions, with an adequate margin of safety.

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Ready and safe access with clear head room shall be provided to all the newly supplied parts of the plant for operation, inspection, cleaning and maintenance.

- 4.3.1 While carrying out the R&M work as per this Specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items/ equipment supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipment / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipment / foundations / structure and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

4.4 Training Requirements

Bidder shall include in his offer the training programme for Owner's Operation & Maintenance staff in view of introduction of new systems/ equipment. This training shall be organized before handing over the unit.

- 4.5 In case there is any difference in scope of work and services as described in this section of the Specifications and individual Specification volumes, then more stringent of the Scope of work and services shall prevail.

4.6 Detail Scope of Work:

4.6.1 Coal Handling Plant

{Describe in this chapter, all the equipment/components which need to be replaced/refurbished/retrofitted as finalized in the DPR on the basis of RLA/CA and EA report. Scope with regard to Civil, structural and architectural work as required for the Power Plant due to incorporation of new equipment/components shall also be incorporated in this chapter.}

The Bidder shall include in his scope the following works for the R&M of the Unit, which are based on RLA/CA and EA studies. The overall scope of work shall include but shall not be limited to the scope of work mentioned below. Any other items not specifically mentioned but considered necessary by the Bidder for carrying out the R&M work, shall also be included in his scope so as to meet the intended performance of various equipment & systems.

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Table: 4.1

Equipment	Scope of Work	Quantity
COAL HANDLING SYSTEM		
<i>Wagon Tipplers</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Side Arm Charger</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Apron Feeder</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Dribble Feeder</i>	[.....]	[.....]
	[.....]	[.....]
<i>Track Hopper</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Paddle Feeder</i>	[.....]	[.....]
	[.....]	[.....]
<i>Belt Conveyor</i>	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
Transfer Tower	[.....]	[.....]
[for all Transfer Point]	[.....]	[.....]
	[.....]	[.....]
Flap Gate	[.....]	[.....]
[For all Flap Gate]	[.....]	[.....]
	[.....]	[.....]
Stacker –Cum - Reclaimed	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Vibrating Grizzly Feeder	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Roller Screen	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Primary Crusher	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Secondary Crusher	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
Travelling Tipper	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Bunker sealing arrangement	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Chute & Hopper & Skirt Boards	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Metal Detector	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Inline Magnetic separator	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Belt Weighing System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Coal Sampling	[.....]	[.....]

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[Logo of Utility]

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
Wagon Tippler Dust Suppression System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Dry Fog system for Transfer Tower	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Ventilation and air Conditioner	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Dust Extraction for Coal crusher	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Elevator	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Crane and Hoist	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Piping]	[.....]	[.....]

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Equipment	Scope of Work		Quantity				
	[.....]		[.....]				
	[.....]		[.....]				
[Valve]	[.....]		[.....]				
	[.....]		[.....]				
	[.....]		[.....]				
[Fittings]	[.....]		[.....]				
	[.....]		[.....]				
	[.....]		[.....]				
[Low Pressure Piping and Fittings]							
Tag No.	Description	Fluid	Size	Schedule / Thickness	Class	Material	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Motorized Valves]							
Tag No.	Service Description	Size/ Type	Class	End Conn.	Travel time	Drg. No.	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment		Scope of Work			Quantity	
<i>[Manually Operated Valves]</i>						
Tag No.	Service Description	Size/ Type	Class	End Conn.	Material	Qty
<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>
<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>
<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>
<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>	<i>[...]</i>
<i>[Control Valve]</i>						
Replacement/ Retrofitting of Control Valves		<i>[.....]</i>			<i>[.....]</i>	
		<i>[.....]</i>			<i>[.....]</i>	
		<i>[.....]</i>			<i>[.....]</i>	
<i>[Electrical Works]</i>						
<i>MV Switchgear</i>						
<i>[Breaker]</i>		<i>[.....]</i>			<i>[.....]</i>	
		<i>[.....]</i>			<i>[.....]</i>	
		<i>[.....]</i>			<i>[.....]</i>	
<i>[Relays]</i>		<i>[.....]</i>			<i>[.....]</i>	
		<i>[.....]</i>			<i>[.....]</i>	
		<i>[.....]</i>			<i>[.....]</i>	
<i>[Meters]</i>		<i>[.....]</i>			<i>[.....]</i>	
		<i>[.....]</i>			<i>[.....]</i>	

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[72]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[CT and VT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other components]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
LV Transformers	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer HV/LV coil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Tap changer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[73]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT]	[.....]	[.....]
[Any other part/system of Service transformer(oil type/dry type)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
LV Switchgear (PMCC MCC)		
[Air circuit breaker/MCCB/SFU/MCB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT/PT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Numerical relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[AC/DC Starters]	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[74]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Electronic over load relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transducers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ground bus]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Switch socket]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Push button station]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Terminal block]	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[75]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of LV Switchgear (PMCC/MCC)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
DC System		
DCDB	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Air break switch	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Annunciation system	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system DC system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
NSPBD		
[Bus duct enclosure]	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[76]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Bus duct conductor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Support insulators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Disconnecting link/flexible]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[support structure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of NSPBD]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
MV Cables		
[Joint and termination kit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[77]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Any other part/system of HV cables]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
LV Power & Control cables		
[Lugs and Glands]	[.....]	[.....]
Any other part/system of LV power and control cable]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
MV Motors & LV Motors		
[Motor terminals box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor stator winding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor Rotor winding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[78]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
Motor cooling system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearings]	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of MV/LV motors]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Motor Actuators		
[Motor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Position indicator/Transmitter]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Limit switches]	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[79]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of motor actuators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Cable Carrier System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Cable Tray]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Conduit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Trench/Duct bank]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[80]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Termination/joints]	[.....]	[.....]
[Any other part/system of Cable carrier system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Illumination System		
[Distribution boards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting transformer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[DC light with self contained batteries]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[81]	25.09.2014

Equipment	Scope of Work	Quantity
[Lamps and fixtures]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Industrial socket outlet]	[.....]	[.....]
	[.....]	[.....]
[Fan and regulators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Switches and switchboards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Street or road light poles]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[High mast tower]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting junction box and conduits]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[82]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Any other part/system of lighting system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Earthing & Lightning Protection system		
[Electrode]	[.....]	[.....]
[GI flat/wire]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air terminals]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Clamp/test links]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Shielding mast]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of earthing and lightning]	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[83]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
protection]	[.....]	[.....]
Control & Instrumentation Works		
Wagon Tripler Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Weighing System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Stacker Cum Reclaimer Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Metal Detector System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
In Line magnetic Separator Control	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Conveyor Control System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[84]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

Equipment	Scope of Work	Quantity
Bunker Level Monitoring	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Dust Suppression & Extraction System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Vibration Monitoring System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
UPS System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Belt Weigher	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Pull Chord Switch	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Belt Way Switch	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[85]	25.09.2014

Equipment	Scope of Work	Quantity
<i>Belt Monitoring Unit</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Zero Speed Switch</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Under Belt Switch</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Chute Blockage Switch</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Proximity Switch</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>RF Type Level Switch</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>Speed Probe</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[86]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

Equipment	Scope of Work	Quantity
Speed Transmitter	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Vibration Monitor	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Vibration Sensor	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Pressure / DP Gauges	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Temperature Gauges	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Pressure / DP Switches	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Temperature Switches	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[87]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

Equipment	Scope of Work	Quantity
RTD	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Level Transmitters (Radar Type,	[.....]	[.....]
	[.....]	[.....]
Pressure & Differential Pressure Transmitters	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Impulse Pipeline & Instrument fittings	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Instrumentation & Control Cabling	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Junction boxes	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Any Other System	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[88]	25.09.2014

Equipment	Scope of Work	Quantity
Civil Works		
[Wagon tippler underground structure and shed]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Track Hopper underground structure and shed]		
[Stockpile area paving and drains]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Coal slurry settling pond]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Stacker cum reclaimer foundations]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Conveyor galleries and trestles (foundation and super structures)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Crusher house	[.....]	[.....]

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors- Coal Handling Plant Volume-II, Section-I	[89]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
structure and foundations]	[.....]	[.....]
	[.....]	[.....]
[Junction houses, tunnels, pent houses, transfer towers and their foundations]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Compressor house building]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Reclaim hopper pits and sheds]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CHP switchgear cum control room building]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Dust suppression, extraction and ventilation system structures and foundations]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

4.6.2 Miscellaneous

- a. In addition to the above listed works, scope of civil / structural / architectural works and supplies shall be as detailed below.

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Bidder shall carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions of the buildings, structures, foundations & facilities mentioned in this specification and identification of modification requirements in any other structure or foundation not included here.

Bidder shall be provided with the existing drawings and documents as listed in Annexure-I by the Owner to facilitate the civil / structural / architectural, refurbishment and replacement works.

Subsequently Bidder shall prepare and submit for approval by Owner, a detailed scheme including methods techniques, requirements etc. for carrying out civil/structural/architectural R&M works to executed in the plant.

b. The scope of Civil / Structural / Architectural works to be carried out by the Bidder under this package shall generally cover the following:

- Inspection and checking the design adequacy of the foundations of existing structure like [wagon tippler structure, track hopper structure, stacker-reclaimer, conveyor galleries and trestles, crusher house, junction houses, tunnels, pent houses, transfer towers, compressor house, switchgear cum control room building, dust suppression/extraction/ventilation system structures etc] for all the applicable loads and construction of new foundations / modification of existing, wherever required.
- Inspection and checking the design adequacy of existing structures [wagon tippler structure, track hopper structure, stockpile, conveyor galleries and trestles, crusher house, junction houses, tunnels, pent houses, transfer towers, compressor house, switchgear cum control room building, dust suppression/extraction/ventilation system structures etc.] for any corrosion/damage and rectification / strengthening of the same.
- Carrying out all interior / exterior architectural repair and replacement works [such as flooring, painting, plastering, door/windows, roof finishing, water proofing, sheet cladding, roof sheeting, new false ceiling, glass partitions, lighting works replacement or modification of AC duct where ever applicable] is also included in contractors scope. etc.
- Any other civil related work required in buildings / structures of the package from aesthetics ambience & ease of operation point of view.

In addition to this any other modification/alteration to existing nearby foundation/structural steel/concrete/underground pipes work if required for satisfactory execution of intended work covered under this specification shall be carried out by the Bidder. Supply of all material required for the above work is included in Bidder's scope

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c. Supplies for Civil/Structural Work

The Bidder shall supply all material needed for completion of all civil, structural and architectural works as per this specification. The Bidder's scope of supply generally includes but is not limited to the following:

- Supply of cement, steel (for reinforcement as well as for any other use), grout, admixture for RCC work, sand and all other construction/ architectural / building materials as may be required for any repair/modification of existing civil works / foundation or for construction of new foundation / civil works.
- Supply of structural steel for all structural erection / modification / strengthening.
- Supply of all foundation bolts, and nuts base plates, embedments with lugs, miscellaneous steel where ever needed
- Supply of steel helical springs and viscous dampers for new equipment (if any).

d. Construction Enabling Works

[The owner shall provide the following facilities to the by Bidder to carry out the construction work.

- *Temporary Stores to store construction material.*
- *Fabrication Yard]*

e. Quality Control Laboratory

[To conduct acceptance test on all construction material, weldments, concrete cubes etc laboratory facilities if available in the existing unit shall be used. In case the laboratory facility is not available within the unit, Bidder shall get the testing at his own cost from a reputed test laboratory approved by the Owner.]

f. Construction Tools & Materials Supplied By the Bidder. The Bidder shall arrange adequate number and type of machinery and equipment for proper setting out and timely completion of the various works covered under the scope of the work. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expense.

The Bidder shall provide all fuels and lubricants required for the operation and maintenance of construction machinery and equipment as well as his transport vehicles at his own cost.

g. The Bidder shall furnish manufacturer's test certificate for all the manufactured items supplied by him. Representative specimens of the material shall also be submitted to the Owner and shall be tested at a recognised testing laboratory at the Bidder's cost in case Owner so desire.

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h. Work Execution and Supervision:

The Bidder shall have at the site accredited and qualified engineers and foremen / supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the works.

i. The Bidder shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner with full understanding of the importance of work for a R&M project of this magnitude.

j. In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accident. He shall also report such accidents to all the competent authorities wherever such reports are required by those authorities.

k. Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner is not in accordance with the specification / bid document.

l. During inclement weather, rains etc., the Bidder shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at the Bidder's cost and any damage to works shall be made good by the Bidder at his own expense.

m. Safety of Adjacent Plant/Equipment and Civil Structure

While carrying out the R&M work as per this specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items / equipments supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipments / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipments / foundations / structures and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

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4.6.3 Spares

All spares as specified in Annexure-II of this Specification in accordance with Clause No. 9.

4.6.4 Consumable, Oil & Lubricants

All the first fill and consumables such as greases, oil, lubricants, servo fluids/control fluids, gases and essential chemicals etc. as required up to the complete commissioning of the Coal Handling Plant, are covered in the scope of Bidder. Suitable standard lubricants as available in India are preferable. Efforts should be made to limit the variety of lubricants to minimum.

4.6.5 Embedded Parts & Fixture

All fixtures, embedded parts, steel embedment including fixing lugs and welding between them, foundation plates, grouting, nuts, bolts etc. for fixing all the equipment, piping on civil works shall be included in scope work of this package. All structures which would be required by the Bidder for supporting the piping shall also be included in scope of work of this package.

4.6.6 Other Services

The scope of Erection, Commissioning and Testing shall include the following:

- a) Complete pre-commissioning work including tests of facilities such as line flushing, hydraulic testing, chemical cleaning of pressure parts etc and all other tests as mutually agreed in the Bidder's quality assurance program as well as those identified in the Specification.
- b) Supply of all consumables (except coal and fuel oil for firing) like chemicals for chemical cleaning, passivation, inhibition etc., oil for line flushing, any other consumable as required for above pre-commissioning/ commissioning activities.
- c) Necessary arrangement as requires for the start up of various equipment & systems of Coal handling package.
- d) Supply of all temporary equipment such as tanks, piping, including supports, valves, pumps and all necessary instrumentation for successful conductance of pre-commissioning and commissioning activities. All temporary equipment and instruments shall be clearly listed out in the Bid.
- e) Providing safety barricades and signage during dismantling, erection and testing etc.

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- f) Supply of all labour, skilled/semi skilled supervisors, engineers and any other manpower.
- g) All the erection materials and consumables like shims, welding rods, soldering and brazing alloys, industrial gases, insulating tapes, compounds, chemicals etc. required for the erection and commissioning works.

Note: The temporary equipment specifically brought by the Bidder solely for the pre-commissioning and commissioning work shall, on completion of these activities, remain the property of the Bidder.

The selection of material of all the temporary equipment/instruments shall be compatible with the service conditions expected during pre-commissioning/ commissioning activities.

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5 TERMINAL POINTS & EXCLUSIONS

5.1 Terminal Points

For all terminal points, scope of this contract shall include supply of matching flanges, gaskets, bolts, nuts etc including any isolation valve. Terminal Points mean Engineering, Procurement and Erection in entirety. The terminal points of the complete package to be supplied shall be as follows.

(a) Coal Handling System

*[Track Hopper: At Track Hopper top (Rails are excluded from Bidder's Scope
Wagon Tippler: Up to Wagon Tippler Table (Rails on Tippler Table are under the scope of Bidder. However, rails beyond Tippler Table are excluded from Bidder's Scope*

Tripper Floor: Top of Tripper Floor (Bunker & Tripper floor/Mill building are excluded from Bidder's scope; however foundation & fixing arrangement of all the CHP equipment in the Tripper floor including Tripper floor & Bunker Ventilation System is in the CHP Bidder's scope.]

(b) Service Water

*[One number stub connection with isolation valve shall be provided on service water supply header Near CHP control room at °N, °E.
Bidder has to provide service water lines and valves for all the areas covered under this package.]*

(c) Drinking Water

*[One number stub connection with isolation valve shall be provided on service water supply header Near CHP control room at °N, °E.
Bidder has to provide drinking water lines and valves for all the areas covered under this package.]*

(d) Compressed (Service & Instrument air System) Air System

*[Service Air Header near CHP Control Room at : °N, °E]
[Instrument Air Header near CHP Control Room at : °N, °E]*

(e) Electrical

Between equipments which are covered under CHP package, supply and termination at both ends are in the scope of CHP contractor. Between equipment supplied by CHP contractor and others, scope of work is defined is as below.

- *[MV cable: At the terminal of 6.6 kV Station switchgear of TG package. All Power and control cables from the terminals of 6.6kV Station Switchgears are included in the scope of CHP package.]*

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- **[Cable Carrier System:** At the point outside of Coal handling Main Switchgear room. Complete Cable carrier system in side CHP battery limit is in the scope of CHP bidder. However Connection to interplant cable carrier system at Main switchgear room will be carried out by eBOP package Contractor.]
- **[Earthing and Lightning System:** At the terminal of Riser provided by others at below ground peripheral earthing of Main CHP switchgear room.]

Note:

- [Only relay contacts (1 NO/1 NC) shall be provided by the other package contractor. The required auxiliary relays, control cables including their laying & termination shall be in the scope of CHP Bidder. Similarly, necessary contact (1 NO/1 NC) required by other package Contractors shall be provided by CHP Bidder.]
- [Wherever Power is tapped from Purchaser's board, Bidder's scope starts from the outgoing terminals of the respective board. Bidder has to include all necessary termination materials, cables, trays, conduits, supporting structure, terminations, and necessary earthing accessories in his scope.]

(f) Control & Instrumentation

[Instrumentation Cabling & interface between CHS PLC and DCS: Redundant Modbus TCP/IP through FO cable (by BIDDER) shall be provided between CHP PLC and Common Station DCS. All hardware and software requirements at the CHS PLC end to establish Modbus TCP/IP interface with Common Station DCS shall be in BIDDER scope.]

5.2 Exclusions

- [Locomotive]
- [Railway rakes]
- [Rails]
- [Bulldozer]
- [Marshalling Yard]
- [Services water outside terminal point]
- [Potable water outside terminal point]
- [6.6kV Station switchgear]
- [Below Ground Ear thing]
- [Fire Detection and alarm system.]

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6 GENERAL TECHNICAL REQUIREMENTS

6.1 Codes & Standards

- 6.1.1 Apart from some specific application, the proposed R&M equipment shall comply with the appropriate Indian Standard / DIN or equivalent international Standard. Specification as listed below in this section and mentioned in detailed Specifications, each incorporating the latest revisions at the time of tendering.
- 6.1.2 Wherever specified or required the Plant & Equipment shall conform to various statutory regulations such as Indian Electricity Rules/Act, Indian Boiler Regulations, Factories Act, etc.
- 6.1.3 In the event of any conflict between the codes and standards referred above, and the requirements of this Specification, the requirements, which are more stringent, shall govern.
- 6.1.4 In case of any change of code, standards and regulations between the date of purchase order and the date, the Bidder proceeds with manufacturing, the Owner shall have the option to incorporate the changed requirements.
- 6.1.5 List of Reference Codes/Standard
- a) American Society of Mechanical Engineers (ASME).
 - b) American National Standards Institute (ANSI).
 - c) American Society for Testing and Materials (ASTM).
 - d) American Institute of Steel Construction (AISC).
 - e) American Welding Society (AWS).
 - f) Architecture Institute of Japan (AIJ).
 - g) Bureau of Indian Standards Institution (BIS).
 - h) British Standards (BS)
 - i) Central Board of Irrigation and Power (CBIP) Publications.
 - j) Deutsches Institut für Normung (DIN).
 - k) Electric Power Research Institute (EPRI).
 - l) Emission regulation of Central Pollution Control Board (CPCB)
 - m) Federal Occupational Safety and Health Regulations (OSHA)
 - n) Heat Exchanger Institute (HEI).
 - o) Hydraulic Institute (HIS).

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- p) Indian Electricity Rules.
- q) Indian Boiler Regulations (IBR).
- r) Indian Explosives Act.
- s) Indian Factories Act.
- t) Conveyor Equipment Manufacturing Association (CEMA).
- u) Institute of Electrical and Electronics Engineers (IEEE).
- v) International Electro-Technical Commission Publications.
- w) Instrument Society of America (ISA).
- x) International Organization for Standardization (ISO).
- y) International Electro-technical Commission (IEC).
- z) Japanese Standards (JIS).
- aa) Japanese Electro-technical Committee (JEC).
- bb) National Fire Protection Association (NFPA).
- cc) National Electrical Manufacturer's Association (NEMA).
- dd) National Electric Code (NEC).
- ee) Power Test Code for Steam Turbines (PTC).
- ff) Ministry of Environment & Forest (MoEF), Govt. of India
- gg) Standards of Manufacturer's Standardization Society (MSS).
- hh) Tariff Advisory Committee (TAC) rules.
- ii) Tubular Exchanger Manufacturer's Association (TEMA)
- jj) CEA regulations
- kk) State Pollution Control Board (SPCB) Regulations/Norms
- ll)

6.2 Name Plates

- 6.2.1 Instruction plates, nameplates or labels shall be permanently attached to each main and auxiliary item of plant in a conspicuous position. These plates shall be engraved with the identifying name, type and manufacturers serial number, together with the loading conditions under which the item of plant has been designed to operate.
- 6.2.2 Items such as valves, which are subject to hand operation, shall be provided with nameplates so constructed as to remain clearly legible throughout the life of the plant giving due consideration to the difficult climatic conditions to be encountered. Nameplates shall be securely mounted where they will

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not be obscured in service by insulation, cladding, actuators or other equipment. Direction of flow is also to be engraved.

6.2.3 All trade nameplates and labels shall be in Bilingual language. All measurements shall be in M.K.S. Units.

6.2.4 The size and location of nameplates shall be subject to Approval of the Owner.

6.3 Guards and Fences

6.3.1 Effective guards and fences must be provided to prevent injury to operators.

6.3.2 Mesh guards which allow visual inspection of equipment with the guard in place are generally preferable. The guards shall be constructed of mesh attached to a rigid framework of mild steel rod, tube, or angle and the whole galvanized to prevent loss of strength by rusting or corrosion. The guards shall be designed to facilitate removal and replacement during maintenance.

6.3.3 Guards for couplings and rotating shafts shall be in accordance with BS 5304-1975 or similar approved standard. All rotating shafts and parts of shafts must be covered.

6.4 Operation, Maintenance & Availability

6.4.1 Equipment/works offered shall be designed for high availability, high reliability, low maintenance and ease of operation & maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability, availability, operability and ease of maintenance. He shall also furnish details of availability records in plants stated in his experience list.

6.4.2 Wherever required platforms and walkways with access ladders having hand rails shall be provided to facilitate operation and maintenance.

6.5 Materials

6.5.1 In selecting materials of construction of equipment, the Bidder shall pay particular attention to the atmospheric conditions existing at the Site and the nature of material/fluid handled. Wherever deviations are taken in respect of materials specified, the reasons shall be spelt out clearly in the proposal.

All materials shall be new, and shall be of the quality most suited to the proposed application.

6.5.2 As far as possible; materials shall be in accordance with Indian or international standard Specifications. Where such standards are not available, sufficient information shall be provided to allow the Owner to assess the suitability of the material for the particular application.

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All materials used shall have performed lengthy satisfactory service in similar or more arduous conditions to those proposed by the Bidder.

- 6.5.3 All parts which could deteriorate or corrode under the influence of the atmospheric, meteorological or soil conditions at the Site, or under the influence of the working conditions shall be suitably and effectively protected so that such deterioration or corrosion is a minimum over the life of the plant.

6.6 Lubricants, Chemical and Control Fluids

- 6.6.1 Provision shall be made for suitable efficient lubrication where necessary to ensure smooth operation free from undue wear.
- 6.6.2 Non ferrous capillary tubing shall be used throughout.
- 6.6.3 Oil baths shall be provided with filling and drain plugs, both of adequate size. An approved means of oil indication including level switches and temperature indication shall be provided.
- 6.6.4 Lubrication points shall be conveniently situated for maintenance purposes. It must be possible to carry out lubrication from a gangway or landing and without the removal of guarding or having to insert the hand into it. Where accessibility to a bearing for oiling purposes would be difficult a method of remote lubrication shall be fitted.
- 6.6.5 The Bidder shall provide a detailed and comprehensive Specification for all lubricating oils, greases and control fluids required for the entire plant. A sufficient supply of these shall be provided by the Bidder for initial commissioning, first fill and till handing over of the unit.
- 6.6.6 The Bidder shall supply a detailed schedule giving the lubricant testing, cleaning and replacement procedures. All equipment and facilities necessary for the testing, cleaning and changing of lubricants and control fluids shall be provided. The Bidder shall endeavour to reduce the varieties and grades of required lubricants, chemicals and control fluids to a minimum, matching them where possible to those already in use in the generating station in order to simplify procurement and minimize storage requirements. All lubricants, chemicals and control fluids shall be of internationally recognized standards and shall be easily obtainable from a large number of Indian suppliers. Bidder shall also indicate the equivalent Indian Standard for the above for easy procurement in future.
- 6.6.7 No lubricant or control fluid shall have toxic or other harmful effects on personnel or on the environment.

6.7 Plant Life and Mode of Operation

- 6.7.1 On completion of the R&M project, the plant/equipment and systems individually and collectively shall be possible to operate continuously with

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routine maintenance and overhauls for an economic service life of not less than [20/25 years] under the prevailing site conditions and for the type of duty intended.

- 6.7.2 After R&M of Coal Handling system and associated auxiliaries, the unit shall be able to operate to its rated capacity continuously and there shall be no restriction of the operation of the supplied system.

6.8 Packaging & Marking

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing all the materials, the limitations from the point of view of availability of railway wagon sizes in India should be taken account of. The details of various wagons normally available with Indian Railways for transportation of heavy equipment shall be considered by the Bidder. The Bidder shall be responsible for all loss or damage during transportation, handling and storage due to improper packing.

The identification marking indicating the name and address of the consignee shall be clearly marked in indelible ink on two opposite sides and top of each of the packages. In addition the Bidder shall include in the marking gross and net weight, outer dimension and cubic measurement. Each package shall be accompanied by a packing note (in weather proof paper) quoting specifically the name of the Bidder, the number and date of Contract and names of the office placing the Contract, nomenclature of contents and Bill of Material.

6.9 Protection

Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures. Coated surfaces shall be protected against impact, abrasion, discoloration and other damages. Surfaces that are damaged shall be repainted.

Electrical and C&I equipment shall be protected against moisture and water damages. All external gasket surfaces and flange faces, couplings, rotating equipment shafts, bearings and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection. All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors.

All piping, tubing and conduit connections on equipment and other equipment openings shall be closed with rough usage covers or plugs. Male threaded openings shall be closed with rough usage covers or plugs. Female threaded openings shall be closed with forged steel plugs. The closures shall be taped to seal the interior of the equipment. Open ends of piping, tubing and conduit shall be sealed and taped.

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Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Bidder's expense.

6.10 Painting

6.10.1 General

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. Surfaces not easily accessible after shop assembly shall be treated before-hand and protected for life of the equipment. Surfaces to be finish painted after installation shall be shop painted with at least two (2) coats of primer. Steel surfaces, which are not to be painted, shall be coated with suitable rust preventive compound subject to the approval of the Owner.

All paints shall be used in accordance with the manufacturer's instructions. No thinners or other substance shall be added to the coating material without the approval of the Owner. The quality and vendor of the paints shall require approval of the Owner.

All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

All primers shall be well marked into the surface, particularly in areas where pitting is evident, and the first priming coat shall be applied as soon as possible after cleaning, within four hours maximum. If the drying interval between successive coats, which should not exceed one week, has been so long as to endanger the adhesion of the following coat, the paint already applied shall be lightly rubbed down with fine abrasive paper before putting on the next coat.

Paint spraying on large surfaces shall not normally be done indoors, except with the approval of the Owner. Spray guns shall not be used outdoors in windy weather or near unprotected surfaces of a contrasting colour and under no circumstances shall spray guns be used where spray may be carried into or onto exposed electrical equipment.

Paint containers shall not be opened until required and the paint shall be mechanically mixed thoroughly before use, and agitated occasionally during use.

Electrical equipment shall be shop finished with one or more coats of primer and two coats of high-grade oil resistant enamel. The interior of all panels' cabinets and enclosures shall be finished with gloss white enamel.

The Bidder shall furnish sufficient touch up paint for one complete finish coat on all exterior factory surfaces of each item of equipment. The touch up paint shall be of the same type and colour as the factory applied paint and

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shall be carefully packed to avoid damage during shipment. Complete painting instructions shall be furnished.

Shop primer for steel and iron surfaces which will have a continuous operating temperature below 35 °C shall be selected by the Bidder, in accordance to the relevant standard. Special high temperature primer shall be used on surface exposed to operating temperature above 35 °C.

The colour scheme shall be submitted during execution of Contract for approval by the Owner.

6.10.2 Preparation

Oil and grease shall be removed from the surface by washing with a suitable detergent, rinsing with clean water, and drying.

Surfaces to be shot blasted shall be cleaned to Swedish Standard SA 2.5 or equivalent, and all dust remaining after cleaning shall be removed.

The priming coat shall be applied without delay.

6.10.3 Damaged Paintwork

Any damaged paintwork shall be corrected / modified as follows:

- a) The damaged area, together with an area extending 25 mm around its boundary, shall be cleaned down to bare metal.
- b) A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm around the perimeter of the original damage.
- c) The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

6.10.4 Painting Systems

The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as stated below, unless otherwise specified elsewhere in this Specification.

a) Surfaces Subject to Weathering

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	35 micron DFT per coat

The total minimum DFT shall be 140 micron.

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b) Surfaces Inside Buildings

All surfaces shall have a minimum of three coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	25 micron DFT per coat

The total minimum DFT shall be 120 micron.

The type and colour of primer & finish coat shall be selected by the Bidder after approval by the Owner.

6.11 Environment Protection

6.11.1 Environment Protection

The plant & equipment under this R&M project shall be designed for installation and operation in harmony with the surrounding environment and all measures of pollution control shall be ensured by the Bidder to restrict pollution from the liquid effluent and RPM emission within the limits as given below with due consideration of Environment (Protection) Rules.

6.11.2 For Liquid Effluent

During construction activities, Bidder shall maintain the statutory compliance of State Pollution Control Board and MoEF in respect of pollution control and environmental protection within and around plant boundary. Any specific requirement of State Pollution Authorities over and above shall be maintained.

6.11.3 Noise Level Requirement

The plant & equipment under this R&M project will be designed, constructed and provided with suitable acoustic measures to ensure the noise level criteria as per the following stipulations of MoEF & State Pollution Control Board.

- a) Maximum noise level shall not exceed 85 dB (A) when measured at 1.0 m away from the noise emission source.
- b) Maximum noise level from its source within the premises shall not exceed 70 dB (A) as per Environment (Protection) Rules 1986, Schedule-III, 'Ambient Air Quality Standards' in respect of noise.
- c) Any statutory changes in stipulations regarding noise limitation that may occur in future according to State Pollution Control Board or Central pollution Control Board or Ministry of Environment & Forest regulation during tenure of

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the Contract, the Bidder shall comply with the updated/amended requirement.

An exception will be made for the plant at startup operations of other big pressure reducing devices operating during emergency periods and for the safety valves.

6.12 Inspection and Testing

6.12.1 Inspection and Tests during Manufacture

6.12.1.1 The method and techniques to be used by the Bidder for the control of quality during manufacture of all plant and equipment shall be agreed with the Owner prior to the Award of Contract.

6.12.1.2 The Owner's general requirements on quality control and shop tests as mentioned in Section II of Volume-II.

6.12.1.3 Owner shall be informed for witnessing the shop tests of any item of the plant or equipment for checking the compliance with the Specification requirement and or related standards prior to leave place of manufacturing.

6.12.1.4 Advance notice shall be given to the Owner as agreed in the Contract, prior to the stage of manufacture being reached, and the piece of plant must be held at this stage until the Owner has inspected the piece, or has advised in writing that inspection is waived. If having consulted the Owner and given reasonable notice in writing of the date on which the piece of plant will be available for inspection, the Owner does not attend, the Bidder may proceed with manufacture having forwarded to the Owner duly certified copies of his own inspection and test results.

6.12.1.5 The Bidder shall forthwith forward to the Owner the Test Certificates in [...] copies for approval.

6.12.1.6 Under no circumstances any repair or welding of castings be carried out without the consent of the Owner. Proof of the effectiveness of each repair by radiographic and/or other non destructive testing technique, shall be provided to the Owner.

6.12.1.7 All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.

6.12.1.8 Where accurate alignment is necessary for component parts of machinery normally assembled on site, the Bidder shall allow for trial assembly prior to dispatch from place of manufacture.

6.12.1.9 All materials used for the manufacture of equipment covered under this Specification shall be of tested quality. Relevant test certificates shall be

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made available to the Owner. The certificates shall include tests for mechanical properties and chemical analysis of representative material.

- 6.12.1.10 All pressure parts connected to pumping main shall be subjected to hydraulic testing at a pressure of 150% of design pressure. The duration of the pressure tests shall be sufficient, as approved by the Owner, to show any leakage paths and to permit a thorough examination of the component whilst under pressure.
- 6.12.1.11 All necessary non destructive examinations shall be performed to meet the applicable code requirements.
- 6.12.1.12 All welding procedures adopted for performing welding work shall be qualified in accordance with the requirements of applicable code. Radiography, magnetic particle examination magnuflux and ultrasonic testing shall be employed wherever necessary/ recommended by the applicable code.
- 6.12.1.13 The Bidder shall furnish the quality procedures to be adopted for assuring quality from the receipt of material at site, during storage, erection, pre-commissioning to tests on completion and commissioning of the complete system/equipment.

6.12.2 Performance Tests at Site

- 6.12.2.1 The full requirements for testing the system shall be agreed between the Owner and the Bidder prior to Award of Contract. The completely erected System shall be tested by the Bidder on site under normal operating conditions. The Bidder shall also ensure the correct performance of the System under abnormal conditions, i.e. the correct working of the various emergency and safety devices, interlocks, etc.
- 6.12.2.2 The Bidder shall provide complete details of his normal procedures for testing, for the quality of erection and for the performance of the erected plant. These tests shall include site pressure test on all erected pipe work to demonstrate the quality of the piping and the adequacy of joints made at site.

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7 LAYOUT CONSIDERATION

{Effort should be given to keep the Layout of the newly equipped system / packages under the R&M project unchanged to the extent possible with respect to existing layout to avoid disturbance to the existing equipment & facilities for which any modification/changes are not envisaged based on RLA/LA and EA assessment. However a general guidelines, which needs to be followed, as required, are given below :}

The broad salient features of the existing and expected layout arrangements of various equipment in the plant are given as hereunder:

- 7.1 The arrangement of the turbine- generator in the main plant building is of *[longitudinal type]*. The boiler centre line is in the *[same as that of TG condenser]*. Unit pitching distance between centre lines of two boilers is *[approximately 120m]*. The column spacing of main plant building is *[about 10 m]*.
- 7.2 Boiler is provide side mill /frount mill rear mill.
- 7.3 Clear walk ways of minimum *[1.5 m]* width at all the levels shall be provided.
- 7.4 Trestles to be provided for routing of Conveyor, cables, pipes etc. shall have a clear height of 8.0m at road crossings so as to clear the road spaces, approach to maintenance bays of different equipment. A walkway with hand rails and toe guards of 750 mm (minimum) width shall be provided all along length of the trestle for maintenance.
- 7.5 Conveyor inclination should not exceed $[..^{\circ}]$ at feeding zone and $[..^{\circ}]$ in the other area.
- 7.6 Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized taking into account the fire water sprinkler system wherever provided.
- 7.7 Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 2.5 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment and clear headroom within main structures and cable trays etc.
- 7.8 Adequate space shall be kept in conveyor galleries, underground TPs, Tunnels, Crusher house, over ground TPs, and in stockpile areas for the installation of fire protection equipment.

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- 7.9 The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards etc. shall be observed while developing the layout.
- 7.10 The available existing layout details of the plant are indicated in the enclosed drawings as Annexure-I. However, Bidder to suggest his own modified layout arrangement which shall be subject to approval of the Owner.

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8 PERFORMANCE GUARANTEES

The term "Performance Guarantees" wherever appears in this Section shall have the same meaning and shall be synonymous to "Functional Guarantees".

Similarly the term "Performance Tests" wherever appears in this Section shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

8.1 General Requirements

8.1.1 The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in this technical Specifications.

8.1.2 The guaranteed performance parameters furnished by the Bidder in the Bid proposal, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.

8.1.3 The Bidder shall demonstrate all the guarantees covered herein under Category I, II & III during functional guarantee / acceptance test. The various tests which are to be carried out during performance guarantee/acceptance test are listed elsewhere in this Section. The guarantee tests shall be conducted by the Bidder at site in presence of Owner.

8.1.4 All costs associated with the tests including the cost associated with the supply, calibration, installation and removal of test instrumentation shall be included in the price offered by Bidder.

8.1.5 At all times during the Performance Tests the emissions as applicable and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.

8.1.6 It shall be the responsibility of the Bidder to make the plant ready for the performance guarantee tests.

8.1.7 All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Bidder shall get these instruments calibrated in an independent test institute approved by the Owner. All test instrumentation required for performance tests shall be supplied by the Bidder and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subjected to the approval of the Owner. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.

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- 8.1.8 Tools and tackles, thermowells (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the Bidder free of cost.
- 8.1.9 The Performance/ Acceptance test shall be carried out as per the agreed procedure. The PG test procedure including demonstration tests shall be submitted within *[90 days]* of the date of Notification of Award and finalization of the PG test procedure shall be done within *[180 days]* from the date of Notification of Award. After the conductance of Performance test, the Bidder shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. However, preliminary test reports shall be submitted to the Owner after completing each test run.
- 8.1.10 The PG test procedures shall be submitted for equipment/ system & subsystem under Bidder's scope for all Guarantees under category I, II & III as mentioned below, as per latest International codes & standard including correction curves, meeting the Specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.
- 8.1.11 The Bidder shall submit for Owner's approval the detailed Performance Test procedure containing the following:
- Objective of the test.
 - Various guaranteed parameters & tests as per Contract.
 - Method of conductance of test and test code.
 - Duration of test, frequency of readings & number of test runs.
 - Method of calculation.
 - Correction curves, as applicable to various system/equipment.
 - Instrument list consisting of range, accuracy, least count, and location of instruments.
 - Scheme showing measurement points.
 - Sample calculation.
 - Acceptance criteria.
 - Any other information required for conducting the test.
- 8.1.12 In case, during performance guarantee tests, it is found that the equipment/systems has failed to meet the guarantees, the Bidder shall carry out all necessary modifications and/or replacements to make the

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equipment/system comply with the guaranteed requirements at no extra cost to the Owner. However, if the Bidder is not able to demonstrate the guarantees, even after the above modifications/replacements within [ninety (90) days] or a reasonable period allowed by the Owner after the initial performance guarantee tests have been completed, the Owner will have the right to impose the stipulated clauses under Guarantee Category I, II & III as specified in this Specification:

8.1.13 For Category-I Guarantees

Reject the equipment/system/plant and recover from the Contractor payments already made

(OR)

Accept the equipment/system/plant after levying Liquidated Damages (LD) as specified in Clause No. 5.6 of Volume I. The LDs shall be prorated for the fractional parts of the deficiencies.

8.1.14 For Category-II Guarantees

Reject the equipment/plant/system and recover, from the Contractor, the payments already made. Conformance to the performance requirements under Category-II is mandatory.

8.1.15 For Category-III Guarantees

Reject the equipment/system/plant & recover, from the Contractor, the payments already made.

(OR)

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the Contract price an amount equivalent to the damages as determined by the Owner. Such damages shall however be limited to the cost of replacement of the equipment/systems replacement of which shall remove the deficiency so as to achieve the guaranteed performance.

8.2 Performance Guarantees under Category-I

The performance guarantees which will attract liquidated damages shall be as follows:

- (i) **Total Auxiliary Power Consumption** – The auxiliary power consumption shall be calculated using the following relationship.

$$P_{au} = \sum P_u$$

P_{au} = Guaranteed Unit Auxiliary Power Consumption.

P_u = Power consumed by each of the continuously running equipment of Coal

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Handling Plant System under the scope of Bidder.

[While guaranteeing the auxiliary power consumption the Bidder shall necessarily include all continuously operating equipment of Coal handling package. Auxiliary power shall be guaranteed stream wise as defined below for Stream-I, Stream-II & Stream-III. The auxiliaries to be considered shall include but not be limited to the following:

A. Stream – I: Unloading & Direct feeding to bunker

- i. Unloading & Feeding equipments under Track Hopper complex.
- ii. Unloading & Feeding equipments under Wagon Tippler complex.
- iii. Conveying Stream (Belt conveyors) to Crusher House
- iv. Screening, Crushing and dust extraction equipments in crusher house.
- v. Conveying stream (conveyors) from crusher house to coal bunker.
- vi. Bunker filling equipment and dust extraction system for bunker.
- vii. Inline Magnetic Separator
- viii. Dust Suppression System
- ix. Dust Extraction System
- x. Scoop Coupling
- xi. Sampling System
- xii. Travelling Tripper

B. Stream – II: Unloading & Stacking at Stockyard

- i. Unloading & Feeding equipments under Track Hopper complex.
- ii. Unloading & Feeding equipments under Wagon Tippler complex.
- iii. Conveying Stream (Belt conveyors) to Crusher House
- iv. Screening, Crushing and dust extraction equipments in crusher house.
- v. Yard Conveyors
- vi. Stacker cum reclaimer
- vii. Inline Magnetic Separator
- viii. Dust Suppression System
- ix. Dust Extraction System
- x. Scoop Coupling
- xi. Sampling System
- xii. Travelling Tripper

C. Stream – III: Reclaiming & Feeding to bunker

- i. Conveying stream (conveyors) from crusher house to coal bunker.
- ii. Bunker filling equipment and dust extraction system for bunker.
- iii. Stacker cum reclaimer
- iv. Yard Conveyer
- v. Inline Magnetic Separator
- vi. Dust Suppression System
- vii. Dust Extraction System

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- viii. Scoop Coupling
- ix. Sampling System
- x. Travelling Tripper
- xi. Vibrating Feeder (if any)]

Note:

The Bidder shall furnish a list of equipment for each of the stream to be covered under auxiliary power consumption for the approval of Owner.

8.3 Guarantees under Category-II

The Performance Guarantees, conformance to which is mandatory are as follows:

Liquid Effluent: *Liquid Effluent discharge to an outside body, from the plant battery limit, shall meet statutory requirements State Pollution Control Board.*

8.4 Guarantees under Category-III

- Each crusher shall be capable of handling rated capacity with specified maximum lump size of coal even while handling damp and sticky coal having 20% moisture (including surface moisture) during monsoon season. The largest size of crushed coal shall not exceed those specified in the specification.
- Screens shall screen out 95% of sized material even during rainy season
- Stacker / reclaimer shall be stable under specified design condition and shall meet all requirements specified. The bucket wheel reclaimer shall reclaim at rated capacity specified while handling well compacted, damp and sticky coal during rainy seasons. The capacity shall be arrived at on working for 6 hours over complete cross section of the stock pile. Also, the stacker shall stack coal at the rated capacity specified.
- The capacities of all equipment / conveyors / feeders shall be equal to or more than the specified.
- Each stream and each path shall be tested at rated capacity for 24 hours to prove that the system functions satisfactorily without any trip due to overload or system fault. For the purpose of conducting guarantee test coal, flow shall be divided into following coal flow paths:
 - *[Wagon tippler/ track hopper to coal bunkers*
 - *Wagon tippler/ track hopper to crushed coal storage via stacker cum reclaimer.*
 - *Wagon tippler/ track hopper to one stream to crushed coal stockpile and other stream to coal bunkers.*
 - *From crushed coal stockpile to coal bunkers via stacker cum reclaimer.*

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- *From crushed coal stockpile to coal bunkers via emergency reclaim hoppers*
- *Guaranteed capacity in T/h of the following:*
 - *All Belt Conveyor*
 - *All Types of Feeders*
 - *Crushers*
 - *Wagon tippler with side arm charger*
 - *Paddle Feeder*
 - *Stacker Reclaimer*
- All drive motors shall be suitable for direct-on-line starting and capable of starting fully loaded conveyors / feeders.
- Noise level produced by any rotating equipment (other than crusher) individually and collectively should not exceed 85 dBA at a distance of 1.5 metre from it in any direction under any load condition.
- Vibration level of equipments at bearings shall not exceed the following limits for different equipment. Vibration levels shall conform to the limits specified below and shall be measured as per BS 4675.
- Dust Control System
At the outlet of the dust extraction system, the dust concentration should not exceed 50 mg/Nm³
Respirable dust at 2m from source: Maximum 2 mg/Nm³ for all transfer points other than bunker area maximum 5 mg/Nm³ in bunker area

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9 SPARE PARTS

The Bidder shall include in his scope of supply all the necessary mandatory spares, start up and commissioning spares and recommended spares and indicate these in the relevant schedules. The general requirements pertaining to the supply of these spares is given below:

9.1 Mandatory Spares

The list of mandatory spares considered essential by the Owner is enclosed in Annexure-II of this Specification. The Bidder shall indicate the prices for each and every item (except for items not applicable to the Bidders design) in the 'Schedule of mandatory spares' whether or not he considers it necessary for the Owner to have such spares. If the Bidder fails to comply with the above, the cost of such spares shall be deemed to be included in the Contract price. The Bidder shall furnish the population per unit of each item in the relevant Schedules. Whenever the quantity is mentioned in "sets" the Bidder has to give the item details and prices of each item.

Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the R&M Contract unless specified otherwise, and the fraction will be rounded off to the next higher whole number. Wherever the requirement has been specified a 'set' it will include the total requirement of the item for a unit, module or the R&M Contract scope or as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.

All mandatory spares shall be delivered at site at least two months before scheduled date of initial operation of the first unit. However, spares shall not be dispatched before dispatch of corresponding main equipment.

Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise. Price of mandatory spare parts will also be evaluated.

9.2 Recommended Spares

In addition to the mandatory spare parts mentioned above, the Bidder shall also provide a list of recommended spares for [five (5)] years of normal operation of the plant and indicate the list and total prices in relevant schedule. The list shall take into consideration the mandatory spares specified and should be independent of the list of the mandatory spares. The

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Owner reserves the right to buy any or all of the recommended spares. The recommended spares shall be delivered at project site at least two months before the scheduled date of initial operation of first unit. However, the spares shall not be dispatched before the dispatch of the main equipment.

Prices of recommended spares will not be used for evaluation of the Bids. The price of these spares will remain valid up to execution of the Contract. However, the Bidder shall be liable to provide necessary justification for the quoted prices for these spares as desired by the Owner.

9.3 Start-up & Commissioning Spares

Start up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system till the handing over of the Plant. The Bidder shall provide all such start up and commissioning spares and keep an adequate stock of the same to be brought by him to the site for the plant erection and commissioning. These must be available at site before the equipment are energized. The unused spares, if any, should be removed from there, only after handing over of the plant. All start up spares which remain unused at the time shall remain the property of the Bidder.

9.4 General Requirements

The Bidder shall indicate the service expectancy period for the spares parts (both mandatory and recommended) under normal operating conditions before replacement is necessary.

All spares supplied under this Contract shall be strictly inter-changeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desiccators packs as necessary.

All the spares (both mandatory and recommended) shall be manufactured along with the main equipment components as a continuous operation as per same Specification and quality plan.

The Bidder will provide Owner with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the Owner to identify and finalize order for recommended spares.

Each spare part shall be clearly marked or labeled on the outside of the packing with its description. When more than one spare part is packed in a single case, a general description of the content shall be shown on the

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outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.

All cases, containers or other packages are to be opened for such examination as may be considered necessary by the Owner.

The Bidder will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on Vendors for items/ components/ equipment covered under Contract and will further ensure with his Vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such Vendors.

The Bidder shall warrant that all spares supplied will be new and in accordance with the Contract documents and will be free from defects in design, material and workmanship.

In addition to the recommended spares listed by the Bidder, if the Owner further identifies certain particular items of spares, the Bidder shall submit the prices and delivery quotation for such spares within [30 days] of receipt of such request for consideration by the Owner and placement of order for additional spares if the Owner so desires.

The Bidder shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered in the Contract. The Bidder shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the Owner [at least 2 years] advance notice so that the latter may order his bulk requirement of spares, if he so desires. The same provision will also be applicable to Sub-Bidders. Further, in case of discontinuance of manufacture of any spares by the Bidder and/or his sub-Bidders, Bidder will provide the Owner, two years in advance, with full manufacturing drawings, material Specifications and technical information including information on alternative equipment makes required by the Owner for the purpose of manufacture/procurement of such items.

The prices of all future requirements of spares beyond [five (5)] years shall be derived from the corresponding Ex-works price at which the order for such spares have been placed by the Owner as a part of the mandatory spares or recommended spares. Ex-works order price of future spares shall be computed in accordance with the price escalation formula to be furnished by Bidder indicating base price reference variation indices for material, labour

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etc. Based on the formula and considering escalation indices prevailing at the time of order of spares, order price shall be worked out. The base indices will be counted from the scheduled date of successful completion of trial operation of the last plant/equipment under the project. The above option for procuring future recommended spares by the Owner shall remain valid for the period of fifteen *[fifteen (15)]* years from the date of successful completion of trial operation of the last plant/equipment. In case the spare parts from the same sub-Vendor are not available due to obsolescence or any other reason, the Bidder shall supply the spares for a period of *[fifteen (15)]* years from an alternative source.

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10 ANNEXURE

10.1 Annexure-I (List of Existing Drawing)

{Available as Built/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned in Annexure-I for their information & familiarization of the existing Unit}

10.2 Annexure-II (Mandatory Spares)

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II}

10.3 Annexure-III (List of Sub-Vendors)

{List of Sub-vendors for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the format in Annexure-III}

10.4 RLA/CA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.5 EA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.6 [Geotechnical Investigation Report]

{Not attached with this document. This is to be provided by Utilities}

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-I, ANNEXURE-I
LIST OF EXISTING DRAWING**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-I

List of Existing Drawing

{Available as Built/RFC drawing of the Existing Unit shall be provided to the Bidders as per the list mentioned below for their information & familiarization of the existing Unit}

i) MECHANICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[General Layout (Plot Plan)]
2	[.....]	[General layout battery limit]
3	[.....]	[Symbol /Legends]
4	[.....]	[Flow Scheme For Coal Handling System]
5	[.....]	[GA of Conveyor No...]
6	[.....]	[GA of Conveyor No...]
7	[.....]	[GA of Conveyor No...]
8	[.....]	[GA of Yard Conveyor No...]
9	[.....]	[GA of Stacker cum Reclaimer]
10	[.....]	[GA of Transfer Tower No..]
11	[.....]	[GA of Transfer Tower No..]
12	[.....]	[GA of Transfer Tower No..]
13	[.....]	[GA of Crusher House.]
14	[.....]	[GA of Track hopper]
15	[.....]	[GA of Track wagon Tippler]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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S.No.	Drawing/Document No.	Title
16	[.....]	[GA of CHP Control Room]
17	[.....]	[GA of Tippler Floor]
18	[.....]	[Any other Drawing]
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ii) **ELECTRICAL**

S.No.	Drawing/Document No.	Title
1.	[.....]	[Key Single Line Diagram of Power Plant]
2.	[.....]	[Metering & Protection Single Line Diagram of Power Plant]
3.	[.....]	[Key Single Line Diagram/Power Distribution Diagram of Coal Handling System]
4.	[.....]	[General Arrangement & Schematic Diagram of 6.6kV CHP Boards]
5.	[.....]	[General Arrangement & Schematic Diagram of CHP Service Transformer]{Application Wise to be provided}
6.	[.....]	[General Arrangement and Schematic drawing of LV switchgear]{Application Wise to be provided}
7.	[.....]	[General Arrangement and Schematic drawing of DC system of CHP package]
8.	[.....]	[Cross Section drawings and Data sheets of Cables]. {Voltage grade as well application wise i.e power , control wise to be provided}
9.	[.....]	[General Arrangement and Data sheet/Document of of NSPBD]
10.	[.....]	[Cable Tray Layout and BOQ of Cable Carrier System]. {Building wise to be provided}
11.	[.....]	[Lighting Layout and BOQ & Calculation of Lighting]

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		System]. {Building wise to be provided}
12.	[.....]	[Earthing & Lightning BOQ and Layout]. {Building wise to be provided}
13.	[.....]	[Any other drawings /documents for CHP package(if applicable)]

iii) **CONTROL & INSTRUMENTATION**

S.No.	Drawing/Document No.	Title
1	[.....]	[PLC Configuration Drawing For Coal Handling Plant]
2	[.....]	[PLC Control Room Layout Drawing]
3	[.....]	[Instrument Installation Diagram (Pressure Gauge)]
4	[.....]	[Instrument Installation Diagram (Pressure Switch)]
5	[.....]	[Instrument Installation Diagram (Temperature Gauge)]
6	[.....]	[Instrument Installation Diagram (Radar Type Level Transmitter)]
7	[.....]	[Instrument Installation Diagram (Level Measurement using gauge & switch)]
8	[.....]	[Instrument Installation Diagram (Level Measurement using DP Transmitter & Displacer type Transmitter)]
9	[.....]	[Instrument Installation Diagram (Level Measurement for Open/Close Vessels)]
10	[.....]	[Instrument Source Connection Details – Pressure Measurement on Pipe]
11	[.....]	[Instrument Source Connection Details – Temperature Measurement on Pipe]
12	[.....]	[Instrument Source Connection Details – Level Measurement]
13	[.....]	[Grounding Scheme for Cabinets/Panels]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No.	Drawing/Document No.	Title
14	[.....]	[C&I Power Supply distribution cabling Philosophy]
15	[.....]	[C&I Instrumentation cabling Philosophy]
16	[.....]	[Logic Diagrams of Coal Handling System]
17	[.....]	[Cable Interconnection Drawing]
18	[.....]	[Drive Control Philosophy-Bidirectional drive (ON-OFF Type MOV)]
19	[.....]	[Drive Control Philosophy-Bidirectional drive (Inching Type MOV)]
20	[.....]	[Drive Control Philosophy- LT drive]
21	[.....]	[Drive Control Philosophy- HT drive]
22	[.....]	[Drive Control Philosophy-Solenoid Valve]
23	[.....]	[Drive Control Philosophy-VFD]
24	[.....]	[Any Other Drawing]

iv) CIVIL

S.No.	Drawing No.	Description
1	[.....]	[Geotechnical Investigation Report]
2	[.....]	[Road, drains, trench layouts etc., as available]
3	[.....]	[Design documents of the existing structures]
	[.....]	[Drawings of existing structures & foundations]
4	[.....]	[Drawings for loading data of the existing structures & foundations]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-I, ANNEXURE-II
MANDATORY SPARES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-II

Mandatory Spares

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II. Available Mandatory spares of the existing Unit, which can be used after completion of R&M work, shall also be verified before finalization of the below mentioned Spare List.}

A. MECHANICAL

1. Coal Handling System System

S.No	Description	Quantity	Remarks
1.0	MECHANICAL		
1.1	IDLERS		
1.1.1	<ul style="list-style-type: none"> 350 troughing idlers complete with base frame and mounting brackets, etc. 	100 no. s	
1.1.2	<ul style="list-style-type: none"> Rolls for above 	300 n. os	
1.1.3	<ul style="list-style-type: none"> Troughing idlers complete with base frame and mounting brackets, etc. (for belt feeders) 	10 no. s	
1.1.4	<ul style="list-style-type: none"> Rolls for above 	30 no. s	
1.1.5	<ul style="list-style-type: none"> 350 impact idlers complete with mounting brackets and base frame etc. 	100 no. s	
1.1.6	<ul style="list-style-type: none"> Rolls for above 	300	
1.1.7	<ul style="list-style-type: none"> 350 troughing training idlers complete with base frame and brackets, etc. (if used) 	10 % of total installed quantity	
1.1.7	<ul style="list-style-type: none"> Transition idler complete 	5 no. s	

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S.No	Description	Quantity	Remarks
1.1.8	<ul style="list-style-type: none"> Flat return idlers complete with mounting brackets, etc. 	100 no. s	
1.1.9	<ul style="list-style-type: none"> Flat Return Idlers complete with mounting brackets, etc. (for belt feeders). 	10 no. s	
1.1.10	<ul style="list-style-type: none"> Flat return trainer complete with mounting brackets, etc. 	10 no. s	
1.1.11	<ul style="list-style-type: none"> Belt cleaning spiral rubber disc return idler complete with mounting brackets, etc. 	10 no. s	
1.1.12	<ul style="list-style-type: none"> Two roll 10o troughing return idler assy. 	40 no. s	
1.1.13	<ul style="list-style-type: none"> Rolls for above 	40 no. s	
1.1.14	<ul style="list-style-type: none"> SS Idlers 	2 Sets of each type	
1.2	CONVEYOR GEAR BOXES (including boom conveyor & belt feeders)		
1.2.1	<ul style="list-style-type: none"> Oil seals 	2 sets	
1.2.2	<ul style="list-style-type: none"> Bearings 	1 set	
1.2.3	<ul style="list-style-type: none"> Hold back device 	2 no. s	
1.2.4	<ul style="list-style-type: none"> Cooling fan with cover 	2 no. s	
1.2.5	<ul style="list-style-type: none"> Complete gear box assembly with hold back device 	1 set	
1.3	CONVEYOR DRIVE AND CONVEYOR BELT		
1.3.1	<ul style="list-style-type: none"> Gear Coupling 		
1.3.2	<ul style="list-style-type: none"> Gear Coupling 	2 no. s	
1.3.3	<ul style="list-style-type: none"> Bolts for gear coupling 	2 sets	

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S.No	Description	Quantity	Remarks
1.3.4	<ul style="list-style-type: none"> Seal kit for gear coupling (o-ring) 	2 sets	
1.3.5	a) Fluid coupling		
	<ul style="list-style-type: none"> Fluid coupling complete 	1 no	
	<ul style="list-style-type: none"> Multi Disc assembly (for fluid coupling), if applicable 	4 no. s	
	<ul style="list-style-type: none"> Resilient Drive plate Assly., if applicable 	1 no	
	<ul style="list-style-type: none"> Bearings 	1 no	
	<ul style="list-style-type: none"> Seal kit for fluid coupling 	2 sets	
	<ul style="list-style-type: none"> Fusible plug 	10 no. s	
	<ul style="list-style-type: none"> Complete actuator and engaging assembly (including motor, gear box etc.) 	1 set	
	<ul style="list-style-type: none"> Water pump motor (individual or group) 	1 set	
	<ul style="list-style-type: none"> Oil filters 	5 sets	
	<ul style="list-style-type: none"> Oil/ cooler valves (if applicable) 	2 set	
1.3.6	b) Belting		
	<ul style="list-style-type: none"> Conveyor Belt 		
	<ul style="list-style-type: none"> Main Conveyors 	1	
1.3.7	<ul style="list-style-type: none"> Boom conveyor, belt feeder and bunker seal belt 	1 no .s	[complete length of

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S.No	Description	Quantity	Remarks
			each]
1.4	PULLEYS		
1.4.1	Pulleys complete with shaft excluding bearing & plummer blocks (complete with lagging)	1 no .s	[No. of each type & size in pulley drum and shaft Ø]
1.4.2	Plummer block complete with bearings & sleeves	2 no .s	[Nos. each type & size]
2.0	IN LINE MAGNETIC SEPARATORS		
2.1	Cleated conveyor belt	1set	
2.2	Motor, gear box drive assembly complete	1set	
2.3	Pulleys with Plummer blocks and bearings	1 set of each size & type	
3.0	COAL CRUSHER		
3.1	Plummer Block assembly complete including bearing, lock nut, lock washer etc. (DE + NDE)	1 set	
3.2	Shaft seal	4 sets	
3.3	Hammer sets	5 sets	
3.4	Rotor assembly complete consisting of rotor shaft & keys, End discs, Centre discs, distance rings, suspension bars, disc clamping nuts and shaft extension etc. but without hammers, bearings and pillow blocks as applicable	1 sets	

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S.No	Description	Quantity	Remarks
3.5	Cage bars, if applicable	4 sets	
3.6	Breaker plate	4 sets	
3.7	Liners	2 sets	
3.8	Suspension bars	4 sets	
3.9	Kick-off plate	4 sets	
3.10	Fluid coupling		
	• Fluid coupling complete	1 set	
	• Seal kit (sealing rings)	2 sets	
	• Fusible plugs	8 nos	
	• Oil pump motor set (if applicable)	1 set of each type	
	• Water pump motor set (if applicable)	1 set of each type	
	• Oil filter	3 sets	
	• Complete actuator and engaging assembly (including motor, gear box etc.)	1 set	
	• Cooler assembly (if applicable)	1 no	
	• Oil Cooler valves	2 nos of each type	
	• Gear Coupling of crusher drive along with bolts and sealing kit.	2 sets	
4.0	VIBRATING SCREENING FEEDER		
4.1	Bearings	2 no. of each type and	

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S.No	Description	Quantity	Remarks
		size	
4.2	Seals	2 no of each	
4.3	Liners	1 set	
4.4	Screen plates	4 sets	
4.5	Complete vibrating assembly consisting of all rotating parts including drive & driven unbalanced shafts including bearings, casing, spring, vibrating blocks, main shaft, sheave & unbalanced weights as applicable.	1 set of each type and rating and direction	
4.6	Hoses (if applicable)	2 sets	
4.7	Drive unit assembly (including electric motor, hydraulic pump, hydraulic motor, flexible shaft, gear box, as applicable)	1 set	
4.8	Base springs, rubber pads	2 sets of each type & size	
4.9	V belts	4 sets of each type & size	
5.0	ELECTRIC HOISTS		
5.1	Brake linings	2 sets of each type	
5.2	Rope guide & rope tighter	1 no. of each type	
5.3	Limit switch	2 nos. of each type & size	
5.4	Gear box/gear set	2 sets of each type & size	
5.5	Motor/geared motor	1 no of each type & rating	
5.6	Drum bearing	1 set of each type & rating	
6.0	FLAP GATES (INCLUDING THAT OF TRIPPERS)		

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S.No	Description	Quantity	Remarks
6.1	Limit switch	8 no of each type & rating	
6.2	Actuator (complete with motor, gear box, limit switches etc.)	1 no of each type & rating	
6.3	Oil seals of Actuator	2 no of each type & rating	
6.4	Flap Gate Shaft	1 no of each type & rating	
6.5	Pressure nut	12 no of each type & size	
7.0	SUMP PUMP		
7.1	Complete pump assembly with pump, motor, coupling base etc.	1 set	
7.2	Impeller with key & nut	2 sets of each type & size	
7.3	Oil seal	2 no of each size	
7.4	Coupling bolt with bushes	2 set of each type	
7.5	Pump shaft	2 Nos. of each size	
7.6	Shaft sleeve	2 Sets of each size	
7.7	Bearing bush	2 Sets of each size	
7.9	Set of bearings	2 sets	
8.0	DUST SUPPRESSION & SERVICE WATER SYSTEM		
8.1	Pump impeller with key and nut	1 Sets of each type and size	
8.2	Pump Shaft	1 No. of each type and size	
8.3	Bearings	1 Set of each type and size	
8.4	Wearing rings	2 Sets of each type and size	
8.5	Shaft sleeve	2 Sets of each type and size	
8.6	Bushing	2 Sets of each type and size	

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S.No	Description	Quantity	Remarks
8.7	Coupling bolts & nuts (with bushes)	1 Set of each type & size	
8.8	Spray nozzles	50 Nos. of each type and size	
8.9	Spray nozzles (for plain water dust suppression)	25 Nos. of each type and size	
8.10	Solenoid valves	5 % of each type & size	
8.11	Gate valve	2 Nos. of each size	
8.12	Strainers	1 Nos. of each size	
8.13	Compressor		
	• Air filter element	8 no. s	
	• Oil filter	6 no. s	
	• Discharge check valve	3 no. s	
	• Oil Pump Parts (including distance ring, eccentric rings, Pump element, Pin, Key O, Ring) as applicable)	2 sets	
	• Inlet valve assembly	2 no. s	
	• Electronic regulator	3 no. s	
9.0	VENTILATION SYSTEM		
9.1	V-Belt	1 Set of each type	
9.2	Pre-filter element of pressurizing fans	2 Set of each type	
9.3	Foundation Rubber pads	1 Set of each type and size	
9.4	Bearings	1 Set of each type and size	
9.5	Plummer Blocks	1 Set of each type and	

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S.No	Description	Quantity	Remarks
		size	
10.0	TRAVELLING TRIPPER		
10.1	Complete drive assembly including gearbox, coupling, brake etc.	1 set	
10.2	Bearings for reducer	2 set	
10.3	Drive axle with wheels, plummer blocks, bearings etc.	1 set	
10.4	Oil Seals	2 Nos. of each size	
10.5	Non-drive axle with wheels plummer blocks, bearings etc.	1 Set of each type	
10.6	Chain assembly with sprockets	1 Set of each type & size	
10.7	Festoon Roller assembly for flexible cable	4 no .s	
10.8	Pulleys and Plummer block bearings	1 No. of each type	
10.9	Plummer block with bearing for cable reel drums	1 Set of each type	
11.0	REVERSIBLE STACKER/RECLAIMER (Including boom conveyor & Intermediate conveyor)		
11.1	Fluid coupling (complete)	1 No. of each type	
11.2	Fluid coupling spares		
	• Fusible plug	4 Sets of each type of coupling	
	• Oil seals	4 Sets of each type of coupling	
	• Bearings	2 Sets of each type	
11.3	Couplings consisting input and output halves (for travel drive)	1 No. of each type	

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S.No	Description	Quantity	Remarks
11.4	<i>Bearings excluding slewing bearings</i>	<i>1 No. of each type</i>	
11.5	<i>Hydraulic pump & hydraulic motor drive for luffing system</i>	<i>1 Set of each type</i>	
11.6	<i>Hydraulic pump & hydraulic motor drive for slew mechanism</i>	<i>1 Set of each type</i>	
11.7	<i>Hydraulic pump & hydraulic motor drive for bucket wheel mechanism</i>	<i>1 Set of each type</i>	
11.8	<i>Hydraulic cylinder</i>	<i>1 No. of each type</i>	
11.9	<i>Repair kit for hydraulic cylinder including oil seals etc.</i>	<i>2 Sets for each type of cylinder</i>	
11.10	<i>Grease pump</i>	<i>1 No. of each type</i>	
11.12	<i>Hoses</i>	<i>2 Sets of each type and size</i>	
11.13	<i>Solenoid valves with coils</i>	<i>2 No. of each type</i>	
11.14	<i>Slew gearbox</i>	<i>1 No. of each type and size</i>	
11.15	<i>Gearbox of bucket wheel</i>	<i>1 No. of each type and size</i>	
11.16	<i>Carbon brushes for current collector of cable reeling drum</i>	<i>2 Sets for each drum</i>	
11.17	<i>Plummer blocks and bearings of (CRD)</i>	<i>1 Set of each type</i>	
11.18	<i>Traverse drive assembly consisting of reducer, couplings, brake assy. etc.</i>	<i>1 No. of each type and direction 1 no</i>	
11.19	<i>Brake shoes</i>	<i>4 sets for each type of brake</i>	
11.20	<i>Complete bucket with liner etc</i>	<i>1 Bucket</i>	
11.21	<i>Drive assembly of cable reel drive</i>	<i>1 Set of each</i>	

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S.No	Description	Quantity	Remarks
	<i>consisting of motor, gearbox, coupling, brake etc. as applicable</i>	<i>type</i>	
11.22	<i>Chain & chain sprockets</i>	<i>1 Set of each type</i>	
11.23	<i>Cable guide assembly</i>	<i>1 Set of each type</i>	
11.24	<i>Various plummer block used in Stacker reclaimer</i>	<i>1 No. of each type & size</i>	
11.25	<i>Plummer block with bearing for cable reel drums</i>	<i>1 Set of each type</i>	
11.26	<i>Seal kit for thrustor assembly</i>	<i>1 Set of each type</i>	
11.27	<i>Thrustor cylinder assembly</i>	<i>1 Set of each type</i>	
12.0	<i>ELEVATOR</i>		
12.1	<i>Brake</i>		
	• <i>Tool to brake</i>	<i>1 no</i>	
	• <i>Fan</i>	<i>1 no</i>	
	• <i>Magnet coil with housing pads</i>	<i>2 no</i>	
	• <i>Brake pads</i>	<i>6 no</i>	
	• <i>Adjusting sleeve</i>	<i>2 no</i>	
	• <i>Fixed brake disc</i>	<i>2 no</i>	
12.2	<i>Worm Gear</i>		
	• <i>Worm Gear</i>	<i>1 no</i>	
	• <i>O' Ring</i>	<i>2 Nos. of each type</i>	
	• <i>Sealing ring</i>	<i>2 Nos. of each type</i>	
12.3	<i>Door Front</i>		

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S.No	Description	Quantity	Remarks
	• Bearing	2 nos.	
	• Roller	3 no. s	
	• Bushing	2 no. s	
12.4	Limit Cams		
	• Sensor	1 no s	
	• Switch	2 no. s	
	• Switch	2 no. s	
	Switch arm	2 no. s	
12.5	CAD		
	• Guide Roller	0.5 the total ones installed each type or minimum 1 no. whichever is higher	
	• Switch	1 no	
12.6	Sliding Door		
	• Rollers	4 Nos. of each type	
12.7	Machinery		
	• Guide roller	2 no. s	
	• Pinion	1 no	
	• Rubber inserts	6 no .s	
	• Grove ring	6 no. s	
	• Brake motor	1 no	
12.8	Cable trolley		
	• Ball bearing	2 no. s	
13.0	DUST EXTRACTION SYSTEM		

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S.No	Description	Quantity	Remarks
13.1	Plummer Blocks	2 Sets of each type	
13.2	Bearing of fans & motor	1 Set of each type	
13.3	Pulley	2 Nos. of each type	
13.4	Belts	2 Sets of each size	
13.5	Motor terminal blocks with studs for all motors	1 Set of each rating and type of motor	
13.6	Spray nozzle	10 Nos. of each type	
13.7	Solenoid valve with coil	2 Nos. of each type	
14.0	SIDE ARM CHARGER		
14.1	Gear box spares		
	• Gear Internal	1 Set of each type	
	• Oil Seal	1 Set of each type	
	• Bearing	1 Set of each type	
14.2	Carriage Wheels		
	• Bearing	1 Set of each type and size	
	• Plummer Block	1 Set of each type and size	
14.3	Coupling	1 Set of each type	
14.4	Travel Wheel Assembly	1 no	
14.5	Bearing	1 No of each type	
14.6	Motors		
	• Motor including slip ring motor	1 Set of each type & size	
	• Bearings	1 Set of each type & size	

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S.No	Description	Quantity	Remarks
	<ul style="list-style-type: none"> Oil Seal 	1 Set of each type & size	
14.7	Brakes		
	<ul style="list-style-type: none"> Complete assembly 	1 No. of each type & size	
	<ul style="list-style-type: none"> Linings & springs 	1 Set of each type & size	
14.8	Couplings		
	<ul style="list-style-type: none"> Complete assembly 	1 No. of each type & size	
	<ul style="list-style-type: none"> Pins, bushes and nuts 	1 Set of each type & size	
14.9	Hydraulic Power Pack		
	<ul style="list-style-type: none"> Hydraulic pump with electric motor, coupling, valves & servo motor (mounted on pump) etc. 	1 Set of each type and rating	
	<ul style="list-style-type: none"> Solenoid Valves complete with coils 	1 Set of each type & size	
	<ul style="list-style-type: none"> Filter element (1 No. Pressure filter + 1 No. Return Filter) 	4 Sets of each type	
	<ul style="list-style-type: none"> Hydraulic Hoses 	1 set	
	<ul style="list-style-type: none"> Hydraulic Motor 	1 No. of each type	
	<ul style="list-style-type: none"> Hydraulic cylinder 	1 No. of each type	
	<ul style="list-style-type: none"> Oil cooling fan with motor 	2 Sets of each type	
	<ul style="list-style-type: none"> Oil filling motor 	1 No. of each type	
	<ul style="list-style-type: none"> Servo motor 	1 No. of each type	
15.0	WAGON TIPPLER AND ACCESSORIES		
15.1	Speed Reducers		

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S.No	Description	Quantity	Remarks
	<ul style="list-style-type: none"> Internals complete including input and output shafts and gears etc. 	1 Set of each type & rating	
15.2	Brakes		
	<ul style="list-style-type: none"> Complete assembly 	1 No. of each type & size	
	<ul style="list-style-type: none"> Lining & springs 	1 Set of each type & size	
15.3	Couplings		
	<ul style="list-style-type: none"> Complete assembly 	1 No. of each type & size	
	<ul style="list-style-type: none"> Pins, bushes and nuts 	1 Set of each type & size	
15.4	Hydraulic Power Pack		
	<ul style="list-style-type: none"> Hydraulic Pump with electric motor, coupling, valves (mounted on pump) etc. 	1 Set of each type & size	
	<ul style="list-style-type: none"> Hydraulic Motor 	1 No. of each type & size	
	<ul style="list-style-type: none"> Valves 	1 No. of each type & size	
	<ul style="list-style-type: none"> O.P. coolers 	1 no	
	<ul style="list-style-type: none"> Filter Elements 	10 Nos. of each type	
	<ul style="list-style-type: none"> Pressure Switch 	1 No. of each type	
	<ul style="list-style-type: none"> Temperature Switch 	1 No. of each type	
15.5	Bearings (not covered separately)	1 Set of each type & size	
	<ul style="list-style-type: none"> Limit Switches 	2 Nos. of each type	
	<ul style="list-style-type: none"> Cylinder Manifold block with all valves mounted on it 	1 set	
	<ul style="list-style-type: none"> Hydraulic cylinder with piston 	1 Set of each type & size	

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S.No	Description	Quantity	Remarks
	<ul style="list-style-type: none"> Seals of hydraulic cylinder and pumps etc. 	2 Sets of each type	
	<ul style="list-style-type: none"> Hydraulic hoses 	2 sets	
	<ul style="list-style-type: none"> Rod end bearings with housing 	1 Set for all four clamps	
	<ul style="list-style-type: none"> Pressure Switches 	1 no	
	<ul style="list-style-type: none"> Common manifold block complete with all vales mounted on it 	1 no	
	<ul style="list-style-type: none"> Main Pivot bearing 	1 no	
	<ul style="list-style-type: none"> Pinion support & bearing 	1 No. of each type	
	<ul style="list-style-type: none"> Pinion 	2 nos	
	<ul style="list-style-type: none"> Latch (Pinion & rack segment locking device) 	1 no	
16.0	APRON FEEDER		
6.1	Head Pulley complete with shaft	1 no	
16.2	Tail pulley complete with shaft	1 no	
16.3	Drive Motor	1 No. of each type & size	
16.4	Gear Box	1 No. of each type and size & direction	
16.5	Complete internals of gear box including input and output shafts	1 Set of each type & size	
16.6	Reduction Gears	1 Set of each type & size	
16.7	Fluid coupling, flexible coupling etc.	1 No. of each type & size	
16.8	Traction rollers	20 % of population	
16.9	Carrying idlers	20 % of population	

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S.No	Description	Quantity	Remarks
16.10	Return Rollers	20 % of population	
16.11	Sprocket segments	2 Sets of each type & size	
16.12	Link chain	20 % of each type & size	
16.13	Pans (flights)	10 %	
16.14	Plummer Blocks	1 No. of each type & size	
16.15	Bearings	1 Set of each type & size	
16.16	Hydraulic Cylinders	1 Set of each type	
16.17	Hydraulic Cylinder seal kit	2 Set of each type	

B. ELECTRICAL

S.No / Cl. No.	Item	Quantity	Remarks
1.	MV BOARD		
	SPARES FOR VACUUM CIRCUIT BREAKER		
	(Spares for each rating of Breaker)		
	Closing & tripping coils each	10 Nos.	
	Spring charging motors	5 Nos.	
	Aux. switch assembly, limit position switches	5 Nos. each	
	Operating mechanism rods	5 Nos.	
	Surge suppressor units	5 Nos.	
	Vacuum bottles	5 Nos.	
	Multipin plug and socket for control	5 Sets	

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S.No / Cl. No.	Item	Quantity	Remarks
	Complete drawout finger contact assembly each type	2 Nos.	
	SPARES FOR SWITCH GEAR		
	Busbar support insulators of each type	20 Nos.	
	Switches of each type	5 Nos.	
	Aux.switches/Limit position switches of each type	5 Nos.each	
	Numerical Relays of each type	1 No.	
	Auxiliary relays of each type	1 No.	
	Interposing relay for DCS each type	1 No.	
	Clustered type LED of each type/colour	2 Nos.	
	CTs of each ratio , type and rating	3 Nos.	
	VTs of each ratio , type and rating	3 Nos.	
	Timer each type	1 No.	
	Check synchronizing relay	1 No.	
	Meters of each type	1 No.	
	Fuses of each type and rating	20 Nos.	
	Disconnecting type Terminal block for CT wiring	5 Nos.	
	Non-disconnecting type Terminal Block	5 Nos.	
	Shrouds each type	5 Nos.	
	MCB of each type and rating	5 Nos.	
	Shutter mechanism complete of each type	5 Nos.	
2.	SERVICE TRANSFORMER		
	SERVICE TRANSFORMERS - 6.6/0.433KV (To be repeated for each service area)		

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S.No / Cl. No.	Item	Quantity	Remarks
	<i>(For the following items each type & rating to be repeated)</i>		
	<i>HV Bushing</i>	<i>1 Set</i>	
	<i>LV Bushing</i>	<i>1 Set</i>	
	<i>Neutral Bushing</i>	<i>1 Set</i>	
	<i>RTD</i>	<i>3 No</i>	
	<i>Complete Winding Temperature scanner</i>	<i>1 No</i>	
	<i>Current Transformer</i>	<i>2 No.</i>	
	<i>Support Insulator</i>	<i>5 Set</i>	
3.	LV SWITCHGEAR/PMCC/MCC		
	<i>(For the following items each type & rating to be repeated)</i>		
	<i>Breaker complete with operating mechanism</i>	<i>1 No.</i>	
	<i>Closing coil</i>	<i>2 No.</i>	
	<i>Tripping coil</i>	<i>2 No.</i>	
	<i>Operating mechanism rod</i>	<i>3 No.</i>	
	<i>Fixed and moving contact assembly</i>	<i>2 Set.</i>	
	<i>Spring charging motor</i>	<i>2 No.</i>	
	<i>Breaker Protection Module</i>	<i>1 No</i>	
	<i>Gasket</i>	<i>5 Set</i>	
	<i>Aux. switch assembly</i>	<i>3 Set</i>	
	<i>Limit Position Switch</i>	<i>3 No</i>	
	<i>Busbar support insulators of different sizes</i>	<i>3 Set</i>	
	<i>Switches</i>	<i>3 No.</i>	
	<i>Numerical Relay</i>	<i>3 No.</i>	
	<i>Auxiliary relay</i>	<i>2 No.</i>	

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S.No / Cl. No.	Item	Quantity	Remarks
	Interposing relay of each type for DDCMIS	2 No.	
	Clustered type LED	5 No.	
	Current Transformer	6 No.	
	Voltage Transformer	6 No.	
	Meters	2 No.	
	Power Fuse	5 No.	
	Control Fuse	5 No.	
	Timer	2 No.	
	Check synchronizing relay	1 No.	
	Disconnecting type Terminal block for CT wiring	5 No.	
	Non-disconnecting type Terminal Block	5 No.	
	Electronic overload relays	2 No.	
	Single phase control transformer 415V/110V	5 No.	
	Intelligent Controller Module	5 No.	
	Power contactor	1 No	
	MPCB	1 No	
	MCB	1 No	
	MCCB/SFU	1 No	
	Push button with contact assembly	3 No.	
	ACDB/PDB PANEL (To be repeated for each board)		
	(For the following items each type & rating to be repeated)		
	Power Fuse	2 No.	

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S.No / Cl. No.	Item	Quantity	Remarks
	Control Fuse	5 No.	
	Push button with contact element	2 No.	
	Ammeter	2 No.	
	Voltmeter	2 No.	
	Terminal Blocks	2 No.	
	MCB	2 No.	
	SFU/MCCB	2 No.	
4.	DC System		
	BATTERY CHARGER & DCDB (To be repeated for each service area)		
	(For the following items each type & rating to be repeated)		
	Thyristor / SCR	6 No.	
	Diode	6 No.	
	Contactactor	2 No.	
	Relay	1 No.	
	Selector switch	2 No.	
	Control switch	2 No.	
	Meter	2 No.	
	PCB	2 Set.	
	Push Button with contact element	2 No.	
	Control Transformer	2 No.	
	LED indication lamp	5 No.	
	Switch Fuse Unit / MCCB	2 No.	
	Power Fuse	3 No.	
	Control Fuse	3 No.	
	Semi conducting Fuse	6 No.	
	MCB	2 No.	
5.	NON-SEGREGATED PHASE BUS DUCTS (LT) (To be repeated for		

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S.No / Cl. No.	Item	Quantity	Remarks
	<i>each Bus duct Unit)</i>		
	<i>(For the following items each type & rating to be repeated)</i>		
	<i>Busbar support insulators of different sizes</i>	<i>2 Set</i>	
	<i>Flexible Connectors (for equipment connection) (Complete set for all the phases)</i>	<i>2 Set</i>	
	<i>Expansion joints (for conductor for all the phases)</i>	<i>2 Set</i>	
	<i>Silica gel breather</i>	<i>2 No</i>	
6.	MOTORS AND ACTUATORS (TO BE REPEATED FOR EACH SERVICE AREA)		
	<i>(For the following items each type & rating to be repeated)</i>		
	<i>Motor bearings</i>	<i>1 Set</i>	
	<i>Torque/Limit switch</i>	<i>5 Set</i>	
	<i>End Limit switch</i>	<i>5 Set</i>	
	<i>Position transmitter for inching type</i>	<i>2 No</i>	
7.	ILLUMINATION SYSTEM		
	<i>MLDB/LDB Panel (To be repeated for each board)</i>		
	<i>(For the following items each type & rating to be repeated)</i>		
	<i>Temperature surveillance unit for Lighting Transformer</i>	<i>1 No.</i>	
	<i>RTD element for Lighting Transformer</i>	<i>1 Set</i>	
	<i>Busbar support insulators of different sizes</i>	<i>2 Set</i>	
	<i>Power Fuse</i>	<i>2 No.</i>	

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S.No / Cl. No.	Item	Quantity	Remarks
	Control Fuse	2 No.	
	Push Buttons with contact element	5 No.	
	Ammeter	1 No.	
	Voltmeter	1 No	
	Power Terminal Block	2 No	
	MCB	2 No.	
	MCCB/SFU	2 No.	
	ALDB/LDB PANEL		
	<i>(For the following items each type & rating to be repeated)</i>		
	Busbar support insulators of different sizes	2 Set	
	Power Fuse	20 No.	
	Control Fuse	20 No.	
	Push button with contact element	5 No.	
	Ammeter	2 No.	
	Voltmeter	2 No	
	Electronic energy meter	2 No.	
	Terminal Blocks	5 No	
	MCB	5 No.	
	SFU/MCCB	5 No.	

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

C. INSTRUMENTATION & CONTROL

S.No	Item	Quantity/Unit	Remarks
1	Programmable Logic controller (PLC) for Coal Handling Plant		
1.1	Power Supply Unit/Module for PLC and I/O	10% of each type & Model, minimum 1 no whichever is higher	
1.2	Input/ Output modules	10% of each type & Model, minimum 1 no whichever is higher	
1.3	Central Processor Unit Module	1 no. of each type & Model	
1.4	Communication Module	1 no. of each type & Model	
1.5	Interface Module	1 no. of each type & Model	
1.6	PLC Backplane I/O Bus without modules	1 no. of each type & Model	
1.7	Network adapters/converter, LIU,OLM, Network/ Ethernet Switch and other network hardware used	1 no. of each type & Model	
1.8	Display Units (LCD/LED/TFT)	1 no. of each type & Model	
1.9	Keyboard	2 nos.	
1.10	Mouse	2 nos.	
1.11	Hard Disk Drive Unit (capacity as per requirement)	1 no.	
1.12	CD/DVD Read/Write Drive	1 no.	
1.13	CDs/DVDs	25 Nos.	
1.14	Installation Software (for OWS, EWS, Controllers, Firewall Security and any supporting softwares)	1 no. copy of CD/DVD of each requirement	
1.15	Interconnecting Cables with connectors (within panels)	1 no. of each type	
1.16	Prefab Interconnecting Cables with connector	1 no. of each type & length	
1.17	System Bus Cable With Connector	1 no. of each type & length	
1.18	IO bus cable with connector for remote IO units	1 no. of each type & length	
1.19	Loose Connectors	3 nos. of each type	
1.20	Batteries for RAM battery back-up	1 set for each type and model no. of CPU	
1.21	Printer Paper	3000 sheets of each type	
1.22	Printer Cartridge / Toner/ Ribbon	5 Nos. of each type	

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S.No	Item	Quantity/Unit	Remarks
2	UPS for CHP Package)		
2.1	Intelligent UPS		
2.2	Silicon Controlled Thyristors, Diodes & Power Transistors	100%	
2.3	Capacitors	1 set	
2.4	CT's, CVT's, VT's, Chokes, AC/DC isolators, Contactors, Timers, Relays	10% of each type and rating	
2.5	Fuses of Each Type & Ratings	100%	
2.6	Fuse Free Circuit Breakers	5%	
2.7	Electronic Modules	10%	
2.8	Lamp Holders With Series Resistors	10%	
2.9	Cooling Fans	1 nos of each type	
2.10	Digital/Analog panel meters/indicators	1 nos of each type	
2.11	Relays of all types including overload relays	10%	
3	Field Instruments for Coal Handling Plant		
3.1	RTD (single/Duplex type), Thermocouple	10% of each type & Range	
3.2	Pressure Gauge, DP Gauge	10% of each type & Range	
3.3	Temperature Gauge	10% of each type & Range	
3.4	Level Gauge	10% of each type & Range	
3.5	Pressure Switch	10% of each type & Range	
3.6	Differential Pressure Switch	10% of each type & Range	
3.7	Level Switch (Capacitance/RF Type/Float/Displacer etc)	10% of each type & Range	
3.8	Level transmitter (Ultrasonic, Radar type)	1 no. in each type and range	
3.9	Pneumatic power Cylinder	1 No. of each type & Range	
3.10	Solenoid Valve with coil	1 No. of each type & Range	
3.11	Belt Weigher	10% of each type & Range	
3.12	Pull Chord Switch	10% of each type & Range	
3.13	Belt Sway Switch	10% of each type & Range	
3.14	Belt Monitoring Unit (BMU)	10% of each type & Range	
3.15	Zero Speed Switch	10% of each type & Range	
3.16	Under Belt Switch	10% of each type & Range	

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S.No	Item	Quantity/Unit	Remarks
3.17	Chute Blockage Switch	10% of each type & Range	
3.18	Electromechanical Type Limit Switch	10% of each type & Range	
3.19	Proximity Switch	10% of each type & Range	
3.20	Speed Probe	10% of each type & Range	
3.21	Speed Transmitter	10% of each type & Range	
3.22	Vibration sensors	2 nos. in each type and range	
3.23	Vibration Monitor	1 no.	
3.24	Accessories for Transmitters & Gauges(valve manifold, snubber, isolation valve, drain valve etc.,)	2 nos. in each type and range	
3.27	Solenoid Valve with coil	10% of each type & Range	
3.29	Smart Valve Positioner	10% of each type & model	
3.3	Air Filter Regulator	10% of each type & range	
4	Process connection Piping for Coal Handling Plant		
4.1	2 way, 3 way valves for instruments	10% of each type, size, rating, class, material & model	
4.2	Fittings	10 Nos. of each type, rating, material & size	
4.3	Valve manifolds (2way, 3 way & 5way)	10 % of each type, rating & model	
4.4	Air Filter Regulator	10 % of each type, model & range	
5	Instrumentation cables & Accessories For Coal Handling Plant		
5.1	All Instrumentation Field Cables from Instrument to JB and JB to DCS/PLC (including compensating cable)	5% of total installed Length (In running meter) if total installed length < 1000 metres or 1 no. of 1000 metre. Drum if total installed length > 1000 metres, of each type, pair & size	
5.2	Fiber optic cable	1000 metres of each type and size	
5.3	Communication cable from PLC to RIO	1000 meters in each type and size	
5.4	Communication cable from PLC to OWS/EWS	500 meters in each type and size	
6	Cabinets, Panels & Junction Box For Coal Handling Plant		
6.1	Terminal Blocks	5% of each type & rating (for types of total quantity > 100 nos.)	
6.2	MCB	10% of each type & rating	
6.3	Fuse	50% of each type & rating	

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

S.No	Item	Quantity/Unit	Remarks
6.4	Junction box	1 no. of each size & material	
6.5	LED Indicator	10% of each type, Colour & voltage rating	
6.6	Panel/Cabinet cooling fan	5% of each type & model	
6.7	Panel/Cabinet door switch	5% of each type & model	
6.8	Panel/Cabinet CFL	5% of each type & model	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-I, ANNEXURE-III
LIST OF SUB-VENDORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-III

List of Sub-vendor

{List of approved vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the given format.}

A. MECHANICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

B. ELECTRICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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C. CONTROL & INSTRUMENTATION

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

D. CIVIL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-II, PART-A
DETAILED TECHNICAL SPECIFICATION-MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
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VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II:DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

Document Number	Rev No.	Description	Page No.	Date of Issue
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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

COAL HANDLING PLANT (PACKAGE NUMBER: R&M-SP-04)

VOLUME-II, SECTION-II, PART-A DETAILED TECHNICAL SPECIFICATION- MECHANICAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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1

GENERAL

This section deals with the technical requirements of Coal Handling Plant which shall be designed adequately for continuous, smooth and trouble free operation throughout the extended life of the power plant.

Bidder should visit, inspect and examine the site and its existing facilities, interface areas and shall obtain all necessary information as to mitigate risks, contingencies and other adverse circumstances that may influence or affect his offer. Further, bidder to note that, since the proposed R&M assignment is to be executed in an existing plant, he should take adequate precautions to protect all existing equipment, structures, facilities, buildings etc. from damage.

Any relocation or modification, of existing facilities (both over ground and underground) including pipelines, cables, roads, drainage or any other facilities, which is present within the area of the proposed facilities, shall be included in scope of work. The said modification, if any, can only be taken up with prior approval of the owner.

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2

CODES & STANDARDS

The design, manufacture, inspection and testing of the Coal Handling System shall comply with all the currently applicable statues, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall confirm to the latest edition of the following standards & codes. Other internationally acceptable standards/codes, which ensure equal or higher performance, shall also be accepted.

- **Belt Conveyor System**

IS: 11592: Code of practice for selection and design of Belt Conveyors.

CEMA: "Belt Conveyors for Bulk Materials" published by Conveyor Equipment Manufacturers' Association.

IS: 7155: Codes of Practice for Conveyor Safety.

IS: 1891 (Part-I): General Purpose Belting

IS: 8598: Idlers and Idler Sets for Belt Conveyors

IS: 4009 (Part-II): Conical Head Grease Nipples

IS: 8531: Pulleys for Belt Conveyors.

IS: 226: Structural Steel (Standard Quality)

IS: 4682: Codes of Practice for Lining of Vessels and Equipment for Chemical Processes.

IS: 11592: Code of practice for selection and design of Belt Conveyors.

IS: 3531: Pulleys for Belt Conveyors

CAN / CASA - M422 M87: Canadian standard association.

IS: 2062: Steel for General Structural Purposes – Specification
Conveyor Equipment Manufacturers Association (CEMA)

- **Drive equipment like gears etc.**

IS:3688 : Dimensions for shaft ends

IS:3681: General plan for spur & helical gears

IS:7403 : Code of practice for selection of standard worm and helical gear boxes Belt Scales/ Weighers

NEMA Standards

NEC For electronic circuit enclosures.

IS:11547: Electronic weighing in motion system.

- **Dust Control Equipment**

IS:778 : Gun Metal gate, globe & check valves for general purpose.

BS:5150 :Cast Iron Gate Valve for water works purposes

BS:5152 :Cast Iron Globe Valve for water works purposes

BS:5312 :Cast Iron Check Valve for water works purposes

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IS:1239 : Mild Steel tubes & fittings.
 IS:2379 :Colour for the identification of pipe line.
 IS:3589 :Electrically welded steel pipes for water, gas & sewage (200 to 2000 mm)
 IS:5312 : Swing check type reflux (non return) valves.
 IS:1520 : Horizontal centrifugal pump for clean, cold fresh water.
 IS:5120 :Centrifugal pump for clean, cold & fresh water.
 BS: 5169 & BS:1123 : Air Receivers.
 ANSI B 31.1:Code for pressure piping.
 Hydraulic institute Standards of U.S.A
 IS:210 Cast Iron
 IS:318 Bronze

- **Ventilation equipment**

IS:3588 : Specification for electrical axial flow fans.
 IS:2312 :Propeller type AC Ventilation fans
 IS:3963 :Specification for roof-extractor units
 IS:4894 :Centrifugal Fans
 IS:655: Specification for Metal Air Duct
 ARI:210: Standard for Unitary air conditioning equipment.
 ARI:270: Standard for application, installation and servicing of unitary equipment.
 IS:8183: Specification for bonded mineral wool.
 IS:661: Thermal insulation for cold surfaces.
 IS:4671: Expanded polystyrene for thermal insulation purpose.
 IS:8148: Packaged Air conditioners.

- **Crushers & Vibrating Screens**

IS: 8723: Dimensions for vibrating conveyors and feeders with rectangular or trapezoidal trough
 IS: 286: Austenitic-Manganese Steel Castings - Specification

- **Monorail and Hoists**

IS:3938 : Specification for Electric Wire Rope Hoist
 IS:3832 : Chain pulley blocks
 IS:2429 : Round steel short link chain
 IS:6216 :Short link chain grade 80
 IS:8610 :Points hooks with shank for general engineering purposes
 IS:210 : Cast Iron Castings

- **Chutes and Hoppers**

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IS: 4682: Code of practice for lining of vessels and equipment for chemical processes.

IS:226 : Structural Steel (Standard Quality)

- **Elevators**

IS:4722 Rotating Electrical Machines – Specification

IS:325 Three-phase induction motors

IS:1753 Aluminum conductors for insulated cables

IS:1554 Specification for PVC Insulated (Heavy Duty) Electric Cables

- **Locomotives**

RDSO : Research Design and Standard Organization

IEC-34 : Rotating Electrical Machines

IS- 1540: Balancing of Rolling Components

IS-1239 : Mild Steel Tubes

IS-2494: V-Belts

IS- 4005: Grease Nozzles

IS-1460: High Speed Diesel Oil

IS- 7624: Storage Batteries

- **Other Relevant codes**

ASTM-D-2234: Standard Methods for collection of a Gross Sample of Coal

ASTM-D-2013: Standard Method of Preparing Coal Samples for Analysis

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3 SYSTEM DESCRIPTION

- a) Track Hopper: Coal is discharged from the wagons (bottom discharge) to the RCC Track Hopper lined with [50 mm thick guniting]. The paddle feeder are employed to evacuate ROM coal from the track hopper and feed this coal to the parallel conveyor running below the track hopper. Length of the track hopper is [210 meters]. The essential requirement of such a system is bottom discharge wagon.
- b) Wagon Tippler: Coal is also unloaded from the BOXN type railway wagons by wagon tippler. [Rotary/Rotaside] Wagon tippler will be employed for tipping operation. The coal from BOXN type wagon will be unloaded into the underground RCC wagon tippler hopper. In this system, the Side Arm Charger (SAC) will drag the wagons one by one to place this wagon on wagon tippler table. After predetermined time, it goes back and drags another wagon and so on.
Apron Feeder is employed to evacuate ROM coal from the wagon tippler hopper and feed this coal to the parallel conveyor running below the hopper.
- c) Coal from [Wagon Tippler / Track Hopper] is transported to Crusher House. Discharge from each incoming conveyor is envisaged to be halved with the suitable gate and chute arrangement and shall be fed to the [Roller Screen/Vibrating Grizzly Feeders]. [Roller Screen/Vibrating Grizzly Feeders] will segregate (-) 20 mm size coal and feed to downstream conv. Oversize (+) 20 mm coal from each [Roller Screen/Vibrating Grizzly Feeders] will be discharge into each crusher. The crushed coal from both the crushers will be discharged to downstream conveyor through intermediate belt feeders.
During direct feeding of coal to Coal Bunker, crushed coal from the crusher house is transferred to the coal bunker through belt conveyors via Junction Towers located in between Crusher House and Tripper Floor. [...] nos. of Travelling Trippers, mounted on each belt conveyors at Tripper Floor shall feed coal to bunkers in each mill building.
- d) In case bunkers are full, the crushed coal from Crusher house is directly sent to stockpile for stacking and during unavailability of Coal from external sources, coal is reclaimed from Stock Yard to feed the coal to Bunker. Bucket wheel Stacker-cum-Reclaimer shall be installed on yard conveyor for the stacking and reclaiming operation. There shall be one reversible stacker-cum-reclaimer, which shall be capable to stack and reclaim from the stockpiles having [fifteen days] coal requirement for [...] No. unit of [210/215/220/250] MW. Electronic belt weighers shall be installed on conveyors to measure the coal received and coal sent to bunker.
- e) In line magnetic separators shall be located prior to crusher house and prior to coal bunker to eliminate the tramp metals. Metal detectors shall be installed suitably for detecting non-ferrous metals prior to crusher house and prior to

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coal bunker with LT conveyor motor drive. Online coal sampling system shall also be installed in Junction Tower prior to entry to coal bunker.

- f) Dust extraction systems having bag dust collector, vent fan with ducting arrangement, shall be provided to extract coal dust in Crusher house and Boiler bunkers and the extracted dust to be fed to the down streamside of conveyor / bunkers.
- g) Dust suppression systems having water spray arrangement with fixed spray nozzles shall suppress coal dust at all other discharge and feeding points of coal. Dust suppression system with swivelling water sprinklers arrangement to suppress dust in coal stockyard shall be provided. Dust suppression system shall also be provided for all the unloading and discharge points of wagons in unloading hoppers. In Built Dust suppression system shall be provided in the paddle (Rotary Plough) feeders.

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4 DESIGN CRITERIA

4.1 System Capacity Calculation and Assumptions

Following design criteria shall be adopted for the design of the coal handling plant:

	Particular	Value
i	Turbine Heat Rate	[...] kCal/kWh
ii	Boiler Efficiency	[...]%
iii	Gross Plant Heat Rate	[...] kCal/kWh
iv	PLF	100%
v	GCV of Worst Coal	[...] kCal/kg
vi	Plant operating working hours	[14] hrs
vii	Margin in arriving rated capacity	10%

Based on the above criteria, calculated values are as follows:

Daily Coal Consumption at TMCR [...] TPH

Daily Coal Consumption at BMCR [...] TPH

Conveying Capacity considering 14 hrs of CHP operation [...] TPH

Conveying Capacity (round off) [...] TPH

Conveying Capacity (with margin) [...] TPH

Rated Coal Conveying Capacity (round off) [...] TPH

2x100% Conveying streams including 2x100% equipment shall be provided for Coal Handling Plant with rated capacity of [...] TPH for [...] No. unit of [210/215/220/250] MW power plant.

Provision shall be kept for conveying stream changeover at transfer points for flexibility in operation in the event of failure of any conveying stream.

- a) Coal is sourced from [...] coal field. The annual coal consumption shall be [...] Million tons considering 100% PLF at BMCR.

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- b) Coal Handling Plant operation 14 hours/ day, based on continuous operation of a [unit/units] at BMCR load with worst coal.
- c) The track hopper shall be of RCC construction; approximately [...] m long and the inclination of hopper wall with horizontal shall be minimum [...] deg. The minimum holding capacity of track hopper shall be [...] T (approx.) considering the effect of repose angle of the coal inside the hopper while sizing and designing the hopper. The unloading time of rake containing NBOX (if applicable) type wagon shall be [...] hrs (max.) and for BOBR wagons shall be [...] hrs (max.).
- d) [Interconnection of the Conveyors, Transfer point is made for transfer of coal from [...] stage to [...] stage and vice versa during emergency condition.]
- e) [...] no's of Emergency reclaim hopper (ERH) each of [...] T capacity is provided to reclaim coal by dozers when stacker reclaimer is not in operation and is fed to the coal bunker through a series of conveyors and various Transfer Points.
- f) All hoppers, tunnels and underground transfer towers shall be provided with sump & sump pumps (1 operating + 1 standby). The drive motor of all the sump pumps shall be mounted at least 1.0 meter *above* the floor level. The sump pumps shall be suitable to handle coal slurry and impeller shall be of non-clog type.
- g) Wherever the conveyor crosses the road, a minimum clearance of [8 m] shall be provided below the structure. At the rail crossings, this clearance shall be as per the Indian Railways requirement.
- h) Provision is to be kept with platforms, and monkey ladder for crossing over the conveyors at approximately every 100 m intervals of route length and minimum one per conveyor.
- i) Provision for Fire Hydrant ring main encompassing the coal stockyard is to be kept to combat incidence of fire due to self ignition.
- j) Necessary water distribution network for drinking and service water with pumps, piping, tanks, valves etc. will be provided for distributing water at all transfer points, control room etc.
- k) Special precautions shall be taken for pollution control by providing dust extraction and dust suppression system in different transfer points and ventilation system for underground tunnels. In addition, roof extraction fans will be provided in the key areas like boiler bunker floors. Pressurised ventilation system with unitary air filtration unit will be provided for MCC Building.
- l) A centralized control room with microprocessor based control system is to be provided for operation of the coal handling plant. Except locally controlled equipment like roof extraction / Dust suppression / Ventilation equipment sump pumps, water distribution system etc. all other inline equipment would

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have provision of remote control. However, provision of local control would also be provided. All necessary inter locks. Control panels, MCC, diagram etc will be provided in the main control room for safe and reliable operation of the coal handling plant.

4.2 Wagon Tippler

- a) [Rotary/Rotaside] wagon tippler shall be provided complete with all structural members, tippler platform, tipping mechanism, tippler drive motors, brakes, couplings, shafting and all automatic controls for positioning, tipping and discharging the entire contents of the wagon into the hopper.
- b) The tippler shall be design to handle gross load of [140] tons taking into consideration a [4] axled bogie wagon with an axle load of [32.5] tons plus the overloading caused due to variable density of the bulk material and heap loading of wagon.
- c) Wagon tipper design should take care of Locomotive (weighing upto 150 MT) moving at tipper table at speed of [8] Kmph.
- d) Bidder shall source Rotaside wagon tippler form a manufacturing/supplier who has supplied minimum [...] nos. of [Rotary/Rotaside] wagon tippler suitable for tipping Indian Railways wagons used for transportation of coal or other minerals which are in successful operation for a minimum period of two (2) years as on date of bid opening.

4.3 Wagon Unloading System

- a) The rake comprising of about [58] numbers of wagons shall be pushed into the rack of in haul equipment by a locomotive. Further placing of wagons over tippler platform and carrying away the empty wagon shall be accomplished with the help of a side arm charger whose travel length shall suit the requirement of wagon tippler hopper dimensions approved by RDSO/railways authority.
- b) Wagon tipplers shall be suitable to handle any type of wagons being used by Indian railways as on date for transporting of coal as per IS-10095 (Latest Edition) and shall conform to all stipulations with regard to suitability for handling wagons having width, height and length over coupler faces as indicated by RDSO/railway authorities at the time of approval of wagon tippler drawings.
- c) Maximum moving dimensions of locomotive and wagon as per Indian Railways norms shall be adopted for providing clearances with respect to structure, equipment and tippler Arrangement.
- d) Complete wagon tippler and accessories shall have the approval of concerned Indian Railway Authorities and RDSO. Further, the Bidder shall submit to the owner detailed drawings of wagon tippler and accessories including civil and structural drawing.

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- e) The top opening of wagon tippler hopper shall be suitable for receiving coal from wagons for which the wagon tippler drawing shall be approved by RDSO/railway authorities.
- f) The Bidder shall obtain all statutory approvals from the relevant RDSO/railways authorities, before the wagon tippler complex is put into operation.

4.4 Wagon Tippler Hopper

- a) The wagon Tippler hopper shall be of RCC construction and adequately sized to accommodate the coal load for at least three (3) nos. 8 wheeled wagon of RDSO design used by Indian Railways. For effective volumetric capacity computation of the hopper, the angle of repose of coal shall be considered 37° . The minimum valley angle of the hopper shall be considered as 60° . Apron feeders shall be provided below the hopper opening to evacuate coal from the hopper and feed onto associated belt conveyors below. Complete inside surfaces of the hopper shall be provided with 50 mm thick gunting.
- b) Steel grating of mesh size [350] mm x [350] mm over wagon tippler hopper is to be provided. The hopper and grating shall be designed for movement of front end loader/Bulldozer over them. Bulldozer weight shall be considered as about [35] T.
- c) Wagon tippler shall be designed in such a way that the space for mounting the pay loader is available so that over sized coal can be removed.
- d) During each cycle of operation, the tippler shall be capable of holding, unloading and replacing the wagon to its original position without damage to the tippler or the wagon or the track.
- e) The Tippler shall be suitable for continuous operation, 24 hour a day, round the clock.
- f) The tippler shall be designed to allow passage of all standard board gauge 1676 mm Indian railways [diesel locomotives] over tippler table at restricted speed.
- g) The wagon tippler shall be suitably counter balanced at each stage of operation so as to require minimum driving power.

Equipment Data Sheet:

General	
a) Wagon Type	Standard broad gauge, Wagons of RDSO design used by Indian Railways to carry coal.

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b) Quantity	[...]
c) Moving Profile	As per Indian Railway norms
d) No. of Tips	25 (minimum) per hour
e) Rail Gauge	1676 mm
f) Weigh bridge	Load cell type
g) Duty	Continuous 24 hours
Design and Construction	
Wagon Tippler Hoper	
a) Construction	RCC construction
b) Size	[...]
c) No of openings	One(1)
d) Angle of Repose of coal for Wagon tippler hopper sizing	[37] degree
e) Lining	[...] mm thick gunting
f) Steel Grating	
i. Mesh Size	[350] mm x [350] mm
ii. Grating Section	[200] mm x [30] mm thick flats
Wagon Tippler	
g) Type	[Rotasid/Rotary] type
h) Tipping angle	Maximum 160 degree for Rotasid
i) Duty Requirement	Continuous operation
j) Counter Balancing	Suitable to keep power requirement at minimum
k) Cradle	Heavy welded steel plate construction trunion mounted
l) Driving Gear	
• Racks	Cast steel rack section bolted to end
• Pinion	Multiple pinions meshing with rack
m) Rail Table	Rolled steel joints with steel rails mounted on it.
n) Drive	Hydraulic motors. Coupled with planetary gear box
o) Brake	Electro hydraulic thruster operated
p) Clamping	Hydraulically operated

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q) Top And side stops

Self aligning type made of resilient material.

4.5 Side Arm Charger

- a) The side arm charger is used for wagon positioning at the wagon tippler hopper for unloading of materials. It shall be used for pushing/pulling a rake of [58] wagons of [110] tonnes gross weight each and locating wagons one by one on tippler.
- b) The side arm charger (SAC) shall be mounted alongside the main rail track and shall run on its rail track parallel to the main track. It shall have a minimum stroke of approximately from point just over one wagon length ahead of tippler to a point just beyond the tippler on the outgoing side. The rail envisaged for S.A.C shall be standard rail section.
- c) It shall be fitted with an arm pivoted at right angles to the track capable of being raised and lowered and carrying at its outer end an automatic coupler to couple the train.
- d) The charger frame shall consist of a single fabrication from rolled steel sections and plate on which every other item shall be directly mounted to form a robust and compact unit.
- e) The charger shall run on four cast steel wheels mounted on spherical roller bearings.
- f) To resist the moment reaction of the pushing force, two pair of steel side guide rollers shall be fitted. They shall be fitted on spherical roller bearings and shall have a simple lockable adjustment for true running and to take up wear. The side guide rollers shall run on the sides of the heads of the charger running track.
- g) The arm shall be of welded construction. Raising and lowering of the arm shall be by means of a hydraulic power cylinders mounted on the charger frame. A spring-loaded coupler shall enable automatic coupling of the arm to the wagon coupler. An actuator release mechanism with a hydraulic cylinder shall be provided for decoupling.
- h) The charger shall have adequate power for hauling a train load of 30 fully loaded wagons on a straight & level track and shall be suitable to position all types of wagons at the centre of wagon tippler. It shall be hydraulically driven by means of a pinion and land mounted rack.
- i) Drive pinion shall be mounted on output shaft of the hydraulic drive module.
- j) The side arm charger shall have a hydraulic power pack mounted on board, which shall provide power to independent hydraulic motors for charger traverse and arm hoist. The power pack shall be of complete with variable displacement pumps, proportional control valves with electronic cards, filters, piping, tank and accessories.

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- k) The charger shall be electrically interlocked with tippler for proper sequential operation with respect to operational and safety requirements.
- l) Easy access, adequate, maintenance spaces, working platforms, inspection covers shall be provided for all the equipment located in the side arm charger for safe and quick maintenance. All edges and openings shall be provided with toe guard. Chequered plates on floor shall be provided to prevent slipping.
- m) Centralised system of lubrication shall be provided for the equipment. However, all parts of the equipment needing manual lubrication shall be easily accessible. All oil pipes and grease nipples shall be well covered to prevent materials from falling on them.
- n) PLC based control is envisaged for control, interlock indicator, protection & annunciation for Side Arm Charger.
- o) The equipment shall be of Robust construction suitable for operation in dusty, humid and outdoor operation. The SAC rail & main rails shall be supported on R.C.C foundation. The SAC shall be operated automatically and controlled from common W.T. control room.

Equipment Data Sheet:

- 1. Quantity : [...]
- 2. Capacity (tones) : Suitable to haul [58 nos.] loaded
- 3. Travel (Meters) : As per system requirement
- 4. Track gauge, mm : Std. Broad gauge (1676 mm)

4.6 Track Hopper Complex and Shed

- a) The track hopper shall be of RCC construction, approximately [210] m long and the inclination of hopper wall with horizontal shall be minimum 60 deg. The minimum holding capacity of track hopper shall be [...] Te (approx.) considering the effect of repose angle of the coal inside the hopper while sizing and designing the hopper.
- b) Track Hopper shall be designed in such a way that the space for mounting the pay loader should be provided so that over sized coal can be removed from or crushed on the grizzly.
- c) The track hopper shall be designed structurally considering the load of the pay loader and supposing that the hopper is completely filled with coal upto the grating level.
- d) Coal of [(-) 250] mm (occasionally up to [(-) 400 mm]) size will be received at site by bottom discharge type wagons.
- e) Liners on paddle feeder table shall be provided as specified elsewhere in this specification. [50 mm] thick guniting shall be provided on track hopper walls and rail/grating supporting beams.

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- f) Maintenance bay shall be provided at both ends of the track hopper along with erection hatch, staircase, etc.
- g) Size of the maintenance hatch shall be liberally decided to provide ample maintenance, erection and handling facilities to space the paddle feeder along with its all accessories including carriage, drive system, control system, cable reeling drums.
- h) Shed shall be provided over entire length of track hopper. Adequate rail clearance shall be provided all round the rail track. The shed structure shall be designed suitably for installation of electric traction wire over the rail tracks inside the shed. The support for the traction wires shall be taken further shed structure. Adequate clearance shall be provided for satisfying clearance requirements of Railways/RITES.
- i) Covering sheds over Track Hopper shall be of steel frame construction with permanent color coated zincalume / Galvalume sheet on roof and side sheeting. Adequate number of louvers shall be provided for the sheds for natural ventilation. The Bidder shall provide hand-railings on both sides clearing the tracks for entire length of hopper to prevent any person falling inside. All doors and windows etc. shall be provided as necessary. The shed must be suitable for installation of electric traction wire by other agency.
- j) Steel gratings over track hopper of opening size [350] mm square have to be provided to allow coal of [300] mm lump size (occasionally up to (-) [400] mm. Also provision of manual unloading of coal from side discharge wagon has also to be provided by extending grating on both sides of track hopper to facilitate the same.

4.7 Junction (Transfer) Towers & Drive Houses

[Structural steel frame construction work with RCC roof and Floors providing sufficient space to accommodate the entire equipment like head end, drive unit and tail end of various conveyors, supports for conveyor bridges, tensioning arrangements etc. Cladding shall be of Metal sheeting. Ample space (min 1.5 m) shall also be provided for maintenance purposes. Minimum clear head room of 3.2 m shall be available at all floors of Transfer Tower. 5 mm thk MS x 400 mm dia. floor cleaning chute at all floors of Transfer Tower shall be provided. Chute shall terminate (outside the building) about 1500 mm above ground level. Tramp iron collecting/disposal chute upto last operating floor shall also be included under the scope of bidder's work.]

4.8 Conveyor system & related equipments

- a) Complete design of the conveyor system including power requirements, belt tensions, coasting time and radius calculation shall be calculated based on

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procedure given in the latest edition of IS 11592. A minimum margin of 15% for conveyor drives and 10% for other equipments shall be provided over and above the demand power required at design capacity. The motor rating and the frame size is to be selected as per IS 325/R20 series for L.T. motors and R20 series for H.T. motors, keeping all the above mentioned provisions and other applicable factors like derating etc. Other details regarding the motor are specified in Electrical Section.

- b) All unidirectional belt conveyors will be provided with head end single / dual motor snub drive with gear box, coupling, etc. Fluid coupling will be provided as high speed coupling when the consumed power is more than 30 kW, otherwise Pin Bush coupling will be provided. The Geared Couplings shall be used between gearbox and pulley. Wherever required, electro-hydraulic thruster type brake shall be used for all inclined conveyors. Gearboxes shall be provided with integral holdback devices to prevent rollback.
- c) For balancing coasting times between entire CHP equipment, if required, brakes should be used to reduce conveyor braking time. Use of fly-wheel to increase coasting time will not be permitted. Electro-hydraulic thruster type braking system shall be provided for such requirements.
- d) Idler friction factor under wet and dirty condition shall be used for conveyor tension and power calculation. This value shall be considered as 0.025.
- e) Carrying and return idler spacing in the region of convex curve shall be half the normal spacing.
- f) Profile of conveyor, inclination & radius of curvatures indicated in the enclosed drawings are the optimum requirements. Bidder shall try to retain the same as far as practicable.
- g) Each conveyor shall be provided with V type deck plate with adequate thickness steel plate at loading points, discharge points, and at take up locations.

Technical Data Sheet:

SI No	Item Description	Parameters
1.0	Rated capacity (TPH)	[...]
2.0	Design capacity (TPH)	[...]
3.0	Operation (Hr/Day)	24
4.0	Material Specification	
4.1.	Bulk Density (volumetric) kg / cum	[...]
4.2	Bulk Density (gravimetric) kg / cum	[...]

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4.3	Lump size (mm)	[...]
4.4	Angle of repose (Degree)	[...]
4.5	Angle of surcharge (Degree)	[...]
5.0	Belt width (mm)	[...]
6.0	Troughing Angle (Degree)	[Carrying Side - 35°, Return Side-10°/Flat]
7.0	Average belt strength	FR Grade
8.0	Cover thickness minimum	[5 mm Top cover, 3 mm Bottom cover]
9.0	Cover grade	Conforming to ISO: 340
10.	Maximum allowable belt sag (%)	[2]
11.	Factor of safety	[10] min.
12	Normal working tension	Less than [85]% of rated tension
13	Carrying idler tilt	[2]deg (0 deg for belt feeders)
14	Min concave radius	[250] m
	Min convex radius	[50] m
15	No of plies	Min [3]
16	Take up type	Gravity
17	Maximum permissible speed	[2.5] m/sec
18	Designed speed of belt conveyor	[...] m/sec (Approx.)
19	Conveyor No.	Conveyors [...], [...],[...],....

4.8.1 Belting

- a) Minimum tension in belt during running condition is to be checked considering maximum allowable belt sag at 2% of the idler spacing. The type of belt shall be for Heavy duty application.
- b) Maximum belt tension developed in the belt corresponding to design capacity during running condition should not exceed 85% of the maximum allowable belt tension of the selected belt as recommended by manufacturers. During starting condition tension of the belt should not exceed 150 % of maximum

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allowable belt tension or as specified by the manufacturer, whichever is lower.

- c) Belt shall have sufficient impact resistance to withstand impact at loading zone.
- d) The belt shall have adequate longitudinal flexibility so as to easily flex around pulleys and lateral flexibility so as to trough adequately to give a troughing angle of 35 deg even when the belt is empty. Belts shall have sufficient lateral stiffness to support the load.
- e) No. of splices in the belt should be minimum but not less than [4]. Belts should be despatched on reels. Oil or grease should not come in contact with belt.
- f) If short lengths of belt are required to be cut from belt in store, proper coating shall be applied on the exposed ends.
- g) For all the conveyors the number of plies, cover thickness, factor of safety etc. shall be as per the recommendation of belt manufacturer, but not inferior to the figures as tabulated in data sheet.

4.8.2 Idlers

- a) The rollers shall be mounted on EN-8 or equivalent material spindles by means of heavy-duty ball bearings. The bearings shall be seize-resistant adequately sealed and lubricated for life. The rolls shall be supported from fabricated steel brackets. For adjusting the alignment of the idlers, slotted holes shall be provided in idler supporting base plates. Direction of belt travel shall be clearly marked on the brackets of carrying idlers. The minimum diameter shall be not less than [152] mm. The bearing of size [30] mm for carrying idler and [20] mm for return idler. The bearings shall be sealed and lubricated for life. The bearings shall be seize resistant ball bearings. The rolls shall be supported from fabricated steel brackets. Fixing arrangement shall be drop in type. For adjusting the alignment of the idlers slotted holes shall be provided in idler supporting base plates. The minimum wall thickness shall be of 4.0 mm.
- b) Friction factor of idlers shall never be more than 0.015 while testing at shop.
- c) Idler rollers shall be waterproof, dust proof and weather proof against a high velocity water jet. All idlers shall be provided with minimum double labyrinth dust seal.
- d) Impact idlers shall be so designed as to avoid direct loading impact, belt damage and excessive punishment to carrier. Impact rubber disc shall be mounted on steel tubes and securely held in place. All Impact Idler Frames should be made from rolled channel sections.
- e) Return rollers shall be of two-roll type for Tripper Conveyors and conveyors longer than 400 m, which will be V-type with 10-deg. troughing angle. For other conveyors return idler shall be straight type.

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- f) Self aligning troughing & return idlers shall be similar in construction to troughing & return idlers respectively and shall be made to swivel with respect to central pivot and having positive action for automatically aligning the belt.
- g) For a particular size of belt each type of idlers and their components is to be identical to ensure inter-changeability.
- h) Suitable number of adjustable transition idlers at head end as well as the tail end at the steps of 10 Deg is to be provided for all conveyors.
- i) All conveyors shall be provided with one self-cleaning type rubber disc return idlers located near the head pulley.
- j) Proper arrangement is to be provided in the brackets of all types of idlers for preventing the rollers from the coming out of the brackets during normal/ abnormal operation.

4.8.3 Pulleys

- a) Pulleys shall be of mild steel construction and welded type with continuous rim and two end discs fitted with compression hubs. Pulley shafts shall be keyed to hubs.
- b) The snub pulleys on each conveyor is to be located to provide a belt wrap on the drive pulley of not less than 210 Deg.
- c) Bearings is have provision of greasing from one accessible side at a convenient location. All pulley bearings located below ground level should be split bearing only. All non-drive pulley shafts will be press-fitted in addition to being keyed.
- d) Plummer blocks shall be installed supported on rigid frame having machined surface. Adjustable screw and lock nut shall be provided on one side of plummer blocks for aligning purpose. The plummer block shall be dust tight with double labyrinth seals. Conical head shape nipples, suitable drain plug and eyebolt shall be provided. Side covers of plummer block shall be heavy-duty metallic sheets. 4-bolts plummer blocks shall only be used.
- e) The pulleys below inline magnetic separators shall have shell and hub of non-magnetic SS-304.
- f) Pulley shaft deflection at hub shall be maximum 5 minutes. Pulleys of same diameter shall be interchangeable as much as possible in totality and component wise.
- g) All drive pulley surfaces shall be hot lagged with vulcanised natural rubber with grooved in Herringbone pattern. All non-drive pulleys shall be vulcanised rubber lagged with plain lagging.
- h) All pulleys shall be provided with keyed forged steel shafts of EN8 or equivalent material of adequate proportion running in heavy-duty roller

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bearings with proper greasing arrangement.

Technical Data Sheet:

Sl. No.	Item Description	Design Criteria
1.0	Service	For head & drive, head snub, bend, take- up, tail & tail-snub pulleys (if required) to be used in all conveyors, belt feeders and traveling trippers.
2.0	Min. Drive Pulley Width	[...] mm
3.0	Min. Balance Pulley Width	[...] mm
3.0	Lagging to be provided	For all pulleys
3.1	Lagging Material & Thickness	Natural rubber blended with styrene butadiene rubber
3.2	Lagging Pattern	Herringbone-groove-pointing towards direction of Belt Travel or Diamond shaped for drive otherwise plain
3.3.	How lagging is secured	Vulcanised.
3.4	Abrasion loss	[250] mm ³ as per DIN 53516
3.5	Hardness of lagging material	Shore hardness - 60 Deg. \pm 5
4.0	Construction Features	
4.1	Type of Construction	Welded Steel as per IS-8531
4.2	Pulley Material	Mild Steel conforming to IS:2062
4.3	Pulley Shaft Material	EN-8/Equivalent
4.4	Pulley Diameter	As per IS-1891 or belt manufacturer's standard whichever is higher.
4.5	Shell plate thickness	Min. [16] mm (Exact to be determined by Bidder from actual Belt Tensions)
4.6	Angle of Wrap for drive pulley.	220 deg. drive pulley

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4.7	End Disc Thickness	[24] mm
4.8	Type of Pillow Block	Heavy duty split type with side covers.
4.9	Type of bearing	Antifriction double-row spherical roller.
4.10	Bearing life (hours)	30000 h.
4.11	Type of sealing	Double Labyrinth with synthetic sealing.
4.12	Lubrication	Through Manual grease gun.

4.8.4 Motor

- a) H.T. motors shall be provided for equipment as required. Rating of the drive motors in no case shall be less than 115% of the demand power required at specified design capacity. The motor rating shall be at 50 Deg C. Motor having rating *up to 200 kW shall be LT and rating above 200 kW shall be HT*. Details of motor requirement shall be indicated in the relevant Electrical section.

4.8.5 Gear Box

- a) Gear box mechanical ratings should not be less than the rating of its drive motor or 1.5 times of the demand power considering design capacity at motor output or as per manufacturers selection method whichever is higher. The Gearbox should be selected giving due care to Thermal ratings along with the proper cooling method of the same. Above is subject to Owner's approval. Gearboxes should be of similar handing and completely interchangeable for all twin conveyors.
- b) Successful Bidder should provide the input and output shaft extension to accommodate the high-speed coupling and low speed coupling respectively. The details of coupling hubs will be furnished to successful bidder.
- c) Helical and bevel helical gears shall be generated by hobbing machine with necessary precision and accuracy. Right hand thread shall be provided unless otherwise stated.
- d) Worm gear box shall not be used for conveyor / feeder application.
- e) Input shaft shall be integral with the first stage pinion duly heat-treated and hardened. Low speed shafts shall be manufactured from heat-treated carbon steel and precision ground. Shaft ends shall be properly sealed to prevent any ingress of dust.

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Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.0	Location	[...]
2.0	Type of Prime Mover	[...]
3.0	Type of high speed coupling	[...]
4.0	Type of low speed coupling	[...]
5.0	Frequency of Start	[...]
6.0	Reducer Base Frame	[...]
7.0	Gear Box service factor.	[...] (To be taken for 24 Hrs continuous duty & moderate shock)
8.0	Type of cooling	[...]
9.0	Material of Construction	
a	Casing/Housing	Cast Iron Grade-FG-260 of IS-210 / Equivalent and stress relieved.
b	Gear & Pinion	Case hardened high tensile Carbon/Alloy Steel, heat-treated, ground & polished.
c	Shaft	Heat treated Forged/Alloy Steel.
10.0	Bearing	
a	Make	[SKF/FAG/NTN Or Equivalent]
b	Type of Bearing	Antifriction Ball/Roller.
c	Lubricating medium	Oil/ Grease of recommended quality.
d	Type of enclosure	Totally enclosed, oil tight and dust proof.
11.0	Holdback Details	
a	Hold back type	Integral with gear box
b	Location of holdback	Input shaft of Gear Box
c	Mounting	On Machined/Ground Surfaces

4.8.6 Fluid Coupling

- Fluid coupling shall be radially removable type so that it can be taken out for maintenance from its installed position without shifting the corresponding motor & gear box from its position.
- Primary speed - Stall Torque curve shall be such that secondary side of fluid coupling can start rotating only when motor speed has reached minimum

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85% of rated of speed.

- c) Coupling shall be suitable for full load, part load & no load starting of the drive equipment without hampering safety of the motor and rate of acceleration.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.0	Location/Conveyor No.	[...]
2.0	Fluid coupling requirement	Fluid coupling shall be used to connect gear box with motor above 30 kW
3.0	Type of coupling	Delayed fill type
4.0	Equipment on Input side	Sq. cage Induction Motor
5.0	Equipment on Output side	Gear Box
6.0	Maximum allowable slip	3%
7.0	Type of rotation	Shall be capable of rotating in both directions.
8.0	Starting Torque (kg-m)	Adjustable in the range of 120% to 270 % of running torque.
9.0	Balancing	Dynamically Balanced

4.8.7 Flexible Coupling

- a) The service factor of the couplings shall not be less than 1.5 times the drive motor rating. Due consideration shall have to be made for fluctuation of torque and also for starting and braking of the conveyor. Both at starting and at braking condition the torque through the coupling may be as high as 225% of the corresponding running torque, for duration of about 30 secs. The simultaneous worst loading condition is to be considered.
- b) Geared Couplings shall be able to absorb parallel and angular misalignment. These shall have crowned external teeth of the hub, which shall engage, with the straight internal teeth of the sleeve. The pressure angle, the amount of crowning and backlash values shall be so chosen with a view to achieve the best results in the load carrying capacity. Lubrication arrangement shall be adequate to ensure silent operation and minimum wear of gear teeth. Coupling shall be dust proof and suitable sealing device shall be provided. The

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Pin Bush Coupling shall consist of two Cast Steel Flanges fitted with high tensile bolts & rubber bushes. Couplings shall be capable of being disconnected easily by withdrawal of Pin.

Technical Data Sheet:

Sl. No.	Item Description	Parameters	
1.0	Type of Coupling	Flexible Gear	Pin Bush
2.0	Equipment connected on input side	Gear box	Electric Motor
3.0	Equipment connected on output side	Belt Conveyor Pulley.	Gear box
4.0	Shaft dia (Input & Output)	Bidder to decide	
5.0	Brake-drum to be provided.	Bidder to decide	
6.0	Prime Mover	Electric Motor.	
7.0	Material of Construction		
7.1	Hub & Flanges	Forged Steel	
7.2	Gear	Alloy Steel	-
7.3	Retainer disc.	Forged Steel	-
8.0	Permissible misalignment (Approx.)		
8.1	Parallel.	3 to 5 mm	
8.2	Angular	(±) 1.5 Deg.	

4.8.8 Take-up Arrangement

- a) Take up weight material shall be cast iron blocks. Automatic type gravity take up shall be provided for all the conveyors with suitable take up pulleys, bend pulleys, counter weights, guide rails, mesh guard, take-up tower and other necessary items. Depending upon the space available, vertical or horizontal type gravity take-up will be provided.
- b) Suitable guards marked up scale attached to the frame to monitor belt stretch and access/maintenance platforms with handrails, etc. shall be provided. Adequate access from conveyor gallery/transfer house/ground etc., shall be provided to inspect, repair and maintain the gravity take-up arrangement.

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- c) The prime consideration shall be to locate the automatic take-ups at a place where these will work best, in relation to drive. Height of take-up guide structure shall be sufficient to allow the take-up weight movement up and down for all operating conditions of the conveyor and to allow minimum two (2) vulcanising lengths margin in the belt or percentage of conveyor length (3%) whichever is larger.
- d) Suitable buffer arrangement shall be provided to arrest the fall of take-up pulley in order to avoid damage of the pulley assembly in case of belt snapping. Similar buffer arrangement shall be provided for take-up weight also in case of take-up weight travel zone terminating above a building floor. Suitable sand pits shall be provided at ground below the take-up weights.
- e) Manual hoists shall be provided with mono-rails for holding the take up pulleys during splicing and belt change. In case of double stream conveyors, a partition of 3 mm steel plate is be provided the two take up pulleys along entire travel zone of take up pulley.

4.8.9 Belt Cleaners

- a) V-plough type internal scrapers at tail end of each conveyor shall be provided and diagonal type internal belt cleaners shall be provided at both ends for reversible conveyors & belt feeders.
- b) Each blade should be provided with suitable arrangement to press the wiping edge gently but firmly against the belt. Rubber strips should be adjustable after wear.
- c) For cleaning the carrying side of belt at discharge point, external belt scrapers shall be fitted. As a minimum, this shall consist of two stage scraping. The first stage shall be polyurethane blade pre-scrapper mounted on a torsion shaft to impart pressure on the belt. The second stage of scraping shall consist of sharp ultra-wear-resistant multi blades. Each blade shall be individually tensioned, located behind the head pulley at discharge points. The belt scrapers shall be arranged such as to feed the scrapings into the transfer chutes.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.0	General Information	Technical Particulars
2.0	Material to be scraped	Coal
3.0	Bulk Density (T/Cu.M)	[0.8]
4.0	Moisture Content	[20] %.
5.0	Length of Blade	Adjustable (not less than belt width).
6.0	Pulley Width	As per IS 8531

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4.8.10 Brakes

- a) The brake shall be used to reduce coasting time of the conveyor. The braking torque shall be adjustable so that it can effectively stop the conveyor in a given time.
- b) The brake shall be external, spring operated thruster released type. The brake shall normally be in closed position when there is no power supply in the thruster motor. As soon as the thruster motor is energised the brake will be released and remain in that condition as long as the conveyor is in operation.
- c) The brake shoes shall be lined with replaceable non-metallic brake liner e.g. Ferodo brake lining, copper asbestos lining etc. The maximum design unit pressure shall be much below the recommended unit pressure for the liner material to achieve a long wear life of the brake.
- d) The size of the brake shall be amply designed / selected so that the heat generated by the braking action is quickly dissipated.
- e) The brake liners shall be riveted to the steel brake shoe by means of copper rivets. The head of the rivets shall be sunk into the brake liner contact face so that it does not come in contact with the brake drum till the wear life of the liner exists.
- f) One no. Electro-hydraulic thruster of sufficient capacity shall be adopted for brake release. The thruster shall work in vertical position. Thruster shall be suitable for continuous duty for 24 hours a day. The size of the thruster shall be so selected that the temperature rise for the specified duty is within limit even on the hottest day. The electro hydraulic thruster shall be fitted with the brake. Limit switches shall be provided for brake applied/released position.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.0	Type of Brake	Electro Hydraulic Thruster
2.0	Material of Construction a) Base b) Brake arm c) Shoes d) Springs	Welded Steel Welded Steel C.I. Spring Steel
3.0	Adjustment	Stroke length and operating time to be adjustable
4.0	Thruster	Class B Insulation, IP 65 protection

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Sl. No.	Item Description	Parameters
5.0	Electrical	Panel should be complete with rectifier set, ON/OFF switch, protection devices, physical brake release switch/contact, etc.

4.8.11 Belt Feeder

The belt feeders shall be reversible type with drive at one end and take up at the other. Power and tension calculation of the belt feeder shall be done as per CEMA / IS / BS. Material shear phenomenon shall be considered in the tension calculation. Belt feeder shall be provided with one no. self aligning idler on both carrying and return side and one no. of zero speed switch.

4.8.12 Hold Backs

Integral holdbacks shall be provided for all inclined conveyors to prevent reverse rotation of the conveyor after being stopped in loaded conditions due to power failure or during normal operational delays. The hold back shall instantaneously engage without shock and be capable of protecting equipment and personnel. It shall be released instantly when 'power resumes or the 'delay' is removed. It should have the following components, the hold-back drum, steel side arms, wedge plate, hardened steel rollers, self-aligning counter-balanced supporting brackets etc and shall be integral to the gear box.

4.9 Coal Feeders

4.9.1 Paddle feeders

- a) Paddle feeder shall have capacity to scoop out coal at the guaranteed capacity in both forward and reverse motions with no indication of wheel slipping. Each paddle feeder shall be designed for guaranteed capacity while handling entire range of lump sizes. Traveling paddle feeders of self-contained, self-propelled type shall be furnished to scoop out coal from the Track hopper and each feeder shall be capable of travelling back and forth along the entire length of the hopper and transfer the coal from the hopper uniformly onto the conveyors below.
- b) It shall operate on the principle of positive discharge and shall not depend on friction or moisture content. All equipment's shall be designed to withstand any rate of acceleration imparted by drives or any strain resulting from a sudden change in load. Further, the design of paddle feeder carriage should be such that it does not run off from its rails due to sudden change in load or

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other reasons.

- c) The Bidder shall include in his proposal necessary electricals for paddle feeder and carriage such as motorized cable reeling drum with trailing cables, cable trays for resting the trailing cables, and end limit switches for protection against over travel of the feeder carriage. The cable reeling drum and trailing cable of each feeder shall be suitable for the entire length of the hopper. Mechanical track stops shall also be provided. Dust suppression equipment for paddle feeder shall also be provided.
- d) For designing the paddle wheel as well as travel drive, Bidder shall consider the hopper fully loaded with coal on either side of the paddle wheel to the maximum capacity. The hydraulic system normal average working pressure shall be selected considering the above loading condition. Further hydraulic system shall be designed to stall / trip beyond a certain pressure above the normal average working pressure. Feeder carriage drive shall be suitably designed so that the forward & reverse movement of carriage can be achieved without stopping the scooping operation. Tank filled with water in DS trolley shall also be considered for travel drive. Rail having section of adequately size structure shall be designed considering two-wheel support and accounting no frictional force from the other two wheels and considering hydraulic motor stall condition. The hydraulic motor shall be selected based on 110% of actual power requirement motor output shaft at specified guaranteed capacity. The capacity of paddle adjustment shall be 0 to 100% of the guaranteed value. Bidder's design of paddle feeder should not incorporate a separate loading table (impact cradle) below the paddle feeders. However, the height of fall of coal between paddle wheel and conveyor belt shall be kept minimum. Further, the provision of maintenance bay for ease of maintenance of paddle feeder shall be provided and the length of the skirt board shall adequately extended on both sides of the paddle wheel so that there is no spillage of coal on to the paddle feeders trolley. Minimum 500 mm extension shall be considered for this purpose. Hydraulic components shall be provided with dust proof cover for protection against spillage of coal/ dust.
- e) The paddle feeders shall run on rails mounted on the supporting structures of associated conveyors. Both paddle feeder and carriage drives shall be mounted on the feeder carriage. The feeder carriage shall be of steel construction and of robust design. Skirt plates shall be provided integral with the equipment for collecting the material drawn by the paddle feeder from the track hopper and discharging on to the conveyor belt. Feeder skirts of paddle feeders shall be extended at least by 500 mm on either side of the paddle wheel to avoid spillage of coal. Necessary baffle/retainer plates for suitably guiding the flow of coal from track hopper to the reclaim conveyor being fed by paddle feeders shall be provided. Hand railing shall be provided on the top deck of feeder carriage together with an access ladder. The feeder carriage

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shall be provided with suitable number of double flange wheels of steel construction, complete with sealed bearing unit. The drive mechanism shall be suitable for continuous reversible motion of the carriage. Start/stop switches shall be provided at the local control panel for the operation of paddle wheel and feeder carriage. The carriage shall automatically reverse its motion, when two paddle feeders operating on the same track come within a predetermined distance. Suitable anti-collision device (infrared and mechanically operated limit switch type) shall be provided. Provision shall be made to trip the track hopper conveyor from respective paddle feeder and provision shall be made for tripping of paddle feeder from CHP main control room.

- f) Suitable indication of paddle wheel rpm shall be provided on the paddle feeder control panel and flow rate indicator of belt weigh scale shall also be duplicated on control panel of paddle feeder. Suitable rail cleaners shall be provided at the leading as well as trailing side of the feeder carriage for both tracks.
- g) Suitable cable trays minimum 300 mm above floor shall be provided along the travel of paddle feeder for supporting and guiding the trailing cables. In order to save flexible cables from damage due to tension/over-tension protection switches shall be provided. Spacing of carrying idlers in the loading zone of paddle feeders shall be 500mm. Various equipment of Paddle Feeder assembly shall be easily accessible. It shall be possible to replace electrical, mechanical and hydraulic components of paddle feeder when in position. Various drive equipment and hydraulic/other components shall be so arranged that coal spillage from track hopper mouth does not accumulate near/over them.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.0	General Information	
1.1	Type	Mobile Rotary plough
1.2	Location	Below track hopper
1.3	No of starts/min. for drive	15 with min 10 consecutive starts
1.4	Capacity	Rated [...] TPH Designed [...] TPH
1.5	Spacing of carrying idlers in the loading zone of Paddle feeder.	[500] mm (maximum)

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Sl. No.	Item Description	Parameters
1.6	Duty	24 Hours/Day
1.7	No of equipment	
2.0	Paddle Wheel	
2.1	Material for Vanes	High strength steel with Mn steel liner plates (replaceable)
3.0	Drive arrangement	
3.1	Paddle Wheel	Stepless Hydraulic drive.(Carriage mounted)
3.2	Feeder Carriage	Electric Motor with gearbox & flexible coupling. Or Hydraulic drive. (Carriage mounted)
3.3	Minimum no. Of starts per hour for drive	15 starts/min. (with minimum 10 consecutive starts).
3.4	Paddle Wheel Speeds	Higher speed : suitable for 75% of conveyor guaranteed capacity Lower speed: Suitable for 50% of conveyor guaranteed capacity.
4.0	Paddle Feeder Rails.	
4.1	Size	Adequately size
4.2	Support arrangement	To be mounted on supporting structure of conveyor.
5.0	Feeder Carriage Wheel	
5.1	Type.	Double Flange. Wheel shall be sized based limiting bearing stress.
5.2	Bearing	Sealed type.
6.0	Material of Construction.	
6.1	Paddle	Steel Construction.
6.2	Shafts	EN-8.
6.3	Paddle Wheel	High tensile Steel with abrasion resistant liner.
6.4	Feeder carriage wheels.	Forged Steel
7.0	Others	

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Sl. No.	Item Description	Parameters
7.1	Anti-collision Device	Required
7.2	Control	Local
7.3	Location of control panel	On the feeder carriage
7.4	Dust Suppression	On the carriage
7.5	Paddle Wheel	Retractable.
7.6	Moisture in coal	[20%]

4.9.2 Vibrating Feeders

- Vibrating feeders shall be electromechanical type. Feeder shall consist of adequately sized trough mounted on flexible springs supported from platform with adequate clearance space.
- One or two unbalanced motors shall vibrate the trough. The amplitude and frequency of vibration and the supporting structure design should be such that equipment along with its structure should work satisfactorily with minimum noise level. The chute above the vibrating feeder shall be designed so that there is free flow of material.
- The vibrating feeder shall be lined with SS-304 liner of adequate thickness. The hopper outlet configuration shall be suitable for the selected feeder size so that smooth flow is ensured.
- Provision of variation of capacity by mechanical as well as electrical means to take care of variation in coal characteristics shall be incorporated in the design.
- The liner shall be secured with the main plate by means of countersunk bolts.
- Provision to change the angle of inclination of the vibrating feeder shall be provided.
- The vibrating feeder shall have the provision to adjust feed rate. Feed rate adjustment would be required to obtain specified output even for change of physical properties like moisture, lump size etc, of the material.
- Proper sealing should be provided between the trough and the chute work.
- It shall be complete with all the electrical requirements.

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Technical Data Sheet:

Cl.NO.	Item Description	Parameters
1	Location	Emergency reclaim hopper
2	Quantity	[...]
3	Size of coal to be handled	[-20] mm
4	Type of feeder	Electro-Mechanical
5	Design Capacity of coal to be handled	[...] TPH for each feeder
6	Design for operating hours	24
7	Drive margin over design capacity	[15] %
8	Constructional Features	
8.1	Vibrator tray	Heavy duty mild steel tray with min. 16 mm thick replaceable wear resistant liner
8.2	Down slope of the tray	[10°] maximum
8.3	Type of mounting	Foot mounted type, mounted on a number of coil spring to withstand impact of feeder load
8.4	Type of discharge rate controller	Unbalanced Weight

4.9.3 Apron Feeder and Dribble Feeder

- The apron feeder shall be suitable for continuous duty and shall be robust in construction. It shall be capable of absorbing the shock load due to impact of falling large coal lumps of up to 250 mm size (occasionally (-) 400 mm) and other heavy metallic components / pieces without damaging the feeder. The feeder shall be provided with reliable tensioning arrangement to take care of elongation in the feeder.
- The driving and driven ends with sprocket shafts shall be supported in heavy-duty antifriction bearing with minimum triple labyrinth sealing for dust protection and shall have provision for external lubrication. The Sprocket shaft shall be constructed for alloy steel. The design shall be sturdy and shall withstand fatigue and provide torsional stability.
- The steel chain shall be constructed out of wear resistant deep hardening

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alloy steel, in heavy sections. The steel sections shall be held together by alloy steel bar pins with wheels on either side which will move on rails. All sections shall be so designed that it can operate under the worst conditions of operation with wet coal, muddy coal etc. without jamming. All parts shall move smoothly.

- d) The entire assembly of the feeder parts, the bearings, driving and driven sprockets etc shall be housed on heavy duty structural frame with arrangement for mounting the same on RCC foundation.
- e) The hydraulic drive system shall consist of a low speed, high torque, hydraulic motor of hollow shaft design, to be mounted directly onto the driven shaft of the equipment using a shrink disc (Ring Feeder Coupling) the reaction torque shall be taken by a Torque Arm bolted to the hydraulic motor and fixed on structure. The hydraulic motor shall be driven by a power pack placed conveniently near the hydraulic motor so as to minimise pressure drop in pipelines.
- f) The hydraulic motor output in terms of speed and torque shall be monitored using a suitable electronic controller installed in the power pack, which receives speed signal from the machine PLC. In turn, the controller supplies signals to the machine PLC regarding actual speed, hydraulic pressure etc. It should also be possible to monitor the prevailing belt tension on the tight and slack side of the belt to adjust the tension in the take up for conveyors which do not have gravity take ups.
- g) The drive arrangement shall be able to smoothly go from zero to set speed, providing the specified starting torque, and from running to zero speed as per pre-programmed start and stop ramps, without the usage of fluid couplings, gearboxes etc.

Technical Data Sheet of Apron Feeder:

Sl. No.	Item Description	Parameters
1.	Location	Wagon Tippler Hopper
2.	Duty	Continuous
3.	Design Capacity	[...] TPH (rated) and [...] TPH (design)
4.	Capacity Range	20% to 110%
5.	Number required	[...]
6.	Material to be handle	Coal
7.	Max. Lump size	[(-)250 mm],occasionally (-) 400 mm
8.	Material of	
8.1	Sprocket	Deep hardening alloy steel

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Sl. No.	Item Description	Parameters
8.2	Shaft	Forged Alloy Steel
8.3	Chain	Deep hardening alloy steel
8.4	Joining Pins	Induction hardening alloy steel.
8.5	Supporting Frame	Carbon Steel
8.6	Rollers	Deep hardened forged alloy steel.
9.	Bulk density	[...] T/M3
10.	Length of Apron	To suit the requirement
11.	Drive Details	Hydraulic motor directly mounted on the drive shaft without any gear box unit.
12	Moisture in coal	[20] %

Technical Data Sheet of Dribble Feeder:

Sl. NO.	Item Description	Parameters
1.	Designation of conveyor	Dribble Feeder
2.	Belt Width	Bidder to decide
3.	Belt Speed	Max. 1.5 m/s
4.	Capacity of conveyor	[100] TPH minimum
5.	Lift	Bidder to decide
6.	Centre to Centre distance	Bidder to decide
7.	Hours of Operation	24
8.	Materials handled	Coal
9.	Bulk Density of material	800 T/m3
10.	Lump size of material	(-) 250 mm, (occasionally -) 400 mm)
11.	Angle of surcharge	20 Deg
12.	Troughing angle	20 Deg

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Sl. NO.	Item Description	Parameters
13.	Type of fabric	EP belt
14.	No. of Ply	Bidder to specify
15.	Grade	FR grade
16.	Designation of belt	Bidder to specify
17.	Cover thickness (min)	
a)	Top, mm	[8] mm
b)	Bottom, mm	[4] mm
18.	Breaker ply required	Yes
19.	Type of Joint	Vulcanized Joints
20.	Take-up	Screw take up
21.	Moisture	[20] % max.

4.9.4 Vibrating Grizzly Feeder

- a) The vibrating Grizzly feeder shall of mechanical type. Vibrating Grizzly Feeder shall be provided before each crusher so as to ensure uniform feeding of above 20 mm size of coal to crusher and remove below 20 mm size of coal from feed to crusher.
- b) The grizzly feeder shall be capable to segregate (-) 20 mm size of coal, along with fines, coal dust and muck & muddy coal (which is likely to be encountered during rainy season) etc. The segregated material shall be directly fed on to the corresponding belt conveyors provided under each grizzly feeder. Oversize coal shall be fed to coal crusher. The width of the Vibrating grizzly feeder shall be at least equal to the regular crusher feed opening dimension so as to feed the material uniformly over the entire length of crusher rotor without any deflection in the feeding chute. The screening area excluding solid deck area shall be min. 0.75 m² per 100 mT/h of incoming feed. Inclination of the grizzly pan shall not exceed 10 deg. from horizontal. The equipment shall be designed and installed in such a manner, that choking does not occur during operation, particularly during rainy season when the coal gets sticky.
- c) The deck of vibrating grizzly feeder shall have continuous solid deck section in the impact zone under direct coal fall and remaining deck shall be fitted with grizzly bars. The solid deck section shall be provided with replaceable abrasion resistant liner plate, preferably of TISCRA /SAILHARD of adequate thickness. The grizzly bars shall be trapezoidal in section and made of

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abrasion resistant manganese steel. The bars shall be rigidly fixed with main frame along the length of grizzly deck.

- d) The vibrating grizzly feeders shall be mounted on the floor with the help of helical springs made of alloy steel. No rubber/synthetic material for the support shall be acceptable. Vibrator bearings shall grease lubricated double spherical roller type suitable for vibrating equipment. Selection of bearings and its calculations shall be subjected to the approval of Owner. The Bearing shall be sized to 8000 hours of operation. The drive unit shall be complete with mechanical type vibrator, suitable for adjustment for maximum performance.
- e) Suitable sealing arrangement shall be provided between the vibrating structure and chute work to avoid dust nuisance in the surrounding area.
- f) The grizzly feeder shall be of approved and proven design/make. Rubber impregnated canvas would be provided at inlet and outlet interface with fixed chute. Proper arrangement to avoid dust ingress into lubricant of eccentric shaft shall be provided. Necessary arrangements shall be provided for maintaining the complete vibrator assembly. Marker plate shall be mounted to indicate the stroke length and stroke angle.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1	Type	Vibrating-Electro Mechanical
2	Duty	Continuous
3	Design Capacity	[...] TPH (rated) & [...] TPH (design)
4	Number Required	[...]
5	Max. Lump Size	(-)250 mm (Occasionally (-)400mm0
6	Max. Moisture Content	[20] %
7	Bulk Density of Material	[0.8] T/Cu.m for volume calculation [1.2] T/Cu.m for weight calculation
8	Grizzly Bars	Manganese Steel as per IS:276
9	Output	(-) 20 mm
10	Shafts	Forged Steel

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Sl. No.	Item Description	Parameters
11	Solid Deck	MS-2062
12	Solid Deck Liner	TISCRAI/SAILHARD min.10 mmthick
13	Support	Helical Springs
14	Bearing	Double spherical roller ,grease
15	lubricated, life	8000 running hours
16	Output	Uniform feeding of (+) 20 mm coal to Crusher
17	Inclination	10 deg. max from horizontal
18	Grizzly	Size Suitable to pass (-) 20 mm coal
19	Drive	Margin over design capacity 15%

4.10

Crushers

4.10.1

[Primary Coal Crusher]

Primary Coal Crusher shall be mounted on RCC deck with suitable vibration isolation supported suitably on steel beams integrated with main building frame works.

Crusher shall be supplied with complete accessories and subsystems. The crusher shall be capable of delivering the normal rated output even when handling the damp sticky coal having maximum moisture content. Bidder to ensure no clogging and building up of material on crushing element. The entire inside surface of crusher coming in contact with abrasion resistant steel liners of requisite thickness.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1	Type of crusher	Rotary Breaker
2	Quantity	[...] Nos. [...] (W) + [...] (S)

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Sl. No.	Item Description	Parameters
3	Location	Primary Crusher House
4	Material to be crushed	Coal
5	Maximum Moisture Content	20%
6	HGI	[45 – 65]
7	Input size	[(-)250] mm
8	Maximum percentage of oversized lumps	1 to 5%
9	Maximum Lump size	[400] mm
10	Capacity	[...] TPH(rated) each [...] TPH (design) each
11	Crusher & Motor	Not more than 750 RPM
12	Output Size	[(-)150] mm
13	Design moisture content	[20]%
14	Hours of operation/day	24 hrs
15	Allowable crusher vibration	80 microns
16	Noise Level at a distance of 1 m horizontally and 1.5 m above the ground level	85 dBA

4.10.2 [Secondary] Crusher

- The Crushers of [...] TPH shall be provided. The crusher shall be of ring granulator type such that the crushing action is accompanied by the minimum of attrition. Uniform crushing impact shall be assured. The Crusher shall be suitable to handle coal with size of *[(-) 250 mm when no primary crusher is in the upstream feed with occasional 1-2% coal of (-) 400mm size.] / [(-) 150 mm incase of primary crusher is installed at the upstream]*. 98% output of the crusher shall be down to (-) 20 mm.
- Thermodynamically, the ratio of surface energy produced to the kinetic energy expended should be maximum. Accordingly, the number of central

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discs along the rotor shaft shall be maximum with minimum spacing in between.

- c) The crusher shall be capable of delivering the normal rated output even when handling damp sticky coal having maximum moisture content. No clogging or building up of material on the crushing element shall develop. The material for major components of crusher shall not be inferior to the quality and standards as mentioned below:

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.	Type of crusher	Ring Granulator
2.	Quantity	$[...] \times [...] \% (W) + [...] \times [...] \% (S)$
3.	Location	[Secondary] Crusher House
4.	Material to be crushed	Coal
6	Total Moisture	[20]%
7	Hard Grove Index	[45 – 65]
8	Input Size	(-) As per Sl. No. (a) above
9	% of (-) 20 mm in feed	30 %
10	Maximum percentage of oversized lumps	1 to 5 %
11	Maximum Lump size	250 mm
12	Coal Feeding Arrangement	Through vibrating grizzly feeder (However, the crusher shall be designed /sized considering zero passage of coal through grizzly)
13	Guaranteed Capacity Design Capacity	Guaranteed [...] TPH (Rated) [...] TPH (design) each
14	Crusher & Motor RPM	Not more than 750 RPM
15	Design moisture content	[20] %
16	Guaranteed output size	98% (-) 20 mm.
17	Type of fluid coupling	Scoop tube type
19	Hours of operation/day	Continuous (24 hours)
20	Allowable crusher vibration	80 microns

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Sl. No.	Item Description	Parameters
21	Noise Level at a distance of 1 m horizontally and 1.5 m above the ground level	85 dBA
22	Installation of Crusher	Viscous damper or resilient damper with building structure.
23	Number of rows of hammers	[...] rows placed at [90] deg.
24	Hammer profile	Toothed only.
25	Weight of each hammer	Not more than 40 kg.
25.1.	Grade of balancing	Q-16 as per VDI-2060 1966
26	Material of Construction.	
26.1	Casing	Heavy gauge rolled steel plate.
26.2	Ring/Roller/ Hammer	Manganese steel to IS - 276 Gr. III.
26.3	Rotor Shaft	ASTM - A668 Class E
26.4	Suspension bars	ASTM - A322, Grade AISI 4140
26.5	Frame	Rolled Steel.
26.6	Breaker Plate	Manganese steel IS-276 Gr. III
26.7	Rotor discs	ASTM-A108. AISI 1045
26.8	Cage assembly	Mn-Steel - IS:276
26.9	Internal parts in contact with coal	Material composition is as that of breaker plate above, min. 20 mm thick.
27.0	Crusher Bearing	
27.1	Plummer block type	Split type, minimum four HT fixing bolt of adequate size.
27.2	Bearing type	Antifriction spherical roller ,
27.3	Life	Min. 30000 working hours.
27.4	Lubrication of bearing	Manual grease gun.

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Sl. No.	Item Description	Parameters
27.5	Enclosure	Dust tight
27.6	Type of bearing seal	Multiple Labyrinth seal
28	Vibration monitoring system	Required. Vibration shall be measured at each location in Horizontal as well as vertical direction

4.11 Travelling Tripper, Bunker Sealing & Bunker Level Indicator

- a) The Travelling tripper on bunker conveyors shall be motor driven type. It shall consist of structures, supports, walkways, rails, belt scrapper with adjustable rubber strip, rubber lagged head and bend pulleys complete with shaft bearings, chutes, stops, limit switches, brakes etc. The tripper shall have provision for dropping coal both sides of conveyor into the bunker and back to the conveyor for the purpose of skipping intermediate bunkers. The rating of tripper travel motor shall be adequate to move the tripper smoothly either in same or opposite direction to belt direction under fully loaded conditions. Adhesive weight requirement and tractive effort calculations shall be subject to approval of Owner. Coefficient of adhesion shall be considered as maximum 0.15. Minimum two drive axles shall be provided for tripper travel. Arrangement shall be provided at the starting point of the tripper to avoid folding of belt.
- b) In case of tripper running at a speed more than its rated speed due to chute jamming or other reason, conveyor shall trip and annunciation shall appear. Supply of adequate length of rails to cover the runway length for the motor driven tripper shall be included. The supporting structures for the rails with necessary end stops shall also be supplied under this specification. Suitable belt hold down guide pulley shall be provided over the concave curve of belt over tripper. The Bidder shall include in his proposal necessary electricals for traveling trippers such as motorized cable reeling drum with trailing cables, cable trays for resting the trailing cables and end limit switches for protection against over travel of the tripper. The cable reeling drum and trailing cable of each tripper shall be suitable for the entire length of the bunker bay. Mechanical track stops shall also be provided. The cables shall have copper conductors, proper insulating material and braided armouring in accordance with IS: 691.
- c) The travelling trippers shall be provided with fail safe A.C. thruster operated brake of totally enclosed type which shall engage as soon as tripper travel motor stops. A.C. thruster operated rail clamps with hand operation facility from either side of the tripper shall also be provided.

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- d) For selection and specification of drive motor, gearboxes and all other equipment associated with tripper relevant clauses of this specification shall be referred to. All drive equipment shall be selected based on 115% of actual power requirement at specified guaranteed capacity. Further complete drive equipment shall be suitable for minimum 60 starts/hours.
- e) Monorail & electric hoist shall be provided for lifting conveyor drum to bunker floors. Monorail all along the bunker conveyor to facilitate maintenance of tripper shall be provided.

Technical Data Sheet:

Sl. NO.	Item Description	Parameters
1	Type	Motorized, traveling on rails
2	Material handled	Coal
3	Coal Size	[(-) 20] mm
4	Hours of Hours. Of operation/day	Continuous
5	Belt fabric	All synthetic fire resistant. 5 mm top & 3 mm bottom cover.
6	Belt width	As per requirement
7	No. required	[...] (W) + [...] (S)
8	Capacity	[...] TPH (rated) [...] TPH (design)
9	Max. moisture of handling material	[20] %
10	Travelling Tripper Details	
	Construction material of frame	Structural steel (IS-2062)
	Type of lubrication	Grease Gun
	Wheel material	Cast Steel./ Forged steel

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Sl. NO.	Item Description	Parameters
	Bearing life	30000 hrs
	Idlers	
	Troughing angle	35 Deg
	Spacing	1200 mm Max.
	Bearing type	Seize – Resistant.
	Method of lubrication	Life lubricated
	Bearing Life	30000 hrs
	Type of sealing	Double labyrinth with synthetic sealing
	Pulley	
	Lagging	12 mm neoprene rubber for discharge pulley only.
	Material	MS (IS-2062)
	Shaft material	EN-8 or equivalent.
	Type of bearing & life	Double row spherical roller, 30,000 Hrs.
	Type of Sealing	Double labyrinth with synthetic sealing
	Chute	
	No. of ways	Two (2) way
	All plates of vertical chutes and chutes with more than	16/20 mm thick. Weldable quality Tiscral/Equiv steel

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Sl. NO.	Item Description	Parameters
	Top Plate	10 mm thick. Mild Steel
	Chute Dimensions	Smallest dimension is not be less than three (3) times the maximum lump size. Cross
	Minimum valley angle	[...] Deg
	Drive.	
	Motor margin for tripper bogie on design power at the motor shaft	110%
	Minimum no of starts	60 start/hr
	Tripper angle (belt)	14 deg. (Max.)

4.11.1 Bunker Sealing Arrangement

- a) The sealing belt shall be of suitable grade (minimum 2 plies) with 5 mm x 5 mm covers (fire resistant) in line with other conveyor belting. The belt shall rest on 16mm MS round bars spaced at 200 mm provided over the bunker slot (minimum 1100 mm) on tripper floor for tripper conveyor. Needed guide rollers, bearings, brackets, safety guards etc. shall be provided by the Bidder. The bunker sealing arrangement shall keep the bunkers sealed and prevent dust emission into tripper room. The width of the bunker seal belt shall be at least 100 mm more than the bunker slot opening. Separate openings shall be provided on the bunker floor of each bunker to measure level of coal in the bunker. Hinged dust sealed door / flaps shall be provided on these openings. Suitable grating to be provided in between bunkers in the tripper travel zone. Openings on the tripper floor for level measurement shall also be provided.
- b) Suitable dust cover shall be provided over tripper head pulley. Serrated rubber seal shall be provided at open side to prevent dust nuisance. Suitable dust tight access doors shall be provided. Counter-weighted type belt cleaner shall be provided below the tripper head pulley for cleaning the carrying side of the belt. The tripper shall run on rails of adequately size with double flanged wheels. Rails for tripper travel shall be mounted on supporting structure of respective conveyors. Suitable system for monitoring position of tripper shall be provided. In addition, travel end limit switches and end stops shall also be provided. Suitable access platform of chequered plate with ladders, hand

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railing and walkways on both sides shall be provided for access/maintenance of equipment on tripper. In addition, crossover platform shall be provided with tripper so that operator can cross the belt through the same.

- c) Suitable rail cleaners shall be provided on leading and trailing edge of tripper for either track. 3mm deck plate continuous shall be provided below carrying idlers on the trippers. For specification of flap gates/actuator on trippers relevant clauses of this specification shall be referred to. Walkway of 800 mm wide shall be provided on both side of the tripper Provision shall be kept for automatic tripping of bunker bay conveyor in the event of travelling tripper getting dragged (i.e. travel speed in excess of rated speed).

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1	Type	Single flat belt sealing
2	Location	Tripper Floor
3	Number	As required
4	Sealing belt	
4.1	Grade	Suitable to be decided by the bidder
4.2	Width(mm)	As per system requirement
4.3	Number of plies	3
4.4	Material of cover	F.R. Grade
4.5	Cover thickness (top/bottom) in mm	5/3

4.11.2 Bunker Level Indicator

- a) [...] nos. ultrasonic non-contact type level indicators for each bunker to be provided to get continuous level indication, low level and high level alarms. For each unit, one no. local panel to be provided which will be mounted on tripper floor. Each panel will have indicators for continuous level indication of each bunker, audio and visual annunciation of high and low level.
- b) The equipment should be complete with level indicators, contactors, alarm, lamps, hooters, test-reset-accept push buttons, main switch, cable gland etc.
- c) Indicator shall be provided with isolated 4-20 mA DC output (Nos. as required) for remote transmission of bunker level indication at CHP main control room as well as in central control room in power house without degradation in signal.

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4.12 Stacker cum Reclaimer

- a) Travelling Stacker cum Reclaimer operating in conjunction with reversible yard conveyor shall be provided. Stacker-cum-Reclaimer shall be capable of both stacking and reclaiming complete with adequate length of rail track, cantilever boom conveyor, intermediate conveyor, support carriage with vibrating feeders (if required), boom hoist, reclaimer bucket wheel, control panel, operators cabin, electrical power distribution system, motorised cable reeling drum, adequate length of trailing cables etc. The design capacity of the yard conveyor shall not be less than 110% of the rated (guaranteed) capacity. For bucket size calculations and boom conveyor capacity, a peak reclaim capacity of 125% of rated capacity shall be considered. The drive train of yard conveyor consisting of motor, scoop type fluid coupling, gear box etc. shall be provided at both ends of the yard conveyor. Both the drive train at each end of the yard conveyor shall run simultaneously in one direction and reversed depending upon stacking or reclaiming operation of the machine. The continuous motor rating at 50 °C Ambient of the drive motors to be provided on each side of the yard conveyor shall be 120% of the actual power requirement at motor output shaft. The actual requirement at motor output shaft of both the motors at each end shall be calculated based on 75% of the total load demand at design capacity.
- b) Stacker cum Reclaimer shall be capable of operating at high wind velocities up to [65] km/h. It shall also be able to withstand maximum wind velocity as indicated in "Criteria for Wind Resistant Design of Structures & Equipment" placed in the document on civil aspect, when it is not operating. An anemometer shall be provided which shall indicate the wind velocity in the control cabin. Electro-hydraulic thruster operated rail clamp shall be provided for holding the stacker cum reclaimer. Suitable arrangement shall be provided for keeping the stacker-reclaimer in fixed stable position when the weather is stormy. Stacker-cum-reclaimer shall operate on rail track of 52 kg/m running for adequate length to cover the entire coal stockyard. The ratio of boom length (as specified) to the rail track gauge shall not exceed 5. Top of rail level shall be maintained at 1.0 m above the ground level, i.e., coal pile base level unless specified otherwise. Suitable number of rail scrappers shall be provided. The machine shall be mounted on traverse carriage provided with driven and non-drive wheels of cast or forged steel and double flange design. The track wheels shall be combined in pairs in the track wheel bogies. The wheels shall rotate on self-aligning roller bearings. Between the motor and the gearing, electro-hydraulic thruster brake shall be provided. The reclaimer shall be traversed by manual control at any desired speed within its speed range. During stacking/reclaiming operation, the equipment travel shall be limited to its travel zone and shall automatically stop when the machine reaches the extreme ends of such travel zone.

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- c) The lower works of the under-carriage of the machine shall be designed to transmit load on the wheel sets of the travel carriage in such a manner that the equipment is stable during normal operating condition as well as during hazardous weather condition with maximum permissible variation in center distance of rails and rail top levels. The rail mounting for under-carriage shall be four legged system with hydraulic/mechanical equalizing arrangement to make it three point suspension system for the best stability during operation. The traverse carriage and the under-carriage shall be interconnected in a manner, which will permit uniform distribution of overloads even if the rails are not level.
- d) The upper frame of the machine shall be designed in such a manner that minimum number of angular movement points affects the luffing operation. In addition, the variation of moment/torque on slew bearing shall be minimum. The ring bearings shall be dimensioned in such a way that all forces can be safely transmitted to the structures of the wheels.
- e) The roller bearing slewing ring shall be sealed against penetration of water and dust. Angular movement points (hinge points) namely between equalising beam and base frame, luff pivots and hydraulic cylinder hinge points shall be provided with maintenance free bearings requiring no periodic lubrication during entire life span of bearings. Minimum life span of self lubricating type bearings shall be [20/25] years with average 10 hrs. daily operation.
- f) The luffing motion shall be through hydraulic pumps and cylinders. In case of more than one cylinder being used for boom luffing operation, necessary provisions shall be provided such that the differential oil pressure between two cylinders are always maintained within permissible limits, during luffing operation and as well as when the boom is fixed at any position. In case of any undue increase in differential pressure, the hydraulic circuit shall trip and suitable alarm indication shall be provided before tripping. The hydraulic system of luffing shall be such that in case of failure of hydraulic system due to leakage or any other reason the boom could be held in position. The boom shall revolve by at least 210° about the center of the receiving hopper and discharge/reclaim material on/from both sides of track anywhere within specified radius of the boom. The boom conveyor shall be of adequate design capacity to match with the rate of peak reclaiming by the bucket wheel. Boom conveyor with [...] m length shall be provided with a Belt Weighing Scale with weighing accuracy (in the horizontal position of the boom) of $\pm 1\%$ for a range of 20% to 120% of boom conveyor capacity. The belt scale shall provide only flow rate indication in the Operator's Cabin on the Stacker/Reclaimer.
- g) The bucket wheel assembly shall consist of [...] numbers of buckets of cell-less design and stationary annular chute. The bucket shall be of suitable shape and design, which will enable to empty out the material fully from the

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bucket, and to prevent spilling of the scooped material during transfer to boom conveyor. The buckets shall be readily removable. Bucket size shall be selected for peak reclaim capacity based on maximum 80% degree of fill with respect to water fill capacity of the bucket. Further, not more than 50% of annular ring volume shall be considered as effective volume. Rate of bucket discharges shall not exceed 55 per minute. The bucket wheel drive shall be complete with electric motor, reduction gear unit moving in oil bath and suitable coupling between motor and the gear unit. Bucket wheel drive system, structural members, mast, hydraulic system etc shall be designed considering completely wet coal with max. surface moisture. Adequate safety devices shall be provided to prevent overloading of the bucket wheel drive, particularly when wheel will get stuck-up in the stockpile. In such an event, the power supply of the drive shall get automatically cut-off. Suitable electro hydraulic thruster brake shall be provided to avoid backward movement of the bucket wheel after the power supply is cut-off and during maintenance work.

- h) The boom conveyor with bucket wheel assembly, the mast and counter weight mounted on the upper structure shall rotate on the bearing ring. The drive mechanism shall consist of the gear rim and drive unit shall comprise of motor, safety coupling, gearbox and pinion. Protective devices against overloads shall also be provided. The slew speed shall be variable. Boom conveyor shall be provided with self-training arrangement of latest design to avoid belt sway in the boom conveyor. One tripper shall be furnished for stacker-cum-reclaimer unit for working in conjunction with the yard conveyor. The tripper & intermediate conveyor shall be complete with supporting structure, walkways, platforms, railing, belt scrapper, head pulleys, bend pulleys, hold-down pulley, chute and support with adequate number of wheels in bogie construction travelling on the same rails as those of the stacker-cum-reclaimer. The intermediate conveyor will be skewed longitudinally to enable to receive material (during stacking) from tripper conveyor. The intermediate conveyor shall be of adequate capacity to match with the design capacity of stacking which shall be 110% of rated capacity of stacking. For other details, the relevant clauses of belt conveyor system of this specification shall be referred to. The intermediate conveyor shall be completed with supporting structure, walkway, railings, platforms, belt scrappers, head pulley, tail pulley and necessary chute work.
- i) Group wise lubrication system shall be provided combining different zones of lubrication points under different groups depending upon location and number of lubrication points.
- j) Each group lubrication unit shall be independently functional through separate pump (motorised), grease container, valves, metering devices, pipes and other accessories etc. Preferably, the grease entry into various lubrication points shall be vertically downwards. The grease container shall have adequate

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capacity for supply of lubricants to all points and grease quantity for the points to be greased shall be adjustable. Further, all the lubrication points shall be easily accessible.

- k) The stacker-reclaimer shall receive power through trailing cables. Separate motorized cable reeling drums for power and control cable shall be provided with arrangements for winding and rewinding of the cables. The trailing cables shall run in a cable tray. Further, the trailing cable arrangement shall be such that the cables run in-between the track rails. Cushion shall be provided in the cable reeling drums for about 30 m extra cabling length.
- l) Limit switches shall be provided to prevent traverse movement, slew and hoisting etc. beyond the respective safe extremities. Interlocking shall also be provided for S/R rail clamps and travel motors. Travel drive equipment and slew drive equipment shall be suitable for 150 starts/hr. with continuous reversals.
Hydraulic control shall be provided for:
 - (a) Hoisting/luffing
 - (b) Operator cabin level adjustment
 - (c) Equalising arrangement for travel carriage (in case of hydraulic equalising)
axial piston pumps shall be provided for pressurizing hydraulic control fluid. All drive equipments shall be selected based on 120% of actual power requirement at specified design capacity. In addition to the requirements elaborated above, the structural design of the stackerreclaimer shall be supplemented with ISO 5049/1 & FEM (Federation Europeenne De La Manutention Section-I – Rules for Design of Hoisting Appliances).
- m) Suitable RCC platform to be provided at one end of travel of the stacker-cum-reclaimer to rest the head end of the boom while either under maintenance or out of operation. The under-carriage shall be fabricated of steel plates and section. The wheel mounting arrangement shall be such that the wheels can be dismantled easily from their supports.
- n) 800 M wide walkways with hand railings shall be provided on both sides of boom conveyor. The upper structure shall consist of rigid box type steel plate construction on which the super-structure supporting mast, boom with bucket wheel and counterweight boom with ballast are erected. The upper works shall be mounted on under-carriage by means of large diameter ring bearing of double roll roller type. The boom shall be fabricated from rolled steel plates and sections and shall be of luffing type. The counterweight boom with ballast, which balances the boom conveyor, shall be mounted on the upper structure and shall be suitably dimensioned. The counterweight boom shall be fabricated with rolled steel plates and sections. Suitable boxes shall be

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provided for placing the counter weights.

- o) The stacker-reclaimer shall be provided with one enclosed dust proof & air conditioned operator's cabin and so located as to enable the operator to get clear vision of both sides of the track and the field of operation. The cabin shall be suitable for operation in monsoon and tropical conditions and the inside ambient temperature shall be maintained at 27 °C. The cabin shall be provided with toughened glasses with wipers and the arrangement shall be such that glasses can be cleaned from outside without any scaffolding. Cabin door shall be provided with hydraulic door closures. The cabin shall be kept in horizontal position through hydraulic cylinders irrespective of the angle of inclination of the boom conveyor. All controls for operation of all parts of the stacker reclaimer unit shall be provided in the cabin within easy reach of the operator. Lights and fan for operator's cabin and adequate number of floodlights for all necessary illumination for working at night shall also be provided.
- p) Electrical/MCC room shall be fabricated of sheet steel with suitable floor matting. The room shall be dust tight and air conditioned. Fireproof insulation shall be provided under the roof of MCC room. Further, the door shall be provided with hydraulic door closer. Adequate number of impact idlers shall be provided integral with stacker-cum-reclaimer at the region where the bottom conveyor feeds material through transfer chutes onto the yard conveyor for the protection of the yard conveyor.
- q) Suitable arrangement shall be provided at the starting point (belt take off point) of the tripper to avoid folding of belt while the tripper is in tension. Brakes shall be provided for decelerating driven equipment/conveyor as per requirement. Rail clamps shall be provided for various mobile machines travelling on rails as specified for those machines.
- r) The necessary Electro Hydraulic Thrustor (AC) brakes, totally enclosed and fail safe, shall be provided as required for various equipment's. Braking torque shall be adjustable from 0 to 100% of rated braking torque. The brake shall be actuated by compression springs. The spring shall apply braking force directly to the shoe without using lever arm linkages.
- s) Rail Clamp shall be designed for holding the machine stationary. Rating of the rail clamp shall be subject to the approval of Engineer. Rail Clamp shall be actuated by compression springs, the spring shall apply the clamping force directly on the Rail clamp mechanism without using lever arm linkages once power supply is cut-off. The force transmission mechanism from spring to rail clamp faces shall be very simple with minimum linkages. The electro hydraulic thrustor shall be fitted with the brake. Limit switches shall be provided for brake applied/released positions. The windings shall be provided with class- B insulation suitable for 415V \pm 10% at 50 Hz \pm 5% and combined variation of \pm 10%. Brake lining shall be asbestos with inter woven brass wires

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capable of withstanding 200°C temperature. The lining shall be fixed to the shoe by counter sunk screws. Electro Hydraulic thruster shall be fitted directly above spring without any intermediate linkage mechanism. Rail clamp shall be provided between the two travel wheels. Further, limit switches shall be provided for Rail clamp 'ENGAGED' and 'DISENGAGED' signals. Minimum clearance between the Rail clamp face and rail surface shall be 50mm. However, this clearance may not be uniform for both the faces of Rail clamp throughout the length of rails. Rail clamp shall operate satisfactorily under this condition without the need for any adjustments. Complete Rail Clamp mechanism shall be manufactured from forged steel.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1	Type	Reversible with bucket wheel type Stacker-cum-Reclaimer
2	Stacking capacity	Rated capacity: [...] TPH Designed capacity: [...] TPH
3	Reclaiming capacity	Average: [...] TPH Peak: Maximum 125 % of average reclaiming Capacity
4	Quantity	[...]
5	Total travel	To suit layout & requirement.
6	Stockpile Section	[...] No., Trapezoidal Section
7	Width	At base [...] m.
8	Height	[...] m
9	Duty	24Hours/Day
10	Material to be Stacked / Reclaimed	Coal
11	Size of crushed coal	[/-] 20 mm
12	Moisture content	Max [20] %

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Sl. No.	Item Description	Parameters
13	Bulk Density	[0.8] T/cu.m for volume calculation & [1.2] T/cu.m for Load calculation
14	Structural Design Data.	
14.1	Code of construction for structural work	IS - 800 or Equivalent
14.2	Wind Pressure (Operating)	Corresponding to wind velocity [...] km/hr
14.3	Non Operating Wind Pressure (strom)	Corresponding to wind velocity [...] km/hr
14.4	Stability Factor	For operating condition with maximum operating wind factor 1.5 For non-operating condition with maximum wind velocity 1.5
14.5	Type of construction Material for structural steel	IS 2062
15	Bucket wheel	
15.1	Material of construction	Fabricated steel structure
15.2	Holding brakes	To be provided
15.3	Bucket Drive	AC squirrel motor [...] no.
15.4	Material of construction of bucket	Abrasion resistant steel
15.5	Material of construction of wheel	Wear resistant steel. MS IS 2062
15.6	Discharge rate	[...] / min (approx.)
15.7	Liner	Manganese steel

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Sl. No.	Item Description	Parameters
16	Carriage	
16.1	Travel speed	[15] m/min (max) [7.5] m/min (min)
16.2	No. per carriage	[...]
16.3	No. of starts of travel motor	Minimum [150] starts per hour
16.4	Wheel dia/ base	To be decided by the bidder
16.5	Type of brake for travel drive	Thrustor operated
16.6	Material of construction	Cast alloy steel 42 Gr M04
16.7	Slewing Range	(±) 105 deg. from the centre line of the trunk Conveyor.
17	Operator's Cabin	Shall be provided with all standard accessories including fan, light etc. & the cabin shall be pressurized and all requisite safety devices

4.12.1 Coal Stack Yard

The coal stockyard shall be elevated above grade level and the coal shall be distributed over the pile area or reclaimed by travelling stacker cum reclaimer. Dead storage of coal, shall be reclaimed by bull dozers and shall be formed by heaped coal on both side of the live pile. Space required for such a live/dead pile arrangement shall be kept free of any permanent facilities

4.13 Transfer Points, Galleries, Trestles, Sheds

- a) [Bidder to keep the dimension of existing building dimension unchanged to the extent possible, however actual size of the building shall be determined based on the modified system requirement by the bidder and the same shall be put in for Owner's approval.
- b) All over ground and overhead conveyors shall be located in suitably enclosed bridge structure. Structural steel bridges of adequate width and depth shall be provided complete with conveyor bottom deck plates, walkways of chequered plates with anti-skid arrangements hand rails, (on both sides of each conveyor

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belt except where equipment like paddle feeders, stacker-reclaimer, trippers etc. traverse over the conveyor), conveyor supports etc.

- c) The Conveyor Bridge shall have cladded with metallic sheet on roof and both sides, properly screwed or locked to steel structure as required. Adequate provision of windows shall be kept. A continuous slot opening of 500 mm shall be provided on both sides just below the roof sheeting.*
- d) For twin conveyor galleries, the central walkways will be 1100 mm (clear) wide with handrail on one side and the side walkways will be 800 mm (clear) wide with handrail. For single conveyor gallery, the walkways will be 1100 mm (clear) wide in one side and 800 mm (clear) on other side with handrails 10mm dia. steel bars shall be provided @ 500mm for inclined walkways upto 14 degree. For above 14 degrees walkways shall be stepped. For natural lighting, transparent sheets will be provided in lieu of roof and side sheeting at the intervals of 10 meters alternatively on either side of locations.*
- e) The floor areas just under the return belt shall be open, except where the conveyors cross the road, rail track other buildings and facilities etc. where 3.15 mm thick steel seal plates shall be provided. Further, for the conveyors in the bunker area and passing through Boiler/ESP area shall have seal plates of 3.15mm thickness all along the conveyor galleries. These conveyors shall be provided with steel seal plates in such a way that complete gallery bottom surface area shall form a single waterproof floor.*
- f) It is envisaged to clean the conveyor gallery with water periodically. All the water coal slurry shall be suitably guided to down comers (min 100 mm dia.) provided at every trestle. Each down comer shall lead the coal slurry into a 2 cu.m brick wall tank at ground level having 2-nos. decanting taps at suitable elevations. Decanted water shall be led to the nearest storm water drain of the Owner. Necessary arrangement shall be provided to avoid choking of down comers by bigger coal lumps and for cleaning of choked down comers.*
- g) Structures and floors shall be so designed as to provide suitable space for routing cables and conduits. Provision shall be kept with platforms and ladders for crossing over the conveyors at approximately every 500m intervals of route length.*
- h) Wire mesh guard shall be provided at tail pulley, flexible coupling and take-up pit. For fluid coupling guard should be of 3-mm thick MS plate. All guards shall be easily removable types with inspection door. Walk way clearances for all buildings, platforms around equipment / conveyor etc. shall be minimum 1200 mm.]*

4.14 Chutes, Hoppers and Skirt Boards

4.14.1 Chute & Hopper

- a) The cross-section of the chute shall be selected based on the following guide

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lines: Smaller dimension of the chute cross-section shall not be less than three (3) times the lump size of the material the cross-sectional area of the chute shall not be less than Five (5) time the material flow area. The actual valley angle and chute design shall be finalized after carrying out coal flow ability studies at worst conditions.

- b) Transfer chutes shall be adequately sized and sloped to ensure smooth flow of coal without any accumulation anywhere.
- c) Complete chute work and hopper above the drive floor for conveyors provided with 'In-line belt magnetic separators' shall be of 10 mm thick SS - 304 in the zone of magnetic field.
- d) Direct impact of material on conveyor belt shall be avoided by providing an inclined surface at 60 degrees valley angle at the feeding point to guide the material in the direction of belt travel. Further, chute construction below flap gate shaft shall be such that so as to ensure that there will not be any accumulation of coal dust between chute and flap gate in that zone.
- e) Hoppers and Chutes shall be made of minimum 20 mm thick TISCRAI or equivalent material. Long chutes guiding flow from considerable height shall be provided with impact plates wherever change in direction of flow takes place. Hinged inspection doors (generously sized) of leak proof construction shall be provided for access/ maintenance purpose, at approachable heights for chutes and flap gates. All chutes should have one inspection door at every floor and for the ones in between the floors (more than 1.5 meter above the operating floor level) suitable access for trouble free maintenance shall be provided. Maximum distance between two inspection doors in a chute shall be 2 m.
- f) Bottom side of the chutes on which the coal slides shall be welded to the side plates to form a trough. Bottom sides along with its adjacent sides shall be flanged and made from TISCRAI or equivalent material of 20 mm thickness. The non-striking surface i.e. the covers of the trough shall be of 10 mm thick mild steel and bolted to the flange provided on the trough. Inside welding shall be provided in the corners for permanent sealing.
- g) Complete chute work in the region of flap gates shall be fabricated from 20 thk TISCRAI or equivalent. In case of vertical chute (valley angle more than 80 degree) complete chute, work shall be of 20 mm thick TISCRAI or equivalent material. While finalizing the chute work inside the building, arrangement for shifting and replacing chute legs, proper handling arrangement/wall openings, trolleys, hoists shall also be provided. While fabricating the chute, the constituent plates used shall be in one piece. No welds in between shall be allowed.
- h) In the zones of direct impact due to Coal trajectory, wear resistant backing plate with stiffeners shall be provided in coal flow chutes. Similar backing

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plates & stiffening arrangement shall also be provided on the chute surfaces having direct coal fall.

- i) Hoods over the conveyor head pulleys shall be made of suitably stiffened minimum 4 mm M.S. Plates and shall be provided with hinged and gasketed inspection doors with suitable access to them. Further, serrated rubber seal shall also be provided at the very inlet of head chute to minimize dust nuisance.
- j) Separate maintenance sealed door shall be provided for access to belt cleaners in head pulley hood impact plates, flap gates for maintenance and inspection doors shall be of hinged with positive locking facility.
- k) Tramp Iron Chutes and Dust and Debrise Chute shall be of 1m x 1m size and shall be of 6mm thick MS Construction.
- l) Emergency Reclaiming Hopper (ERH) and Shed
Provision of two [2] no. emergency reclaim hopper shall be kept. The grid over it shall be designed for the accidental movement of the bull dozers. The hoppers are to be constructed with RCC. Shed over hopper is required with color coated sheets for roof and side cladding.

4.14.2 Skirt Boards

- a) Skirt board shall ensure centralized loading of conveyor belt to avoid coal spillage. Suitable 'Skirt Plates' of minimum 3.0 meters length shall be provided at each feeding point of conveyor.
- b) Skirt shall be terminated over idler only. Skirt board shall be provided with top cover and bottom of the skirt board shall be fitted with moulded rubber strip. Increasing gap shall be maintained between skirt plates and belts towards direction of flow. Bell-shaped skirt board, which facilitates central loading of material on belt, shall be preferred.
- c) The width of the Skirt Boards shall be two-third the conveyor belt width. In the belts before Crusher House where coal of appreciable lump size (250 mm) is being conveyed, the gap between the bottom of the skirt board and the belt shall be made to increase uniformly in the direction of belt travel. The height of the skirt shall be sufficient to contain the material volume. In Belt Feeder skirt height shall not be less than 800 mm and in conveyors 750 for uncrushed and 600 for crushed coal. Rubber flaps shall be provided at the interface with the stationary chute/skirt to minimize dust generation. Adequate stiffeners shall be provided in the flange area. Region of flap gates shall be fabricated of Tiscral or equivalent material. In case of vertical chutes complete chute work shall be of 16 mm Tiscral or equivalent material. All care shall be taken while designing, to combine good sealing with minimum belt wear.

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Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.0	Chutes & Hoppers	
1.1	Minimum valley angle	60 °
1.2	Material of Chute work	[20 mm thk. Triscal / equivalent 10 mm thk MS All four sides of 20 mm thk. Triscal/ equivalent SS-304 non-magnetic steel 10 mm thk.]
1.3	Inspection doors	Hinged & leak proof construction.
1.4	Chute Construction Corners Joints Bolt size Bolts spacing Fixing Arrangement	One face of removable bolted flange connection Bolted flange joints of dust tight construction Min. M-16 Not more than 125 mm C/C Bolts with plain and spring washers
2	Skirt Boards	
2.1	Length	Min. 3 m for each feeding point for Belt Conveyor & Continuous for Belt Feeder.
2.2	Height	Not less than 800 mm for belt feeder. Not less than 750mm for uncrushed and 600mm for crushed coal in conveyors.
2.3	Width	2/3 of belt width
2.4	Plate thickness Side Top cover	Min. 10 mm thick Tiscral/equivalent 6 mm thick. M.S. plate
2.5	Material handled	Coal

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Sl. No.	Item Description	Parameters
2.6	Material flow rate handled	[...] TPH
	Rated Designed	[...] TPH
2.7	Moisture in coal	[20] %

4.15 Flap Gates and Rack & Pinion Arrangement.

4.15.1 Flap Gates

- a) The motor operated 2 position flap gates shall be provided in transfer chutes a specified and shall be complete with electrically operated actuators. The gates shall be of robust construction and suitable for trouble free operation. The face of the flap gate shall be made out of 20 mm thick TISCRAAL or equivalent material.
- b) The equipment shall be capable of being operated for at least 15 switching per hour at rated load and thrust and shall be suitable for 10 Nos. consecutive switching at rated load and thrust.
- c) The motor rating for the actuator shall be so selected as to provide sufficient thrust for operation of the flop gates against the moving weight of coal and/or flap gate. The flap gate travel shall be in the range of 60 deg. to 70 deg. The motor shall be completely dust tight.
- d) The actuators shall be capable of preventing any over travel. Suitable travel dependent limit switches controlling the travel of the flop gates on either direction shall be furnished. These shall be placed internal to the drive unit and shall be completely dust-proof. The limit switches shall be capable of adjustments to vary the total length of travel of the gates.
- e) Provision for alternative manual operation shall also be made using declutchable hand wheel. The diameter of hand wheel shall be selected considering convenient force to be applied by a single operator. However, minimum diameter of hand wheel shall be 500 mm. Limit switch for safety of person operating the hand wheel shall be provided.
- f) All the two way chutes, one way of which is leading towards the future conveyor, shall be provided with blind flange and flap gate with a provision to mount an actuator in future.
- g) Flap Gate mounting shall be suitable for easy removal from chute. Provision shall be made for non-reversal of gate during operation. Shaft design shall be such that it can take care of the maximum torque which can be supplied by the Gear Mechanism (for manual operation) in case of jamming.
- h) All the actuators in the plant should be selected on the basis of heaviest

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loading, but the rating shall not be less than [3500] kg at a lever arm 1.0 m in any case. For flap gates longer than 1500 mm (from shaft centre) actuator rating shall not be less than [3500] kgm.

- i) Alternative provision for manually positioning the flap gate using de-clutchable hand wheel shall be kept. Such mechanism shall enable positioning the gate with 25 Kgf effort. The hand wheel diameter shall be at least 500mm. However limit switch shall be provided for the safety of the person manually operating the hand wheel.
- j) Suitable thrust dependent limit switches shall be provided in the actuator, which shall trip off the actuator motor in case of excessive thrust due to jamming of the gates during its travel in either direction. The same shall also be integral to the drive unit and shall be dust proof.

Technical Data Sheet:

Cl.NO.	Item Description	Parameters
1.0	Service Requirement	
1.1	Type	Linear actuator operated, 2-Position
1.2	Location	As per Flow Diagram
1.3	Required numbers	As per Flow Diagram
1.4	Capacity	[...] TPH (Rated) [...] TPH (Designed)
1.5	Size handled	Uncrushed: [(-)250] mm Crushed: [(-)20] mm
1.6	Chute valley angle and gate	60°
1.7	Hours of operation/day	24
2.0	Flap Gate Requirement	
2.1	No. of switching per hour	15/hr and 10 nos. consecutive switching at rated load and thrust.
2.2	Travel	As required.
2.3	Actuator type	Electric
2.4	Speed of Travel	50mm/Sec. (min.)
2.5	Minimum thrust	[500] kg.
2.6	Minimum Stroke Length	[300] mm.

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Cl.NO.	Item Description	Parameters
3.0	Material of Construction	
3.1	Gate	Tiscral/equivalent plate, 20mm thick, welded construction.
3.2	Shaft	EN-8.
3.3	Shaft Size	[...] mm dia.min.
3.4	Chute Plate	Tiscral / SAILHARD
4.0	Bearing	
4.1	Type	Dust proof, self aligning anti friction ball or roller.
4.2	Type of sealing	Double labyrinth (min.)
4.3	Method of lubrication	Single shot, pressure lubrication.
5.0	Miscellaneous Requirement	
5.1	Type of protection	IP – 55
5.2	Type of limit switches	Thrust dependent Position dependent.

4.15.2 Rack and Pinion Arrangement

- Rotary actuator operated rack and pinion gates shall be provided at various locations. The gate shall be mounted such that coal load does not act vertically on gate.
- Suitable manually operated rod gates shall be provided over rack and pinion gates for their easy operation and maintenance.
- The rack and pinion gates shall be of mild steel construction with liner plate of 10 mm thick tiscral or equivalent material. The gates shall be operated by means of double rack and pinion. The material for rack & pinion wheel shall be cast steel and shaft shall be EN.-8.
- Approach/maintenance platforms complete with chequered plate floor, hand railings, ladder etc. shall be provided for all gates.
- Provision for alternative manual operation of motorised rack and pinion gates shall also be made. Limit switch for safety of person operating the hand wheel shall be provided. Manual effort required to operate the rack and pinion gate shall not exceed 25 kg.

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Technical Data Sheet:

Sl. No.	Item Description	Parameters
1.0	Type	Motorized Double rack and pinion type
2.0	Location	[...]
3.0	Quantity	[...]
4.0	Material size	(-) 250 mm ((-) 400mm Occasionally) & (-) 20mm uncrushed coal
5.0	Material flow rate	[...] TPH-above VGF [...] TPH-above VF
6.0	Hours of operation	24 Hours
7.0	Travel speed of the gate	3 M / Min (minimum)
8.0	Locking device to be provided	Yes, Electromagnetic brake
9.0	End limit switch to be provided	Yes - Both travel and thrust dependent.
10.	Drive type	Rotary actuator operated.
11.0	Material of Construction	
11.1	Slide gate	MS with SS 304 Liner (5 mm thick)
11.2	Rack	Cast Steel
11.3	Pinion	Cast steel
11.4	Drive Shaft	EN 8
11.5	Safety guard	MS
11.6	Guide Rollers	CI IS 210, FG 160
11.7	Chain & sprocket	IS : 2429
12.0	BEARING	
12.1	Type	Dust tight anti friction ball bearing with double labyrinth seal.
12.2	Life	Minimum 30,000 working hours
12.3	Method of lubrication	Oil / Grease pressure lubricated.

4.16

Belt Weighing System

- a) Bidder to provide the [...] nos. of belt weighers complete in all respects along with all accessories and nuts and bolts required for smooth and trouble free operation of the equipment.

Following are the design and construction requirements:

- a) Suitable provision shall be made for indication of the following to the Operator

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at CHP control room.

- Daily & cumulative coal unloaded by track hopper/Wagon tippler.
 - Daily & cumulative coal sent to the stock pile.
 - Amount of coal available in the stock pile.
 - Daily & cumulative coal reclaimed from the emergency reclaim hopper.
 - Daily & cumulative coal sent to the boiler bunker.
- b) At least one calibrating attachment for each two (2) weighers.
- c) Each weigh scale shall comprise of a weigh platform with minimum four (4) nos weighing idlers, unitized, fully floating (not on pivot points) type.
- d) The weigher shall have 100% overload protection for the cells and 250% overload protection for the structure.
- e) The speed sensor shall resist material build-up and be driven by return belt. The shaft of these wheels/roller shall transmit the motion through gear/chain and sprocket mechanism.
- f) Fully automatic zero and span calibration facility shall be provided.
- g) All clearance from statutory bodies like weights and measure inspector etc. are to be arranged by the Bidder without any extra cost.

Technical Data Sheet:

Sl. No.	Item Description	Parameters
1	Ambient Temperature	50°C
2	Relative Humidity	100%
3	Type	Electronic load cell type
4	Operation	Microprocessor based fully automatic
5	No. of floating idlers	Minimum Four
6	Load Cell	
	Type	Strain gauge type hermitically sealed
	Minimum	Four
	Over load protection	100% of rated belt scale capacity
	Structural capability	250% of rated belt scale capacity

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4.17 In-Line Magnetic Separators

4.17.1.1 Design and Construction Requirement

- a) There shall not be any dead spot in the magnetic separator through which magnetic particles may pass. ILMS discharge should be such that it can be conveniently taken to a chute.
- b) The transformer and rectifier assembly shall be housed in a dust tight enclosure. These units shall be complete with all measuring instruments and protection required.
- c) The belt shall operate at a speed of at least 15m/min. greater than the associated conveyor belt speed. The belt shall be direct driven. The drive system shall have at least 20% margin over the actual requirement by the driven equipment.
- d) The belt should have properly spaced cleats and should be of fire resistant grade.
- e) The belt should be selected for high temperature occurring beneath the magnet and because of impacts of sharp edges of tramp iron.
- f) The motor and gear reduction unit for driving the inline belt shall be adequately sized with minimum 20% margin to avoid any overloading during operation.
- g) Manual cross travel shall be provided to move it away to facilitate maintenance.
- h) The magnet shall be made out of steel with low hysteresis loss. Additional pole cover to be provided to increase magnet flux.
- i) Suitable local control panel for each magnetic separator shall be provided complete with isolating switch, fuses, contactor, push buttons, lamps, transformer/rectifier unit, ammeter, voltmeter and other necessary accessories.
- j) The steady state temperature of magnetic core shall not exceed 25 °C max. over the ambient temperature.
- k) A minimum force index of 100,000 and a minimum flux density of 1000 gauss shall be available at the lowest location in coal thickness all through the width of coal bed, from where steel pieces are to be picked.
- l) Flux density V/s distance curves of the magnet at centerlines along full length and width of the magnet shall be submitted for Owner's approval.
- m) The cross section of magnet shall be suitably designed to provide sufficient area for magnetizing the coil effectively covering full cross section of the discharge material. The inline magnetic separator shall be located such that it picks-up tramp iron from coal trajectory after it has been discharged from head pulley.

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- n) Necessary calculation in support of the strength of magnet shall have to be furnished for Owner's approval.
- o) The tramp iron chute shall be of nonmagnetic SS-304 up to influence zone of magnet and shall be of min. 6 mm thick plate in general.
- p) Tramp iron pieces should be discharged such that it falls onto the tramp iron chute.

Technical Data Sheet:

Sl. No.	Item Description	Design Criteria
1.0	ILMS Location	Conveyor No. [...], [...],.....
	SM Location	Conveyor No. [...], [...],.....
2.0	Hours of operation/day	24 hours continuous.
3.0	Qty. of ILMS	[...] nos
	Qty. of SM	[...] nos.
4.0	Type	In-line D.C. operated, Electromagnetic suspended type.
5.0	Force Index	Min. 100000
6.0	Flux density	Min. 1000 gauss.
7.0	Lifting Capacity	MS cube of 20 mm size Rail. wagon brake shoe (Cast iron: 15Kg. Wt.) MS plate: 250 mm x 250 mm x 100 mm size. Shovel teeth & spikes: Carbon steel, typ, size. MS round, L/D ratio: max. 5, 50 Kg. wt.
8.0	Mounting height	400 mm from top of belt or bottom of falling material trajectory to face of separator belt.
9.0		
10	Magnet Cooling	Either air cooled or oil cooled. In case of oil cooled oil level gauge and oil temperature measurement gauges shall be provided. In case of air cooled thermistor relays to be provided.
11	Belt width	[...] mm
12	Insulation	Class H

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Sl. No.	Item Description	Design Criteria
13	Core	CRGO sheet steel
14	Material of magnetic coil	Copper strip wounded double glass insulated as per IS:4685 Part-II.
15	Transformer	Dry type and housed in a dust tight enclosure. Shall have suitable no. of tapplings.
16	Degree of protection for transformer & magnet	IP-55
17	Rectifier Unit	Self contained, floor mounted, silicon of adequate capacity rated for 3 Ph, 50 Hz AC input and 200/250V DC output
18	Rectifier panel	Sheet steel enclosed minimum 2 mm thick free standing with enclosure to IP-55 class of protection.
19	Rectifier panel	
20	Indicating lamps	3 Nos. for AC & 1 No. for DC.
21	HRC fuses	On both AC & DC load side.
23	Voltmeter	1 no. on AC side for phase indication and 1 no. on DC
24	Ammeter	1 no. on DC side.
25	Contactors	1 no.
26	Non Magnetic Chute	Yes
27	Turn-buckle with slings	Yes
28	Hardware	Yes

4.18 Metal Detector

Metal Detectors are to be provided on conveyors after detecting metals will drop a flag on the conveyor and stop the conveyor.

4.18.1 Design and Construction

- Metal Detector shall be mounted on conveyor structure. The search coil shall be totally enclosed sealed with epoxy resin to prevent ingress of dust and moisture. One side of the coil should be able to operate for mounting around the belt conveyor without disturbance.
- Control panel shall have indication, minimum for 'POWER ON', 'TRAMP METAL DETECTED', 'BYPASS', 'SEARCH COIL FAULT' and an audible hooter having minimum range of 250m.

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Technical Data Sheet:

Sl. No.	Item Description	Design Criteria
1.0	Type	Electronic
2.0	Location	Gallery of Conveyor No. [...], [...]
3.0	Numbers Required	[...]
4.0	Material Handled by Belt	Coal
5.0	Bulk Density	[0.8] T/cu. m
6.0	Moisture Content	[20]%
7.0	Duty	24 Hours (continuous)
8.0	Conveyor Capacity	[...] TPH
9.0	Belt Width	[...] mm
10.	Belt Speed	[...] m/s
11.	Troughing Angle	35 deg.
12.	Belt	Synthetic
13.	Type of Metal to be detected	Ferrous & Non-ferrous
14.	Minimum size of metal to be	25 mm dia. steel ball
15.	Purpose of Installation	To protect Coal Crusher
16	Suppressor Coil	Required to suppress false alarm
17	Marking device	Sand bag marker
18	Protective device	Reqd. to prevent damage of the equipment due to oversize lump
19	Local panel	Required

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4.19 Stone Picking

- a) Manual Stone Picking arrangement at a suitable location in the conveyor gallery before the primary crusher house shall be provided complete with platforms, overhead lighting, hand railings, suitable seating & holding arrangement for manual pickers and disposal chutes to ground level etc. Two (2) nos. manual pickers (One on each side) shall be positioned for each belt. Each manual picker shall cover 3 m long belt stretch adjacent to each other. The picked up stone lumps (upto 600 mm size) shall be collected over the conveyor gallery walkway level from where these stones can be pushed into the hopper/chute upto disposal trolley at the ground level. Disposal chute from discharge hoods of length upto 2 meter from ground level shall be provided etc.

4.20 Belt Vulcanizing Machine

- a) Belt Vulcanizing Equipment shall be suitable for hot vulcanizing of belt splice and shall be of easy-to-handle type.
- b) Equipment should be suitable for vulcanizing of entire splice width in single setting. Equipment should be capable of applying uniform pressure over the splice by pneumatic or hydraulic means.
- c) Heating element should be preferably of flexible type.

4.21 Hoists and Chain Pulley Blocks

Electric Hoists and Chain Pulley blocks shall be provided as required for handling and maintenance of plant and equipment.

4.21.1 Design and Construction

- a) For the Hoists with more than [2.0 tonne lifting capacity or more than 10.0m] lift, motor operated hoist blocks for both travel and lift shall be provided. Other hoist blocks shall be of hand operated type for both travel and lift. However, all monorails coming out of the building shall be provided with electric hoist blocks, irrespective of load and lift.
- b) The centre line of monorail shall not deviate by more than 500 mm from the centre of gravity of any equipment that is to be lifted.
- c) Monorails shall be extended outside the building to handle the equipment to ground level. Suitable machinery well and hand railing/grating shall be provided on various floors of buildings, as necessary.
- d) Trolley movement and hoisting shall be effected by using 2 separate motors. Motors shall be as per technical requirements indicated in the electrical Section. However, the motors shall be suitable for 150 starts per hour.
- e) Trolley shall be designed to accommodate a wide range of I beams and shall

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- be capable of travelling on straight as well as curved monorails with the design being such to maintain uniform distribution of pressure on the flanges.
- f) Motor operated geared trolley shall have two (2) pairs of wheels, one pair of which shall be driven through motor. The Hoist trolley frames shall be fabricated from structural steel.
 - g) Mountings shall be designed to facilitate easy removal of the wheels, bearings and journals for quick and easy maintenance. All exposed couplings, shafts, gear wheels, pinions and chain drives, etc. shall be safely encased and guarded completely.
 - h) Trolley wheels shall be of forged steel and shall be single flanged with taper tread. Trolley wheel bearings shall be antifriction roller bearings Hooks shall be swiveling type with forged circular shank section and operate on ball or roller thrust bearings with hardened races. Lock to prevent hooks from swiveling shall be provided. The lifting hooks shall comply with the requirements of IS 3815 as applicable and shall have a safety latch to prevent rope coming off the hook.
 - i) Hoist ropes shall be extra flexible, improved plough steel rope with well lubricated hemp core. The rope shall be fastened to the drum with an attachment having strength equal to that of the rope. They should be hemp cored regular lay 6/36 construction with a breaking strength of 160-180 kgf/cm². Minimum no. of falls of rope shall be four. However, for high lifts two falls non-rotating ropes shall be used.
 - j) Rope drums with flanged ends shall conform to IS-3938 of sufficient strength to sustain crushing and bending loads arising from the pull of rope.
 - k) Each end of the rope shall be anchored to the drum in such a way as the anchorage is readily available for maintenance. Each rope shall have not more than two (2) full turns of the drum when the hook is at its lowest position and one (1) spare groove when the hook is at its highest position. The leading rope taken by the drum should not slope sideways when slack and it should not get caught between the gear wheel. Rope drum, gear box, block etc. should be fabricated out of weldable quality steel. All gears and pinions shall be hardened and ground. Strength, quality of steel, heat treatment, face, pitch of teeth and design of gearboxes shall conform to IS: 4460.
 - l) All antifriction bearings shall be of approved type and make which are interchangeable with corresponding sizes of other make bearings. Motor bearings shall be of the ball or roller type. Bearing housing shall be split or so designed as to permit easy removal of the shaft. Bearings shall be designed to exclude dirt and to prevent leakage of oil or grease. Drip pans shall be provided to accept accidental leakages and drippings.
 - m) All hoists/ chain pulley blocks shall be selected to have minimum headroom and shall be selected to lift heaviest piece of equipment further it shall be

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- possible to handle any equipment without disturbing other equipments. All components of hoists of identical capacity and duty shall be interchangeable
- n) Hoist should be provided for lifting and moving the crusher during installation as well as during repair and maintenance. For inspection/ maintenance of hoist components a fixed platform with ladder shall be provided for each hoist.
 - o) The hand chain wheels shall be made of cast iron, the wheels shall be with flanges and designed to ensure effective operation of hand chain. Further, suitable local brakes shall be provided as per IS: 3832 to avoid and sustain in all working conditions.

4.22 Dust Suppression System

The dust control system is required for control of fugitive dust emissions from dust generation points such as track hopper/wagon tippler, transfer points, feeders, crushers etc.

Dust control is achieved by dust suppression system. Dust Suppression system shall comprise of:

- a) Pumps complete with drive motors, base frame with foundation bolts and nuts, suction pipe line with isolating valve and other accessories like coupling guard, pressure gauges etc. Duplex strainer at the discharge end of each pump.
- b) RCC storage tank(s) complete with float valve, manhole, ventilation connection, pump suction connection, drain & over flow connection, low & high level switch etc.
- c) Clarified Water shall be drawn from the water storage tank by [2x100%] electric motor driven pumps, and delivered through a pipe network system to spray heads at the dust suppression zones. All required interconnection piping works with pipe fittings from the main pump onwards, up to the application points. All required valves for proper operation of the complete DS system.
- d) Solenoid valves shall be provided for open/close control of solution line to each spray head. Each spray head shall consist of minimum 4 nos. nozzles. Spray heads shall be provided at coal loading, discharge and at skirt board zone. Pressure at inlet to spray head shall not be less than 3.5 kg/cm²(g).
- e) Trolley mounted pumping arrangement shall be provided for supplying water to the mobile paddle feeders. In this arrangement, tank, supply pump(s) and spray nozzle header shall be mounted on paddle feeder trolley. The tank on P/F trolley shall be filled through flexible hose tapings on a ring header, which will remain, flooded through a connection to on ground storage tank. This storage tank shall have make up connection from the common dust suppression system. Each spray head shall have a provision for installing a pressure gauge at least at two locations.

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- f) Service water piping complete with tap points with globe valve, quick connection coupling and flexible hoses.
- g) Any other equipment and/or material, which are not specifically mentioned but required for the completeness and reliable & trouble free operation of the system/equipment.

(i) Dry Fog Type Dust Suppression System

Complete with water supply system, compressed air system, pressure regulating units, flow activation system, necessary instrumentation for auto & manual operation, drives, pumps, maintenance platforms, along with associates civil/structures & electrical works.

(ii) Piping Fittings, Valves and Accessories

The material to be supplied for completing the pipe work shall include but not be limited to the following:

- Straight piping, bends, tees, elbows, branches, laterals, crosses, reducing unions, couplings, caps, blank flanges, saddles etc. necessary for making reliable piping system.
- Gaskets, ring joints, jointing material etc. as required.
- Instrument tapping connections, stubs.
- Gate / plug, globe and check valves to start/stop, regulate and to prevent back flow.
- Duplex Strainers.
- Anchors, hangers and supports as required including secondary steel embedment etc.
- Bolts, nuts, fasteners as required for interconnection piping, valves and fittings as well as for terminal points.
- The entire water piping of DS / SW / PW / CW / DE system shall be routed/supported on concrete pedestal and conveyor galleries. Wherever the layout does not permit the pipes to be routed over ground, the same shall be buried in conformity to the relevant standards & shall be provided with necessary protective coating as per relevant standards and as specified elsewhere in the specification.
- Painting, anti-corrosive coatings etc. outside pipes as necessary.
- Welding electrodes and welding rods.
- The area around storage tanks, strainers, valves etc. (located outside pumphouse) shall be paved.

(iii) Design Requirement

At specified locations dry fog dust suppression system shall be provided which comprises spray nozzles discharging plain water & air in a fine spray to form dry fog to capture air borne dust particles and direct them into the main coal flow. This dry fog shall be discharged through spray

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heads at the dust suppression zones. The dry fog dust suppression system shall consist of the following:

- a) Fogging system & controls consisting of:
 - Spray bar assemblies.
 - Pressure regulating units
 - Flow activation system
 - Instrumentation for auto spray
- b) Compressed air system consisting of:
 - Two (2) nos. (one no. working and one (1) no. standby) air compressors (screw type) for each group of dry fog dust suppression system, alongwith air receivers as specified elsewhere.
 - Air receivers
 - Various instrumentation & valves.

Each spray head in CHP shall have a provision for installing a pressure gauge whenever required. Further, pressure gauges shall be provided at least at two locations.

c) Service Water (SW) System

Service water connections are to be provided in conveyor galleries and tunnels at 50 meter intervals. Adequate number of these connections shall be provided in all transfer houses with minimum one no. at each floor and with minimum two (2) nos. at each floor in crusher house. Each connection shall be provided with one (1) no. 32 NB globe valve and quick coupling. One (1) no. hose pipe with nozzle shall be provided in each building.

d) Potable water (PW) system

Potable water connections are to be provided in all transfer points, wagon tippler top, crusher house, all tripper floors, the machinery well at both ends of track hopper, track hopper top at both ends and all control rooms/MCC rooms and toilets etc. Water shall be drawn from the water storage tank by electric motor driven pumps and discharged via a pipe work system to the overhead drinking water storage PVC tanks of 250 litres capacities. The drinking water storage tanks shall have provision for maintenance & drain.

Hoists with monorail of adequate capacity shall be provided in the service water/dust suppression/potable water pump houses.

Technical Data Sheet:

Dust Suppression System (Dry Fog Type)

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Operation	Water & air sprayed by Fogging nozzle
Location of spray	At all coal discharge & receipt point on all transfer point & crusher house
Pressure at inlet of spray head	0.5 Kg/cm ² for water (min.) 5.0 Kg/cm ² for air (min.)

4.23 Wagon Tippler Dust Suppression System

Clarified Water shall be drawn from the water storage tank by electric motor driven pumps and discharged via a pipe work system through spray heads.

Technical Datasheet:

Wagon Tippler Dust Suppression System (Plain Water Type)

Capacity of each nozzle	2.0 lpm (min) at 4.5 kg/cm ² (min)
Nozzle Spacing	500 mm
No of nozzles	1 no.
No of nozzles operating simultaneously	All

4.24 Coal Yard Dust Suppression System

- a) [CW Blow down Water/ Services Water] is to be drawn from the water storage tank by electric motor driven pumps and discharged via a pipe work system through spray heads. Spray heads shall comprise of swiveling type spray units spaced at an interval of approximately [30] meters around each coal pile. Manually operated globe valve shall be provided to control water supply to each spray unit. One no. pump shall be provided for each individual stock pile with common header. Flow and Pressure at inlet to spray unit shall not be less than [500] LPM and [4.5] kg/cm²(g).

Technical Data Sheet:

Dust Suppression for Track Hopper & Coal Stockyard

1.0 Track Hopper		
1.1	Operation	Water sprayed through nozzles
1.2	Pumps	2x100% for water.
1.3	Mini no of nozzles per spray head	4

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1.4	Trolley Mounted Arrangement for paddle feeders	
1.5	Ring Header	100 NB on both sides of Track Hopper
1.6	Hose Tapping	At 25 meter intervals suitable for tank filling in 5 minutes
1.7	Trolley tank capacity	Suitable for 1/2 hrs operation of Paddle Feeder
1.8	Nozzle spacing for track hopper	500 mm
1.9	Nozzles	Fogging type
1.10	Flow from each nozzle	2.0 Lpm
2.0	Dust Suppression For Coal Stack Yard	
2.1	Pump	[2 X 100%] electric motor driven
2.2	Spray Head Type	Swiveling type spray unit
2.3	Throw of Sprinklers	Suitable to cover entire stockpile surface.

4.25 Dust Extraction System

Dust extraction system will be complete with:

- a) Centrifugal fan unit complete with electrical drive motor, pair of slide rails for motor and common base frame with foundation bolts, drive pulley, V belts, belt guard, vibration isolators, dampers and flexible connections with matching flanges, sheet metal canopy over motor, butterfly damper at fan inlet. Bag filters with integral hopper shall be provided with automatic online bag cleaning system. Necessary valves, solid state electronic timers, air piping etc. Dust collecting hoods at each dust extraction points with butterfly dampers. Dust outlet with motorized rotary air lock feeder arrangement. Screw conveyor wherever required shall be provided. Dust disposal chute with outlet duct for feeding the dust back to the conveyor/bunker. Complete ducting work with duct supports. Fan discharge side ducting chimney/stack with exhaust cowl and bird screen.
- b) Compressor unit complete with drive units, air filter, air receiver, air drier (if

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required), pressure gauge, safety valve, piping along with fittings etc. Structural steel shed for housing fan and motor, wherever it is not possible to locate the same inside the nearby junction tower/building. Any other equipment which is not specifically mentioned, but required for completeness and trouble free operation of the system. The minimum extraction quantity at various dust extraction points and design of the whole system shall be as per the recommendations of "American Conference of Governmental Industrial hygienists" (ACGIH).

- c) The dust laden air shall be sucked through suction hoods and collected in bag-filter. The clean air from outlet of Pulse-jet bag filter shall be discharged into the atmosphere. Dust collected shall be disposed into the outgoing conveyors/ bunkers through dust disposal chute. There shall be minimum two suction points for each belt conveyor, one at the feed point and one at the discharge point. The exhaust air from the centrifugal fan shall be discharged into the atmosphere through exhaust chimney/stack. The chimney/stack height shall be at least 3.0 M above from the nearest building but it shall be no way less than 30.0 M above the ground. All dust extraction systems shall be started or stopped manually locally with indication at the main CHP control desk.

4.26 Service Water System & Sump Pump

Service water distribution system complete with water supply system, valves, quick couplings, hose pipes with nozzle, piping, pumps, drive motors with canopy, couplings with enclosure, electricals, including supporting structures, handling for equipment's, civil and structural works and necessary accessories shall be provided throughout the coal handling plant area.

Bidder to provide the service in conveyor galleries and tunnels at 50 meter intervals. Adequate number of these connections shall be provided in all transfer houses with minimum one no. at each floor and with minimum two (2) nos. at each floor in crusher house. Each connection shall be provided with one (1) no. 32 NB globe valve and quick coupling. One (1) No. Hose pipe with nozzle shall be provided in each building.

All hoppers, tunnels and underground transfer towers shall be provided with sump & sump pumps (1 operating + 1 standby). The drive motor of all the sump pumps shall be mounted at least 1.0 meter above the floor level. The sump pumps shall be suitable to handle coal slurry and impeller shall be of non-clog type.

4.26.1 Water supply pumps

The pumps shall be complete with drive motors, base plate and other accessories. The constructional features of the pump shall be as follows:

- a) Pump casing may be axially or radially split. The casing shall be of robust

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- construction. Casing drain and vent connections shall be provided.
- b) Impeller shall be made in one piece and securely keyed to the shaft. Locking device shall be provided to prevent its loosening during all conditions of operation.
 - c) Replaceable shaft sleeves shall be provided to protect the shaft where it passes through bearings and stuffing boxes. The end of the shaft sleeve assembly shall extend through the packing gland. Shaft sleeve shall be securely locked or keyed to the shaft to prevent loosening or rotation. Shaft and shaft sleeves shall be machined and assembled for concentric rotation.
 - d) The design of the shaft shall take into consideration the critical speed, which shall be at least 20% away from operating speed.
 - e) Wearing rings shall be of renewable type. Opposed wearing surface shall be of hardened material and shall have a hardness difference of at least 50 BHN.
 - f) Pump bearings shall be of antifriction type. Bearings shall be readily accessible without disturbing the alignment of pump.
 - g) Pumps shall be furnished complete with flexible -coupling.
 - h) Couplings guards made of expanded metal and bolted to the base plate shall be furnished.
 - i) The common base plate for pumps and motor shall be in one piece and shall be made of fabricated steel.
 - j) Pump speed shall be less than 1500 rpm for pumps of capacity more than 10 m³/h.

Technical Data Sheet:

Service Water Pump	
Casing	Axial or radially split with drain & vent connection
Material	Bronze conforming to Gr.I of IS:318
Impeller	One piece, keyed to shaft along with locking device
Material	Bronze conforming to Gr.I of IS:318
Shaft	Critical speed at least 20% away from operating speed
Material	Medium carbon steel
Impeller and casing wear	Bronze conforming to Gr.I of IS:318

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ring	
Sump Pump	
Type	Vertical, centrifugal, single stage, semi open or open (non clogging) type impeller
Duty	Intermittent. However, to be designed for continuous operation
Fluid to be handled	Sludge/Coal slurry
Coupling	Directly driven through flexible or rigid coupling/V-Belt
Materials	
Casing	Alloy Cast Iron (350 BHN) (min. 2.7% Ni, 1% Cr.)
Impeller	Alloy Cast Iron (350 BHN) (min. 2.7% Ni, 1% Cr.)
Impeller Shaft	Stainless steel
Line Shaft	EN-8 to BS; 970

4.26.2 Pipe Fittings, Valves & Specialties:

- For completing the pipe work shall include but not be limited to Straight piping, bends, tees, elbows, branches, laterals, crosses, reducing unions, couplings, caps, blank flanges, saddles etc. necessary for making reliable piping system.
- Gaskets, ring joints, jointing material etc. as required.
- Instrument tapping connections, stubs.
- Gate, globe and check valves to start/stop, regulate and to prevent back flow.
- Duplex Strainers
- Anchors, hangers and supports as required including secondary steel embedments etc.

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- Bolts, nuts, fasteners as required for interconnection piping, valves and fittings.
- Underground pipe protection for all underground pipe work.
- Painting, anti-corrosive coatings etc. inside and outside pipes as necessary.
- Welding electrodes and welding rods.

4.27 Data Sheet for Dust Control & Miscellaneous System

1	General	Description
1.1	Dust Control	Dust suppression/extraction system
1.2	Miscellaneous System	Service water system, potable water system, cooling water system
2.0	Design Requirement	
2.1	Dust Suppression	
	Operation	Water sprayed through nozzles
	Pumps	[2x100%] for water
	Spray Head	
	(i) Minimum no. of nozzles per spray head	4 (four)
	(ii) Pressure at inlet (dry fog)	Min. 0.5 kg/cm ² for water Min. 5 kg/cm ² for air
	(iii) Pressure at inlet (Plain water)	Min 2.5 kg/cm ²
2.2	Dry Fog System	
	Compressor	[Screw type]
	No. Of compressors	[One working & one standby] per group
	Air receiver	One no. of min. [2 cu.m] capacity located near compressors & [200 liters] capacity at various location

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1	General	Description
	Nozzles	Dry fog type
2.3	Service Water System	
	Water connections	
	a. Conveyor galleries and tunnels	Every 50 m
	b. Transfer points	Min. 1 no. At every floor
	c. Crusher house	Min. 2 nos. At every floor
	Connection details	32 NB plug valve
	Hose pipes with hose reel	One in each building of 25 mtr. Length with nozzle
2.4	Potable water system	
	Pumps	[2x100%] electric motor driven
	Water connections	
	Transfer points	Minimum one (1) no. at each floor
	Crusher house	Minimum two (2) no. at each floor
	Tripper floor	Minimum one (1) connection at each machinery well in track hopper
	Machinery wells	Minimum one (1) connection at each machinery well in track hopper
	Control room	Minimum one (1) no at each floor
	MCC rooms and toilets	Minimum one (1) each
	Track hopper top	Min. One (1) no at each end
	Wagon tippler top	Min. One (1) no.

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1	General	Description
3.0	Construction Requirement	
	Water supply pumps for DS/SW/PW/CW	
3.1	Casing	Axial or radially split with drain & vent connection
3.2	Impeller	One piece, keyed to shaft along with locking device
3.3	Shaft	Critical speed atleast 20% away from operating speed
3.4	Shaft sleeves	At bearings & stuffing boxes
3.5	Bearings	Antrifriction type
3.6	Wearing rings	Renewable type (preferable)
3.7	Pump speed	Below 1500 rpm for capacity more than 10 cub. m/hr
3.8	Head flow characteristics	Suitable for parallel operation
3.9	Materials	
	Casing	Cast iron to IS:210 FG 260
	Impeller	Bronze conforming to Gr. I of IS:318
	Impeller Wearing ring	Bronze conforming to Gr I of IS:318
	Casing wearing ring	Bronze conforming to Gr. I of IS:318
	Shaft	Medium carbon steel
	Shaft sleeve	Stainless steel conforming to AISI416 hardened

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1	General	Description
	Gland packing	Impregnated teflon
3.10	Pipings & Fittings	
3.11	Joints	
	Pipe to pipe	
	Pipe size < 50 NB	Socket welding/screwed
	Pipe size > 65 NB	Butt welding
	Pipe to valves	
	Pipe size < 50 NB	Screwed
	Pipe size > 65 NB	Flanged
	Isolation of flow	Plug/Gate/Sluice valves
	Regulation of flow	Globe valve
	Valves	
	Size > 65 NB	Bolted bonnet outside screw rising type
	Size < 50 NB	Union bonnet with screwed ends for Globe valve & screwed ends for plug valve
	Materials for Pipework	
	For size 200 NB and larger	ERW carbon steel pipes to API-SL-Gr B/IS:3589 with minimum thickness 6.35 mm
	For size 150 NB to 65 NB	ERW carbon steel black pipes to IS:1239 (Part-Heavy class)
	For sizes below 65 NB	ERW carbon steel galvanized pipes to IS:1239 (Part-I) Heavy class

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1	General	Description
3.12	Materials for Valves & Specialities	
	Cast iron valves	65 NB and above
	Body and bonnet	Cast iron to IS:210 Gr. FG-200
	Disc for non-return	Cast iron to IS:210 Gr. FG-200 valves
	Seating surfaces and rings	13% chromium steel
	Hinge pin for non return valves	Stainless steel type AISI:316
	Stem for gate and globe valves	13% chromium steel
	Back seat Bush	13% chromium steel
a	Gun metal valves (50 NB & below and upto a working pressure of 10 kg/cm ²)	
	Body	Gun metal to IS:318 Gr.2
	Trim	Gun metal to IS:318 Gr.2
b	Duplex strainer	
	Body	MS fabricated
	Strainer	Stainless steel type element AISI-316
c	Pressure Gauge/Switch (to be provided with isolating valves gauge cock, snubber and siphon)	
	Dial size	150 mm

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1	General	Description
	Accuracy	(+ /-) 1 % of range span
	Bourdon	AISI-316 SS
	Block	AISI 316 SS
	Movement	AISI 316 SS
	Case and Bezel	Die cast Alum. Weather proof case stove enamelled block with screwed type inner bezel of ABS plastic and glycerine filled
	No. of contacts	1 No. + 2 NC
	Type of contact	Adjustable throughout the range
	Degree of protection	IP.65]
d	Solenoid valve (to be provided with isolating valve)	
	Type	2/2 way diaphragm type pilot operated
	Diaphragm	Molded synthetic rubber
	Body	Forged brass/SS
	Pressure	0.5 to 10 kg/cm2
	Protection class	[IP 65]
e	Flow switch (to be provided with isolating valves)	
	Body	Forged steel
	Extension rod/wire	SS 304

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1	General	Description
	Sleeve and sleeve pipe	SS 304
	Cover	Die cast aluminium
	Max working pressure	10 kg/sq.cm
	Repeatability	+ 0.5%
	No. of contacts	2 NO + 2 NC
	Type of contact	Adjustable throughout the range
	Protection class	[IP-65]
	Level Switch	
	Type	Displacer operated magnetic type
	Displacer	SS-316
	Wire rope	SS-316
	Spring housing spring and sleeve pipe	SS-316
	Cover	Cast aluminium
	No. of contacts	1 NO + 2 NC
	Type of contact	Adjustable throughout the range
	Protection class	[IP-65]
f	Level gauges	
	Type	Float type mechanical gauge with arrow scale
	Accuracy	(+ /-) 1% of full scale range
	Material of construction	

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1	General	Description
	Float & Guide wire	316 SS
	Elbows	Suitable grade of SS
	Housing	Mild steel
	Cable fastener	SS 304
h	Plain water dust suppression nozzles	
	Type	Fogging, non-clogging type
	Material	Stainless steel
	Nozzle housing	To ensure protection of nozzle against damage
	Y Strainer	
	Body	SS 304
	Plug	SS 305
	Filter Element	SS 316, 60 mesh

4.28 Ventilation and Air Conditioning System

4.28.1 Mechanical Ventilation:

Air quantity of mechanical ventilation system shall be estimated based on equipment and solar heat loads and the temperature rise inside the building. Only filtered air to supply inside the building. The ventilation system shall be consist of adequate nos. of supply and exhaust air fans, filters, ducting along with motor, support, maintenance platform, civil and structural work and necessary accessories shall be furnished for ventilating underground portion of transfer points, underground conveyor tunnels. Exhaust fan shall be provided for tripper floor, toilets, and battery rooms with all necessary accessories.

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4.28.2 Pressure Ventilation System:

The pressurized ventilation system having adequate nos. of supply fans with washable metallic pre filter, HDPE fine filter, and self closing flap (gravity louver shutter), ducting along with motor, electricals, supporting structure, maintenance platform, shall be provided in Switchgear/electrical room of coal handling plant. Pressure ventilated area shall be designed considering 15 ACH to maintain these area pressurized slightly above atmospheric pressure to prevent ingress of dust from outside.

4.28.3 Air Conditioning System:

Air conditioning system shall be provided for Control room of CHP Control building, wagon tippler control room, office room of wagon tipper control room, MCC room, stacker reclaimer control cabin etc. It shall be designed considering the equipment heat load, solar heat gain in to the room, occupancy, air changes, etc. to maintain temperature and humidity within the air conditioned area.

[2X100%] Packaged Air Conditioning unit shall be provided for CHP Main control Room Building, Wagon Tipper Control Building and offices, Mini split units shall be provided for other small control rooms/ cabins of the CHP area. Complete air conditioning shall be consist of Supply air duct, return air duct, filters, insulations, electrical, C&I, support and structures, maintenance platform etc shall be provided.

Ventilation and Air Conditioning system shall be designed and installed conforming to "ASHRAE" or other relevant code.

Technical Data Sheet:

1	Air-conditioning system	For CHP control room, MCC room on S/R and operators cabin, S&T control room, Office room in MCR & S&T control room & PLC room of coal sampling units.
	Temperature to be maintained	24 ± 1 deg. C
	Humidity to be maintained	50 ± 5% relative humidity

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	Fresh Air intake	More than 1.5 air changes per hour
2	Filters	
i	Metallic Filters	
	Max. air velocity	2m/sec..
ii	HDPE filters	
	Efficiency	90% down to 5 microns
	Max. velocity	2.5 m/sec.
	Testing	As per BS 2831
iii	High Efficiency Filter	
	Efficiency	99.9% down to 5 microns
	Pr. drop across	10 mm W.C.
	Testing	As per BS 2831
Insulation for A/C Ducting Resin Bonded Mineral wool as per IS:8183		
i	Density	24 kg/cub.m
ii	Thermal conductivity	0.49 mw/cm deg.C

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5 QUALITY ASSURANCE, INSPECTION & TESTING

The Bidder shall adopt Quality Assurance Programmes as per relevant standards subject to Owner's approval, to ensure that the equipment and services under the scope of work, whether manufactured or performed within the Bidder's works or at his sub-vendor's premises or at the Owner's site or at any other place of work, are in accordance with the specifications. Such programmes shall be outlined by the Bidder and shall be finally accepted by the Owner after discussions before the award of the contract. The QA programme shall be generally in line with IS/ISO-9001. The Quality Assurance Programme of the Bidder shall generally cover the following:

- a) Organization structure for the management and implementation of the proposed Quality Assurance Programme.
- b) Quality System Manual.
- c) Design Control System.
- d) Documentation and Data Control System.
- e) Qualification data for Bidder's key personnel.
- f) The procedure for purchase of materials, parts, components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
- g) System for shop manufacturing and site erection controls including process, fabrication and assembly.
- h) Control of non-conforming items and system for corrective actions and resolution of deviations.
- i) Inspection and test procedure both for manufacture and field activities.
- j) Control of calibration and testing of measuring testing equipment.
- k) System for Quality Audits.
- l) System for identification and appraisal of inspection status.
- m) System for authorizing release of manufactured product to the Owner.
- n) System for handling, storage and delivery.
- o) System for maintenance of records, and
- p) Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

5.1 General Requirements - Quality Assurance

- a) All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the stages, as per a comprehensive Quality Assurance Programme. A programme

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of inspection/tests to be carried out by the Bidder for some of the major items is given in this technical specification. This is, however, not intended to form a comprehensive programme as it is the Bidder's responsibility to draw up and implement such programme duly approved by the Owner. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Bidder and will be submitted to Owner for approval.

- b) Manufacturing Quality Plan (MQP) will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Bidder's/ Sub-vendor's Quality Control Organization, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted to the Owner for review and approval. The format for MQP shall be submitted by the Bidder for the approval of the Owner before the award of Contract.
- c) Field Quality Plans (FQP) will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Bidder's "Site Quality Control Organization", during various stages of site activities starting from receipt of materials/equipment at site. The format for FQP shall be submitted by the Bidder for the approval of the Owner before the award of Contract.
- d) The Bidder indicate in the QP the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., These Quality Plans and reference documents/standards etc. will be subject to Owner's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Owner shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Owner or his authorized representative and beyond which the work will not proceed without consent of Owner in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to the Owner along with technical justification for approval and dispositioning.
- e) The material shall be dispatched from the manufacturer's works after the same is accepted by the Owner.
- f) All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature chart. Tests shall be carried out as per applicable material standards and/or agreed details.

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- g) All welding and brazing shall be carried out as per procedures drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Owner.
The welding/brazing procedures shall be followed as per Indian/International Standards.
- h) All brazers, welders and welding operators employed on any part of the contract either in Bidder's/sub-vendor works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Owner.
- i) Welding procedure qualification & Welder qualification shall be as per Indian/International Standards. However, where required by the Owner, tests shall be conducted in presence of Owner for the site erection. Any other statutory requirements for the equipment/systems shall be complied with.
- j) On all back-gauged welds MPI/LPI shall be carried before seal welding.
- k) Unless otherwise proven and specifically agreed with the Owner, welding of dissimilar materials and high alloy materials shall be carried out at shop only.
- l) No welding shall be carried out on cast iron components for fabrication or repair.
- m) All non-destructive examination shall be performed in accordance with written procedures as per International Standards but qualified operator. NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.
- n) All plates of thickness above 40 mm and all bars stock/Forging above 40 mm diameter shall be ultrasonically tested.
- o) The Bidder shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-vendors.
- p) For components/equipment procured by the Bidders for the purpose of the contract, after obtaining the written approval of the Owner, the Bidder's purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-vendor shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the vendor's quality control organization, the relevant reference documents/ standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful vendors shall be finalized with the Owner.
- q) If required, the Owner shall carry out quality audit and quality surveillance of the system and procedures of the Bidder's or their sub-vendor's quality management and control activities. The Bidder shall provide all necessary assistance to enable the Owner carry out such audit and surveillance. The

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- Bidder shall also take requisite corrective measures for restoring/ improving the system in line with the outcome of such quality surveillance and audits.
- r) The Bidder shall carry out an inspection and testing programme during manufacture in his work and that of his sub-vendor's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identity and acceptability of all materials, parts and equipment. Bidder shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.
 - s) Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Bidder in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.
 - t) For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.
 - u) Rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Owner.
 - v) In case any deviation is observed with respect to relevant document or good engineering practices, and the same is considered by the Bidder to be acceptable, as it is or with certain rectifications/ modifications, based on his detailed technical analysis, then the Bidder shall refer the same to Owner along with reason for deviation, proposed corrective action, technical justification for suitability of the proposal and preventive measures for avoiding recurrence of similar deviations. Based on his evaluation, the Owner may accept the proposal as it is or with modifications or may reject the same. Such proposals shall be raised in suitable Non-conformity report format (NCR). The NCR can be raised irrespective of the CHP stages in the QP.
 - w) Burn in and Elevated Temperature Test Requirement for Electronics Solid State Equipment:
 - x) All solid state electronic systems/equipment shall be tested as a complete system/equipment with all devices connected for a minimum of 168 hours (7 Days) continuously under energized conditions prior to shipment from manufacturing works, as per the following cycle.

Elevated Temperature Test Cycle

During the elevated temperature test which shall be for 48 hours of the total 168 hours of testing, the ambient temperature shall be maintained at 50 °C.

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The equipment shall be interconnected with devices which will cause it to repeatedly perform all operations it is expected to perform in actual service with load on various components being equal to those which will be experienced in actual service.

During the elevated temperature test the cubicle doors shall be closed (or shall be in the position same as they are supposed to be in the field) and inside temperature in the zone of highest heat dissipating components/modules shall be monitored. The temperature rise inside the cubicle should not exceed 10°C above the ambient temp at 50 °C.

Burn in Test Cycle

The 48 hours elevated temperature test shall be followed by 120 hours of burn in test as above except that the temperature shall be reduced to the ambient temperature prevalent at that time.

During the above tests, the process I/O and other load on the system shall be simulated by simulated inputs and in the case of control systems; the process which is to be controlled shall also be simulated. Testing of individual components or modules alone shall not be acceptable.

In case the Bidder/ sub-vendor is having any alternate established procedure of eliminating infant mortality of components, the detail procedures followed by the Bidder/ sub- vendor along with the statistical figures to validate the alternate procedure may be submitted to the Owner for his consideration.

The Bidder/Sub-vendor shall carry out routine test on 100% item at Bidder/sub-vendor's works. The quantum of check/test for routine and acceptance test by Owner shall be generally as per criteria/sampling plan defined in referred standards. Wherever standards have not been mentioned quantum of check/test for routine / acceptance test shall be as agreed during detailed engineering stage.

5.2 QA Documentation Package

The Bidder shall submit the QA Documentation in *[two hard copies and two CD ROMs]*, as identified in respective quality plan with tick (✓) mark.

Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Bidder/ sub-vendor and the same shall be submitted to the Owner in *[2 hard copies*

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and 2 CD-ROMs], within two weeks of dispatch of the equipment.

Typical contents of QA Documentation is as below:-

- a) Approved Quality Plan.
- b) Material mill test reports on components as specified by the specification and approved Quality Plans.
- c) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
- d) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
- e) Heat Treatment Certificate/Record, if applicable (Time- temperature Chart).
- f) All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).
- g) Inspection reports duly signed by the Inspector of the Owner and Bidder for the agreed Customer Hold Points.
- h) Certificate of Conformance (COC) wherever applicable.

Similarly, the Bidder shall be required to submit two sets [two hard copies and two CD ROMs], containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.

5.3 Inspection, Testing and Inspection Certificates

- a) The word 'Inspector' shall mean the Owner's Inspection engineer and/or agency acting on behalf of the Owner to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- b) The Owner's Inspection Engineer and/or agency acting on behalf of the Owner shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Bidder shall obtain for the Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, permission to inspect as if the works were manufactured or assembled on the Bidder's own premises or works.
- c) The Bidder shall give the Owner [fifteen (15)] days written notice of any material being ready for inspection/testing. Such tests shall be to the Bidder's account except for the expenses of the Inspector's. The Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within [fifteen (15)] days of the date on which the equipment is noticed as being ready for test/inspection

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failing which the Bidder may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the Owner duly certified copies of test reports in *[two (2) copies]* for his review and approval.

- d) The Owner's Inspection Engineer and/or Owner's inspection agency acting on behalf of the Owner shall within fifteen *[(15) days]* from the date of inspection as defined herein give notice in writing to the Bidder, on any objection to any drawings and all or any equipment and workmanship which is in his opinion is not in accordance with the contract. The Bidder shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Owner, giving reasons therein, that no modifications are necessary to comply with the contract. After due consideration, the Owner may accept or reject the same.
- e) When the factory tests have been completed satisfactorily at the Bidder's or sub-vendor's works, the Owner shall issue a certificate to this effect within *[fifteen (15) days]* of completion of tests. The completion of these tests or the issue of the certificates shall not bind the Owner to accept the equipment should it, on further tests after erection be found not to comply with the contract.
- f) In all cases where the contract provides for tests whether at the premises or works of the Bidder or any sub-vendor, the Bidder, except where otherwise specified, shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Owner, to carry out effectively such tests on the equipment in accordance with the Contract and shall provide the facilities to accomplish testing.
- g) The inspection by the Owner's Inspection Engineer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Bidder in respect of the contract.
- h) To facilitate advance planning of inspection in addition to giving inspection notice, the Bidder shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.
- i) All inspection, measuring and test equipment used by Bidder shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Bidder shall maintain all the relevant records of periodic calibration and instrument identification. Wherever asked

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specifically, the Bidder shall re-calibrate the measuring/test equipment in the presence of Owner's Inspection Engineer agency.

5.4 Shop and Site Tests

- a) Shop tests will include all tests to be carried out at Bidder's works, at works of his sub-vendor and at works where raw material supplied for manufacture of equipment is manufactured.
- b) All materials will be of tested quality supported with correlated test certificates.
- c) Shop and Site tests will include electrical, mechanical, performance and hydraulic tests in accordance with relevant IS or any other approved standard or any other tests called for by the Owner under these specifications to ensure that the plant being supplied fulfills the requirements of the specifications. For equipment not covered by any IS or other approved standards, the tests to be carried out will be in accordance with the quality plan to be agreed to between the Bidder and the Owner.

5.5 Site Tests

The successful Bidder will prepare and submit detailed quality plans in the format prescribed by Owner setting out the quality practice and procedures to be adopted by him for assuring quality for each equipment under this specification from the receipt of material at site, during storage, erection, pre-commissioning to final commissioning of the plant. These procedures will necessarily include all checks/tests conducted at site for preservation, assembly, alignment, positioning of the equipment, foundation preparation, welding/bolting, heat treatment, non-destructive examination, hydraulic test, running test, performance test etc. The above will be discussed and finalized by the Bidder with the Owner.

The Bidder will also furnish detailed quality procedure proposed by him for storage, preservation, painting, acid cleaning, alkali boil out, steam blowing, hydraulic test, air/gas tightness test etc. to the Owner. The same will be discussed and finalized by the Bidder with the Owner.

5.6 System Checking / Reliability Trials:

- a) Successful Bidder will carry out tests at site to prove to the Owner that each equipment of the supply complies with requirements stipulated and is erected in accordance with requirements specified. Before the plant is put into trial operation the Successful Bidder will be required to conduct tests to demonstrate to the Owner that each item of the plant is capable of correctly performing the functions for which it was specified and its performance, parameters etc. are as per the specified/approved values. These tests may be conducted concurrently with those required under commissioning sequence.

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5.7 Indicative checks

The details of the tests to be carried out in the various equipments are to be submitted by the Bidder for Owners approval as mentioned above. However, some indicative checks on different items are given below which should necessarily form a part of the Quality Assurance Programme to be agreed with by the Owner.

a) Pumps

- All materials should be of tested quality and test certificates to be provided. Shaft forgings to be also subjected to ultrasonic testing and hardness checks. Impellers to be dynamically balanced.
- All pumps to be performance tested as per Hydraulic Institute Standard or relevant Indian Standard. Performance test to include check for noise, vibration level and temperature rise.

b) Valves Pipes & Fittings

- Leakage & hydraulic test to be carried out as per relevant code.

c) Fan

- Dynamic balancing of the fan impellers shall be carried out.
- Shop run test shall be conducted on all centrifugal fans including check for noise and vibration level.
- Performance test shall be conducted on one fan of each type at shop for capacity, pressure, efficiency and power consumption.

d) Travelling Tripper and Bunker Sealing

- Shaft and wheel forgings- Chemical, Mechanical and ultrasonic test shall be conducted.
- Shop running test shall be carried out and shall include check for noise and vibration level.

e) Idlers

- Check for run out and free movement shall be carried out on idlers. Run out shall be restricted as per IS:8598.
- Test for dust proofness and water proofness of the Idlers shall be conducted at shop. The detailed procedures for the same shall be submitted for review and approval.
- Check for dynamic friction factor for idlers shall be also conducted. Procedure for the same shall be submitted.

f) Belting

- Rubber cover shall be checked for tensile strength and elongation at break

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before and after aging.

- For finished belts, checks for elongation at 10% nominal tensile strength, tensile and elongation at break in longitudinal (warp) direction, tensile and elongation at break in transverse (weft) direction shall be carried out.
- Adhesion test between individual plies and cover and plies shall be carried out.
- Test for fire resistance of the belt shall be conducted.
- Test for procedure qualification for belt vulcanizing joint shall be done at either shop or site (before erection). Procedure for belt vulcanizing joint shall be discussed and finalised during QP finalisation.
- There will be a limitation on the no. of repairs allowed on the belts, Following will be the acceptance norm for the cover repairs.
- The maximum size of a repair shall be limited to a size equivalent to one fifth the belt width.
- The maximum number of patch repairs shall not exceed 5 per 100 mts. However, the total number of patch and dough filling repairs shall not exceed 10 per 100 meters.
- Small local repair of size 25 mm x 25 mm to a limited extent shall not be counted of repairs. However, in case of cluster of repairs, it shall be counted as a patch repair.
- In no case shall the cover thickness or the width of belt be less than that given in specification. No negative tolerances will be allowed in the same.
- Rubber cover shall also be checked for abrasion, tear strength and hardness.

g) Belt Vulcanising Machine

- Check for tensile strength shall be carried out on a sample vulcanised belt joint for each type of belt.

h) Pulleys

- In addition to Chemical & Mechanical properties, pulleys shaft forging shall be subjected to ultrasonic testing to ensure internal soundness.
- 100% MPI on welds shall be conducted and 10% RT/UT on butt welds shall be conducted.
- Static balancing of pulleys shall be carried out after rubber lagging.
- Checks on rubber lagging to include abrasion loss, shore hardness test, peel-off strength test and physical properties peel - off strength shall be 10 kg/ Cm, Abrasion loss shall be less than 250 cubic. mm when tested as per DIN 53516.

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i) Pull chord & Belt Sway Switches

- Endurance test for mechanical and electrical durability.
- Degree of protection test.
- HV & IR test
- Acceptance tests
- All tests as per IS 13947 (Part 4 Sec 1) shall be carried out on the switches.
- Over all dimension and functional test shall be carried out.

j) Zero speed switch & under belt switch

- Endurance test for mechanical and electrical reliability.
- Degree of protection test
- The following environmental tests as per IS : 9000
Dry test, Damp heat cycle test, Vibration test, Bump test, Temp. humidity cycle test (for electronic components).
- Burn in test at 50 Deg. C for 48 hours shall be done.
- Acceptance test.

k) Paddle Feeders

- Shaft and wheel forgings - Chemical, Mechanical, Hardness and Ultrasonic Test shall be conducted.
- Shop trial run to be conducted and performance test shall include checks for noise and vibration level.

l) Vibrating Grizzly Feeders

- Shop trial run test shall be conducted and the same shall include all checks for amplitude, frequency, temperature rise and noise level.

m) VMS and Crusher

- All plates above 20 mm thickness to be ultrasonically tested for laminations.
- Shaft forgings and suspension bars to be checked for hardness, microstructure and ultrasonic testing in addition to check for chemical and mechanical properties.
- Following minimum NDT requirements to be ensured for welds:
Butt welds - 10% UT/RT and 100% MPI.
Fillet welds - 10% MPI.
- Crusher rotor to be statically and dynamically balanced. Procedure to be submitted for approval.
- No-load trial run test to be carried out at shop and to include check for

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temperature rise, noise and vibration levels.

n) In Line Magnetic Separators

- Tests to demonstrate maximum & minimum separation capacity, gauss strength, guaranteed power consumption.
- Test at works and site for flux density at face of magnet.
- Test at site for strength at the face of conveyor around the magnet.
- Checking at site the capacity of the magnetic separator to separate specified items. Buried at different depths below the coal heap.
- Test for current drawn by the magnet after 4 hours of operation.
- Dimensional, visual check alongwith control panel.
- Operation, temperature rise, lifting capacity, force index and gauss strength.
- HV & IR.

o) Metal Detector

- Test for minimum size of metal to be detected.
- Correct marking of metal piece.
- Environment tests like - Dry heat, Damp heat cycle test, Vibration test, Bump test, Temperatures humidity and cycle test.

p) Coal Sampling

- Free carriage & cutter movement, speed of cutter and dust door closing & sealing shall be tested for samplers.
- "No load test" shall be carried out for crushers
- Final testing of brakes shall include load, HV/IR & heat run tests.

q) Rack & Pinion Gates/Flap Gates

- MPI/DP Test shall be conducted on rack and pinion.
- Functional checks on the gates shall be carried out.
- Actuator Output Thrust
- Travel
- Safety Features
- Manual Operation

r) Gear Boxes

- In addition to physical and chemical properties checks, the shaft and gear forgings shall be subjected to ultrasonic testing and hardness test.
- MPI to be carried out on Gears after heat treatment to ensure freedom from defects.

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- No Load shop trial run to be conducted on gear boxes which should include check for temperature rise, noise and vibration level.

s) Flexible Coupling

- Ultrasonic testing shall be conducted on forgings for gear sleeve and gear hub, if gear coupling is provided.
- MPI shall be carried out after heat treatment to ensure freedom from cracks.
- Final inspection of geared coupling shall include check for angular misalignment capacity and interchangeability.

t) Fluid Coupling

- Dynamic balancing shall be carried out for the rotating parts. Check for leak tightness of the coupling shall be carried out.
- Functional test on fusible plug for each type of coupling shall be conducted at shop. All couplings to be run tested at shop on no load.
- Check for temperature rise, torque-speed, torque-slip characteristics and over speed test shall be included during full load performance test of one coupling of each type preferably at full load.

u) Belt Scales

- Dimensional check shall be carried out on the Belt Scales.
- Belt scale shall be calibrated with test weight/test chain in static and with test weight for dynamic condition.
- All electronic modules shall be subjected to burn in test as per sub-section QE.
- General check for load cell shall be carried out.
- Type test shall be carried on load cells.
- Enclosure test shall be carried out to check degree of protection.
- Accuracy/performance check shall be demonstrated.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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* * * * *

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**VOLUME-II,
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION- ELECTRICAL**

**RENOVATION & MODERNISATION
OF
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1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of Coal Handling Plant complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 List of Attachments

The following List of attachments is enclosed along with this specification.

[Note: List of attachments is depends on specific project scope of work. R & M consultant may attach the attachments as per project specific scope of work. For reference all attachments are considered in this package as per scope of work considered]

Legend: O: USE, X: NOT USE

Sl.No	Attachment Number	Description	Rev No	Application
1	E1	Motor	R1	O
2	E2	Motorized Actuators	R1	O
3	E3	LV Transformers(Dry type/Oil type)	R1	O
4	E4	415V Switchgear, MCC and DBs	R1	O
5	E5	415V Non Segregated Bus Duct	R1	O
6	E6	220V DC system	R1	O
7	E7	HV Cables	R1	O
8	E8	LV Cables	R1	O
9	E9	Illumination system	R1	O
10	E10	Cable Carrier System	R1	O
11	E11	Earthing and Lightning Protection system	R1	O

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

12	E12	6.6kV Switchgear	R1	O
13	E13	Variable Frequency Drives	R1	O

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**RENOVATION & MODERNISATION
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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E1
TECHNICAL SPECIFICATION FOR MOTORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E1

1.0 MOTOR

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Electric Motor complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS : 325	:	Specification for three phase induction motor.
IS : 900	:	Code of Practice for installation and maintenance of induction motors
IS : 996	:	Single phase AC motors
IS : 1231	:	Dimensions of three-phase foot-mounted induction motors
IS : 1271	:	Thermal evaluation and classification of electrical insulation.
IS : 2223	:	Dimensions of flange mounted ac induction motors.
IS : 2254	:	Dimensions of vertical shaft motors for pumps
IS : 3177	:	Crane duty motors
IS : 4029	:	Guide for testing three phase induction motors.
IS : 4691	:	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	:	Specification for rotating electrical machinery.

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IS : 4728	:	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	:	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	:	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	:	Designation of Method of Cooling of Rotating electrical machines.
IS : 8223	:	Dimensions and output ratings for foot mounted rotating electrical machines with frame numbers 355 to 1000.
IS : 8789	:	Values of performance characteristics for three phase induction motors.
IS : 12065	:	Noise level of motors.
IS : 12075	:	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	:	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	:	Temperature rise measurement of rotating electrical machines
IS : 12824	:	Type of duty and classes of rating assigned.
IS : 14222	:	Requirements and method of Impulse withstand test
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IEC: 60034	:	Rotating electrical machines.
NEMA, MG-1	:	Motors and Generators
ISO : 1940-1	:	Mechanical vibration – Determination of permissible residual unbalance

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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All motors shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment.
- b. AC Motors shall be of [constant speed, squirrel cage, three/ single phase, induction type.] Motors shall be rated for [continuous duty/intermittent duty]. They shall also be suitable for long period of inactivity. They shall also be suitable for direct online starting (DOL starting).
- c. DC motors provided for emergency service shall be shunt / compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.
- d. Power supply for AC motors shall be as follows:

Table: 2.0

1.	[Below 0.22 kW]	:	240V, 1 Phase, 50Hz
2.	[From 0.22 kW up to & including 160 kW]	:	415V, 3 Phase, 50Hz
3.	[Above 160 kW]	:	6.6kV, 3 Phase, 50Hz

- e. All AC motors shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- f. DC motors shall be rated for 220V DC supply with voltage variation of -15% to +10%.
- g. The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, break down and full load torques are available for the intended service.

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- h. Moreover, motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
- i. Motors shall be capable of developing the rated full load torque even if the supply drops to 70% of the rated voltage.
- j. For 6.6kV motors, locked rotor current not to exceed [600%] of full load current, including positive tolerance, except for BFP. For BFP the starting current shall be [450%] of FLC. For 415 V motors Locked rotor current not to exceed [600%] of full load current with IS tolerance.]
- k. For DC motors, the starters shall be provided to limit the starting current to [2] times of the full load current.
- l. Maximum continuous motor ratings shall be at least [10%] above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.
- m. Accelerating torque at any speed with the lowest permissible starting voltage shall be at least [10%] motor full load torque. Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.
- n. The motors shall be suitable for bus transfer schemes provided on the 6.6kV and 415V systems without any injurious effect on its life. If motors are connected to an automatic bus transfer system, they may be subjected to 150% of the nominal voltage during changeover of buses due to the phase difference between the incoming voltage and motor residual voltage. In such cases, motors shall be capable of restarting under full load after momentary loss of voltage.
- o. Motors shall be of [energy efficient of type Eff-2] as per IS: 12615/equivalent IEC/ International Standards.
- p. Motor shall be designed to keep torsional and rotational natural frequencies of vibration of the motor and driven equipment at least 25% above the motor operating speed range.

1.3.1 System Grounding

Table: 3.0

(a)	6.6 kV	:	Low Resistance Grounded to limit the earth fault current to [300 Amps]
(b)	415 V	:	Solidly Grounded
(c)	220V DC	:	Ungrounded

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1.3.2 Fault Level

Table: 4.0

(a)	6.6 kV	:	[40 kA for 1 second]
(b)	415 V	:	[50 kA for 1 second]
(c)	220V DC	:	[25 kA for 1 second]

1.3.3 Degree of Protection

Table: 5.0

(a)	Indoor Motors	:	[IP 54]
(b)	Outdoor Motors	:	[IPW 55]
(c)	Cable Box located in Indoor Area	:	[IP 54]
(d)	Cable Box located in Outdoor Area	:	[IPW 55]

1.3.4 Winding Insulation

Table: 6.0

(a)	For 6.6 kV AC Motors	:	[Class – F]
(b)	For 415V AC Motors	:	[Class – B]
(c)	For 220V DC Motors	:	[Class – B]

1.3.5 Winding Conductor Material

Table: 7.0

(a)	For 6.6 kV AC Motors	:	Copper
(b)	For 415V AC Motors	:	Copper
(c)	For 220V DC Motors	:	Copper

1.3.6 Bearing

Table: 8.0

(a)	For Drive End	:	[Roller]
(b)	For Non Drive End	:	[Roller / Ball]

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1.3.7 Temperature Rise

Table: 9.0

(a)	For Air Cooled Motors	:	[70 °C] over ambient temperature [Class B]
(b)	For Water Cooled Motors	:	[80 °C] over inlet cooling water temperature [Class B]

1.3.8 Motor Earthing

Table: 10.0

(a)	Motors above 90 kW	:	[50 x 6 mm GI Flat]
(b)	Motors above 30 kW and up to 90 kW	:	[25 x 6 mm GI Flat]
(c)	Motors above 5 kW and up to 30 kW	:	[25 x 3 mm GI Flat]
(d)	Motors up to 5 kW	:	[8 SWG GI Wire]
(e)	Terminal Box	:	[8 SWG GI Wire]

1.3.9 Space Heater

Table: 11

(a)	For Motors 30 kW rating and above	:	Space heater suitable for 1Phase, 240V AC, 50 Hz supply
(b)	For Motors below 30 kW rating	:	No Space heater provided.

1.3.10 Painting

Table: 12

a)	Paint Type	:	Epoxy based with approved class
b)	Paint Thickness	:	[Within 100 to 150 micron.]
c)	Paint Shade	:	[RAL5012 BLUE]

1.4 Specific Requirements

1.4.1 Locked Rotor Withstand Time

- The starting time of the motor shall be at the minimum permissible voltage.
- For motors with starting time up to 20 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot

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condition at highest voltage limit shall be at least 2.5 second more than starting time.

- c) For motors with starting time more than 20 second and up to 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 second more than starting time.
- d) For motors with starting time more than 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- e) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.

1.4.2 Starting Voltage Requirement

I.	All motors (except mill motors):
a)	[85% of rated voltage for motors up to 4000 kW]
b)	[75% of voltage for motors above 4000 kW]

II.	For mill motors:
a)	[85% of rated voltage for motors above 1000 kW]
b)	[90% of rated voltage for motors below 1000 kW]

The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at [125%] rated speed in reverse direction.

The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

1.4.3 Winding and Insulation

a)	6.6 kV AC motors	:	Winding material shall be of copper. Insulation shall be of [Class F with winding temperature rise limited to Class B]. They shall withstand 1.2/50 microsecond switching surges of "4U + 5 KV" (U = Line voltage in KV). The coil inter-turn insulation shall be suitable for 0.3/3 micro second surge of 32 / 12 KV followed by 1 min
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			power frequency high voltage test of appropriate voltage on inter turn insulation.
b)	415V AC & 220V DC motors	:	Winding material shall be of copper. Insulation shall be of [Class B with temperature rise limited to Class B.]
c)	Conveyor motors		Short circuit rings of conveyor motors shall be either joint less or welded type. Brazed joint is not acceptable.

1.4.4 Motor Control

a) For HV Motors

- i. Motors of rating above [160 kW] shall be suitable for 6.6 KV voltage
- ii. Frequent starting motors of rating above [160 kW] shall be suitable to be controlled by vacuum contactors

(b) For LV Motors

- i. Motors of rating less than [132 kW] shall be operated by Contactor from respective MCCs. Motors of rating up to [18.5 kW] shall be provided with MPCBs and Electronic overload relays. Motors of rating above [18.5 kW] and below [45 kW] shall be provided with MCCBs and Electronic overload relays. Motors of rating [45 kW] and above but less than [132 kW] shall be provided with MCCBs and CT operated Electronic over load relays.
- ii. Motors of rating [132 kW] and up to [160 kW] shall be suitable to be controlled by Air circuit breakers from switchgear, PMCCs and shall be provided with comprehensive numerical motor protection relays.
- iii. Only for firefighting system, motor rated [upto 200kW] shall be fed from 415V switch board.

1.4.5 Starting duty

Motors shall be suitable for [3 nos. consecutive Cold starts ups and 2 nos. consecutive Hot starts ups.] Motors shall be suitable for three equally spread starts per hour when the motor is under normal service condition.

1.4.6 Bearings

- a) Anti-friction type radial and thrust bearings (ball, roller) and sleeve bearing shall be rated for minimum standard life of 40,000 hours taking bearing and driven equipment loads (in case the drive is not having

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separate thrust bearing) into account. If bearings are lubricated, loss of grease shall be scarce and it shall not creep along shaft into motor housing. Facility of removal of excess grease shall also be provided for grease lubricated bearings.

- b) Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if Anti-friction bearings can take vertical thrust, thrust & guide bearings are not required.
- c) Bearing shall be effectively sealed against dust ingress and shall be pressure grease gun lubricated. The bearing and housing shall be so designed that greasing shall be possible while the motor is running, without removal of covers.
- d) Where bearing supports are attached to the motor casing, adequate bracing shall be provided on these supports to reduce vibrations and ensure life of bearings.
- e) If the bearings are oil lubricated, a drain plug shall be provided for draining residual oil and oil level gauge shall be provided to show precisely oil level required under standstill and running conditions.
- f) Unless otherwise approved, bearing lubricating system shall be such that no external forced oil or water is necessary to maintain required oil supply to keep bearing temperature within design limits.
- g) Lubricants shall be selected for prolonged storage and normal use of motors in tropical climate and shall contain corrosion and oxidation inhibitors. Greases shall have suitable bleeding characteristics to minimize setting. The selected lubricants shall be indigenously available.
- h) Motors rated above 1000 kW shall have insulated bearings to prevent flow of shaft currents.

1.4.7 Temperature Rise

- a) For Air Cooled Motors, temperature rise of insulation should be limited to [70 °C] over ambient temperature by resistance method.
- b) For Water Cooled Motors, temperature rise of insulation should be limited to [80 °C] over inlet cooling water temperature mentioned elsewhere, by resistance method.

1.4.8 Cooling

[All motors shall be either Totally Enclosed Fan Cooled (TEFC) or Totally Enclosed Tube Ventilated (TETV) or Closed Air Circuit Air Cooled (CACA) type. However, motors rated 3000 kW or above can be Closed Air Circuit Water Cooled (CACW)]

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1.4.9 Enclosure

- a) All motor enclosures shall conform to the degree of protection of [IP54] for indoor and IPW-55 for outdoor installation unless otherwise specified. Motor for outdoor or semi outdoor service shall be of weather proof construction. Motors of large output rating located indoor could have screen protected drip proof (SPDP) enclosure conforming to [IP-23.]
- b) For motors located in outdoor & corrosive locations, FRP canopy shall be provided. In case steel canopy is provided, the same shall be epoxy painted to meet the surrounding atmosphere. Motors located in hazardous areas such as Hydrogen plant shall have flame proof enclosures of Group – IIB conforming to IS: 2148.
- c) For hazardous locations such as fuel oil facilities area, the enclosure of motor shall have flame proof construction conforming to IS 2148.

1.4.10 Noise Level and Vibration

Noise level shall be limited to 85 dB (A) at 1.5 meters from the motor. However the same shall be as per IS: 12065 unless otherwise specified. The peak amplitude of vibration shall be within the specified limits laid down in IS: 12075. Motors shall withstand vibrations produced by driven equipment. HV motor bearing housings shall have flats in both X and Y directions suitable for mounting 80mmX80mm vibration pads. Vibration pads with screwed holes for mounting vibration probes shall be provided at both DE and NDE.

1.4.11 Temperature Monitoring

[In HV motors, at least four numbers simplex/ two numbers duplex platinum resistance type temperature detectors shall be provided for each phase of stator winding]. Each bearing shall be provided with dial type thermometer with adjustable alarm contact and two numbers duplex Platinum resistance type temperature detector (3 wire, 100 ohm at zero °C). In case of CACA and CACW motors dial type temperature indicator shall be provided (one each for hot and cold air temperature monitoring for CACA and CACW and one each for inlet and outlet water temperature monitoring for CACW). If alarm and trip are required for cooling air temperature, temperature switch shall be provided. The contact rating shall be minimum 0.5A at 220V DC and 5A at 240V AC. Flow switches shall be provided for monitoring cooling water flow of CACW motor and oil flow of forced lubrication bearing. Low voltage motors rated 100 kW and above shall be provided with two PT100 RTDs per phase of winding.

1.4.12 Earthing

Motor body shall have two earthing points on opposite sides. Motor terminal boxes shall also have separate grounding terminals.

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1.4.13 Termination

- a) HV motors can be offered with either Elastimold termination or dust tight phase segregated double walled (metallic as well as with insulated barrier) cable boxes. In case Elastimold terminations are offered, then protective cover and trifurcating sleeves shall also be provided. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided in case of cable boxes. The main cable box / terminal box shall withstand *[a fault current up to 40 kA for 0.25 seconds for HV motors and 50 kA for 0.25 seconds for LV motors]*. Separate terminal boxes shall be provided for space heaters and RTDs and NCT (if applicable).
- b) *[All terminal boxes shall be capable of being turned through 360 degrees in steps of 90 degrees unless otherwise specified.]*
- c) For HV motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

1.4.14 Differential Protection

For motors rated 6.6kV, *[2000 KW & above,]* neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box for differential protection.

1.4.15 Tropical Protection

- (a) All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- (b) All fittings and hardware shall be corrosion resistant.
- (c) Space Heater
- (d) Suitable single phase space heaters operated at 240V, 50Hz, 1Phase AC supply shall be provided on motors rated for 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided.
- (e) The space heater shall be sized to maintain the motor internal temperature above dew point when the motor is in idle condition.

1.4.16 Rating Plate

Motor shall have Stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / NEMA-MG-1 and following additional information:

- (a) Type of bearing and recommended lubricants along with location of insulated bearing.
- (b) Temperature rise under normal/abnormal conditions.

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(c) In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.

(d) Year of Manufacture

1.4.17 Drain Plug

Motor shall have drain plugs so located that they shall drain the water, resulting from the condensation or other causes from all pockets of the motor casing.

1.4.18 Dowel Pins

Motor shall be designed to permit easy access for drilling holes through motor feet or mounting flange for installation of dowel pins after assembling the motor and driven equipment.

1.4.19 Painting

The complete motor assembly including fan shall be painted with corrosion proof paints of approved class.

1.4.20 Lifting provision

Motor weighing 25 Kg or more shall be provided with eyebolt or other adequate provision of lifting.

1.4.21 Local Push Button Station (LPBS)

- a) Each motor shall be provided with push button station as per process requirement i.e. Start/Stop or Emergency Stop.
- b) The degree of protection of LPBs shall be IPW 55 for outdoor and IP 54 for indoor applications.
- c) All Push Buttons shall be push to actuate type and stop Push Button shall be lockable in off position as per the scheme requirement.
- d) The Emergency local stop push button of Stay put type shall be provided with Press to lock & turn to release keyless mechanism.
- e) All PBs shall be provided with 2 numbers NO and 2 numbers NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to switchgear module for direct tripping and another contact to control system.
- f) Terminals to be suitable for 2 cores of 2.5 Sq.mm. cable with 20% spare terminals.
- g) All LPBS shall be of Poly Carbonate /FRP / Die Cast Aluminium material.

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I) TestsType Test

For each type & rating of HV and LV motors of rating above [50 kW], the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last[five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- (a) Visual and dimensional check
- (b) Winding resistance measurement
- (c) No load test
- (d) Mechanical vibration
- (e) Direction of rotation versus phase sequence
- (f) Insulation resistance measurement
- (g) High potential test
- (h) Locked rotor test
- (i) Speed/torque test
- (j) Over speed test
- (k) Temperature rise test
- (l) Determination of characteristic
- (m) Degree of protection test for the enclosure.
- (n) Noise level
- (o) Shaft current and bearing insulation test (Applicable for HV motors)

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

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IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.5 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

Dimensional General Arrangement drawing

- a) [Motor sizing calculation
- b) Foundation Plan & Loading
- c) Cable end box details
- d) Space requirement for rotor removal
- e) Thermal withstand curves hot & cold
- f) Starting and speed torque characteristics at 80% & 100% voltage
- g) Complete motor data
- h) Erection & Maintenance Manual
- i) Test reports
- j) QAP]

1.6 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	Technical Particulars	Unit	Parameters	Remarks
1	Motor application		[As per requirement]	
2	Rated Output, kW	kW	[As per requirement]	
3	Maximum continuous kW obtainable without exceeding specified temperature rise	kW	[By Bidder]	
4	Motor type		Squirrel cage induction motor	
5	Duty Cycle (IEC 60034-1)		[S1]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
6	Rated voltage	kV	6.6 kV for HV motors 415 V for LV motors 220V DC for DC motors	
7	Phase/frequency	Hz	50	
8	Allowable variation in supply conditions			
a)	Voltage		6.6 kV	
b)	Frequency		50	
c)	Combined			
9	Method of starting		DOL	
10	CT details for differential protection	Yes/No	For motors of rating > 2000kW	
11	Full load amperes	A	[By Bidder]	
12	Locked rotor current amperes	A	HV(Except BFP): 6 times without tolerance BFP: 4.5 times without tolerance LV: 6 times with IS specified tolerance DC : 2 times with no positive tolerance at rated terminal voltage.	
13	Method of Cooling (IC code)		[As per requirement]	
14	Enclosure (IP Code)		Indoor : IP54 Outdoor : IPW55	
15	Construction (horizontal or vertical)		[As per requirement]	
16	Max. temperature, by resistance method	Deg C	120 deg (Class B)	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
17	Insulation class		HV: Class F LV: Class B	
18	Motor insulation system (describe material used)		[By Bidder]	
19	Bearings		[By Bidder]	
a)	Type			
b)	Quantity			
c)	Lubrication system pressure and flow			
20	Temperature detector (type & quantity)			
a)	Winding		[As per requirement]	
b)	Bearing		[As per requirement]	
21	Space heaters		30 kW and above	
a	Watts (Rating/Operating)	W	[By Bidder]	
b	Volts (Rating/Operating)	V	[By Bidder]	
22	GD ² of motor		[By Bidder]	
23	Power factor		[By Bidder]	
a)	Full load	p.u		
b)	3/4 load	p.u		
c)	1/2 load	p.u		
d)	No load	p.u		
24	Efficiency		[By Bidder]	
a)	Full load	%		
b)	3/4 load	%		
c)	1/2 load	%		
25	Impedance data		[By Bidder]	
a)	locked rotor reactance per phase	Ohm		
b)	Rotor resistance per phase	Ohm		

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S. No.	Technical Particulars	Unit	Parameters	Remarks
c)	stator resistance per phase	Ohm		
26	Net motor weight	Kg	[By Bidder]	
27	Terminal box dimensions H/W/D	Mm	[By Bidder]	
28	Rotor removal clearance	mm	[By Bidder]	
29	Winding connection (star or delta)		HV: Star LV: Delta	
30	Noise Level	dB(A)	[As per requirement]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E2
TECHNICAL SPECIFICATION FOR MOTORIZED
ACTUATORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E2

1.0 MOTORIZED ACTUATORS

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Motor Operated Actuator complete with all accessories for efficient and trouble-free operation of valves, dampers and gates for R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS : 325	Specification for three phase induction motor.
IS : 900	Code of Practice for installation and maintenance of induction motors
IS : 996	Single phase AC motors
IS : 1271	Thermal evaluation and classification of electrical insulation.
IS : 2223	Dimensions of flange mounted ac induction motors.
IS : 4029	Guide for testing three phase induction motors.
IS : 4691	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	Specification for rotating electrical machinery.
IS : 4728	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	Designation of Method of Cooling of Rotating electrical machines.

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IS : 8789	Values of performance characteristics for three phase induction motors.
IS : 9334	Electrical Motor Operated Actuators.
IS : 12065	Noise level of motors.
IS : 12075	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	Temperature rise measurement of rotating electrical machines
IS : 12824	Type of duty and classes of rating assigned.
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package
IEC: 60034-1	Rotating electrical machines.
NEMA, MG-1	Motors and Generators

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All motor operated actuators shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.
- Depending on the required type of services, the rating of motor operated actuators shall be selected. For isolating service, the actuator shall be [rated for three successive open-close operations of the valve/ damper or 15 minutes continuous operation whichever is higher.] Whereas for regulating service, the actuator shall be suitably [time rated for required number of duty cycle or 150 start per hour whichever is higher].
- The actuator shall be accompanied with constant speed, squirrel cage, three/ single phase, induction motor. The motor shall be designed for high

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torque and reversing service. They shall also be suitable for direct online starting (DOL starting).

- d. Motors of actuators shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- e. The motor operated actuator shall be sized for performing open / close operation at rated speed against designed differential pressure at [90%] of rated voltage. The motor shall have [10%] design margin on the shaft design power.

The actuator shall meet the following performance requirements:

- i. Open & Close the valve completely and make leak tight valve closure without jamming.
- ii. Attain full speed of operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- iii. The motor reduction gearing shall be sufficient to lock the shaft when the motor gets de energized and prevent drift from torque switch spring pressure.
- iv. The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.
- v. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

1.4 Specific Requirements

1.4.1 Construction

- a) The actuator shall essentially comprise of drive motor, limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, space heater and internal wiring.
- b) The actuator enclosure shall be totally enclosed, dust tight, weather proof with [IPW 55] degree of protection.
- c) All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

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d) Gear train shall be made of metal (fiber gears are not acceptable). Self locking feature shall be provided to prevent drift under torque switch (wherever applicable) spring pressure when motor is de energized.

e) Manual wheel shall disengage automatically during motor operation.

1.4.2 Type

a) The actuators shall have integral starters along with overload relays with built-in single phase preventer.

b) A 415 V, 3 phase, 3 wire, 50 Hz power supply will be provided from power plant 415 V switchgear through MCCB. Control voltage of the starter circuit shall be 110 V AC or depending on manufacturer's practice. But the same shall be derived from incoming 415 V, 3 phase, 3 wire supply.

1.4.3 Motors

a) Type: The drive motor shall be three phase, squirrel cage induction motor suitable for direct on line starting with starting current limited to six times the rated current

b) Enclosure: The motor shall be totally enclosed, self ventilated with [IPW 65] degree of protection.

c) Insulation: The motor winding shall be insulated with [Class – B] insulation having temperature rise limited to [Class – B].

d) Bearing: The motor bearing shall be [double shielded, grease lubricated and antifriction type].

e) Earthing: At least two earthing terminals shall be provided for the motor body. Separate earthing terminal should be provided for terminal box.

f) Protection: The following electrical protections should be provided for the motor:

- i. Single Phasing Protection
- ii. Overload Protection
- iii. Overheating Protection through thermostat
- iv. Wrong Phase Sequence Protection

g) Limit Switches: Each actuator shall be accompanied with following switches:

- i. Four nos. positional limit switches (2 for open & 2 for close), each adjustable at any position from fully open to fully closed positions of the valve / damper.
- ii. Two torque limit switches, one for each direction of travel, self blocking & adjustable torque type.

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- iii. Four nos. end travel limit switches, two for each direction of travel.
 - iv. A single shaft shall actuate all contacts of limit switches at each position.
- h) Interface: Open/close command termination logic with position and torque limit switches, positioned circuit shall be suitably built in the PCB inside the actuator.
 - i. For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided. Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the DCS shall be energized to initiate opening and closing, by 24V DC signal from the external control system. Potential free contact provided by the IPR shall be utilized in the control circuit of the contactor of motorized actuators.
 - ii. For modulating drive, the command to actuator shall be in form of 4- 20mA signal. The necessary positioning circuit and motor protection shall be provided.
 - iii. Open/close command termination logic shall be suitably built inside actuator.
- i) Hand Wheel: Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall disengage automatically when the motor is energized.
- j) Position Indicator / Transmitter: The actuator shall have
 - i. One built in local position indicator for 0 – 100% travel.
 - ii. One position transmitter of modulating / inching type for remote indication suitable to stabilize 4-20mA signal and operated with [24V DC].
- k) Space Heater: Space heater of suitable rating shall be provided. The power supply shall be derived from main power supply available in the actuator.

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- l) Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be done with [2.5 sqmm] copper wires. All wiring shall be well identified at both ends with ferrules.
- m) Terminal Box:
- i. The terminal box shall be weather proof with removable front cover and cable glands suitable for cable connection. The terminals shall be suitable for connection of [2.5 sq.mm copper] conductor.
 - ii. Necessary double compression cable glands with nickel coating and tinned copper lugs for cables shall be provided.
 - iii. The terminal block shall be suitable for 650V grade power cable.
- .
- n) Rating Plate : Motor and actuator shall have Stainless steel nameplate(s) showing all particulars as per relevant IS/ IEC and following additional information:
- i. Type of bearing and recommended lubricants.
 - ii. Temperature rise under normal/abnormal conditions.
 - iii. Degree of Protection
 - iv. In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.
 - v. Year of Manufacture

1.5 Tests

The actuator and all components thereof shall be subject to routine factory tests as per relevant IS standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

1.5.1 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum [7] days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc.]

1.5.2 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished with requisite no. of copies for approval of the Owner.

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- b) The equipment shall be dispatched from works only after receipt of owner's written approval of shop test reports.

1.6 Drawings Data and Manuals

The drawings, data & manuals for the motorized actuators shall be submitted as indicated below:

1. [Actuator Data Sheet]
2. General arrangement drawing
3. Internal wiring Diagram and Control Schematic.
4. Torque switch and Limit switch contacts development.
5. QAP for Test Reports
6. Manufacturer's Catalogue.
7. Instruction manuals on Installation methods.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		Integral
2.	Application		[As per project specific]
3.	Motor type		Squirrel Cage
4.	Supply voltage	V	415 V, 3 ph, 3 wire.
5.	Phase, frequency	Hz	3ph, 50 Hz
6.	Motor rated voltage	V	415V/230 V
7.	Control Voltage	V	[110 V AC]
8.	Voltage and its variation	V	± 10%
9.	Frequency and its variation	Hz	+ 3 to -5%
10.	Combined V & f variation	%	10%

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S. NO.	DESCRIPTION	UNIT	DATA
11.	Degree of Protection		IPW 65
12.	Winding Insulation		Class B
13.	Temperature Rise (over ambient temperature)	°C	Class B
14.	Painting		[RAL 5012]
15.	Motor Starting		
a)	Method		DOL
b)	Starting Current		6 times

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E3

TECHNICAL SPECIFICATION FOR LV TRANSFORMERS

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E3

1.0 LV TRANSFORMER (DRY TYPE/OIL TYPE)

1.1 General

This specification is intended to cover [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV Transformers (Dry type/Oil type) complete with all accessories for efficient and trouble free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

CODE	NAME OF STANDARD
IS:334	Dimensions for porcelain Transformer bushing
IS:335	New insulating oil for transformers and switchgears
IS:1271	Classification of insulating materials for Electrical Machinery and apparatus in relation to their stability in service.
IS 2026	Specification for power Transformer (all parts)
IS:2071	Method of high voltage testing
IS:2099	High voltage porcelain bushings
IS:2147	Degree of protection.
IS:2705	Current transformers
IS:3202	Code of practice for Climate proofing of electrical equipment
IS:3637	Gas operated relays
IS:3639	Fittings and accessories for power Transformers
IS:5561	Electric Power connectors
IS:6600	Guide for loading of oil immersed transformers

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CODE	NAME OF STANDARD
IS: 11171	Dry type transformers
IS:10028	Code of practice for selection, Installation and maintenance of transformers Part I, II and III
CBIP	Manual on transformers
IEC60076	Power Transformer
IEC 60214	Tappings
IEC 60726	Dry-type power transformers
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
ANSI C57.12.51	Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160 Volts
ANSI C57.12.55	Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard
ANSI/IEEE C57.98	Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
ANSI/NFPA 70	National Electrical Code
IEEE C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.94	Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers

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CODE	NAME OF STANDARD
NEMA ST 20	Dry Type Transformers for General Applications
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The transformers shall be dry type (AN) for indoor location and shall be oil type (ONAN) for outdoor location.
- b) The oil type transformer shall be installed in hot, humid and tropical atmosphere with ambient temperature equal to 50°C. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- c) The transformer shall be capable of continuous operation at specified rating under the following condition:
 - i) Voltage variation - $\pm 10\%$
 - ii) Frequency variation - $[+3\%, -5\%]$
 - iii) Combined voltage and frequency variation (absolute sum) - $[10\%]$
- d) The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.
- e) The noise level shall be limited to the value specified by NEMA Standard Publication No. TR-1-1993 when measured in accordance with conditions outlines in ANSI/IEEE C57.12.90-1999/IS13964/CBIP publication.
- f) The design shall be such as not to cause any undesirable interference with radio or communication circuits.
- g) Transformers shall accept without injurious heating, combined voltage and frequency variation which produce an over fluxing condition of 120% for one (1) minute.

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- h) Each transformer shall be sized based on actual load with 10% margin and considering voltage regulation factor. It shall be sized by considering 100% load connected on the bus considering other transformer outage. An appropriate load factor of 0.9 for continuous and 0.2 for intermittent shall be considered.
- i) The impedance of the transformers shall be chosen such that the fault level on the LV switchgear does not exceed 50kA including the motor contributions and also voltage dip while starting the motor does not exceed 15% at motor terminal.

1.4 Specific Requirements of Transformers

1.4.1 Enclosure (for dry type)

- a) The encapsulated cast resin transformer shall be housed in naturally ventilated floor mounted cold rolled sheet steel cubicle with louvers backed by fine brass wire mesh. The enclosure shall be of bolted type fabrication and degree of protection shall be at least IP32. The minimum sheet steel thickness shall be 2 mm.
- b) Enclosure shall be provided with lifting lugs and grounding terminals at both ends. Further the enclosure door shall have pad locking provision.
- c) The enclosure door shall be interlocked with service transformer incoming breaker such that.
 - The door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position.
 - [6.6] kV side circuit breaker can be closed only when the doors are closed.
- d) Necessary illumination with controls shall be provided in the enclosure.
- e) Thermostatically controlled space heater inside the enclosure of suitable rating shall be provided if necessary.

1.4.2 Tank (for oil type)

- a) For LV transformers, the tank shall be of conventional type.
- b) Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.
- c) Tank shall be designed to permit lifting, by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.
- d) Tank together with radiators, coolers, conservator, bushings vessel and other fittings, shall be designed to withstand full vacuum without permanent distortion.
- e) The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

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- f) The material used for gaskets shall be cork-neoprene or approved equivalent. Gasketed joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather. Spare gaskets shall be provided for all openings as shipping gaskets will not be reused.
- g) Tank shall be provided with all necessary valves.
- h) Tank shall be provided with a pressure release device which shall operate at a pressure below the test pressure for the tank and radiators. This device shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall be rain proof after blowing and shall be provided with a device visible from ground to indicate operation. An equaliser pipe connecting the pressure relief device to the conservator shall be supplied. This device shall be provided for all transformers. Pressure relief device shall be equipped with remote monitoring/alarm contacts

1.4.3 Core

- a) The transformers shall be three phase core type. The core shall be built up with high grade, non-ageing, low loss, high permeability grain oriented cold rolled silicon steel laminations especially suitable for core material. Laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.
- b) CRGO sheets shall be coated with insulation varnish. Insulation shall be able to withstand the curing temperature and shall reduce eddy current to minimum. The core shall be protected from corrosion with a rust-resistant coating.
- c) The core clamping brackets shall be designed to provide an even distribution of clamping forces to the core, yokes and legs and shall be rigidly braced to reduce sound levels and losses.

1.4.4 Winding

- a) The coils shall be manufactured from electrolytic copper conductor with sufficient number of radial supports and fully insulated for rated voltage.
- b) The insulating material shall conform to Class F. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and shall withstand even the severest of temperature fluctuations.
- c) Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. The windings shall be arranged to ensure a free circulation of the air and to reduce the hot spots in the winding.

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- d) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.
- e) The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer, under short circuit stresses, switching or other transients.
- f) All coils rated 1200V or higher shall be subjected to partial discharge tests to ensure a properly cured and void free casting.

1.4.5 Encapsulation (for dry type)

- a) HV and LV coils shall be separately cast under vacuum in fibre glass reinforced epoxy resin compound. The insulation shall be fire resistant, non-inflammable, non-hygroscopic and resistant to temperature fluctuations.
- b) The epoxy shall contain filler material providing characteristics superior to unfilled epoxy including higher temperature rating, better heat conductivity, better arc resistance and adhesion to the conductor, plus a coefficient of expansion closer to that of the conductor material. The epoxy resin shall be self extinguishing.
- c) Encapsulated winding shall be free of internal voids, surface irregularities, etc. No surface finishing of encapsulated winding shall be undertaken after the process of encapsulation.

1.4.6 Insulating Oil (for oil type)

- a) The transformer shall be filled with mineral insulating oil suitably inhibited to prevent sludging.
- b) The quality of oil to be supplied for the transformer shall conform to the parameter specified in IS: 335 with latest amendments. No inhibitors shall be used in oil. Prior to filling oil shall be tested as per IS: 335 for tan delta, specific resistivity, breakdown voltage, moisture content etc.
- c) Transformer shall be dispatched oil filled. 10% excess oil for topping up shall be supplied in non-returnable container suitable for outdoor storage.
- d) Oil preservation shall be by means of conservator tank complete with silica gel breather and oil seal.
- e) Oil preservation shall be by means of bellows/ diaphragm sealed conservator tank with silica gel breather to avoid direct connection between atmosphere and transformer oil. It shall be complete with level gauges, pipes , drain valve etc. The level gauges shall be so placed that same can be readable standing from ground.
- f) Necessary device shall be kept to provide annunciation in the event of rupturing of bellow.

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1.4.7 Tappings (OCTC)

- a) Off-circuit taps as specified shall be provided on the high voltage winding.
- b) The transformer shall be capable of operation at its rated KVA on any tap provided the voltage does not vary by more than $\pm 10\%$ of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be provided.
- e) Off circuit tap changer switch where provided shall be 3 phase, hand operated, by an external handle with position markings and pad locking facility and mechanical stops to prevent over cranking beyond extreme positions.
- f) Arrangement shall be such that switch can be operated at standing height from ground level.
- g) The operating handle can be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator with pad locking facility.

1.4.8 Fittings and Accessories:

The following fittings and accessories shall be provided :

- a) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the purchaser's earthing conductors. Suitable earthing terminals on cable boxes shall also be provided.
- b) Terminal marking and rating plates shall be as per the specified standard.
- c) In case of oil type, the conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of -5°C up to an oil temperature of 100°C , with oil level varying within the minimum and maximum visible levels with necessary accessories.
- d) In case of oil filled type, Valves shall be supplied on the transformer tank and radiators.
- e) Pressure relief device: Pressure relief device shall be provided for transformers rated 2 MVA and above which shall be of sufficient size for rapid release of any pressure that may be generated within the tank and which may result in damage of the equipment
- f) Gas and Oil Actuated Relay (Magnetic Reed Type Gas & Oil Relay):

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A double float type magnetic reed type gas and oil relay as per applicable standard shall be provided for all oil filled transformers. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. These contacts shall be wired up to the transformer marshalling box. The relay shall be provided with shut off valves on the conservator side as well as the tank side.

g) Temperature Indicators

i Oil temperature indicator (OTI)

All oil type transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device. The contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC.

ii Winding Temperature Indicator (WTI):

A device for measuring the hot spot temperature of the winding shall be provided. The accuracy class of winding temperature indicator shall be $\pm 20^{\circ}\text{C}$ or better.

iii Oil Level Indicator:

A magnetic type oil level indicator shall be provided to indicate oil level in the tank.

iv RTD/transducers for remote annunciation:

In addition to the above mentioned indicators, the Oil and winding temperature measurement, RTDs / transducers shall be provided for remote indication in the DCS. RTDs shall be duplex platinum type with nominal resistance of 100 ohms at zero degree centigrade.

h) Bushing Current Transformers for stand by earth fault protection shall be provided in the neutral bushing and lead shall be brought to Marshalling box.

i) Radiator (oil filled type): Tank mounted radiators banks shall have bolted flanged connections and pipe extensions to permit withdrawal of

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transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes (unless otherwise approved) to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. The interconnecting pipes shall be provided with drain plug and air release vents.

- j) Conservator (For oil filled type): The transformers rated below 7.5MVA shall be provided with conventional single compartment conservator with dry air filling the space above the oil.

1.4.9 Bushings

- a) The bushing shall conform to the requirements of IS:2099 and IS:3347.
- b) All transformer bushings shall be of porcelain (for oil filled)/ epoxy (for dry type).
- c) The neutral terminal of 433V winding shall be brought out on a bushing along with the 433V phase terminal to form a 4 wire system for the 433V. Neutral CTs shall be located in the lead coming out of the winding and location of these CTs shall not be inside the tank.
- d) The neutral terminal of secondary shall be brought out through an outdoor. Further this neutral terminal shall be connected by a copper flat of size [50 mm x 6] mm, which shall be brought down upto 100 mm above ground. The copper flat shall be insulated and supported from the tank body.

1.4.10 Terminal arrangement

- a) Cable boxes
- Wherever cable connections are specified, suitable cable boxes shall be provided and shall be air insulated.
 - Cable boxes shall have drilled gland plate of adequate size to receive cables and to allow easy termination.
 - Removable drilled gland planes shall be provided in the cable boxes.
 - The additional supports for the cable boxes shall be galvanised iron.
 - The contractor shall provide earthing terminals on the cable box, to suit [50mmx6] mm GI flat.
- b) Bus duct
- Wherever Bus duct termination is specified a flanged throat or equivalent connection shall be provided for termination of bus duct enclosure. The winding termination shall be outdoor type bushing. The material of the bus duct termination arrangement of the transformer shall be nonmagnetic. The bus duct may be either phase-segregated or non-segregated.

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- ii. Tolerance permissible for the height of terminals and bus duct flange location specified for bus duct termination over ground level is $\pm 5\text{mm}$. Contractor has to ensure that radiator, conservator and explosion vent do not obstruct the path of the bus-ducts.

1.4.11 Marshalling box

- a) A sheet steel weather, vermin and dust proof marshalling box shall be furnished. The sheet steel used shall be at least 2.0 mm (CRCA) thick. The box shall be free standing floor mounted/tank mounted type and have a sloping roof. The degree of protection shall be IP-55 in accordance with IS:2147.
- b) The marshalling box shall have a glazed door of suitable size for convenience of temperature indicators reading.
- c) All incoming cables shall enter the marshalling box from the bottom.

1.4.12 Wiring

- a) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- b) Wiring shall be done with 650V PVC wires in conduit or PVC armored cable. *[Minimum wire size shall be 1.5 sq.mm stranded copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.]*
- c) Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. *[Terminals shall be stud type, suitable for terminating 2 nos. 2.5 mm2 stranded copper conductor and provided with acrylic insulating cover.]*
- d) All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- e) Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

1.4.13 Painting

- a) All steel surfaces shall be thoroughly cleaned by sand blasting and / or by chemical agents, as required to produce a smooth surface free of scales, grease and rust.
- b) The external surfaces, after cleaning, shall be given a coat of high quality red oxide or yellow chromate primer followed by filler coats.
- c) The transformer finished with two coats of epoxy based powder coated paint. The paints shall be carefully selected to withstand tropical heat,

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rain etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

- d) Painting shade shall be subject to owner's approval.
- e) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.14 Name Plate

Nameplates of approved design shall be furnished at each cubicle (one no. each at front as well as at backside of cubicle) and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black background. Self-tapping screws shall hold the nameplate. *[Nameplate size shall be minimum 20 x 75mm for instrument/device and 40 x 150mm for panels. Caution notice on suitable metal plate shall be affixed at the back of terminal Box.]*

1.5 Tests

1.5.1 Type Tests

For each type & rating of LV Transformers, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within *[last five]* years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within *[last five]* years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- a) Temperature rise test
- b) Dielectric test

1.5.2 Routine Tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The following tests shall be performed on each transformer as a minimum:

- a) After assembly, each core shall be pressure tested for one minute at 2KV (r.m.s.) A.C. between all bolts, side plates, structural steel works and the core.

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- b) The wiring for auxiliary power and control circuitry shall be subjected to withstand one minute power frequency test with 2.0KV (r.m.s.) to earth
- c) Measurement of winding resistance
- d) Measurement of voltage ratio and check of phase displacement
- e) Measurement of short circuit impedance and load loss
- f) Measurement of no load loss and current
- g) Dielectric routine tests
- h) Excitation loss and current measurements shall be made at 90%, 100% and 110% of the rated voltage as routine test.
- i) Partial discharge test
- j) Tan delta test

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings/ Data and Manuals

Drawings, data, and manuals for the transformers shall be submitted as indicated below:

- a) *[General Arrangement Drawing]*
- b) *Dimensioned general arrangement drawing showing enclosure, core coil assembly, terminal arrangement, marshalling box and various fittings.*
- c) *Transport/shipping dimensions with weights, wheel base detail etc.*
- d) *Foundation plan & loading.*
- e) *Bus duct/cable termination arrangement.*
- f) *Control schematics and wiring diagrams.*
- g) *Test reports and QAP*
- h) *Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.*
- i) *Instruction manuals on Transformer and its various fittings The manual shall clearly indicate method of installation, checkups and tests to be carried out before commissioning of the equipment.]*

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Note: The drawings, data and manuals listed are minimum requirement only. The Bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted.

1.7 Ratings and Requirements

Table 2.0

6.6/0.420 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Application	[As per project requirement]	[As per project requirement]
2.	Location	Indoor	Outdoor
3.	Type	[Dry Type: epoxy cast resin transformer]	[Oil type transformer]
4.	Reference standard	IS 11171	IS 2026
5.	Rated power (indicative)	[As per project requirement]	[As per project requirement]
6.	Rated winding voltage ratio (line to line)	6.6/0.433 kV	6.6/0.433 kV
7.	Number of phases	3	3
8.	Winding	2	2
9.	Rated frequency	50 Hz	50 Hz
10.	Type of cooling	AN	ONAN
11.	Insulation Class	Class F or Better	Class F or Better
12.	Temperature rise Over ambient temperature of 50°C		
a.	For Winding by	90°C or lower as permissible for class	55°C

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	resistance method	of insulation offered	
b.	For Oil by Thermometer method	Not Applicable	50 °C
13.	Insulation level (LI/AC)		
a.	HV- (LI/AC)	60 KVp/20 kVrms	60 KVp/20 kVrms
b.	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
14.	Vector group	[Dyn11]	[Dyn11]
15.	Short-circuit impedance on principal tap	[As per project requirement]	[As per project requirement]
16.	Parallel operation of transformer	Momentarily	Momentarily
17.	Type of taps provided	OCTC, full capacity	OCTC, full capacity
18.	Taps provided on	H.V. winding	H.V. winding
19.	Range of taps	[+/- 5 % in steps of 2.5%]	[+/- 5 % in steps of 2.5%]
20.	Method of Tap charge control-		
a.	Manual local	Yes	Yes
b.	Electrical local	No	No
c.	Electrical remote	No	No
d.	Automatic	No	No
21.	System earthing		

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a.	H.V.	Non-effectively earthed			Non-effectively earthed
b.	L.V.	Effectively earthed			Effectively earthed
22.	Terminal arrangement				
a.	H.V.	6.6kV(UE) Cable/ busduct			6.6kV(UE) Cable/ busduct
b.	L.V.	Non-segregated phase bus duct			Non-segregated phase bus duct
23.	Neutral for earthing	GS flat connector			GS flat connector
24.	Transformer bushing	HV	LV	LV - N	Same as Dry type transformer
25.	Voltage class KV(r.m.s.)	7.2	1.1	1.1	
26.	Creepage distance mm	[As 25mm/kV]			[As 25mm/kV]
27.	Min. Ph-Ph/ Ph-E clearance mm	As per Standard			As per standard
28.	System fault Level				
a.	HV Side	40 KA (r.m.s.)			40 KA (r.m.s.)
b.	LV Side	50KA (r.m.s.)			50KA (r.m.s.)
29.	Max. Noise level	As per NEMA std. TR-1			As per NEMA std. TR-1
30.	Auxiliary supply	415 V, 3 ph, 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)			415 V, 3 ph 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)
31.	LV neutral side	[As per project]			[As per project]

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	current transformer for standby earth fault protection	requirement]	requirement]
32.	Guaranteed no load loss (kW)	[By Bidder]	[By Bidder]
33.	Guaranteed load loss (kW)	[By Bidder]	[By Bidder]
34.	Efficiency		
a	At full load	[By Bidder]	[By Bidder]
b	At 75% load	[By Bidder]	[By Bidder]
c	At 50% load	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II**

SECTION-II, PART-B, ANNEXURE-E4

**TECHNICAL SPECIFICATION FOR 415V SWITCHGEAR,
MCC & DBs**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E4

1.0 415V SWITCHGEAR, MCC AND DB

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Switchgear MCC and DBs, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2551	Danger notice plates
IS :2705	Current transformers-specification
IS :3156	Voltage transformer specification
IS :3231	Specification for electrical relays for power system protection
IS: 8084	Specification for interconnection busbars for AC voltages above 1kV up to and including 36kV.
IS :8623	Specification for low-voltage switchgear and control gear assemblies
IS :8686	Specification for static protective relays
IS :10118	Code-of practice for selection installation and maintenance of switchgear and control gear
IS :12021	Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 v ac
IS : 13947 (Part 1)	Specification for low-voltage switchgear and control gear
IS : 13947 (Part 2)	Specification for low-voltage switchgear and control gear –part 2: circuit breakers
IS : 13947 (Part 4)	Specification for low-voltage switchgear and control gear -part 4 : contactors and motor feeders

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Codes	Name of Standard
IS : 13947 (Part 5)	Low-voltage switchgear and control gear specification Part 5 : control circuit devices and switching elements
IEC 61439	Low voltage switchgear and control gear assemblies.
CEA	CEA regulations for installation and operation of meters 2006.
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All 415V Switchgear, MCC and DB shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- All 415V Switchgear, MCC and DB shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-) 5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC system	:	-15% to +10%

- 415 V switchgear & MCCs shall be of indoor /outdoor, double front/single front [Preferably single front] and fully draw out type. ACB feeder may be of single tier/two tier configuration depending upon rating. DBs (ACDB / DCDB) shall be of single / double front [Preferably single front] and fixed type. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration shall be provided.
- All AC motor starters shall be suitable for Direct on Line (DOL) starting. Motors rated below [132]kW shall be provided with combination starters consists of MCCB/MPCB, contactors and electronic over load relay and

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the motor starter shall comply with Type – 2 coordination conforming to relevant code and standards. Motors rated [132] kW and above shall be breaker controlled and shall be provided with comprehensive motor protection relay. Motors rated above [160]kW shall be fed from MV Switchgear [Only for firefighting system Motor rated up to 200kW shall be fed from 415V switch board].

- e) For 415 V switchgear & MCCs Feeders rated [630A] and above shall be equipped with Air Circuit Breaker (ACB). Outgoing/Incoming feeders rating below [630] A shall be MCCBs.
- f) For DBs Incomer rated 630A and above shall be ACB. Incomer below 630A shall be MCCB. Outgoing feeder may be MCCB/MCB depending upon the bus fault level.
- g) All ACB shall be draw out type & should have Service, test and disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- h) Local/remote selection shall be provided for all incoming/Outgoing ACB module. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local(Switchgear).
- i) Two out of three breaker logic shall be considered for switchgear/MCC. However mechanical interlock shall be considered for income of MCCB operated DBs.
- j) Also, Local/remote selection switch shall be provided for all motor modules for control from Remote(DCS). Also for breaker operated motor, breaker shall be closed in Test position from local(Switchgear).
- k) All motors shall be provided with Emergency stop push button.
- l) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary MCCB/MCB shall be provided for each MCC, 2 x 100% per section. However breaker shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from bus bars. This control supplies shall be monitored.
- m) All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 415V switchgear, MCC and DBs shall have following minimum features.

- a) All 415V switchgear, MCC and DBs shall be metal enclosed, indoor, floor mounted and free standing type. The panels shall be suitable for cable entry at bottom and busduct connection at top.

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- b) Between 415V Switchgear and dry type transformers, non segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with busduct manufacturer in this regards is covered in this specification.
- c) All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d) Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels
- e) Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f) The switchgear enclosure shall confirm to the degree of protection IP-54 (for outdoor). For indoor, enclosure shall confirm to IP52, however for Busbar chamber of switchboards rated above 1600A, degree of protection shall be IP-42.
- g) Paint shade for complete panels excluding end covers shall be [RAL 9002] and [RAL 5012] for extreme end covers for all board.
- h) The switchgear assembly shall comprise a continuous, line-up of single / multi tier cubicles. The installations of circuit breakers however shall be limited to the bottom two tiers only. Working height shall be limited to [250 mm to 1800 mm] from the floor level.
- i) Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc
- j) A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgears having more than one bus section.
- k) Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable

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terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.

- l) For MCC/DB a full height vertical cable chamber with cable supports shall be provided in each section to facilitate unit wiring.
- m) 2x100%, 415V/110V AC control transformer shall be provided for control, Indication and annunciation supply for contactor operated motor feeder. All the necessary auxiliary and main contactor shall be provided suitable for this control supply.
- n) Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module.
- o) Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- p) Supplier shall provide total 20% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- q) Motors of rating 30 kW and above shall be provided with anti-condensation heaters. Necessary provision for supply of motor space heating shall be considered in the switchgear.
- r) The incoming connection to transformer of more than 1000kVA and inter-connecting sections between switchboards shall preferably be of bus ducts.
- s) It should be possible to carryout maintenance on a feeder with adjacent feeders alive.

1.4.2

Bus and Bus taps

- a) The main buses and connections shall be of high [conductivity Aluminum / Copper] alloy sized for specified current ratings with temperature rise limited [to 40°C over ambient temperature of 50°C].
- b) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminum contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance. Adequate contact pressure shall be ensured by means of two bolts connection with plain & spring washers and locknuts. Temperature rise shall not exceed 105 degree for silver plated joints over an ambient temperature of 50 degree.
- c) Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- d) Bus insulators shall be flame-retardant, track resistant type with high creepage surface. All buses and connections shall be supported and braced to withstand the stresses due to maximum short-circuit current and also to take care of thermal expansion.

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- e) Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f) Power shall be distributed to each module or compartment by a set of vertical bus bars. The vertical bus bars shall run behind the modules. Necessary tee off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.
- g) The clearance between the individual bare phase power bus bars and between the phase and earth bus bars in air shall be not less than [25.4] mm.
- h) Three phase, neutral (with at least [50] % rating of main Bus bar and continuous earth bus shall be provided. Bus bar and tapping shall be provided with color coded PVC sleeves.

1.4.3

Air Circuit Breaker

- a) All Circuit Breakers for incoming feeders and Bus couplers shall be [four] poles; single throw, motor operated and air break type. Circuit breaker for outgoing feeders shall be triple pole, single throw and air break type. However for supply feeders it shall be [four] pole.
- b) Circuit Breakers shall be [draw out type] having Service, Test & Disconnected positions with positive indication for each position.
- c) Circuit breakers of identical rating shall be physically and electrically interchangeable.
- d) Bolted disconnected links shall be provided for all outgoing feeders for isolation of neutral, if necessary.
- e) For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open – close – open operation of the circuit breaker shall be possible after failure of power supply to the motor when the spring is charged after a closing operation.
- f) Mechanical safety interlock shall be provided to prevent the circuit breaker from being racked in or out of the service position when the breaker is closed.
- g) Automatic safety shutters shall be provided to fully cover the female primary disconnects when the breaker is withdrawn.
- h) Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indicator, an operational counter and mechanism to indicate spring charge / discharge condition.
- i) In addition to the auxiliary contacts required for normal breaker operation and indication, each breaker shall be provided with followings for interlocking purpose:-
 - i. Position / cell switch with 4 No + 4 NC contacts.

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- ii. Limit / auxiliary switches shall be convertible type that is facility for changing N.O. contact to N.C. and vice-versa.
- iii. Mechanical stopper to prevent accidental falling while withdrawing.
- j) Breaker cannot be racked in from 'isolated' to 'test' position with the door open together with provision for defeat of this interlocking, however, the door can be closed only when the breaker is brought back to 'isolated' position. Insertion of breaker into 'Service' position not possible if the shutters are not free.
- k) Door can be opened only when breaker is OFF and is in 'Isolated' position. Remote closing of breaker not permitted with door open.
- l) Anti pumping relay / device to ensure that there can be only one closing operation for each closing command.
- m) Suitable trolley arrangement shall be provided for breaker/starter modules. Two trolleys per switchgear room shall be provided so that top most breaker module of all types, sizes and rating can be withdrawn on trolley and lowered for maintenance purpose.
- n) Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage.

1.4.4 Contactors, MCCB and MPCB

- a) Incomers for MCCs and DBs rated below 630A shall be MCCB.
- b) Incomer and bus coupler rated below 630A shall be mechanically Interlocked.
- c) Motor starter contactors shall be of air break, electromagnetic type. Suitable for DOL starting of motor, and shall be of utilization category AC-3 for ordinary and AC-4 for reversing starters. DC contactor shall be of DC-3 utilization category.
- d) The contactors shall be three pole, air break type designed for [duty class III category A.C. –3 with non-bouncing silver / silver alloy.]
- e) Each contactor shall be provided with two (2) normally open and two (2) normally closed auxiliary contacts unless otherwise specifically stated. Rating shall be decided by the bidder.
- f) Reversing contacts shall be electrically and mechanically interlocked.
- g) Contactors with delayed dropout feature shall be provided for some essential auxiliaries. These contactors shall not dropout on power failure if the voltage is restored within 3 seconds.

1.4.5 Electronic over load relays

- a) Electronic overload relays shall conform to IEC:292-1 and shall be triple pole, ambient temperature compensated with adjustable setting, inverse time lag, built in single phase preventer and hand/auto reset type

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provided as per requirement along with necessary command, feedback cable, coupling relays etc.

- b) Provided with 1 NO and 1NC contact of rating same as the auxiliary contact of the contactors.
- c) The relay shall be able to withstand prospective short circuit current without damage or injurious heating till the motor protection MCCB/MPCB clears the fault.
- d) Relays may be direct acting or CT operated, depending on current rating. CTs shall be included in the scope of supply.

1.4.6 Bus Transfer scheme:

Each switchgear of two incomer and bus coupler shall be provided with the following provisions.

- i) Dead bus closing.
- ii) Manual live change over (Momentary paralleling)
- iii) Automatic bus transfer scheme.

1.4.7 Current Transformer

- a) Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made.
- b) CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c) CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d) All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e) CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Voltage Transformer

- a) Voltage transformers(VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b) VTs shall be of the single-phase type. VTs shall be protected on their primary side by MCCBs with interrupting ratings corresponding to breaker rating and by MCB (with auxiliary contacts) on the secondary sides.

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- c) VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d) It shall be possible to replace VTs without having to de-energise the main busbars.
- e) VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.9 Transducer

For all the incoming and the outgoing of 415V Switchgear / MCC/ DB Feeders requiring remote metering and/or current monitoring shall be provided with multi-functional transducers. The output shall be 4-20 mA DC which shall correspond to the normal range.

1.4.10 Secondary Wiring

- a) The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b) Fuse /MCB and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c) Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d) Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with [stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring.]
- e) Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.11 Terminal Blocks

- a) Terminal blocks shall be 660V grade box-clamp type with marking strips, similar to 10 mm² or equal. Terminals for C.T. secondary leads shall have provision for shorting.
- b) Not more than two wires shall be connected to any terminal. If more than two wires at one terminal are required, separate terminals with function wise shorting links shall be provided. [Spare terminal equal in number to 20% of active terminals shall be furnished.]
- c) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged so that individual wires of an external cable can be connected to consecutive terminals.

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1.4.12 Ground bus

- a) A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b) Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c) C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.13 Space Heater

- a) Each vertical section shall be provided with thermostat controlled space heater 5A, 3 pin socket plug.
- b) In addition, motor feeders rated [30 KW and above] shall be wired up for feeding the motor space heater through suitably rated breaker auxiliary NC contact and/or contactor.
- c) Cubicle heater, Motor heater, and Plug socket circuit shall have individual switch fuse units/MCB.

1.4.14 AC Distribution Boards (ACDBs)

- a) AC Distribution Boards shall have MCCB/MCB at incomer depending upon the short circuit rating. Distribution Boards may be fed from switchgear and shall have two incomers. AC distribution Boards shall be of two types - one with 415V, 4-wire, triple pole and neutral (TPN) outgoing feeders and the other with 240V, 2-wire, single pole and neutral (SPN) outgoing feeders.
- b) For small loads, MCB boards with TPN MCB as incomer and TPN/SP MCBs for outgoing may be considered. The feeder rating and quantity shall be as per requirement.
- c) Board shall be single/double front [preferably single front], metal clad, front matched, dust and vermin proof, fixed type, compartmentalized and extensible on both sides.
- d) Bus bars shall have same cross section throughout the length. Rating of the neutral bus bar shall be 50% of the main bus bar. Earth bus bar shall run in bottom chamber throughout the length of the Board.

1.4.15 DC Distribution Boards

DCDBs shall have two incomers and a bus coupler. Incomers and outgoing feeders of DCDBs shall be MCB/MCCB modules. They shall be fixed type and floor mounted. Other constructional features shall be similar to ACDB.

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The feeder rating and quantity shall be as per requirement.

1.4.16 Control & Indication

The circuit breaker shall be wired up for local & remote operation. Each breaker cubicle shall be equipped with following:

- a) Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In switchgear position, the breaker shall be operated from switchgear only in test position with only protection (no interlock).
- b) Two (2) heavy duty, oil-tight, push buttons for Trip & Close.
- c) Circuit breaker shall be indicated electrically. The following indication colour shall be used.

Breaker open - GREEN

Breaker closed - RED

Spring Charged - WHITE

Breaker Auto Trip- AMBER

- d) However, any other indication shall be provided as per owner's requirement.
- e) Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.
- f) For all MCCB feeders, trip indication lamp shall be provided on front of the compartment.
- g) For all starters, ON, OFF and trip indication lamps shall be provided on front of the compartment.

1.4.17 Relays, Protection & Metering

- a) The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- b) All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner.
- c) All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.

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- d) All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- e) Energy meters shall be provided for incomer of 415V Switchgear and MCC and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than 1.0S.
- f) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- g) All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- h) The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- i) All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- j) Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- k) D.C supply shall be supervised by DC supervision relays.
- l) Trip circuit shall be supervised by Trip circuit supervision.
- m) Tripping shall be done through high speed lock out relays.
- n) All meters/ instrument shall be flush mounted on front panel, at least 96mm² size with 90° linear scales and accuracy class of 2.0.
- o) Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- p) For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- q) Metering and protection shall be as per below table

a)	Incomers	
	Protections	Metering
i	Time graded short circuit protection	Local Current (single phase) indication and remote indication through transducer.

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ii	Over current protection	Voltage Measurement for all three phases and remote indication through transducer.
iii	Earth fault protection	KW, Kwhr
b)	Bus coupler	
	Protections	Metering
i	Over current protection(51)	Local Current (single phase) indication.
ii	IDMT Earth fault protection(51N)	
c)	Contactor controlled motor feeders [90kW and above motor only]	
	Protections	Metering
i	Time graded short circuit protection	Local Current indication and remote indication through transducer.
ii	Over current protection	
c)	[Motor Feeders [of 132KW and above only]]	
	Protections	Metering
	Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload etc.	Local Current indication and remote indication through transducer.
[Other feeders]		
a)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection	[Voltage – phase to phase,]
	Fuse failure protection	
b)	Motor feeders (MPCB/MCCB with Contractors)	
	Protections	Metering
	Electronic Overload relay (with single phase preventor), short circuit protection (through fuse/MCCB/MPCB as specified)	
c)	Incoming feeders for ACDB/DCDB	
	Protections	Metering

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	Short circuit protection (if MCCB)	[Voltage (single phase and, Phase Current (1 Phase))] Local indication only.
d)	Outgoing feeders of ACDB/DCDB	
	Protections	Metering
	Short circuit protection (through fuse/MCCB)	

1.5

Tests

I) Type Test

For each type & rating of 415V Switchgear, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted are as follows:

- Measurement of insulation resistance of Circuit Breaker in closed and open positions.
- Measurement of milli-volt drop across Circuit Breaker main contacts and other joints.
- Measurement of Circuit Breaker/Contactor operating time for close & open at nominal voltage and 80% of rated voltage.
- Measurement of resistance, IR value and drop-off/pick-up voltage of close and trip coils.
- Healthiness of limit switch contacts.
- Spring charging motor functional checks.
- Verification of phase sequence and checking of clearances of busbars between phase to phase and phase to earth.
- Measurement of milli-volt drop across busbar joints

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- i) Torque tightness test.
- j) High voltage test on busbar.
- k) Measurement of CT/PT polarity, ratio and knee point voltage.
- l) Electrical and mechanical interlock checks.
- m) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- n) Secondary injection of all metering circuits.
- o) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below

- a) [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening.
- b) Bill of Materials.
- c) Technical Data sheet and Catalogue.
- d) Foundation drawing details with bottom view of switchgear.
- e) Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f) Control Schematics & Wiring diagram.
- g) Inspection and Test Plan (ITP).
- h) Suggestive list of protective relays.
- i) Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

415V switchgears, MCC and DB shall comply with the particulars indicated in the following tables.

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Table- 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		415 Volts, 3 Phase, 4 wire 50 Hz.
2.2	System neutral earthing		Solidly earthed
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		a) 2.5kV b) 1.5kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		90°C for busbars having non-silver plated joints 105°C for busbars having silver plated joints
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	50
b	Dynamic Rating	kA (peak)	105
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		Cu/Al
2.14	Fully draw out (FD)/ Fixed (F)		FD for Switchgear/MCC; F for DBs.
2.15	Entry –Top (T)/Bottom (B)		Top for busduct, bottom for cables
2.16	Degree of protection		IP 52
2.17	Colour finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	GS
2.19	Minimum clearances in air of live parts	mm	As per standard
3.0	Starters		
3.1	Type	DOL	DOL
3.2	Contactor rated duty		AC3 for DOL
3.3	Single phasing preventer required.	Yes / no	Yes
3.4	Thermal overload relay reset	Manual / Auto	Settable for either to Manual or Auto
4.0	Circuit breakers		
4.1	Maker's name		[By bidder]
4.2	Voltage, frequency & no.of phases , poles		415 V, 50 Hz, 3 Ph, 4 Pole
4.3	Rated operating duty		O-3min-CO- 3min -CO
4.4	Circuit breakers type		ACB
4.5	Short circuit withstand current for 1 sec. Duration	kA	50
4.6	Rated making current	kAp	105
4.7	Rated current at site reference ambient temp	A °C	[By bidder]

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S. No.	DESCRIPTION	UNIT	DATA
4.8	Type of operating mechanism		Spring charged motor and manual
4.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
4.10	Control voltage		
a	Spring charging motor	V AC/DC	[220V DC/240V AC]
b	For closing/tripping	V AC/DC	220V DC
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	As per IS
b	Closing at normal voltage	%	As per IS
c	Trip coil	%	As per IS
4.12	Power required for closing at normal voltage	W	[By bidder]
4.13	Power required for tripping at normal voltage	W	[By bidder]
4.14	Spring charging motor details:		
a	Rating	kW	[By bidder]
b	Rated voltage	V, AC/DC	[By bidder]
c	Spring charging	Sec.	[By bidder]
	Electrical and mechanical anti-pumping features been provided	Yes/No	Required
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		415 V, 50 Hz & 3 P for outgoing, 4P for incoming and supply feeders
5.2	Rated operating duty		As per IS
5.3	Rated breaking capacity	kA (rms)	50

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S. No.	DESCRIPTION	UNIT	DATA
5.4	Rated making current	kA (Peak)	105
5.5	On/off operation		
5.6	Manual	Yes/No	Yes
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	Yes
5.8	Auxiliary contacts required	Yes/No	[As per project specific]
6.0	Contactors		
6.1	Make		[By Bidder]
6.2	Rated duty	AC3/A C4	AC3 for DOL AC4 for RDOL
6.3	No of poles		3
6.4	Utilization category		[By Bidder]
6.5	Rated voltage of auxiliary contacts	V	[By Bidder]
6.6	Rated voltage of coil	V	[By Bidder]
6.7	Rated breaking capacity	Factor of rated current	[By Bidder]
6.8	Rated making capacity	Factor of rated current	[By Bidder]
6.9	Limits of operation		As per IS/IEC
a	Supply voltage variation		[By Bidder]
b	Supply frequency variation for closing		[By Bidder]
c	Drop out voltage		[By Bidder]
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		

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S. No.	DESCRIPTION	UNIT	DATA
7.1	Voltage Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
7.2	CT Ratio		Primary current/1A or 5A
7.3	Measuring CTs		CI - 1.0 instrument safety factor 5.0
7.4	Protection CTs		CI 5P20
7.5	Measuring VTs		(min)/phase CI1.0
7.6	Protection VTs		CI 3P
8.0	Control transformers		
8.1	Make		[By Bidder]
8.2	Type		Dry Type
8.3	Applicable standards		As specified in the specification
8.4	Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
8.5	Class of insulation		Class-B or Better
8.6	Rated output	VA	[As per project specific]
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		[By Bidder]
10.2	Make		[By Bidder]
10.3	Type designation		[By Bidder]
10.4	Setting range		[By Bidder]
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		[By Bidder]
11.2	Make		[By Bidder]
11.3	Type		[By Bidder]
11.4	Current setting range		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	[By Bidder]
12.0	Under voltage relay		
12.1	Make		[By Bidder]
12.2	Type		[By Bidder]
12.3	Voltage rating	V	[By Bidder]
12.4	Setting range	V	[By Bidder]
13.0	Auxiliary relays and timers		
13.1	Make		[By Bidder]
13.2	Type		[By Bidder]
13.3	Coil voltage	V	[By Bidder]
14.0	Control/selector switch		
14.1	Make		[By Bidder]
14.2	Type designation		[By Bidder]
15.0	Meters		
15.1	Applicable Standards		As specified in the specification.
15.3	Accuracy Class		Class 1.0 or Better
15.4	Make		[By Bidder]
15.5	Type		Multi function with RS 485 connectivity
16.0	Voltmeter		
16.1	Make		*[By Bidder]
16.2	Type		Moving coil
16.3	Applicable standards		As specified in the specification.
16.4	Accuracy class		Class 1.0
17.0	Ammeter		

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S. No.	DESCRIPTION	UNIT	DATA
17.1	Make		As specified in the specification.
17.2	Type		Moving coil
17.3	Applicable standards		As specified in the specification.
17.4	Accuracy class		Class 1.0
18.0	Indicating lamps		
18.1	Make		As specified in the specification.
18.2	Type		Clustered Led
18.3	Voltage	V	As specified in the specification.
18.4	Wattage of lamp	W	As specified in the specification.
19.0	Push buttons		
19.1	Make		As specified in the specification.
19.2	Type designation		As specified in the specification.
19.3	Contact rating	A	As specified in the specification.
20.0	Space heater		
20.1	Make		As specified in the specification.
20.2	Type		As specified in the specification.
20.3	Rated voltage	V	As specified in the specification.
21.0	Wiring and terminal blocks		
21.1	Voltage grade		1.1 kV
21.2	Insulation		[By Bidder]
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	2.5 for CT & PT 1.5 for Others
b	Control wiring	Sq.mm	1.5 for Others

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S. No.	DESCRIPTION	UNIT	DATA
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		Sliding type
	II) For Fixed Type		Stud & nut type
21.5	Minimum current rating of terminal blocks	A	10

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E5
TECHNICAL SPECIFICATION FOR 415V NON
SEGREGATED PHASE BUS DUCTS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E5**1.0 415V NON SEGREGATED PHASE BUS DUCT****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Non Segregated Phase Busduct, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS 8084	Interconnecting Bus bar for AC Voltage above 1KV up to and Including 36kV
IEC 60947	Low Voltage Switchgear and Control gear
ANSI/IEEE C37.20	Metal-Clad and Station-Type Cubicle Switchgear
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear
IEC 60439	Low-voltage switchgear and control gear assemblies.
BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) The 415V Non-segregated phase bus duct shall serve as an interconnection between the 415V Switchgear and 11/0.433kV LV Transformer. The Non-segregated phase bus duct shall be installed

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indoor/Outdoor in a hot, humid and tropical atmosphere. All panels associated with Non-segregated phase bus duct shall be located indoors/Outdoors.

- b) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- c) For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be as specified in Clause 1.7 Rating and requirements.
- d) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the required short-circuit currents.
- e) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- f) The bus ducts shall be self cooled and shall not be equipped with blower or any other type of forced ventilation.
- g) The equipment rating shall be based on an ambient temperature. Same phase disposition shall be maintained throughout the run of the bus duct. Phase crossover units, if required, shall also be provided inside the Busduct itself.
- h) Bus ducts shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current.

1.4 Specific Requirements

1.4.1 General

- a) 415V Non Segregated Phase Busduct is provided for connection between low voltage side of 11/0.433kV cast resin dry type /oil type transformers and associated 415V Switchgears shall be of TPN (3 phase and neutral) along with necessary bends, flexible at both transformer & switchgear ends, flanges, phase crossover chambers (if required), support structures & accessories including terminations at the equipment ends.
- b) The 415V bus duct shall be metal enclosed, non-phase segregated enclosure type, self cooled and insulated for 1.1kV voltage. The cooling medium inside the duct shall be air.

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- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) The 415V non-segregated phase bus duct will be installed indoor or partially indoor & outdoor depending upon the location of equipment being interconnected in a hot, humid and tropical atmosphere. All panels associated with LV non-segregated phase bus duct will be located indoors.
- e) The continuous current rating and momentary peak withstand current rating of the Busduct between transformers & their associated switchgears shall be same as that of the associated switchgears and as indicated in the specification.
- f) All supporting steel structures shall be hot dip galvanized.
- g) The bus ducts shall be provided with space heaters to control moisture. Slicagel breather if required same shall be provided.

1.4.2 Enclosures

- a) The enclosure shall be rectangular and shall be made of [aluminium alloy/Mild steel] of grade [19000H2] as per IS-5082. The entire bus duct shall be designed with dust, weather and vermin-proof construction. The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- b) *[Phases shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminum alloy) of 3mm for bus rating including and above 3000A whereas enclosures for normal bus current rating (<3000 A) shall be sheet steel fabricated type of 2.5mm thick].*
- c) Enclosures shall be provided with flange ends with drilled dimensions to suit the flanges at the switchgear and transformer ends.
- d) Circumferential neoprene rubber gaskets shall be provided for dust tight joints with adjacent enclosure section.
- h) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion / contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.

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- i) All outdoor bus-enclosures shall be so designed & constructed as to prevent accumulation of rain water on top sheet. Similarly all Gasketed flanged joints shall be suitably protected against direct splashing of rain water in case of outdoor runs. The connection flanges shall be sufficiently stiffened so as not to bend while tightening the bolts.
- j) Outdoor portions of the bus duct, if any, shall have continuous rain hood of non magnetic material or with suitable arrangement for rainwater prevention.
- k) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, switch gear terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets.
- l) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between indoor and outdoor portions of the bus duct.
- m) In case, the bus duct penetrates the firewall, the wall frame assembly and the seal shall be designed for the same fire rating as the firewall.
- n) Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct. Space Heaters shall be provided in the bus duct.
- o) Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- p) Shipping length of the Busduct shall be not more than three (3) meters in length.
- q) Minimum Degree of protection of Busduct enclosure shall be IP-52 for indoor and IPW-55 for outdoor section of the Busduct.

1.4.3 Bus Conductor

- a) The bus conductor shall be of high conductivity, [Aluminium alloy / Aluminium].
- b) The bus conductors shall be given a coat of matt black paint to facilitate heat dissipation. However the sizing of the bus conductor shall consider the conductor as bare.
- c) The bus conductor shall be designed for bolted connections throughout the run.
- d) Flexible connection shall ensure an efficient and trouble-free connection.

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- e) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminium contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- f) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.
- g) The bus bar shall be sleeved with FRLS heat shrinkable, colour coded PVC sleeves at intermittent points for phase identification.
- h) The material of the conductor shall be aluminium alloy of grade [63401WP] as per IS: 5082. The temperature rise of conductor shall be 40 degree over design ambient temperature of 50 degree. Also, the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.

1.4.4 Disconnect Link

- a) Removable bolted disconnected link shall be provided in the bus for the purpose of isolation.
- b) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- c) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- d) A minimum clearance of [300 mm. (12")] shall be provided between the disconnected bus sections with the link removed.

1.4.5 Insulators

- a) The bus conductor supporting insulators shall be flame retardant, non-hygroscopic, high impact and high dielectric strength material with an anti tracking contour.
- b) Material of insulator shall be [Epoxy SMC moulded /FRP].
- c) Spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the short circuit current assigned to the bus duct.
- d) Bus support insulators shall be interchangeable, high creepage, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.

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- e) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- f) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator.
- g) Space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus duct.

1.4.6 Connections & Terminations

- a) All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the switchgear, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the switchgear and auxiliary transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.

1.4.7 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- c) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- d) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.
- e) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.

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- f) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

1.4.8 Ground bus

- a) The ground bus of two numbers of separately run [50x10 mm] minimum GS flat shall be provided along the run of the bus duct. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.
- b) Ground bus shall be finally to connected to power plant earth grid at one end.

1.4.9 Wiring

All wiring for space heaters shall be done with insulated stranded copper conductor of not less than [2.5 mm² cross-section]. Each wire shall be identified at both ends with wire designation as per bidder's wiring diagram and shall be brought out to a terminal box outside the bus duct.

Terminal blocks shall be box-clamp type minimum 10 mm² with marking strips.

At [least 20% spare terminals] shall be furnished in the terminal block.

1.4.10 Name Plate

Suitable name plate shall be furnished with each piece of equipment.

[Materials for name plate shall be plastic / lamicoid, 3 mm thick, using white letters on black background.]

1.4.11 Space Heater

Thermostatically controlled Space heaters shall be provided in the bus ducts, wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation. At least one number space heater with thermostat shall be provided at each transformer and switchgear end.

The space heaters shall be suitable for continuous operation on single phase supply, and shall be automatically controlled by thermostats. Necessary wiring up to junction boxes mounted on bus duct and from junction boxes to switchboards shall be provided.

1.4.12 Painting and Finish

- a) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as

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possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint

- b) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- c) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- d) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].
- e) The interior surface finish shall be as per manufacturer's standard.
- f) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- g) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.
- h) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- i) The paint shade shall be subject to owner's approval.

1.5

Tests

l) Type Test

For each type & rating of 415V Non segregated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test

1.6 Drawings and Documents

Drawings, data & manuals for the 415V Non segregated phase bus duct shall be submitted as indicated below:

- a) [Dimensional GA drawing
- b) Data sheets
- c) Typical calculation for arriving at the size of conductor and the insulator spacing.
- d) Type test report (short circuit, temperature rise test) for similar bus duct manufactured by the proposed manufacturer.
- e) Foundation layout and requirements
- f) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

1.7 Ratings and Requirements

Major technical parameters of 415V non segregated Bus Duct are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table: 2.0

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.	Type of bus duct		Non segregated phase bus duct	
2.	Rated voltage and No. of phase	V	415V, Triple Pole , Neutral(3Phase & 4 Wire)	
3.	Applicable standard		IS 8084	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
4.	System Frequency	Hz	50	
5.	Design ambient temperature	Degree	50	
6.	Rated Current	A	[As per project Requirement]	
7.	Designation (from & to)		[As per project Requirement]	
8.	Type of cooling (NSPBD)		Natural air	
9.	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
10.	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
11.	One minute power frequency voltage withstand	KV (RMS)	2.5	
12.	Continuous current rating at 50°C design ambient air temperature	A	[As per project Requirement]	
13.	Material a) Bus bar b) Enclosure		a) [Aluminum] b) [Aluminum alloy/MS]	
14.	One second short circuit withstand rating	KA (RMS)	50	
15.	Momentary short circuit withstand current	KA (Peak)	105	
16.	Bus bar Support		[FRP/ SMC]	
17.	Degree of protection		IP 52 for indoor IP W55 for outdoor	
18.	Earthing Conductor Material		GS	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
19.	Heating		Thermostat controlled space heater	
20.	Fittings of silica gel breather and drain plug		Required	
21.	Finish of Bus Enclosure		a) Inside: Matt Black b) Outside [RAL 5012]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E6

TECHNICAL SPECIFICATION FOR 220V DC SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E6**1.0 220 V DC SYSTEM****1.1 General**

This specification is intended to cover the *[design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of 220V DC system with its all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS- 266	:	Specification for Sulfuric Acid
IS- 1069	:	Specification for Water for Storage battery
IS- 1146	:	Specification for rubber and Plastic Containers for Lead Acid Storage Batteries
IS-1652-1991	:	Stationary Cells and Batteries, lead acid type (with Plante positive plates) – Specification
IS- 3116	:	Specification for Sealing Compound For Lead Acid Batteries
IS- 8320	:	General requirements and methods of tests for lead acid storage batteries.
IS- 6071	:	Specification for synthetic separators of lead acid storage batteries.
IS-10918-1984	:	Specification For Vented Type Nickel-Cadmium Batteries.
IS-14782-2000	:	Code of Practice for maintenance and testing of large Lead Acid Batteries in Generating Station and Substation.
ANSI-C-	:	Guide for surge withstand capability test.

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37.90a		
IEC - 60623	:	Secondary Cells and Batteries Containing Other Non-Acid Electrolytes – Vented Nickel- Cadmium Prismatic Rechargeable Single Cells.
IEEE-1115-2000	:	Recommended Practice For Sizing Nickel-Cadmium Battery For Stationary Application.
IEEE-485-1997	:	Recommended Practice For Lead Acid Battery For Stationary Application.
IEEE-946-1992	:	Recommended Practice For The Design Of DC Auxiliary Power Systems For Generating Station.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IS:5	:	Colours for ready mix paints.
IS : 694	:	PVC Insulated Cable for working voltages upto and including 1100V
IS : 1248	:	Specification for Direct acting indicating analogue electrical measuring instruments.
IS:13947 Pt-1	:	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS : 13947	:	Specification for low voltage switch gear and control gear
IS : 3231	:	Electrical relays for power system protection.
IS : 3842	:	Application guide for Electrical relays for AC System
IS : 3895	:	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	:	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	:	Code of practice for phosphating of Iron and Steel
IS:6619	:	Safety Code for Semi-conductor Rectifier Equipment.
IS:6875	:	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 VAC or 1200VDC

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IS : 9000	:	Basic environmental testing procedures for electronic and electrical items.
IS:13703	:	Low voltage fuses for voltages not exceeding 1000 V AC, 1500VDC.
EEUA-45D	:	Performance requirements for electrical Alarm Annunciation system

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity (IE) Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) 220 V DC Systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The system shall be suitable for operation in a highly polluted environment.
- b) The permissible voltage variation for 220V battery shall be from -15% to +10%.
- c) The battery shall be of storage type [Lead Acid Plante Positive Plate/Ni-Cd] Type. The Battery shall be of high discharge performance type. The plates shall be designed for maximum durability during all service conditions including high rate of discharge & rapid fluctuation of load.
- d) While estimating the battery size, temperature correction factor [based on lowest expected temperature 5 Deg C], margin on capacity [10%] and aging factor [1.0 for Lead Acid Plante and 1.2 for Ni-Cd] shall be considered.
- e) Cell Voltages for Lead Acid batteries:

i.	Nominal Discharge Voltage/cell	2.0 V
ii.	Float Voltage/cell	2.2 V
iii.	Boost Voltage/cell	2.7 V
iv.	Capacity for ten(10) hour rate at 27°C any time during the entire duty	1.85 V/Cell

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	cycle	
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f) Cell Voltages for Ni-Cd Batteries

i.	Nominal Discharge Voltage/cell	1.2 V
ii.	Float Voltage/cell	1.42 V
iii.	Boost Voltage/cell	1.7 V
iv.	Capacity for five(5) hour rate at 27°C any time during the entire duty cycle	1.14 V/ Cell

- g) 2x100% sets, 220V of either Lead-Acid Plante Type or Nickel-Cadmium battery banks with 2 x100% float cum boost charger catering to 100% of unit as well as station loads shall be provided.
- h) Permissible voltage variation for 220V battery shall be from 190V to 240V.
- i) The Ampere-Hour capacity of DC Storage Battery shall be based on [Three] hours' continuous DC supply at rated voltage to essential auxiliaries.
- j) Batteries shall be suitable for being boost charged to fully charged condition from fully discharged condition within 10 hours.
- k) Lead acid batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.2V/cell.
- l) Ni-Cd batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42V/cell.
- m) The float-cum-boost charger shall be rated to cater to the following:
- Trickle charging current of the battery
 - Equalizing charging of the Battery
 - Boost charging of the Battery
 - Continuous load on the DC system
 - 25% spare capacity over above loads.

1.4 Specific Requirements

1.4.1 Constructional requirements of battery

a) Containers

Container shall be made of transparent glass for lead acid and polypropylene for Ni-Cd batteries. It shall be robust, heat resistance, leak

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proof, non-absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container. The marking for the electrolyte level should be for the upper and lower limits. Container shall be closed / sealed lid type.

The pole sealing arrangement should be such that no acid particle gets entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

b) Vent Plugs

Vent plug shall be provided in each cell. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the spring type hydrometer can be inserted into the vent to take electrolyte sample.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuation of load. The construction of plates shall conform to latest revisions of standards as applicable for type of battery.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative posts shall be clearly marked.

The plante positive plates shall be supported from the ledges of the SAN container. They should not be supported at the bottom of container. Sufficient space shall allowed to allow the creepage of the plates.

d) Sediment Space

Sufficient sediment space shall be provided so that the cells shall not have to be cleaned out during normal life and prevent shorts within the cells.

e) Cell Insulators

Each cell shall be separately supported on PVC / Porcelain / Hard rubber insulators fixed on the racks with adequate clearances between adjacent cells. Minimum distance between adjacent cell shall be more than the bulge allowed for two cells in accordance with relevant IS standard.

f) Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS: 266 and distilled water conforming to IS: 1069 for lead

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acid batteries and battery grade potassium hydroxide for Ni-Cd batteries. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately in a separate non-returnable container. 10% extra electrolyte shall be furnished to cover spillage in transit or during erection.

g) Connectors and Fasteners

Lead or Lead coated copper connectors (For Lead acid Plante Type batteries) and Nickel coated copper connectors (for Ni-Cd batteries) shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated/Nickel coated to prevent corrosion. The thickness of lead coating of connectors should not be less than 0.025 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulated shrouds. End take-off connections from positive and negative poles of battery shall be made by single core cables having stranded aluminum conductors and XLPE insulation. Necessary supports and lugs for termination of these cables on battery shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 30 minutes discharge current of the respective battery and through fault short circuit current which the battery can produce and withstand for the period declared. Suitable number of inter rack connectors shall be supplied by the bidder to suit the battery room layout during the detail engineering.

h) Battery Racks

Steel racks with anti-corrosive epoxy paint for all the battery shall be provided. They shall be free standing type mounted on porcelain / hard rubber / PVC pads insulators. Battery shall be located in the single tier arrangement. However battery having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The battery rack and support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

i) Manufacturer's Identification Systems

The following information shall be indelibly marked on outside of each cell:

- i. Manufacturer's name and trade marks
- ii. Country and year of manufacture
- iii. Manufacturer type of designation
- iv. AH capacity at 10 hour discharge rate
- v. Serial number

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1.4.2 Constructional Requirements of battery charger

- a) The Charger shall be indoor, floor mounted, self supporting sheet metal enclosed cubicle type. All necessary base frames, anchor bolts and hardware shall be supplied. The charger shall be fabricated using cold rolled sheet steel shall not less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied. The lugs for cables shall be made of electrolytic copper with tin coat. The chargers shall be tropicalised and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The chargers shall have hinged double leaf doors provided on front / or backside for adequate access to the charger internals. All the charger cubicle doors shall be properly earthed. The degree of protection of charger enclosure shall be at least IP-42.
- b) All indicating instruments, control and selector switches and indicating lamps shall be mounted on the front side of the charger.
- c) Electronic equipments shall be of modular design consisting of plug in modules in standard 19 inches metallic racks with metallic card guides. The cards should be provided with proper handles. Card to card wiring should be preferably through a motherboard. Unplanned jumpering and track modifications are not permitted and track modifications are not permitted. Mechanical interlocks to prevent wrong insertion of cards should be provided. Each card shall have its junction and test points identified. Maintenance aids such as extension printed wiring boards and jumper leads shall be provided.
- d) The layout of charger equipment shall be such that their heat losses do not give rise to excessive temperature within the charger panel surface. Location of the electronic modules shall be such that temperature rises of the location, in no case, shall exceed 10°C over ambient air temperature outside the charger.
- e) Printed Circuit Boards (PCB)
PCB shall be made of glass epoxy of 1.6 mm thick, fire resistant, bonded with 99.8% pure copper foil, free of wrinkles, blisters, scratches and pinholes. The contact surface of the edge connectors of the PCBs shall be plated with hard gold to a minimum thickness of 5 microns. Component identification shall be printed on PCB by silk screen method. All PCBs shall be tropicalised and masked.
- f) Contactors

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All battery chargers shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. The operating coil shall be rated for 415 Volts AC.

g) Thermal Overload Relay

A thermal overload relay incorporating a distinct single phase protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

h) Rectifier-Transformer and Chokes

The rectifier-transformer and chokes shall be dry and air cooled (AN) type. The rating of the rectifier transformers and chokes shall correspond to the rating of the associated rectifier assembly. The rectifier-transformers and chokes shall have class-B insulation with temperature rise limited to class A insulation value.

i) Rectifier Assembly

The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective charger. The rectifier cells shall be provided with their own heat dissipation arrangement with natural air cooling. The rectifier shall utilize diodes / thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink shall not be permitted to exceed 85 °C absolute duly considering the maximum charger panel inside temperature. Calculations to show what maximum junction temperature shall be and what the heat sink temperature shall be when operating at 200% and 100% load current continuously duly considering the maximum surrounding air temperature of 50°C outside the panel have to be submitted. Necessary surge protection devices and rectifier type fast acting fuses shall be provided in each arm of the rectifier connections.

1.4.3 System Concept for 220 V DC system

- a) First float cum boost charger shall be normally ON in float mode, supplying the D.C. load and at the same time trickle charging the battery and shall (a) provide occasional equalizing charge (b) boost charge the battery up to 2.7/1.7 Volts per cell as required.
- b) The characteristics shall be such that if load is high and exceeds the charger capacity, the excess load shall be supplied by the battery.
- c) The second float-cum-boost charger shall be normally in stand-by (auto float/charge) mode and shall come into the circuit automatically (a) to take over the functions of first float cum boost charger in case of its failure (b) to provide occasional equalizing charge as required, (c) boosting charge the battery up to 2.7/1.7 Volts per cell.

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- d) The float-cum-boost charger shall also have provision for float, equalizing, and boost charging the battery through manual selection. On failure of station A.C. supply, float-cum-boost charger shall go out of service and battery shall take over to supply emergency loads.

1.4.4 Operational requirements of charger

- a) The float-cum-boost charger shall be sized to restore the fully discharged battery to full charge condition in ten (10) hours with 10% margin over maximum charging rate and also to operate as a float charger.
- b) The batteries & chargers shall be so designed that the maximum fault level on DC DB is limited to 15KA (Indicative only; the actual value shall be decided by the contractor after substantiating the same by calculation.)
- c) The battery shall be trickle charged at 2.15 to 2.25 V per cell and 1.4 to 1.42V per cell for lead acid and Ni-Cd battery respectively. All chargers shall also be capable of boost charging the associated battery at 2.0 to 2.7 V per cell for lead acid and 1.53 to 1.7V for Ni Cd at the desired rate. The chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50 °C.
- d) Necessary interlocks shall also be provided to avoid accidental boost mode operation when loads are connected to the bus.
- e) The battery chargers as well as their automatic regulators shall be of static type. Battery chargers shall be capable of continuous operation at the respective rated load in trickle mode i.e. trickle charging the associated lead acid battery/Ni-Cd battery while supplying the DC loads.
- f) Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle / float or Boost charging.
- g) All battery chargers shall be provided with facility both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage / current control, whether automatic or manual. Means shall be provided to avoid current / voltage surges of harmful magnitude/ nature which may arise during changeover from Auto to Manual mode or vice versa under normal operating condition.
- h) Soft start feature shall be provided to build up the voltage to the set value slowly within fifteen (15) seconds. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the charger nor shall it cause blowing of

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any of the charger fuses. The charger shall not trip on overload or external short circuit. After clearance of fault, the charger voltage shall build up automatically when working in automatic mode.

- i) When on automatic control mode, during trickle / float charging, the charger output voltage shall remain within (\pm) 1% of the set value for AC input voltage variation of (\pm) 10%, frequency variation of (+) 3 / (-) 5%, a combined voltage and frequency variation of 10% (absolute sum) and a continuous DC load variation from zero to full load. Uniform and step less adjustment of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire trickle / float charging output range specified. Step less adjustment of the load limiter setting shall be possible from 80% to 100% of the rated output current for trickle / float charging mode.
- j) During boost charging, the battery chargers shall operate on constant current mode (when automatic voltage regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50% to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be vernier type.
- k) Energizing the chargers with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere shall be less than fifteen (15) seconds.
- l) Momentary output voltage of the charger, with the battery connected shall be within 94% to 106% of the voltage setting during sudden load change from 100% to 20% of full load or vice versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above mentioned change.
- m) The charger manufacturer may offer an arrangement in which the voltage setting device for trickle/ float charging mode is also used as output voltage limit setting device for Boost charging mode, and the load limiter of the trickle / float charging mode is also used as Boost charging current setting device.
- n) Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.

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1.4.5 Auxiliary Equipment

- a) DC Voltmeter, DC ammeter and AC voltmeter in 96 mm square shall be provided for each charger. The instruments shall be 240 scale, antiglare glass, flush mounted type, dust proof and moisture resistant. The instrument shall have easily accessible means from zero adjustments. The instruments shall be of 1.5 accuracy class.
- b) In addition to above, following metering provision shall be given for remote metering / recording at PLC/DCS
 - i. Battery Voltage
 - ii. DC voltage of float & Boost charger
 - iii. DC current of float & Boost charger
 - iv. DC load voltage
 - v. DC load current
 - vi. DC Voltage and Current at FCBC
 - vii. Centre Zero Ammeter with Shunt to read Discharge/Charge current
 - viii. Ammeter for Battery Trickle Charge current
 - ix. DC Bus Voltmeter indicating - +ve to Earth, -ve to Earth and +ve to -ve with Selector switch.

The following indications shall be provided

- i. AC Supply – R,Y,B Healthy
- ii. DC supply – Available
- iii. Charger in Float Mode
- iv. Charger in Equalising mode
- v. Charger in Boost mode
- vi. Charger tripped on fault
- vii. D.C Earth fault sensing & alarm

Suitable soft link to be provided for interfacing with DDCMIS.

c) Air Break Switches

All chargers shall have AC input and DC output switches of air break, single throw, load break and fault make type. The contacts of the switches shall open and close with a snap action. Switches shall be rated for 120% of maximum continuous load. 'ON' and 'OFF' position of the switch shall be clearly indicated.

d) Control and Selector Switches

Control and selector switches shall be rotary, stay put type with escutcheon plates showing the functions and positions. The switches shall be of sturdy construction and suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred. The contact ratings shall be at least the following:

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- i. Make and carry continuously - 10 Amps
- ii. Breaking current at 220V DC - 0.5 Amp (inductive)
- iii. Breaking current at 240V AC - 5 Amp. at 0.3 p.f.

e) Fuses

Fuses shall be of HRC cartridge fuse link type. Fuses shall be mounted on fuse carriers which are mounted on fuse bases. Wherever it is not possible to mount fuses on fuse carriers, fuses shall be directly mounted on plug in type bases. In such cases one insulated fuse pulling handle shall be supplied for each charger. Kick-off fuses (trip fuses) with alarm contacts shall be provided for all DC fuses.

f) Indicating Lamps

Three (3) indicating lamps shall be provided to indicate AC supply availability. The indicating lamp shall be of panel mounting, LEDs and capable of clear status indication under the normal room illumination. The lamps shall be replaceable from front. The lamp covers shall be preferably screwed type, unbreakable and moulded from heat resistant material.

g) Blocking Diode

Blocking diode shall be provided in the output circuit of each charger to prevent current flow from the Battery into the charger.

h) Annunciation System

Following annunciation shall be provided for local and remote indications in all chargers(List is indicative only)

- i. AC supply failure
- ii. Rectifier fuse failure
- iii. Surge circuit fuse failure
- iv. Filter capacitor fuse failure
- v. Load limiter operated
- vi. Charger fail / trip
- vii. Battery on Boost
- viii. Battery on Trickle
- ix. DC output fuse failure
- x. Positive grounded
- xi. Negative grounded
- xii. Battery fully discharged
- xiii. AC input under voltage
- xiv. DC voltage low
- xv. DC voltage high
- xvi. DC system earth fault

The annunciation system shall have audio-visual arrangement and shall incorporate acknowledge, reset and test push buttons. On occurrence of fault, the corresponding window lights up and shall stay in lighted

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condition till the fault is cleared and the reset push button is pressed. At least 20% spare annunciation windows with accessories shall be provided.

i) Lamp / Space Heaters / Receptacles

The charger panels shall be provided with:

- i. Internal illumination lamp with door switch.
- ii. Space heater with thermostat control.
- iii. 3-pin 5A receptacle with plug.
- iv. Lamp, heater and receptacle circuits shall have individual switch fuse units/MCB.

1.4.6 Battery Accessories

Each battery shall be furnished complete with following:

- a) First charge of electrolyte plus 10% extra.
- b) Teak wood racks with 3 coats of anti-acid paints.
- c) Stand insulators 5% extra.
- d) Cell inter-connectors 5% extra and one extra end take-off.
- e) Lead-coated connection hardware 5% extra
- f) Cell numbering tag with fixing arrangements
- g) Insulated cable clamps with hardware
- h) Six (6) extra cell with all accessories but without acid
- i) In addition to the above each battery shall be furnished with a set of following accessories.
- j) One (1) Interconnector bolt wrench
- k) One (1) Hydrometer syringe
- l) One (1) Thermometer with specific gravity correction scale.
- m) One (1) Cell testing voltmeter with leads.
- n) One (1) Pocket thermometer
- o) One (1) set of Acid resisting funnels
- p) One (1) set of Acid resisting jugs of adequate capacity
- q) One (1) set of Rubber aprons
- r) One (1) set of Rubber gloves
- s) PVC spill trays under the battery cells
- t) Spanner for cells

Catalogues and Instruction manuals of battery and battery charger to be furnished.

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1.4.7 Painting

- a) All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.
- b) After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality lead oxide primer and stoved after each coat.
- c) The equipment shall be finished in Siemens Gray RAL: 9002 color with two coats of epoxy based powder coated paint except end covers and RAL 5012 for end covers. The coating shall be done electro statically followed by stoving.
- d) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.8 Installation

- a) The battery room floor shall be acid resistant type and walls shall have acid resistant tiles up to a suitable height. Alternatively acid resistant paints are also acceptable. Adequate ventilation shall be provided in the battery room for the removal of hydrogen.
- b) The Battery charger along with D.C. distribution board shall be located in separate rooms.
- c) After erection and connection of the Battery Charger, the contractor shall complete the charging discharging cycles recommended by the manufacturer. The contractor shall rig up a suitable discharge resistor for this purpose.
- d) Connection from Battery terminals shall be made by means of cables. Lead coated terminal connector shall be furnished for this purpose.

1.5 Tests

1) Type Test

For each type of Battery and battery charger, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

All Battery, Battery chargers, Inverters and its components thereof shall be subject to shop tests as per relevant IS/IEC standards. The tests on Battery chargers shall include but not limited to the following:

- a) Voltage regulation check from 0 to 100% loads with $\pm 10\%$ input voltage variation.
- b) Ripple content measurement.
- c) D.C short circuit test to prove ability of current limit.
- d) Measurements of transient overshoot/undershoot during switching ON/load throw-off.
- e) Current limiter operation.
- f) Special tests for electrical equipment, when specified in relevant Indian / International standard shall be carried out on at least one item of each rating.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports. Drawings, Data & Manuals:

1.6

Drawings, Data & Manuals

1. Following drawings/ data and Manuals to be submitted for approval:

- a) [Dimensional battery layout diagram and plan & section.
- b) Connection details of take-off terminals.
- c) Dimensional general arrangement drawings of battery charger clearly showing device dispositions, cable entry, space requirement, etc.

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- d) Sectional views of battery charger.
- e) Charger foundation plan and loading.
- f) Charger schematics and wiring diagrams.
- g) Test reports
- h) Detailed bill of materials
- i) Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.
- j) Instruction manuals of battery and battery Charger. The manual shall clearly indicate method of installation, check-ups, and tests to be carried out before commissioning of the equipment.
- k) Bidders shall note that the drawings, data and manuals listed herein are minimum requirements only. The Bidders shall ensure that other necessary write-ups, curves and information required to fully describe the equipment are submitted with their bids].

1.7 Rating and Requirement

S.No	Technical Particulars	Unit	Parameters	Remarks
1.0	General			
1.1	Bidder's Name			
1.2	Make			
1.3	Application		[For Main plant/BOP]	
2.0	Battery			
2.1	Make and country	:	[By bidder]	
2.2	Type	:	Lead acid(Plante)/Ni Cd	
2.3	Reference standard		As specified in specification	
2.4	Rated system voltage	: (Volts)	220V DC	
2.5	Rated capacity for one hour discharge at 27°C	: (Ah)	[As per project specific]	
2.6	Rated capacity for 10 hour discharge rate at 27°C	: (Ah)	[As per project specific]	
2.7	Nominal voltage per cell	: (V)	2.2V /1.42V	
2.8	End cell voltage	: (V)	1.85/1.14V	
2.9	Number of cells per battery	:	Based on type of battery.	
2.10	Short circuit current	: (kA)	[By bidder]	
2.11	Mounting type	:	[By bidder]	

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S.No	Technical Particulars	Unit	Parameters	Remarks
2.12	AH efficiency at rated load	: (%)	[By bidder]	
2.13	Watt hour efficiency	: (%)	[By bidder]	
3.0	Constructional details		[By bidder]	
3.1	Container			
a	Material			
b	Thickness	Mm		
3.2	Separator			
a	Type			
b	Material			
c	Thickness	Mm		
3.3	Electrolyte			
3.4	Quantity for first filling plus 10% extra			
3.5	Specific gravity at twenty seven (27) degree Centigrade			
a	With all cells fully charged			
b	At the end of discharge			
3.6	Method of supporting elements		[By bidder]	
a	Edges of plates and Inner surfaces of container	Mm		
b	Bottom of negative plates	Mm		
c	Top of plates	Mm		
d	Sediment space	Mm		
3.7	Weather explosion-proof cent plugs are provided		[By bidder]	
3.8	Distance between centre's of cells when erected	mm	[By bidder]	
3.9	Expected life span of battery	Year	[By bidder]	
3.10	Proposed Layout (attach layout)		[By bidder]	
4.0	Battery Charger			
4.1	Number of rectifiers	:	[By bidder]	
4.2	Reference standard	:		
4.3	Make and country			
4.4	Type	:		

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S.No	Technical Particulars	Unit	Parameters	Remarks
4.5	Rectifiers with thyristors Y/N	:	[By bidder]	
4.6	Rated input AC voltage	: (V)	415V, 3ph, 4 wire	
4.7	Frequency	: (Hz)	50	
4.8	Output DC current	: (A)	[By bidder]	
4.9	Rectifier efficiency	: (%)	[By bidder]	
4.10	DC voltage setting adjustment of AVR for float charging		[By bidder]	
4.11	Boost mode:		[By bidder]	
a	Starting rate	: (V)		
b	Finishing rate	: (V)		
4.12	Protection class of cubicles	:		
4.13	Residual ripple	: (%)	[By bidder]	
4.14	Current limiting feather provided	: (Yes/No)	[By bidder]	
4.15	Soft starting feather provided	: (Yes/No)	[By bidder]	
4.17	Voltage and current setter in different mode provided	: (Yes/No)	[By bidder]	
4.18	Type of cooling	:	Natural	
4.19	Paint shade: Indoor and outdoor		[RAL 5012]	
5.0	Constructional details		[By bidder]	
5.1	List of major accessories			
5.2	Diode			
a	Make			
b	Type			
c	Rating			
d	Voltage	V		
e	Current	A		
5.3	Rectifier Transformer			
a	Make			
b	Rating	kVA		
c	Connection			
	Primary Winding			
	Secondary Winding			

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S.No	Technical Particulars	Unit	Parameters	Remarks
d	Voltage			
	Primary Winding	V		
	Secondary Winding	V		
e	Percentage of tap provided			
	Primary Winding	%		
	Secondary Winding	%		
5.4	Control/ Selector switch			
a	Make			
b	Type designation			
c	Voltage Grade	V		
d	Current rating	A		
e	Make and carry			
f	Brake			
g	Spring return or stay out			
h	Type of handle			
i	No. of positions			
j	No. of poles/ ways			
k	Angular Movement			
m	Special features if any			
5.5	Indicating Lamp			
a	Make			
b	Type			
c	Voltage	V		
d	Series resistor value	Ohm		
6	Thickness of battery charger panel sheet steel;	Mm		
5.6	Weight & dimensions		[By bidder]	
a	Length	Mm		
b	Depth	Mm		
c	Height	Mm		
d	Weight	Kg		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E7

TECHNICAL SPECIFICATION FOR HV CABLES

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E7

1.0 HV CABLEs

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of HV cables complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part II)	:	XLPE insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques
IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the

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		cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All HV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The HV power cables shall be 6600V unearthed grade, single/multi core stranded Aluminum conductor, extruded XLPE insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-2). These cables shall conform to IS 7098 (Part II).
- d) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- e) HV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- f) HV cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)
 - v. Installation conditions.
 - vi. Voltage drop under normal running and starting condition
 - vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
 - viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
 - ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.

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1.4 Specific Requirements

1.4.1 Type of Cable

- a) HV cables shall be 6600V unearthed grade, heavy duty, stranded aluminium conductor, XLPE insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-2) cables conforming to IS: 7098 part II.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum to form compact conductor having a resistance within the limits specified.

1.4.3 Conductor Shield

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be provided over the conductor by applying non metallic semi conducting tape or by extrusion of semi conducting tape or by extrusion of semi-conducting compound or a combination of the two. The semi conducting polymer shall be cross linked for XLPE cables.

1.4.4 Insulation

The insulation of the HV cables shall be XLPE type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

1.4.5 Insulation Shield

A non magnetic semi conducting shield shall be put over the insulation to confine electrical field to the insulation. The XLPE cable insulation shield shall be strippable.

The metallic layer of the insulation shield shall be grounded at least at one location in the cable's run. In the case of single conductor cable, care should be taken with regard to ampacity when grounding at more than one point.

For all the cables having insulation shield, it shall have some form of stress relief measure at every splice at termination. This can be stress cones, moulded devices, heat shrink or cold shrink kits. All kits must be suitable for the voltage class and cable size.

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1.4.6 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.7 Armour

HV cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.8 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.9 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than 500m or as per required length.

1.4.10 Identification of cores:

HV power cables shall be identified by color code.

1.4.11 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers

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shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.

b) Workmanship shall be neat, clean and of the highest grade.

c) Special Properties:

All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:

- i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
- ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
- iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
- iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
- v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
- vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
- vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.12 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.13 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]
- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.

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f. ISI marks

g. Nominal cross sectional area of the conductor & no of cores

h. Sequential marking

i. Owner's identification mark]

1.4.14 Fire Proof sealing system

i) General

- a) Fire proof sealing system shall consist of Fire-stops/fire-seals for sealing of cable/cable tray and conduit/pipe penetrations, both horizontal and vertical, through brick or RCC walls/floors, to prevent the spread of fire from one area, which is separated from others by fire-resistant barriers.
- b) 'Fire-breaks' provided on long runs of cable racks/trays to prevent the propagation of fire along the cable rack, within a single fire-area or fire- zone.
- c) The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop/fire-break.
- d) The FPS system shall comply in all respects with the requirements of the codes and standards listed below

IEEE-634 ASTM-E-814

ANSI-IEEE-383 IEC-331 IEC-332

ii) Fire stop/ seal

The FPS system adopted for cables or cable trays penetrating through walls and floor constitute a openings, or cables passing through embedded conduits / pipes / pipe- sleeves, fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

iii) Fire Break

The fire proofing system, other than fire-stops, adopted to retard flame propagation long runs of horizontal or vertical cable trays in the same fire zone or area, in an event of a fire, shall constitute a 'fire-break' and shall be provided by applying a suitable fire –resistance coating on cables and cable trays for the required length, with or without a fire resistant panel, at the point of the fire break to obtain the fire-rating specified.

iv) Application of fire proof sealing system

Fire stops shall be provided for cable penetration openings listed below

The passage of cables/cable trays pipe sleeves/embedded conduits through walls / floors.

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Vertical raceways, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

Cable entry through openings in floor slabs below HT/LT switchgear, MCCs, various Control and relay panels and other bottom entry panels, shall be effectively sealed by fire stop

Location of fire breaks

Firebreaks shall be provided on both cable rack and trenches at all cable tray Intersections and tee-offs.

On linear runs of cable trays between fire stops or fire breaks, fire breaks shall be provided at intervals of 15 metres on horizontal cable runs and 5 m on vertical cable runs.

Fire breaks in linear runs of cable trenches between intersections and tee-offs shall be provided at intervals of 30 metres.

Bidder shall furnish the test certificates for the fire stops and fire breaks after award of contract for Owner/Owner's Representative review. If the certificates are not satisfactory all the tests shall be conducted free of cost. The offered system i.e. fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Owner / Owner's Representative.

v) Test on fire stops

The fire stops shall be subjected to the following type tests:

- a. Fire Rating Test
- b. Hose Stream Test

Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

Preconditioning of fire stop test specimens before conducting the fire rating and hose stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the fire rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable

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penetration fire stop, with a maximum temperature limit on the unexposed surface of 200°C.

Tests on fire breaks

Firebreaks shall undergo the following tests as per ANSI-IEEE-383:

- Ampacity test
- Flame test

1.5 Tests

1.5.1 Type Test

For each type & rating of HV cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 H.V. Power cable, 6600V unearthed grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		6.6 V	
2.	Voltage Grade		6.6/6.6kV Unearthed	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE cables		90°C	
5.	Maximum conductor temperature for		250°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE cables			
6.	Conductor		Aluminum	
7.	Insulation		XLPE	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		Armoured	
11.	System Grounding		Resistance Grounded	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		40 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E8
TECHNICAL SPECIFICATION FOR LV CABLES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E8

1.0 LV CABLES

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV cables for power & control applications complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS:1554(Part I)	:	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100V
IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part I)	:	XLPE insulated PVC sheathed cables for working voltage up to 1.1kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques

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IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All LV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The LV power cables shall be 1100V grade, single/multi core stranded Aluminum conductor, extruded XLPE/PVC insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1). These cables shall conform to IS 7098 (Part I) for XLPE and 1554(part 1) for PVC insulation.
- d) The control cables shall be 1100 V grade, multi core, stranded annealed high conductivity copper with extruded PVC insulated inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1).
- e) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- f) The continuous and short time current carrying capacity of PVC insulated cables shall be based on maximum operating temperature of 70°C and 160°C respectively.
- g) LV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- h) Power cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)

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- v. Installation conditions.
- vi. Voltage drop under normal running and starting condition
- vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
- viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
- ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.
- x. The minimum size of cables to be used shall be as follow :
 - Aluminium conductor : 6 Sq. mm.
 - Copper conductor : 2.5 Sq. mm

1.4 Specific Requirements

1.4.1 Type of Cable

- a) LV power cables shall be 1100V grade, heavy duty, stranded aluminium conductor, XLPE/ PVC insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS: 1554(Part 1) for PVC insulation and IS 7098(Part 1) for XLPE insulation.
- b) Control Cables shall be 1100 V grade, heavy duty with annealed high conductivity stranded copper conductor, PVC insulated, FRLS PVC inner sheathed, armoured and FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS : 1554.
- c) LV power cables of size above 35 sq. mm may be provided with XLPE insulation. Bidder shall clearly indicate the type of insulation provided in the technical bid.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum for LV Power cables and Copper for control cables to form compact conductor having a resistance within the limits specified. All the cables of size 25mm² and above shall have sector shaped conductors.

1.4.3 Insulation

The insulation of the LV power and control cables shall be [XLPE/PVC] type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

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1.4.4 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.5 Armour

LV power and control cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.6 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.7 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than the following:

- a) Power cables: 500m
- b) Control cables: 1000m

1.4.8 Identification of cores and spares:

LV power cables shall be identified by color code. However LV control cables shall be identified by the number of its cores.

[Multi-core control cables shall have 20% spare core, minimum one spare.]

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1.4.9 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.
- b) Workmanship shall be neat, clean and of the highest grade.
- c) Special Properties:
All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:
 - i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
 - ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
 - iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
 - iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
 - v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
 - vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
 - vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.10 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.11 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]

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- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.
- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.5 Tests

1.5.1 Type Test

For each type & rating of LV power and control cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 L.V. Power and control cables, 1100 V grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		415 V	
2.	Voltage Grade		1.1 kV	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE/PVC cables		For XLPE: 90°C For PVC: 70°C	
5.	Maximum conductor temperature for		For XLPE: 250°C For PVC: 160°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE/PVC cables			
6.	Conductor		For power cable: Aluminum	
			For Control Cable: Copper	
7.	Insulation		For power cable: XLPE/PVC	
			For Control Cable: PVC	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		For power cable: Armoured	
			For Control Cable: Armoured	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
11.	System Grounding		415 V system is solidly grounded.	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		50 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E9

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E9

1.0 ILLUMINATION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Illumination System complete with luminaries and all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS 1913	:	Electrical lighting fittings- General and safety requirements
IS 2418 - Part I	:	Tubular fluorescent Lamp
IS 3480	:	Flexible steel conduits for electrical wiring
IS 3646 (Part I to III)	:	Code of Practice For Interior Illumination
IS 4012	:	Dust proof electric lighting fittings
IS4013	:	Flame proof enclosure
IS 6665	:	Code of practice for industrial lighting
IS 5077	:	Decorative light fittings
IS 9537 - Part II	:	Rigid steel conduits for electrical installations

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IS 9583	:	Emergency lighting units
IS 9900	:	High pressure mercury vapor lamp
IS 9974	:	High pressure sodium vapor lamp
IS 10322	:	Luminaries for street lighting
CBIP Manual	:	Substation Equipment, Illumination and Layouts
IES (Illuminating Engineering Society of North America)	:	Application and Reference Volume
IEC 60598	:	Luminaries
CEA	:	CEA regulations and standard technical specification.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All illumination systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The illumination systems shall be suitable for operation in a highly polluted environment.
- b. Lighting fixtures shall be suited for the following range of frequency and voltage variations:
 - i. Voltage Variation : $\pm 10\%$
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

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- c. All emergency DC lighting systems shall be suited for voltage variation from -15% to + 10% of rated voltage.
- d. The design of the lighting systems shall be such that it shall ensure average lux levels specified for different areas.
- e. The illumination system shall comprise of the following:
 - i. Normal AC lighting
 - ii. Normal cum emergency lighting system
 - iii. 220V DC Emergency lighting system
 - iv. Maintenance 24V AC lighting system
 - v. Portable emergency lights with self contained battery packs.

1.4 Specific Requirements

1.4.1 Scope of work

The scope of work shall include design, preparation of Lighting design and manufacture, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with Lighting system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Switchgear room and cable gallery.
- iv) All roads within battery limit.
- v) Perimeter and boundary illumination of the above premises.
- vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room and cable gallery.
- v) FOPH area.
- vi) Transfer towers & Conveyor galleries.
- vii) All roads within battery limit.
- viii) Perimeter and boundary illumination of the above premises.

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- ix) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- c) Balance of plant Area:
 - i) Lighting system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- e) AHP Area:
 - i) Switchgear rooms.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard control room
 - ii) GIS building (if applicable)
 - iii) Transformer area
 - iv) All roads within battery limit.
 - v) Perimeter and boundary illumination of the above premises.
 - vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

1.4.2 Illumination System Description

The plant illumination system shall comprise of the following categories:

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a. Normal AC lighting

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply from the normal lighting distribution boards (LDB). All the lighting fixtures connected to this system shall be available as long as the 415V station / unit auxiliary service supply is available.

b. Normal cum emergency lighting system

Certain lighting fixtures considered essential shall be connected to this system. In this system the lighting circuits shall be fed from lighting distribution board connected to 415V Normal cum Emergency Switchgear. The lighting fixtures connected to this system shall be available whenever normal supply is available in the plant and also whenever DG set supplies the power to 415V Normal emergency switchgear.

These lighting fixtures will go off for a few seconds when normal supply fails but will be automatically restored when the emergency AC bus is re-energized by automatic transfer to standby DG supply.

[20% of the total fittings shall be fed from Emergency lighting for areas such as Switchgear room and control rooms etc.]

c. Emergency 220 V D.C. Lighting

The Emergency DC Lighting System shall be located strategically in critical operating areas and at emergency exits. Emergency DC lighting shall also be provided in the Control rooms, Switchgear/ MCC rooms and other strategically important areas. These fixtures shall be fed from respective Emergency DC Lighting Panels. The Emergency DC Lighting Panels (DC ELLP) shall be fed from 220V DC Distribution Boards (DCDB).

These lights shall remain normally OFF but on failure of AC supply these lights shall be automatically ON. Tube lights with Electronic choke suitable for 230 V, AC / DC operation or other Energy Efficient Lamps may be used for DC emergency lighting.

d. Maintenance 24 V AC Lighting System

For lighting facilities comprising portable hand lamps and/or connection of portable hand tools etc., required during the routine maintenance work, 24V single phase 3 pin sockets with switches shall be provided at selected points in the areas listed below. Such sockets for routine maintenance shall be clearly identified by colour coding in order to distinguish them from the normal 240V power outlets. Necessary outlets shall be made on the inside walls of the building near equipments.

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- i. Boiler area: Near inspection manholes on the boiler platforms and near boiler drum at different levels on all four sides.
- ii. TG building: Near HP & LP heaters, turbine flash tank, blow down tank, near condenser water box and near bus duct termination of generator end.
- iii. ESP columns: Near inspection manholes
- iv. Near de-aerator.
- v. Cable galleries.

Any other areas considered necessary identified during detailed engineering.

e. Portable Emergency Lights

This system shall be provided by portable self-contained battery / automatic charger / inverter fed compact fluorescent lamps in isolated buildings / areas where station D.C. supply is not available. These portable emergency light units shall be switched on automatically on loss of normal AC supply. *[Battery packs for portable emergency lights shall be rated for minimum 3 hours duty and the battery shall be of Ni-Cd.]*

f. Exit lights

Emergency escape signs shall be provided at the exit doors, escape routes, intersection corridors, at different floor levels/directions, windowless rooms, toilets, firefighting equipment, lifts, control rooms, switchgear rooms and the areas considered necessary by bidder. *[9W CFL]* lamp shall be used for exit lamps.

The contractor shall design emergency exit lighting system based on plant layouts and install escape lights at suitable locations considering the various escape routes. Emergency exit lights will be fed from normal-cum-emergency lighting panel, wherever available, *[and will be with in-built battery (Ni-Cd) back up of 3 hours operation.]*

1.4.3

Illumination Calculation

- a. Standard Lumen method shall be adopted for interior and exterior lighting in order to determine the number of lighting fixtures for obtaining the desired average level of illumination.
- b. The coefficient of utilization shall be considered to take care of Lumen loss due to:

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- i. Effect of room dimensions.
 - ii. Absorption of light in luminaries.
 - iii. Absorption of light at various room surfaces i.e. ceiling wall etc.
 - iv. Floor cavity, ceiling cavity.
 - v. Mounting height.
- c. Moreover a maintenance factor shall also be considered to account for the fall of illumination due to aging, pollution like dust deposits etc.
 - d. Voltage drop at the fixture terminals from the MLDB shall [not exceed 3%]. Circuit loading of each lighting Panel shall be done in such a way that almost balanced loading in all the phases i.e. R, Y and B is achieved. At least two sub circuits shall be used for illumination of a particular area. Sub circuit loading of each lighting panel shall be restricted to 2000 Watts.
 - e. Design of lighting system shall be such that the average lux level as specified is achieved. The Bidder shall submit illumination calculation/layout for the purchaser's review.

1.4.4 Lighting Distribution System

- a. Separate lighting transformers shall be provided inside the lighting distribution boards located at required location. Lighting distribution system shall be distinct and separate from the LV main distribution. Lighting transformers shall be encapsulated cast resin dry type.
- b. AC lighting panels shall have 240V single-phase, 2 wire incomer controlled by earth leakage circuit breaker and number of single phase outgoing circuits controlled by MCBs. The lights connected to a circuit or few circuits shall be 'ON' automatically through photocell for outdoor lighting. Provision shall be made for switching 'ON' the rest of the lights. Lighting fixtures in indoor areas shall be controlled from the respective lighting panels
- c. Normal 240 V AC Lighting System
For this system, lighting points shall be supplied at 240 V AC through 415 V, 3-phase, 4-wire, 50 Hz, LDB. The supply shall be derived from 415 V, 3-phase, 4-wire, 50 Hz switchgear through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant. Different circuits shall be used from different source. The whole lighting network shall be balanced as far as possible.
- d. Normal/Emergency 240V AC System
For these systems, the distribution shall be by 415V, 3-phase, 4-wire, 50 Hz supply. This supply shall be derived from 415 V, 3-phase, 4-wire, 50

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Hz normal emergency switchgear for NE & lighting through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant.

e. Emergency 220 V DC Lighting System

The power supply shall be obtained from the nearest 220 V DC switchboard. DC lighting panel will have one (1) incomer controlled by double pole MCB, Outgoing circuits will be controlled by DP MCB. Upon failure of the normal-cum-emergency AC supply, emergency DC lighting fixtures will be made automatically ON. The change over in the reverse direction shall also be automatic.

f. Maintenance 24V AC Lighting System

24 V AC supply for maintenance purposes (for hand lamps and/or hand operated tools) shall be supplied from 24 V AC distribution panel, which receives 240 V power supply from 415 V/240V transformer modules of N/E switchgear. 24 V AC distribution panel consists of one incomer controlled by MCB, one 240/26.5 V dry type transformer of adequate rating and number of outgoing circuits controlled by MCB.

1.4.5 Illumination levels and choice of lighting fixtures

The area-wise distribution of average illumination levels and type of luminaries shall be as indicated below:

[Note: These are indicative only. However as per specific Existing project, Bidder may refer section I of this specification for exact details of type of fixtures.]

Table 2.0

Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
A - TURBINE GENERATOR BUILDING				
1.1	General (auxiliary equipment areas)	200	Industrial well glass fixture, dust & jet proof, die cast aluminium body, stove enamel finish, vitreous enamel reflector integral mounted control gear/industrial bulk head with integral mounted control gear.	1x70 W/ 1x150 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.2	Cable vault	100	Industrial type FTL with vitreous enamel reflector	Energy Efficient FTL
1.3	All switchgear room area (including off-site building control room)	250	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.4	TG Building operating floor	250	Industrial high bay with anodized aluminium reflector with all accessories including control gear	1x400 W Metal Halide lamp
1.5	Unit control room and Switchyard control room	400	Decorative recessed with wide angle mirror optic antiglare type	Energy Efficient FTL
1.6	Battery rooms	150	Corrosion-proof	Energy Efficient FTL
1.7	TG building ground, mezzanine floor and misc. floors	200	Industrial well glass with integral control gear	1x150 W/ 1x250W Metal Halide lamp
1.8	Air washer room and A/C plant room	200	Totally enclosed vapor proof with clear acrylic cover	Energy Efficient FTL
1.9	Unloading and maintenance bay	300	Industrial high bay with anodised aluminium reflector	250 W HPSV lamp (for mounting height > 9m)

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.10	Electrical laboratory, chemical laboratory etc. (air-conditioned)	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
B -	BOILER AREA			
1.1	Boiler area and platforms, ESP area and platforms	100	Dust proof / dust tight well glass fixture	70 W Metal Halide lamp
1.2	Feeder floor areas	150	Dust proof / dust tight increased safety well glass	70 W Metal Halide lamp
1.3	ESP control room	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
C -	VARIOUS OFF-SITE BUILDING			
1.1	Equipment room (pump house)	200	Industrial type with vitreous enamel reflector upto mounting height of 8 M	150 / 250 W HPSV lamp
1.2	Switchgear room	250	Industrial high bay for mounting heights above 8M	Energy Efficient FTL
1.3	Outside working areas	70	Flood light medium beam	250 W HPSV lamp
1.4	Stores	100	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.5	Fuel Oil Tank Farm	50	General Purpose flood light with weatherproof fixture	250 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.6	Fuel oil decanting pump house, Hydrogen storage area, Coal conveyor areas	150	Flame-proof well glass	1 x 70 W HPMV lamp
D -	GENERAL			
1.1	Corridors, walkways, staircase, etc.	100	Industrial type with vitreous enamel reflectors/channel mounted box type	Energy Efficient FTL/1 x 70 W HPMV lamp
1.2	Lockers, toilets, wash rooms, etc.	100	Channel mounted box type	Energy Efficient FTL
1.3	Elevator well	50	Industrial bulk head	1 x 100 W incandescent lamp
1.4	Building periphery lighting	50	Industrial well glass with integral mounted control gear/industrial bulk head with integral mounted control gear/flood light fittings with timer control	70 W HPSV lamp / 400 W HPSV lamp
1.5	Office Rooms	300	Decorative recessed type FTL	Energy Efficient FTL
1.6	Transformer yard and Switchyard	50 on equipment, 20 general	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
1.7	Street lighting	20	Street weatherproof fixture with timer control	150 / 250 W HPSV lamp
1.8	Parking area	70	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
E	DC LIGHT FITTINGS			

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.1	Control room	400	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp
1.2	Other areas	250	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp

1.4.6 Area wise distribution of Lighting system in plant

Area wise lighting distribution shall be as below:

Table: 3.0

Area/building	Percentage Distribution of Lighting		
	Normal	Normal & Emergency	220V DC
Turbine Generator Building (all the bays)	80%	20%	10%
Control rooms	80%	20%	10%
Boiler Area (Grade level & Platforms)	80%	20%	5%
Service building	90%	10%	5%
Various pump houses and electrical switchgear rooms such as AHP, CHP, FOPH switchgear room, etc.	90%	10%	5%
Electro static precipitator	90%	10%	5%
Switchyard and Transformer yard	80%	20%	5%

1.4.7 Lighting System Design

The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of

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lighting specified in following paragraph. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

a. Indoor Lighting

The recommended values of illumination level for various areas in the plant are indicated in the table above. Lighting layouts shall be designed such that the ratio of minimum to average illumination shall not be less than [0.6]. Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/buildings in the plant.

i. Maintenance Factor:

- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Industrial areas with normal interiors such as workshops, stores : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors such a crusher house and junction towers : 0.5

ii. Reflection factor for wall/ceiling

- White and very light colors : 0.7
- Light colors : 0.5
- Middle tints : 0.3
- Dark colors : 0.1

iii. The working plane shall be considered at 0.85 m from the floor level.

iv. The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1 meter.

b. Outdoor Lighting

- i) The recommended illumination levels for outdoor areas are indicated in the above table.
- ii) Mounting height, spacing of flood lights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.05.

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- iii) Maintenance factor shall be generally 0.6 under average conditions.
- iv) Flood lights for area lighting shall be mounted on building structures. For outdoor lighting i.e. around the power plant building and transformer yard provision to be made with 400W outdoor type lamps mounted on wall/structures.
- v) Automatic switching ON/OFF shall be shall be provided through timers/photo cells.
- vi) For road illumination inside the boundary limit lighting poles shall be provided and the distance between the poles shall not exceed 30m.
- vii) Aviation obstruction lights shall be provided on tall installations (Chimney, Cooling Towers etc) as per Airports Authority and international standards. Aviation warning lights shall be high intensity type-A flashing LED type with varying intensity for day and night.
- viii) In an area, the lighting fixtures shall be arranged in different phase / LPs such that even in case one lighting panel is faulty complete lighting is not affected. In any location the lighting shall be arranged from two phases.
- c. The circuit loading on each circuit shall be restricted to 80% of the MCB rating.
- d. The voltage drop from LDB and any fixture shall not exceed 3%.
- e. All lighting design calculations, layouts, conduit wiring diagrams, LDBs and LPs drawings and technical data sheets etc shall be furnished for Owner/ Owner's consultant's approval.

1.4.8 Lighting system equipment

- a. Lighting Distribution Boards (LDB) & Lighting Panels (LP)
 - i. The Lighting Distribution board shall be fed through 415V/433V lighting transformers with off circuit taps $\pm 5\%$ in steps of 2.5%. The lighting transformer shall be cast resin dry type , vector group of [Dy1], class F insulation with temperature rise limited to class F and shall be housed in a suitable enclosure. In general, the transformers shall conform to the specification covered under 'Service transformers. The lighting distribution boards shall consist of MCCB incomer and required number of double pole MCB controlled out going feeders to LPs. The LDB shall be designed for the required short circuit level of [20] kA. All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-52. Outdoor panels shall be weather proof type with IPW-55 protection. The

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thickness of sheet steel enclosures shall be CRCA, 2 mm minimum for load bearing and 1.6 mm for other members.

- ii. Number of outgoing feeders in each LDB shall be provided as per requirement including the minimum 3 nos spare feeders for "Purchaser use". Each outgoing MCB in LDB's shall be of 15 A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB
- iii. Individual control in office buildings shall be through single pole flush type switches/MCBs. In those areas where group controls are required, rotary switches shall be provided
- iv. External area lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers/photo cell.
- v. In high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder / platform / approach shall be provided for maintaining / replacement of light fittings.
- vi. Each of the LDBs shall be provided with voltmeter and ammeter along with selector switches, "SUPPLY ON" indicating lamps, etc. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.
- vii. Two ground pads with bolts and nuts shall be provided on each board for connection to 50x6/25x3 mm GS flat.

b. Lighting Fixtures and Lamps

- i) Fluorescent fixtures with electronic ballast shall be generally provided for a room height upto 5m. Type of fixture shall be industrial type with gasket, clear acrylic cover and enamelled reflector or decorative type to suit the aesthetics. For areas with false ceiling, recessed mounted decorative fixtures with mirror optic louvres shall be used. In control room / computer rooms, decorative mirror optic fluorescent light fittings with antiglare features shall be provided. The surface finish shall be smooth, unobtrusive and scratch resistant.
- ii) Reflector shall be of sheet steel or aluminium, minimum 20 SWG thick and securely fixed by fastening device of captive type.
- iii) Fixture shall be suitable for 19 mm conduit entry and 16 SWG GI earth wire connection.
- iv) Fixture shall be furnished complete with lamps and integrally mounted accessories. These shall include holders, ballast, capacitor, starter, ignitors (separate type) etc.

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- v) For corrosive areas, corrosion proof lighting fixture shall be provided. For hazardous areas, light fittings, conduits, junction boxes etc. shall have to meet the corresponding area classification requirement.
- vi) Medium bay or high bay type of lighting fixtures with HPMV/HPSV lamps shall be used depending on the mounting heights for indoor areas having room height more than 5m. Medium/ High bay fixtures shall be provided with vibration damper wherever required.
- vii) For areas like boiler and outdoor areas such as roads, street, transformer areas and open yards, weatherproof HPSV flood/ street lighting fixtures shall be used. For areas like boiler platforms, weatherproof well glass type HPSV fixtures with wire guards shall be used.
- viii) All type of fluorescent lamps including Compact Fluorescent Lamp (CFL) shall be bi-pin rotary type and either cool daylight or white.
- ix) Mercury / Sodium vapour lamp shall be colour corrected type with screwed cap.
- x) Lamps shall be suitable for use in position and capable of withstanding small vibrations.
- xi) Ballasts shall be of heavy duty, low loss and polyester-filled type with copper winding.
- xii) Ballasts for Mercury / Sodium vapour lamps shall be provided with suitable tappings to set the voltage within range specified.
- xiii) Ballasts shall be free from hum. Ballasts which produce humming sound shall be replaced, free of cost.
- xiv) In multi-lamp fixture, each lamp shall be provided with individual ballast.

c. Switches, Receptacles

- i. In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms, etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided
- ii. 240V, 50 Hz, 3 pin Power Receptacles (5A, 15A) shall be provided in all building/areas of the plant. Inside a building, receptacles shall be provided at interval of 30m or part thereof for hand tools, water coolers, exhaust fans etc. Inside each cabins at

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least two receptacles shall be provided and the same shall be indoor/outdoor/flameproof as per the location. Minimum 2 nos of 5A and 1 no 15A receptacles shall be provided in each room. Receptacles shall be heavy duty, complete with individual plug and switch as described below:

Table: 4.0

S.No.	Type	Description
1	RA	5A, 240V, 2 Pole, 3 Pin with third pin earthed - Suitable for flush mounting in office areas and control room. The switch shall also be flush mounting piano type.
2	RB	15A, 240V, 2 Pole, 3 Pin with third pin earthed - Wall/column mounted, metal clad gasketed construction, suitable for 19 mm conduit entry, screwed metal cover tied with metal chain, weatherproof construction suitable for indoor/outdoor installation. This shall be provided at an interval of 30m, or minimum one in each room.
3	RC	63A, 415V, 3 Phase, 5 pin interlocked plug and switch with fifth pin earthed. Wall/column mounted, metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 4 Core 35 sq.mm AYWY cable. These receptacles shall be provided at an interval of 50m throughout the Plant Area.
4	RD	100A, 415V, 3 phase, 5 Pin interlocked plug and switch with fifth pin earthed Wall/column mounted metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 3.5 Core, 95 sq.mm AYWY cable.

d. Cables and Wiring

- i. Wiring from lighting DBs/panels to individual fixtures, plug points, fans, etc. shall be of single core, 2.5sq.mm, 1100 V grade PVC stranded copper conductors through surface mounted or concealed medium duty GI conduits confirming to IS 1239 with earth wire. The wires in the conduits shall not exceed 60% of the conduit area.
- ii. 1100V grade stranded copper conductor, PVC insulated, colour coded, wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, outdoor areas like transformer yard and road lighting, cabling shall be adopted. The

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specification of cable shall conform to the details indicated in "Cabling System" section.

- iii. Minimum size of wires in case of conduit wiring shall be 2.5sq.mm copper in case of lighting and 4sq.mm copper in case of receptacle wiring
- iv. Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits. Wires of AC and DC lighting system shall be carried out in separate conduits
- v. For outdoor lighting, the cable shall be buried at a minimum depth of 750 mm from ground level or run in cable trays. The buried cables shall have suitable bedding, protective covers and markers
- vi. Material used for saddles, clamps, JBs, etc. shall be galvanized
- vii. Office buildings, laboratory buildings shall have concealed wiring with 2.5sq.mm wires using PVC conduits. In heat zones, i.e. in the areas where ambient temperature is 600 C and above, heat resistant control cables shall be used in hot dip galvanised rigid steel surface mounted conduits

e. Fans and Regulators

- i. The fans shall have three well balanced blades, double ball bearings and shall be reasonably free from noise. Fan motor shall be totally enclosed type with copper winding and class-E insulation. Sweep shall be given as 1200 /1400 mm.
- ii. Regulators shall have minimum five steps. Electronic Regulators with smooth control shall be provided.

f. Flame-Proof Equipment

- i. The enclosure of all flameproof equipment for use in hazardous areas where gases/vapors of Group I, IIA, IIB are present, shall be of cast iron/cast aluminum, stove enamel finished. Chemical corrosion resistant epoxy finish shall be provided in corrosive areas. The construction shall comply with relevant applicable standards
- ii. If the enclosures are additionally required to be weather proof, neoprene gaskets shall be provided to make the enclosure dust and weather proof providing a degree of protection of IPW 55.
- iii. All ferrous parts, exposed to atmosphere shall be suitably plated/galvanized

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- iv. All internal wiring shall be connected to terminal blocks provided in terminal enclosure on incoming side.
- v. Flameproof cable gland entries shall be provided suitable for the cable sizes. The number of required cable entries for junction/terminal boxes as required for branching, terminating of cables for lighting distribution shall be provided. All unused cable entries shall be closed by flameproof plugs.
- vi. Flameproof receptacle unit (socket with associated switch/MCB and plug) shall have interlocking feature such that plug cannot be inserted or taken out with switch/MCB in "ON" position.
- vii. Adequate mounting lugs with necessary hardware shall be provided for mounting the equipment on wall/structure.
- viii. These enclosures shall have inscription warning against opening the enclosure unless the circuit is isolated. Equipment rating and ON/OFF positions of switches/MCBs shall also be designated.
- ix. The BIDDER shall indicate that the enclosures have been tested and certified by relevant statutory authorities for use in hazardous areas.

g. Lighting poles and towers

- i. Lighting poles for street lights and flood lights shall be of swaged and welded steel, pole of height 9M/11M and shall conform to relevant standard. Poles shall be hot dip galvanized internally and externally after fabrication as per IS 2629 / IS 2633 / IS 4759 standards. The Poles shall be designed to withstand the maximum wind speed as per IS 875. The steel sheet used to manufacture steel poles shall be of minimum thickness of 3 mm and shall conform to relevant standard . Junction boxes shall be provided with weather proof flush doors and locking facility. Bidder shall design and furnish the foundation drawings for the poles to withstand basic wind speed of minimum [50]meter/sec.
- ii. The supply of poles/Towers shall be complete with base plate, foundation bolts, hot dip galvanized brackets / necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
- iii. Towers for mounting flood lights shall be e of continuously tapered poly gonol cross section and shall be supplied with all acesssories. Steel structure for towers shall be made of hot dip galvanized steel. A steel ladder and platform at the top shall be provided. The length of each step of the ladder shall be at least

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300 mm and spacing between two adjacent steps not more than 300 mm. The structure shall be suitable for mounting the required number of flood lights, weights of maintenance crew and specified wind pressure. The factor of safety shall be [2] for each part and section. The Contractor's structural design drawings shall be approved by the Purchaser before fabrication.

1.4.9 Name Plate

Name plates shall be furnished for identification of devices and circuits. All switches, controls and indications shall be permanently and legibly marked in English regarding the functions.

1.4.10 Painting

All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.

After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoved after each coat.

The equipment shall be finished in approved color shade by owner with two coats of epoxy based powder coated paint. The coating shall be done electro statically followed by stoving.

Sufficient quantity of touch-up paint shall be furnished for application at site.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

Tests on Lighting Distribution Boards / Panels shall include:

a. Wiring continuity tests.

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- b. High voltage and insulation tests.
- c. Operational tests.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *Lighting panels & distribution boards.*
- b) *Receptacles & Junction boxes.*
- c) *Street light poles & towers.*
- d) *Lighting fixture complete with lamps and accessories.*
- e) *Non-integral/separate type control gear box for lighting fixtures, as applicable.*
- f) *Lux level calculations for each area.*
- g) *Data sheets for lighting fixture, lamps, accessories with light distribution curves, co-efficient of utilization charts etc. Type and routine test certificates of transformer and cables.*
- h) *Control schematic and wiring diagram of 415V AC/220V DC lighting panel with automatic changeover from AC to DC and vice-versa, 415V normal AC Street/area lighting panel with automatic ON/OFF feature.*
- i) *Technical leaflets and data sheet on each piece of equipment/ device such as MCB, switch, fuse, receptacle etc. Type and routine test certificates of transformer and cables.*
- j) *QAP and relevant test certificates*

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- k) Lighting layouts showing the disposition of fixtures, lighting panels/boards, circuit distributions, conduit & wire routing.
- l) Key Single Line Diagram for lighting distribution, board wise single line diagram with feeder loading, cable schedule and interconnection chart, design calculation for lighting.]

1.7

Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC DC	240V, 1Ph, 50Hz 220V DC
1.2	Variation in Supply		
	a) Voltage	%	±10
	b) Frequency	%	±5
	c) Combined voltage & frequency	%	10
1.3	Design Ambient Air Temperature	°C	50
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	50KA for 1 sec
	b) At 220V DC (For DC LP)	kA(DC)	[10] kA for 1 sec
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		G.I
b	Conductor size	SWG	12
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		[By bidder]
2.2	Rated Voltage, phase and Frequency	AC	415V, 3phase, 4 wire, 50Hz
2.3	One Minute Withstand Voltage	V	2500
2.4	Mounting Type		

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S. No.	DESCRIPTION	UNIT	DATA
	a) LDBs		Floor Mounted
	b) Single Phase LP		Wall/Structure mounted
2.5	Type and no of circuits & feeder rating		[As per project requirement]
2.6	Colour shade		[RAL 5012]
2.7	Lighting Transformer		
	a) Type		Epoxy cast resin dry type
	b) Voltage Ratio	V	415/415V
	c) Taps	%	+/-5%
	d) Vector Group		[Dyn1]
	e) Impedance	%	[5%]
	f) Rating	KVA	[As per project requirement]
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		[By Bidder]
3.2	Luminaries		[By Bidder]
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		[By bidder]
	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		[By bidder]
	a) Luminaires		
	b) Accessories		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Schedule of fitting and Accessories		[As per project requirement]
5.0	Technical details of luminaries		[By bidder]
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumen s	
	ii) After 1000 burning hours	Lumen s	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		[By bidder]
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		[By bidder]
a	Power factor		
5.4	Luminaries		[By bidder]
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		G.I
	ii) Suitable upto conductor size	SWG	12
c	Internal wiring size	Sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		[By bidder]
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		[By bidder]
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		CTs VTs
8.1	Make		[By bidder]
8.2	Type		[By bidder]
8.3	Output	VA	[By bidder]
8.4	Accuracy Class		[By bidder]
8.5	Literature enclosed	Yes/No	[By bidder]
9.0	Meters		VOLTMETER AMMETER WATTMETER
9.1	Make		[By bidder]
9.2	Type		[By bidder]
9.3	Accuracy Class		[By bidder]
9.4	Literature enclosed	Yes/No	[By bidder]
10.0	Relays (if any provided)		[By bidder]
10.1	Make		

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S. No.	DESCRIPTION	UNIT	DATA
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a)Normally open		
	b)Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		[By bidder]
11.2	Suitable for use in hazardous area		
	a)Area classification		[Fuel oil pump house, Main oil tank area]
	b)Gases/Vapor group		[By bidder]
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	[By bidder]
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	[By bidder]
12.0	Lighting Control Switches		[By Bidder]
12.1	Make		
12.2	Decorative		
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		[By Bidder]
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	

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S. No.	DESCRIPTION	UNIT	DATA
14.0	Lighting wires		[By Bidder]
14.1	Make		[Point wiring with respect to different length shall be furnished]
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	Conduits		[By bidder]
15.1	Make		
15.2	Rigid Steel		Galvanized
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		[By bidder]
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		Yes
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		[By bidder]
17.1	Make		
17.2	Type of Poles/Towers		

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S. No.	DESCRIPTION	UNIT	DATA
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		[By bidder]
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E10

**TECHNICAL SPECIFICATION FOR CABLE CARRIER
SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E10

1.0 CABLE CARRIER SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Cable Carrier system complete with all accessories for efficient and trouble free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS 800	Code of Practice for structural Steel
IS 1646	Code of Practice for Fire Safety of buildings
IS2667	Fittings for Rigid steel Conduits
IS 3419	Fittings for Rigid Non – Metallic Conduits
IS 3837	Accessories for Rigid Steel Conduits
IS 4649	Adaptors for Flexible Steel Conduits
IS 5216	Guide for Safety Procedures and Practices in electrical Work

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Cable and cable trays shall be installed in an ambient temperature of 50 °C and relative humidity of 95%.
- b) The cable carrier system shall be designed considering the following:
 1. Facility for easy laying of cables.
 2. Access to maintenance.
 3. Neat and aesthetic appearance.
 4. Safety of equipment & personnel.
 5. Ground water seepage.
- c) Cables shall be laid in prefabricated ladder/perforated type trays and in conduits. Direct burial of cable shall be mostly avoided.
- d) Upper cable trays and all vertical cable trays shall be provided with tray covers.
- e) Cable filling in the trays or racks shall not exceed 80%. Conduits if used, the wires in the conduits shall not exceed 40% of the conduit area.
- f) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V cables shall be laid in top trays and cables of subsequent voltage grade in lower tier of trays. Instrumentation cables shall be laid at bottom most tray.
- g) At least 300mm clearance shall be provided between HV and LV cables & LV and control/Instrumentation cables.
- h) Support system for cables shall be prefabricated type.
- i) Single core cables shall be laid in trefoil touching formation. Trefoil clamp shall be provided in a staggered manner.
- j) 1100V grade power cables of [120] mm² size and above shall normally be laid in single layer in trays/on racks.
- k) 1100V grade power cables below [120] mm² may be run in double layers in case of space restrictions.
- l) Control and instrumentation cables can be laid up to a maximum of three layers in each tray/rack.

1.4 Specific Requirements

1.4.1 Scope of work:

The scope of work shall include Design, Preparation of Cable Tray, Trench/Duct bank/Conduit Layout, supply of Cable tray and its Accessories, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the Cable Carrier System

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for following package. The below list indicates area where cable carrier system to be provided but not limited to:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- iv) Laying and Termination of power & control cables for all the equipments of TG package.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room.
- v) FOPH area.
- vi) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- vii) Laying and Termination of power & control cables for all the equipments of Boiler package.

c) Balance of Plant Area:

- i) Cable Carrier System for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
- ii) Laying and Termination of power & control cables for all the equipments of BOP package.

d) CHP Area:

- i) CHP Switchgear room
- ii) Conveyor.
- iii) Crusher House
- iv) Stacker and Reclaimer
- v) Any other area covered in this package.
- vi) Laying and Termination of power & control cables for all the equipments of CHP package.

e) AHP Area:

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- i) AHP Switchgear room.
- ii) Silo Area.
- iii) Any other area covered in this package.
- iv) Laying and Termination of power & control cables for all the equipments of AHP package.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard
 - ii) Transformer yard
 - iii) Inter plant cabling.
 - iv) Any other area covered in this package.
 - v) Laying and Termination of power & control cables for all the equipments of eBOP package.
- g) All civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification. Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Bidder.
- h) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work.
- i) For Terminal Points and Exclusions of Cable Carrier system and Specific scope of work Bidder may refer section I of this specification.

1.4.2 General Installation Requirements:

- a) Cable trays shall be fabricated from 14 gauge mild steel sheets. Cable trays shall be of hot dip galvanized Steel of ladder/perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings to be submitted by Bidder. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanized.
- b) Constructional details, supporting arrangement and installation details for cable trays shall be furnished by Bidder.
- c) Each 2.5 meter section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.
- d) Cable tray covers shall be fabricated from 16 gauge MS sheets. Cable tray covers shall be hot dip galvanized and same shall be provided for all outdoor cable trays and vertical raceways/trays. Covers for vertical raceways shall be in individual, easily removable sections to facilitate cable maintenance.

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- e) Cable Tray of Standard width of 600mm shall be followed. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.
- f) Cable trays shall be ladder type with maximum rung spacing 250 mm depth 100 mm and rung width not less than 50 mm.
- g) Cable trays in areas subjected to excessive coal dust, or mechanical damage shall have hot-dip galvanized sheet metal tray cover installed on front tray in vertical run and inverted 'V' type on upper tray in horizontal run. Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.
- h) Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal / vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.
- i) Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/termination kits, lugs, glands, ferrules, tapes etc. and other accessories, grounding of cable armor. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.
- j) Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.

1.4.3 Cable Routing/Laying

- a) Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some

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cases cables may have to be laid underground and for short runs in conduits for protection while crossing roads and other facilities.

- b) For interplant connections, the cables may be routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.
- c) For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.
- d) In boiler area, trench shall be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.
- e) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.
- f) Cables for redundant equipment/system shall be run in separate trays in separate route.
- g) Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.
- h) Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).
- i) The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall and fire proof doors.
- j) The floor of the cable spreader rooms shall have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably planned to avoid water entry through this place.
- k) Cables shall generally be laid on cable trays either in concrete trenches or overhead supported from building steel/structures. Cables shall be run in concrete trenches in those electrical rooms at ground level, which are without any spreader room below. In mechanical equipment areas (Indoor), overhead cable trays shall generally be used.

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- l) For inter plant connections, the cables shall be routed through an overhead cable bridge pipe cum Cable Bridge. For isolated but long outdoor cable route with very few cables of 3/4 nos., the cables may be directly buried with prior permission from the purchaser.

1.4.4 Installation of Cables

- a) The Bidder shall install, terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.
- b) The HV power cables of 6.6kV shall be laid in trays or racks as follows:
- i) In single layer only.
 - ii) 3 core cables to be laid in touching formation.
 - iii) Cables in trefoil groups of the same circuit shall be laid as indicated below so as to ensure balanced current distribution:

Y Y Y Y

R B B R R B B R and so on.

- c) 1100V grade power cables shall be laid in single layer in trays depends on size of cables. Cable of up to 120 sqmm shall be laid in two layers. Beyond this size single layer will be followed.
- d) Control and Instrumentation cables can be laid up to a maximum of three layers in each tray.
- e) The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.
- f) Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there shall not be more than 2 nos. 90 Deg. Bends between pull points.
- g) Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension, minimum bending radius and no. of bends.

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- h) All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :
- Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.
 - Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.
 - For all HV, LV, Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.
- i) All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.
- j) The portion of galvanized steel, which, if required, undergoes any welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.

1.4.5 Cable Termination and Joints (if applicable and not covered in cable specification)

- a) The Bidder shall supply cable termination and jointing kits in requisite quantity for HV. Power Cables, LV. Power, Control Cables, etc. along with all accessories & consumables required for making termination and joints complete . All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/joints are intended.
- b) The straight through joints of HV. cables shall be heat shrinkable and pre moulded push on type. The end termination kits for HV. cables shall be of {Raychem/3M/Elastimold} type. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.
- c) Glands and lugs required for termination of HV, LV. shall be supplied by the Bidder in required quantity.
- d) Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer etc. Cable glands shall match with the sizes of different HV/LV/Control cables.

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- e) Cable lugs shall be suitable for termination of different cross-sections of L.V./Control cables and shall be of following types:
 - i. Aluminium tubular terminal end for solderless crimping to aluminium conductors.
 - ii. Copper tubular terminal end for solderless crimping to copper conductors.
 - iii. Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.
 - iv. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.
 - v. The terminations shall with tinned copper only.
 - vi. For mill area, the cable shall be routed through GI pipes embedded in Ground.
 - vii. In heat zone areas as far as possible the cables shall be taken away from the area to avoid heat. If cabling in the heat zones can not be avoided, the cables shall be terminated in junction box of IP 67 protection class away from the heat zones and small length of cables may be laid from junction box to the respective equipment to facilitate easier replacement in case of fire. Bunching of cables in the heat zones and boiler areas shall be avoided and laid in separate groups.

1.4.6 Identification

- a) The complete cabling system shall be properly identified. Methods for identification of cabling system will be furnished to the Bidder and the Bidder shall strictly adhere to the said methods.
- b) Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- c) Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate, projected above ground level.
- d) Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) meters in cable tray/trench runs. Cable tags shall also be provided

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inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant / purchaser or his representative.

- a) Checking of continuity / phasing and IR values for all the cables before and after HV test
- b) Checking of continuity / phasing and IR values for all the cables before and after HV test.
- c) HV test and measurement of leakage current after termination of cable kits (for HT cables).
- d) Checking of earth continuity for armour.
- e) Check for mechanical protection of cables.
- f) Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
- g) Check earthing of cable structures.
- h) Check safe head room in gallery area
- i) Check clearance from ventilation duct and light fittings for cable structures.
- j) Check proper fixing of cable structures.
- k) Check for proper drainage and removal of water (if any).

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall

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obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) [General arrangement drawing Cable Tray]
- b) [Cable Tray Accessories like Tee, Cross, Bends, Coupler, Reducer etc]
- c) [Cable Tray support materials]
- d) [Technical Data sheets for cable carrier system].

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		[By bidder]
2.	Size of Tray	mm	[600/450/300/150]
3.	Material		Galvanised Steel
4.	Application		[As per project requirement]
5.	Type of Tray		[Ladder/Prerforated]
6.	Thickness of Tray	mm	2mm
7.	Thickness of Galvanization		[100 microns]
8.	Tray Cover Size	mm	[As per project requirement]
9.	Cable Tray Accessories		[By bidder]

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SL NO.	DESCRIPTION	UNIT	DATA
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	a) [100] b) [50x 50 x 6]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E11

**TECHNICAL SPECIFICATION FOR EARTHING AND
LIGHTNING SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E11

1.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Earthing and Lightning Protection System complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanizing of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:9537	Conduits for electrical installation.
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
CEA	CEA Regulations and standard technical specification for main plant package.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Earthing system design shall consist of earth grids and electrodes buried in soil in the whole plant area, embedded in concrete inside all the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.
- b) The main objectives of earthing system is to:
 1. Provide safety to personnel from contact of dangerous potential caused by ground fault.
 2. Ensure sufficient grounding current for effective relaying.
 3. Stabilize circuit potential with respect to ground.
- c) The earthing conductor shall be designed for fault current of [50 kA] for duration of 1 second.
- d) It is the responsibility of the Bidder to undertake the soil resistivity measurements at site and select suitable size of conductor based on the soil resistivity.
- e) Ground conductor shall be of galvanized steel for above ground and mild steel for embedded and below ground earthing.
- f) Main earth grid conductor shall be mild steel (MS) of [40] mm dia.
- g) Suitable corrosion allowance shall be considered over ground conductor size depends upon soil resistivity.
- h) The main purposes of lightning protection system are to :
 1. Provide protection to structures from lightning strokes.
 2. Provide a low resistance-conducting path to lightning discharge.
 3. Lightning protection shall be provided as per IS: 2309 for Boiler area and other tall structures within the battery limit.

1.4 Specific requirements

1.4.1 Scope of Work

The scope of work shall include Design, Preparation of Earthing and Lightning Layout, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the safety earthing and Lightning Protection system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

- a) TG Area:
 - i) TG Platforms.

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- ii) TG area Grade Levels Maintenance area.
- iii) All equipments, structures etc of TG package.
- iv) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- b) Boiler Area:
 - i) Boiler Platforms
 - ii) Boiler Grade Levels covering coal mill and Maintenance area.
 - iii) ESP Platforms
 - iv) ESP/FOPH switchgear room.
 - v) FOPH area.
 - vi) All equipments, structures etc of Boiler package.
 - vii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- c) Balance of plant Area:
 - i) Earthing and lightning protection system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- e) AHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard, Transformer yard and BTG area are provided with earth mat of [40] mm dia MS Rod conductor buried below 600mm from ground level. Areas like AHP, CHP, Boiler and TG, and all other

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BOP area below grounding system are covered in this eBOP package and above ground earthing for AHP, CHP, Boiler, TG and Mechanical BOP are covered in respective package itself. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system for above ground are covered in respective packages and below ground is covered in this eBOP package in same way as earthing system.

1.4.2 Earthing system

- a) Earthing system shall be designed in accordance with IS 3043 and Indian Electricity Rules and Acts.
- b) Fault current for the earthing system shall be designed for [50] KA for duration of 1 sec.
- c) All electrical equipment, non-current carrying metal parts, structures, building steel, lightning protection system, transformer neutrals shall be connected to station ground grid.
- d) Treated earth pits including riser shall be provided for transformer neutral earthing.
- e) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- f) Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.
- g) All off site area of AHP , CHP etc shall be provide with peripheral earthing with at least two connection to main station earth grid through treated earth pit.

1.4.3 Ground Grid Conductor

- a) Ground grid conductor of mild steel rod shall be used.
- b) *[The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.12 mm (on diameter of conductor) per year over the design life of 40 years.]*
- c) However bidder shall consider as per CBIP norms “ Manual on Earth mat design” the corrosion allowance as below:
 - For soil resistivity greater than 100 ohm-meter: No allowance.

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- For soil resistivity greater than 25- 100 ohm-meter: 15% allowance.
- For soil resistivity less than 25 ohm-meter: 30% allowance.

1.4.4 Underground Grid

- The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80.
- [The ground grid conductors shall be buried in earth at a depth of 600 mm]. The length of ground conductors below earth shall be sufficient to ensure a ground resistance less than one (1) ohm.
- The ground grid conductor shall be so laid as to provide short and direct connection to building steel and major electrical equipment.
- Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.
- All ground grid conductor connections shall be welded type.
- Ground grid shall be interconnected with the ground grid of neighboring areas at least at two (2) points for further reducing the ground grid resistance.
- Suitable pigtails shall be provided and shown in the [layout drawing] for connection with ground grid of neighboring areas.
- A minimum earth coverage of [300] mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.
- In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.
- Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.
- Grounding conductor around the building shall be buried in earth at a minimum distance of [1200] mm from the outer boundary of the building.
- The Bidder shall carryout the grounding of all electrical equipments and connection to main earth grid.

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1.4.5 Ground Electrode

Ground electrodes shall be [40] mm dia. and [3] metre long M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductors. All connections to the conductors shall be done by arc welding process.

1.4.6 Above Ground Connections

- Galvanized steel flats shall be used for all connections above earth.
- Inside building, ground conductors shall be run for each floor supported on building steel and/or cable trays. These ground conductors in turn shall be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.
- Two separate and distinct ground connections shall be provided for each electrical equipment in compliance with I.E. Rules.
- All steel columns and structures shall be connected to the earth mat through earth leads.

All connections above ground shall be welded type except connection to equipment/structures which shall be bolted type.

1.4.7 Risers

Risers are required for connecting the equipment and structures with the ground mat. Risers are to be provided from underground mat to above ground levels where the ends shall be left free for connecting to the equipment. Each riser shall be 1 No. [40] mm dia. M.S. rod and shall project above grade level/concrete floor level by minimum 300 mm. They are to be clamped or supported along the outer edge of the concrete foundation. Connection to the ground mat shall be done by arc welding.

1.4.8 Equipment Ground Lead

- Equipment ground connections shall be sized to carry the ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.
- The minimum ground conductor sizes for various equipment and structures are given in below.

Table 2.0

DESCRIPTION	SIZE	MATERIAL
a) Main Grounding Grid Conductor	[40] mm dia Rod	Mild Steel
b) Riser/Pigtail From Grounding Grid/Mat	[40] 40 mm dia Rod	- Do -

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DESCRIPTION	SIZE	MATERIAL
c) Electrode	[40] mm dia, [3000] mm long Rod	- Do -
d) Conductor used for connection of various equipment/structures as listed below		
HV motors, Earthing ring, Earthing lead to earth pits etc.	[50 x 10] mm	Galvanised steel
Structures, Control Panels, Cable Trays etc.	[50 x 10] mm Flat	- Do -
415V Power Control Centres, Motor Control Centres, Distribution Boards etc.	[50 x 10] mm Flat	- Do -
Local Panels, Lighting Panels	[25 x 6] mm Flat	- Do -
Motors :		
Above 90 kW	[50 x 10] mm Flat	Galvanised steel
Above 30 kW Upto 90 kW	[25 x 6] mm Flat	- Do -
Above 5 kW Upto 30 kW	[25 x 3] mm Flat	- Do -
Upto 5 kW	[8] SWG	- Do -
Miscellaneous Items, viz. Push Button Station, Junction Boxes etc	[8] SWG	- Do -

{ The Above size of Earth flat is indicative only. Bidder shall refer Volume II Section I for size of earth flat used for existing plant or as per design. }

1.4.9 Jointing and Connection

- All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.
- The bending of the large diameter ground conductor where necessary shall be done by gas heating.
- The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- The connections between the riser/pigtail and earthing conductors

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(galvanized steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.
- g) Equipment/structures ground connections shall be coated with weather resistant paints/cold galvanizing paints after proper checking / testing.
- h) Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

1.4.10 Earthing system installation

- a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
- b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750 mm.
- c) The earthing conductor crossing the road / track shall be laid in hume pipe or laid at a greater depth to avoid damage.
- d) When earth conductor passes through floors, walls, etc suitable pipe sleeves shall be provided and the same shall be sealed after installation.
- e) The connection between earthing pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
- f) Metallic conduits and pipes shall not be used as earth continuity conductor.
- g) Street lighting poles, flood light poles & towers, their junction boxes shall be connected to the earthing conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.
- h) The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.
- i) Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten [10] metres. Fence gate shall be separately grounded with flexible connection to permit movement.

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- j) [50 x 10] mm galvanized steel flats(minimum size) shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing. These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground. Earthing conductors can be embedded in concrete floor of the building wherever necessary without having direct contact with the reinforcement rods. At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- k) All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.
- l) Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.
- m) Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.
- n) A continuous [50 x 10] mm (minimum size) G.S. flat earthing conductor shall run along the cable trays and supporting structure of all cable routes. This earthing conductor shall be attached to each section of cable tray/trays through [50 x 10] mm G.S. flats. The earthing conductor shall be securely connected to the earth mat at both ends.
- o) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
- p) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.
- q) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- r) The cable sheaths, screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.
- s) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- t) Main plant earth grid and switchyard earth grid shall be interconnected each other by minimum two numbers of leads.

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1.4.11 Lightning Protection System Design

- a) Lightning protection design and installation work shall be provided on the basis of IS 2309 Code of Practice.
- b) Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down conductors and pipe electrodes.
- c) The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than value specified in IS shall be provided with lightning protection. However, Boiler areas, station building, switchyard building shall be provided with lightning protection irrespective of the arrived risk index.
- d) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.
- e) Down conductors shall run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.
- f) A Lightning electrode shall be provided at the connection point of the down conductor with the station ground.
- g) Galvanized steel rods and flats shall be generally used for air termination and connections. All connections shall be welded type.

1.4.12 Air Terminations

- a) The vertical air terminal rods shall be installed at the roof of Turbo generator building, Boiler and chimney etc to protect these objects from lightning strokes.
- b) The projected length of the Air termination rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.
- c) The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building, the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.
- d) All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size [50 x 6] mm galvanized steel flats.
- e) For chimney air termination, rods interconnected by circumferential conductors will be provided at the apex of flue and also upon outer shell of the chimney. The air termination system will be formed by lead coated copper conductors to prevent melting and corrosion of conductors due to flue gas.
- f) For cooling towers, air termination system will comprise of horizontal

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circumferential conductors at the top

1.4.13 Down Conductors

- a) Galvanized steel down conductors of suitable size [25 x 6] shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.
- b) Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.
- c) The connection between each down conductor and rod electrode (by means of 40 mm mild steel rod riser) shall be made by others. However Bringing down comer with test link at a level of 1500mm approximately from above ground level shall be boiler contractor scope of work.
- d) The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleared on outside of the building wall and column/structure at about 750 mm intervals unless stated otherwise in the drawing.
- e) At all supports for down conductor along the column/wall of the buildings etc. the portion embedded inside the building concrete should not touch the reinforcement bars.
- f) All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.
- g) The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

1.4.14 Switchyard Lightning protection

- a) For switchyard lightning protection shall be provided by lightning masts and/or shield wires.
- b) In case of lightning protection by shield wire, the shield wires provided shall be of GS wire strung across the pinnacles of the gantry tower structures. The size of shield wire shall be based on the lightning impulse current expected and the time duration for which it is likely to flow. Allowance shall be given in the final size to account for corrosion of the shield wire during service at rate of [0.03] mm per annum. However, minimum size of the shield wire shall not be less than [70]sq.mm. The zone of coverage for the shield wire shall be considered as 60 deg between the two shield wires and 45 deg for end shield wires. The down conductors from shield wires shall be run along the towers and

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connected to rod/pipe electrodes.

- c) In case of lightning protection by lightning protection masts, the down conductors from the masts/peaks/shield wires shall be run along the tower and connected to the test links mounted on the towers at 1500m from the ground level. Conductors from the test links shall be connected to the rod/pipe electrodes which in turn are connected to the main earth grid in the switchyard. Calculations for sizing and determining topography and number of lightning masts shall be furnished for approval.

1.4.15 Electrodes (for Lightning Protection)

The electrodes shall be [40 mm] diameter [3000 mm] long mild steel rod. These shall be driven into the ground.

All the electrodes shall be interconnected by means of one (1) [40 mm] dia mild steel rod which shall be laid under ground at a minimum depth of [600 mm] below finished grade level unless stated otherwise. This ground mats/electrode in turn shall be connected to main grounding grid.

1.4.16 Riser (for Lightning Protection)

All risers connected to grounding mat shall be [40 mm] mild steel rods and shall be projected 300 mm above grade level unless stated otherwise.

1.4.17 Jointing & Connection

- a) All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.
- b) The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- c) The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.
- d) All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.
- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- g) The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- h) The steel to copper connection shall be brazed type.

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- i) The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.
- j) The sizes and materials of earthing conductors to be used in lightning protection system are listed below :
- k) Note: The above sizes are indicative only. Actual size shall be as per Bidder design or as per existing plant details as provided in Section I in case of replacement work as called for.

Table 3.0

DESCRIPTION	SIZE	MATERIAL
a) Vertical Air Termination	[20] mm dia Rod	Galvanised steel
b) Horizontal Conductor	[50 x 6] mm flat [25 x 6] mm Flat	-----do-----
c) Down Conductors	[25 x 6] mm Flat	-----do-----
d) Ground electrode / riser	[40] mm dia Rod	Mild Steel
e) Interconnection with earth mat	[40] mm dia Rod	Mild Steel

1.5

Tests

l) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the

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Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

The following test shall be conducted:

- a) Measurement of earth resistance for each electrode.
- b) Measurement of total earth resistance.
- c) Measurement of earth loop resistance for E/F path of biggest LV drive.
- d) Check tightness of all earth connections
- e) Check earthing of all metallic equipments, cable trays, bus bar supporting structures, building column (if steel all elect equipments, pipe lines etc. as per the drawing / specification)

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[Earthing Material like conductor , flat , welding description etc]*
- b) *[Air termination rod and its accessories etc]*
- c) *[Technical Data sheets for Earthing and Lightning system].*

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1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E12

TECHNICAL SPECIFICATION FOR 6.6kV SWITCHGEAR

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E12

1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of 6.6 Switchgear, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 226	Structural steel (standard quality)
IS : 375	Switchgear bus bars, main connections and auxiliary wiring, marking and arrangement
IS : 722	AC electricity meters
IS : 728	Galvanized steel structures
IS : 2099	Specification for bushings for alternating voltages above 1 000 volts
IS : 2147	Degree of protection
IS : 2516	Alternating current circuit breakers
IS : 2544	Specification for porcelain post insulators for systems with nominab l voltages greater than 1 000 volts
IS : 2705	Current transformer specification
IS : 3043	Code of practice for earthing
IS : 3156	voltage transformers specification
IS : 3231	specification for electrical relays for power system protection
IS : 3427	A.C. metal enclosed switchgear and control gear for rated voltages above 1 kV and upto to and including 52 kV.
IS : 4710	Switches and switch isolators above 1000 V but not exceeding 11000 v.
IS : 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
IS : 6875	Control switches push buttons

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Codes	Name of Standard
IS : 8084	Specification for interconnecting bus-bars for ac voltage above 1 kV up to and including 36 kV
IS : 8686	Specification for static protective relays
IS : 9046	Specification for ac contactors for voltages above 1000 v up to and including 11 000 v
IS : 9224	Low voltage fuses
IS : 9385	HV fuses
IS : 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
IS : 9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 v
IS : 10601	Dimensions of terminals of high voltage switchgear and control gear
IS : 11353	Guide for uniform system of marking and identification of Conductors and apparatus terminals.
IS : 13118	Specification for high voltage ac circuit breakers
IEC 6044-1	Current transformer
IEC 6044-2	Voltage transformer
IEC 6056	High voltage alternating current circuit breakers
IEC-60099-1	Non-linear resistor type gapped arrestor for AC systems
IEC-60099-4	Metal oxide surge arrestor without gap for AC system
IEC 60129	A.C disconnectors and earthing switches
IEC 60255	Electrical Relays
IEC-60298	High voltage metal enclosed switchgear and control gear.
IEC 60529	Degrees of protection provided by enclosures
IEC-62271-100	High voltage alternating current circuit breakers.
CEA	CEA regulations
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All 6.6kV Switchgear shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- b. All 6.6kV Switchgear shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-)5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC System	:	(+)10% to (-)15%

- c. All motors rated above 160kW shall be feed from 6.6kV switchgear.
- d. Motor rated [160-600kW] shall be provided with [vacuum contactor/vacuum circuit breaker] and motor rated above [600kW] shall be provided shall be provided with vacuum circuit breakers.
- e. 6.6kV switchgear shall be Indoor, metal clad, floor mounted, Single front and fully draw out type. Design and construction shall be such as to allow extension at either end. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels
- f. All 6.6 kV Circuit breaker shall be draw out type & should have Service, Test and Disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- g. Local/remote selection shall be provided for all incoming/Outgoing Circuit Breaker modules. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local (Switchgear).
- h. Two out of three Incomer logic for 6.6kV Switchgear shall be provided. For Unit and station board one Incomer shall be there from Unit Transformer and Station Transformer respectively. Tie feeder shall be provided between Unit and station switchgear such that in case of loss of supplies to unit switchgear from UAT, the same shall be restored from respective station switchgear. In order to achieve the same, fast bus transfer shall be provided at Unit switchgear.
- i. All motors shall be provided with Emergency Stop Push buttons.
- j. Control and Indication voltage level shall be 220V DC.

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- k. Maximum system fault level at 6.6kV bus including initial motor contribution shall be 40kA for 1 sec.
- l. 6.6kV System shall be earthed through resistance to limit fault current to 300A.
- m. Surge arrestor shall be provided for each motor feeder/Transformer feeder.
- n. The switchgear will be located in a clean but hot humid and tropical atmosphere.
- o. Duty involves direct-on-line starting of large induction motors with motor starting current varying 6 times the full load current. For BFP starting current varying 4.5 times of full load current.
- p. For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and this specification.
- q. The switchgear and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current without any damage or deterioration of material.
- r. All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 6.6 kV switchgear shall have following minimum features.

- a. 6.6 kV switchgear shall be of indoor, metal clad, single front, single tier, floor mounted, horizontal drawout type with vacuum circuit breaker and free standing type. The Panels shall be suitable for cable entry at bottom and bus duct connection at top.
- b. Between 6.6kV Switchgear Incomer and transformer, segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with bus duct manufacturer in this regards is covered in this specification.
- c. All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d. Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and Covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels.

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- e. Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f. The switchgear enclosure shall confirm to the degree of Protection of the [IP4X] for indoor installation. However degree of protection of LV chamber shall be [IP-52]. No louvers/Opening shall be provided on the top of panel. All the other louvers if provided shall have very fine brash or GI mesh screen.
- g. Paint shade for complete panels shall be [RAL 5012] for extreme end covers for all board.
- h. The working zone shall be restricted to [750mm to 1800mm] from floor level. Total height of the switchgear panels shall not exceed [2600 mm].
- i. Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc.
- j. A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgear having more than one bus section.
- k. Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.
- l. Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module at any one cubicle. Further distribution to all verticals shall be in the scope of bidder.
- m. Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- n. Supplier shall provide total 10% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- o. Switchgear shall have provision to receive 415V, 3ph, 4wire supply. Single phase 240V balanced supply shall be derived from 415V, 3ph, 4 wire supply. Each cubicle shall be provided with thermostat controlled space heaters suitable for operation from 240 V \pm 10%, single phase, 50 Hz, + 3% - 5% supply and 5A, 240V AC, 3 pin plug socket and cubicle lamp. The space heaters shall be located at the bottom of the switchboards. Cubicle heater, plug/socket/lamp circuits shall have individual switch fuse units. Motors shall

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be provided with anti- condensation heaters at 240V.Necessary provision for supply of motor space heating shall be considered in the switchgear.

- p. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.
- q. Controls and interlocks as required for the safe switching, operation and maintenance of the switchgear shall be provided. Mechanical interlocks shall be provided in addition to electrical wherever possible.
- r. It should be possible to carryout maintenance on a feeder with adjacent feeders alive.
- s. The Fast Bus Transfer (FBT) panel shall be totally enclosed, floor mounted panel conforming to degree of protection IP-42. The minimum thickness of cold rolled sheet steel used shall be 2.0 mm. The ABT panel shall consist of a lineup of control boards, with cable entry provisions from bottom of panel. The height of FBT panel inclusive of mounting channel, anti-vibration pads etc. shall be restricted to [2400 mm].
- t. The switchgear shall be [natural cooled].
- u. The circuit breakers, contactors, bus VTs shall be mounted on withdrawable truck which shall roll out horizontally from service position to isolated position.

1.4.2

Bus and Bus Taps

- a. The main buses and connections shall be of high conductivity [aluminum / aluminum alloy].Control and auxiliary buses shall be of electrolytic copper/copper wires.
- b. Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- c. Bus insulator shall be flame-retardant, non-hygroscopic, track resistant type with high creepage surface. This shall be of non-carbonizing material such as epoxy bonded fiberglass. Bus bars shall be color coded for easy identification.
- d. The bus bar supports shall be able to withstand stresses due to maximum short circuit and also take care of any thermal expansion.
- e. Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f. The continuous rating of the main bus bars shall be same as that of the incomer circuit breaker and shall carry this continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].

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- g. The busbar chamber shall be provided with inter panel barrier with epoxy cast seal off bushings through which the buses will pass through so as to prevent fire from one panel to another.

1.4.3

Circuit Breaker

- a. The circuit breaker shall be of vacuum type.
- b. The circuit breakers shall be fully draw-out type, having service, test and disconnected positions with positive indicators for service & test positions.
- c. The breakers shall have motor operated spring charged mechanism. It shall be possible to charge the springs manually, if, required. Breakers shall be trip free and shall have an anti-pumping device. The operating duty cycle shall be 0 -3 min.-CO-3 min.-CO.
- d. For motor, spring charging shall take place automatically after each breaker closing operation. One 'open-close-open' operation of the circuit breaker shall be possible after failure of power supply to the motor.
- e. Automatic safety shutters shall be provided to ensure the inaccessibility of live parts after the breaker is drawn out. There shall be distinct overall door for the breaker compartment and shall be lockable.
- f. Truck shall have distinct service, Test and Isolated positions. It shall be possible to close the breaker compartment door in isolated position also. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions.
- g. Outgoing breakers shall be suitable for switching transformers and motors at any load. Motor feeders shall be suitable for frequent direct on-line starting of motor.
- h. Mechanical safety interlocks shall be provided to prevent
 - i. The circuit breaker from being racked in or out of the service position when the breaker is closed.
 - ii. Racking in the circuit breaker unless the control plug is fully engaged
- i. Breakers shall be adequately de-rated to account for design ambient temperature and temperature inside the cubicle.
- j. Equipment and component rating and quantities shall be suitably selected according to the requirements with adequate margin.
- k. Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage

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1.4.4 Contactor

High voltage contactor shall be of AC-3 utilization category and shall be of vacuum type. Fuse and contactor shall be mounted on withdrawable truck. The contactor shall be latched type and shall be complete with mechanical trip indicator, anti pumping relay, surge suppresser, single phasing preventor etc.

1.4.5 Bus Transfer scheme:

The 6.6kV Unit Switchgear shall be connected to their respective unit auxiliary transformer through bus duct. These buses of unit switchgear shall also be connected to 6.6kV buses of station switchgear through tie feeders and breakers located at the unit and station end. Automatic Fast bus transfer scheme shall be provided between 6.6kV unit and station switchgear such that in case of loss of supplies to unit switchgear from UT, the same shall be restored from respective station switchgear. The automatic bus transfer system shall consist of fast, slow etc. transfer in Auto/ Manual mode.

In addition to above, each switchgear shall be provided with the following provisions-

- Dead bus closing
- Manual live change over (Momentary paralleling)
- Automatic slow bus transfer.

1.4.6 Current Transformers

- a. Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made. They shall have sufficient thermal and mechanical capacity to withstand the maximum momentary current rating of the breakers.
- b. CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c. CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d. All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e. CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.
- f. Accuracy class of CT shall be 5P20 for protection, PX for differential protection and 0.5 for metering.

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1.4.7 Voltage Transformer

- a. Voltage transformers (VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b. VTs shall be of the single-phase type. VTs shall be protected on their primary side by fuse and by MCB (with auxiliary contacts) on the secondary sides.
- c. VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d. It shall be possible to replace VTs without having to de-energise the main busbars.
- e. VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Transducer

For Incoming and outgoing feeders remote metering transducer shall be provided. The output shall be 4-20 mA DC which shall correspond to the normal range. All the transducer shall be dual output type.

1.4.9 Secondary wiring

- a. The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c. Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d. Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with *[stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring (applicable for internal panel wiring).]*
- e. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.10 Terminal blocks

- a. Terminal blocks shall be of 1100 V grade, stud type with marking strips. Terminals for CT secondary leads shall have provision for easy shorting, earthing and shall be suitable for connecting 2 cables of 2.5 mm² copper.
- b. Sufficient terminals shall be provided on each terminal block to ensure that

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not more than two outgoing wires are connected per terminal. All spare contacts of auxiliary relays, timers etc. shall be wired up to the terminals. [20%] spare terminals shall be provided on each terminal block.

- c. Terminal blocks shall be located to allow easy access. Wiring shall be grouped such that the individual wires of a cable can be connected to consecutive terminals.

1.4.11 Ground bus

- a. A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b. Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c. C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.12 Control & Indication

- a. The circuit breaker shall be wired up for local & remote operation. Each breaker shall be equipped with following:
- b. Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In Local position, the breaker shall be operated from switchgear only in test position.
- c. Each cubicle shall be provided with Auto/ Manual Switch. Trip selection switch and Trip-Neutral- Close (TNC) switch.
- d. Circuit breaker shall be indicated electrically. The following indication color shall be used.
Breaker closed – Red
Breaker opened – Green
Spring Charged – White
Breaker Auto trip – Amber
- e. However any other indication shall be provided as per owner's requirements.
- f. Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.

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- g. Breakers shall be controlled locally and/or remotely as per plant operational requirement. Necessary Interposing relays & feedback signal shall be provided based on the DCS IO list.
- h. Breaker control supply shall be of 220 V DC. Breaker spring charging motor shall be suitable for 220 V DC.

1.4.13 Cable termination

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection.

1.4.14 Bus duct connection

Bus duct connection shall be generally from top of the switchgear.

All connection bus work shall have the same continuous rating as associated switchgear bus and shall be fully braced for the short circuit current mentioned in specification.

All provision such as matching flange and other accessories shall be furnished for connection to bus duct.

1.4.15 Painting

All sheet steel surfaces shall be chemically cleaned, degreased and pickled in acid to produce a smooth, clean surface free of scale, grease and rust. After cleaning, the surface shall be given a phosphate coating followed by a coat of high quality primer and baking in the oven.

The paint shade shall be subject to owner's approval. Sufficient quantity of touch up paint shall be furnished for application at site.

1.4.16 Relays, Protection & Metering

- a. The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/ diagnostic facilities shall be provided.
- b. All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner. All numerical relays shall be compatible with IEC 61850.
- c. All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.
- d. All AC operated relays shall be suitable for operation at 50 Hz. AC voltage

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operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

- e. Energy meters shall be provided for incomer of 6.6kV Switchgear and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than [0.2S]. The accuracy class of CT and VT for energy metering shall have accuracy class of [0.5]
 - f. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
 - g. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
 - h. The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
 - i. All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
 - j. Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
 - k. D.C supply shall be supervised by DC supervision relays.
 - l. Trip circuit shall be supervised by Trip circuit supervision.
 - m. Tripping shall be done through high speed lock out relays.
 - n. All meters/ instrument shall be flush mounted on front panel, at least 96 mm² size with 90 degree linear scales and accuracy class of [2.0.]
 - o. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
 - p. For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
 - q. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- r. Metering and protection shall be as per below table

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	Protections	Metering
a)	Incomers, Tie Feeders and all Outgoing Feeders except Motor and Transformer Feeders	
	<ul style="list-style-type: none"> • IDMT Over current relay (51) • Instantaneous O/C relay(50) • Inverse time over current relay residually connected for Earth Fault detection (51N). • Inverse time over current relay (51NS) connected to transformer neutral for stand-by earth fault. (Applicable for 6.6 kV Unit and Station Incomer only) 	<ul style="list-style-type: none"> • Current in all the three phases (Metering at Switchgear end) • Voltage of all three phases • (Metering at Switchgear end) • kWh meter • (Metering at Switchgear end) • kVARH meter • (Metering at Switchgear end) • Current in all the three phases • (Remote metering through dual output type transducers) • Voltage in all the three phases • (Remote metering through dual output type transducers) • Watt transducer • (Remote metering through dual output type transducers) • VAR transducer • (Remote metering through dual output type transducers)
b)	Bus Couplers	
	Protections	Metering
	<ul style="list-style-type: none"> • IDMT Over current relay (51) • IDMT Earth fault relay (51N) 	Current on all the 3 phases
c)	[Motor Feeders]	
	Protections	Metering
	<ul style="list-style-type: none"> • Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload with unbalance current features etc. • Differential Motor Protection for Motor rating above & equal to 	<ul style="list-style-type: none"> • Current on all the 3 phases from Local & Remote. • KW meter shall be provided.

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	<p>2000kW.</p> <ul style="list-style-type: none"> Winding and Bearing temperature protection by means of RTDs connecting the same to DCS. The motor protection relay shall check the actual no. of repeated starts and compare the same with the manufacturer's permitted number of starts and prevent further starting attempts once the same is exceeded. Under voltage relay. CBCT for sensitive Earth fault (if required) 	
d)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection (Fuse failure protection No Voltage protection)	Voltage on all the 3 phases from Local & Remote.
e)	Transformer Feeder (6.6/ 0.433kV)	
	Protections	Metering
	<ul style="list-style-type: none"> IDMT Over current relay (51) Instantaneous O/C relay (50) Residual Earth fault protection (51N) CBCT for sensitive Earth fault (if required) Transformer Mechanical Protection (Buchholz protection for oil type transformer/WTI high alarm and trip/ OTI high alarm & trip (for oil type) Stand By Earth fault protection (51N) Connected to transformer Neutral 	Current on all the 3 phases from Local & Remote.

1.5 Tests

I. Type Test:

For each type & rating of 6.6kV Switchgear, the Bidder shall submit the reports

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of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening for Owner's approval. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II. Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative. However the following minimum routine tests shall be conduct.

- Power-frequency voltage tests on the main circuit
- Dielectric tests on auxiliary and control circuits
- Measurement of the resistance of the main circuit
- Partial discharge measurement
- Mechanical operation tests
- Heat Run test
- Pressure tests of gas-filled compartments
- Tests of auxiliary electrical, pneumatic and hydraulic devices
- Verification of correct wiring

III. Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV. Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

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1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below.

- a. *[General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening]*
- b. *Bill of Materials.*
- c. *Technical Data sheet and Catalogue.*
- d. *Foundation drawing details with bottom view of switchgear.*
- e. *Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.*
- f. *Control Schematics & Wiring diagram.*
- g. *Inspection and Test Plan (ITP).*
- h. *Suggestive list of protective relays.*
- i. *Transport/shipping dimensions and weights].*

1.7 Ratings & Requirements

6.6kV Switchgear shall comply with the particulars indicated in the following tables.

Table 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		<i>[By Bidder]</i>
1.2	Place & Country of manufacture		<i>[By Bidder]</i>
1.3	Specifications and Standards		As per Table 1.0
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		6.6 kV/7.2 kV, 3 Phase, 3 wire, 50 Hz.
2.2	System neutral earthing		Non Effectively earthed (Fault current Limited to 300A by neutral grounding resistor)
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz

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S. No.	DESCRIPTION	UNIT	DATA
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		20kV 60kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		Continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	40 kA for 1 Sec
b	Dynamic Rating	kA (peak)	100 kA
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		[Cu/Al]
2.14	Fully draw out (FD)/ Fixed (F)		FD / Single front
2.15	Entry –Top (T)/Bottom (B)		Top for bus duct, bottom for cables.
2.16	Degree of protection		[IP4X] and for LV chamber shall be [IP-52].
2.17	Color finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	[Aluminum]
2.19	Minimum clearances in air of live	mm	As per standard

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S. No.	DESCRIPTION	UNIT	DATA
	parts		
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		6.6kV,50hz,3 phase,3 pole
3.3	Rated operating duty		O-3min-CO- 3min -CO
3.4	Circuit breakers type		VCB
3.5	Short circuit withstand current for 1 sec. Duration	kA	40
3.6	Rated making current	kAp	100
3.7	Rated current at site reference ambient temp	A	[By bidder]
3.8	Type of operating mechanism		Spring charged motor and manual
3.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
3.10	Control voltage		
	Spring charging motor	V AC/DC	[220V DC]
3.11	Closing Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.12	Opening Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.13	Operating time		
	Opening time	ms	< 65
	Breaking time	ms	< 15
	Total tripping time	ms	< 80 (total break time)
	Total Closing time	ms	< 80 ms

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S. No.	DESCRIPTION	UNIT	DATA
3.14	Number of breaks per pole		One
4.0	Contactor		
	Voltage class	kV	7.2
	Short time Rating		[By bidder]
	Duty		AC3
5.0	Fuse		
	Voltage class	kV	6.6
	Rupturing capacity	kAp	100
6.0	Current Transformer		
a	Make		[By bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]
e	Basic Insulation level	kV	7.2/20/60
6.1	CT for differential protection		
	Class		PS class
	Secondary resistance at 75 ° C		[By bidder]
	Knee Point Voltage		[As per purchaser requirement]
	Excitation Current		< 30mA
6.2	CT for Metering		
	Class		[0.5]
	Secondary resistance at 75 ° C		[By Bidder]
6.3	CT for Protection		
	Class		[5P20]
7.0	Voltage Transformer		
a	Make		[By Bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]

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S. No.	DESCRIPTION	UNIT	DATA
e	Voltage ration		[By Bidder]
8.0	Meters		
a	Make		[By Bidder]
b	Type		[By Bidder]
8.1	Voltmeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
8.2	Ammeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
9.0	Indicating lamps		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Voltage	V	As specified in the specification.
d	Wattage of lamp	W	[By Bidder]
10.0	Push buttons		
a	Make		
b	Type		As specified in the specification.
c	Contact rating	A	[By Bidder]
11.0	Space heater		
a	Make		
b	Type		As specified in the specification.
c	Rated voltage	V	As specified in the specification.

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S. No.	DESCRIPTION	UNIT	DATA
d	Power rating	W	[By Bidder]
12.0	Wiring and terminal blocks		
a	Voltage grade		1.1 kV
b	Insulation		[By Bidder]
c	Minimum size of conductor for:		
	• Power wiring	Sq.mm	2.5 for CT & PT for internal panel wiring only and 4 for external wiring
	• Control wiring	Sq.mm	1.5 (for internal panel wiring only)
f	Type of terminal blocks:		
g	I) For Withdraw able Type		Sliding type
h	II) For Fixed Type		Stud & nut type
i	Minimum current rating of terminal blocks	A	10
13.0	ABT Panel		
a	Make		
b	Type		[By bidder]
c	Panel thickness	mm	2
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		Catalogue shall be furnished by the bidder.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E13

**TECHNICAL SPECIFICATION FOR VARIABLE FREQUENCY
DRIVES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E13

1.0 VARIABLE FREQUENCY DRIVE

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Variable Frequency Drives complete with all accessories for efficient and trouble-free operation of of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS-3700	:	Essential ratings and characteristic of semi-conductor devices
IS-3715	:	Letter symbols for semi-conducting devices
IS-4411	:	Code of designation of semi-conducting devices
IS-5001	:	Guide for preparation of drawings for semi-conductor devices
IS-5469	:	Code of practice for the use of semi-conductor junction devices
IS-5621	:	Hollow Insulators for use in electrical equipment
IS-6209	:	Methods for partial discharge measurement.
IS-6297	:	Transformers and indicators for electronic equipment
IS-8789	:	Performance parameters for motors
IS-12729	:	Switchgear and control gear for voltages exceeding

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		1000V- General requirements
IS-13408	:	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IEC 146	:	Semi Conductor converters
IEC 168	:	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V
IEC 270	:	Partial discharge measurement
IEC 297	:	Dimension of panels and racks
IEC 326	:	General requirements and measuring methods for printed wiring boards
IEC 352	:	Solder less wrapped connection
IEC-61800-3,4&5	:	EMC requirements and specific test methods
IEC-60664-1	:	Insulation coordination for equipment within low-voltage systems
IEC/EN-60204-1	:	Safety of machinery-electrical equipment of machines
IEC/EN-60529	:	Degrees of Protection Provided by Enclosures (IP Code)
IEC/EN-61000-3-12	:	Electromagnetic compatibility
IEEE 444	:	Protection standards for converters
IEEE 519	:	Harmonic control & reactive compensation of static power converters

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DIN 41488	:	Electrical engineering dimensions
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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) All VFDs shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The VFDs shall be suitable for operation in a highly polluted environment.
- b) All VFDs shall be suited for uninterrupted operation under the following variations in bus voltage and frequency:
 - i. Voltage Variation : +/-10%
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency
- c) The VFD shall be of modern design for similar applications in power plants. The system shall be commutated inverter type with minimum [six] pulse design, [IGBT based] and PWM controlled or better control system.
- d) VFD shall consist of Input section (rectifier and filter), control section and output section (PWM module, base drive circuits).
- e) VFD shall include an input filter for limitation of the harmonic current. General requirements of VFD shall conform to IEC 61800-2 and IEEE-519.
- f) VFD shall follow EMC directives as specified in IEC-61000.
- g) VFD model shall be suitably selected based on actual cable length from VFD to motor terminals. Shielded cables suitable for VFD applications shall be provided by the bidder.
- h) For [12 pulse] VFD, required 3 winding transformer and necessary cabling shall be provided by the bidder.
- i) Bidder shall provide inverter duty motor to withstand voltage stresses produced by PWM action

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1.3.1 Performance requirements:

- a) The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise.
- b) The system shall be suitable for the load characteristics and the operational duty of the driven equipment.
- c) The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment:
 - i. Variable torque changing as a function of speed i.e. speed squared.
 - ii. Constant torque over a specific speed range.
 - iii. Constant power over a specific speed range where the torque decreases when speed increases.
- d) The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The system shall be designed for linear continuous speed control from [10% to 100%] of driven equipment's rated speed and shall be of a modern proven design.
- e) The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800-4 and it shall be considered in the design of the motor.
- f) Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 115% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than one minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- g) During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit up to 60 seconds.
- h) The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- i) The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95 % of the minimum operational speed for more than 10 seconds.
- j) Maximum noise level of motor shall be measured as per relevant IS standard.

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- k) Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and troubleshooting/ maintenance.
- l) Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

The drive system shall ensure following:

- i. VFD induced torque pulsation are limited to maximum 1% (even at low speed) so there is minimal stress to the equipment
- ii. Motor is protected from dv/dt stresses.
- iii. No appreciable increase in motor audible noise.

1.3.2 Control requirement:

- a) The VFD and motor characteristics shall be suitable for load specific torque-speed characteristics.
- b) Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.
- c) The system shall also be equipped with a facility which shall restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart the converter shall be capable of synchronizing on to a rotating motor and develop full acceleration torque within 10 seconds.
- d) The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.
- e) The drive motor shall be speed controlled corresponding to 4-20 mA reference input signal unless otherwise specified upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed at the last speed reference available prior to the loss of signal.
- f) It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/manual selection shall be from VFD panel unless otherwise specified.
 - i. With the selector switch in "manual" mode, the operator shall be able to set the speed through keypad, mounted on front of the drive panel or from speed increase/decrease push buttons from the field. Motor operated potentiometer shall be provided as a speed set point device.
 - ii. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's DCS (Process Control) system. Necessary equipment required for interfacing with DCS shall also be provided in the drive panel.

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- g) The required provision for the interface with remote I/O (*as per requirement*) shall be through hardwired connection (with potential free contacts and transducers)
- h) Drive system shall have provision for interface with upper level automation such as electrical control system.
- i) The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.
- j) Bypass Feature
 - i. Bypass breaker / contactor-HRC fuse complete with protection, annunciation and metering shall be provided.
 - ii. All Variable frequency drives (VFD) having bypass feature shall have motor protection relay along with necessary control and metering etc. Switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended by opening its isolation devices.
 - iii. Safety interlock between inverter and bypass breaker/contactors shall be provided such that closing of healthy device is inhibited in case of external fault.

1.4 Specific Requirements

1.4.1 Constructional Requirements

- a) Panel Construction
 - i. The panel shall include suitable semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors (if required), filters (if required), control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of integrated standards.
 - ii. Upstream breaker include suitable semi conducting power devices (Diodes / IGBT) modules will be provided on the front door.
 - iii. Safety Interlock shall be provided so that power cabinet cannot be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.
 - iv. The drive shall be suitably housed in sheet steel panels fabricated with 2 mm thick cold rolled sheet steel. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. The maximum and minimum operating height shall be 1800 mm and 400 mm respectively.

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- v. Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600 mm clear from bottom of the cable gland plate.
- vi. Bus bars shall be of electrolytic copper, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.
- vii. All the switches component and accessories which are essential for normal and emergency operation shall be mounted on the door and shall be operable externally. Digital meters shall be preferred. Analogue instruments, where provided, shall be switchboard type, back connected, 72x72mm. Scale shall have red mark indicating maximum permissible operating rating.
- viii. All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- ix. All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with PVC insulated, fire retardant, copper conductor wire. 1.5 mm² size wire shall be used for control circuits, 2.5 sq.mm for CT/PT circuits and 0.75 mm² for electronic circuits. The control fuse rating is 10 Amps or less and 2.5mm² size for control fuse rating above 16A for electrical circuits and 0.7 mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered. Minimum 20% spare terminals shall be provided.
- x. All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipment and power electronic equipments shall be used.
- xi. All low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.
- xii. DC link capacitor and pre charging and discharging circuit shall be preferably mounted in the rear of the panel. Suitable removable type hooks shall be provided for lifting the panel.
- xiii. Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- xiv. All equipment shall be complete with double compression glands, lugs etc.

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b) Cooling

- i. The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Bidder shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N + 1) shall be provided.
- ii. Necessary starters shall be provided within the VFD panels for the ventilation fans, any other auxiliary motor etc.
- iii. The system provided shall be interfaced with drive starting and shut down such that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., shall be incorporated in the overall sequence logic.
- iv. MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easily accessible location.

1.4.2 Motor

The motor shall be designed, constructed and tested in accordance with the Specification for high Voltage Induction / Synchronous Motor, in addition to the following requirements:

- a) The motor shall be suitable for VFD control.
- b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- c) The motor shall be designed to operate continuously at any speed in the operating range for the driven equipment (ie; ID fan / Coal feeder).
- d) The permitted voltage variation shall take into account the voltage drop across the AC drive and all other system components upstream the motor.
- e) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications.
- f) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- g) The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4.

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- h) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

1.4.3 Static Power Converter

- a) The static power converter shall consist of a line side converter for operation as a rectifier and a load side power converter for operation as a fully controller inverter. Power converter shall be fast switching, most efficient and low loss type.
- b) The converter shall be co-ordinated with the transformers. The converter shall be able to withstand a three phase short circuit current until interrupted by normal breaker operation.
- c) Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- d) All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- e) The current rating of the converters semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range. If the parallel connection of semi conductor is applied, the above current rating shall not be less than 140% of the above values.
- f) All power diodes shall be of silicon type with minimum V_{BO} rating at 2.5 times the rated operating voltage.
- g) The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise nor reducing its service factor due to harmonic currents generated by the inverter operation.
- h) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions / tools.
- i) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

1.4.4 Converter Transformer

- a) The converter transformer, if provided, shall be copper wound dry type. Insulation class of dry type transformer shall be H with temperature rise of body limited to 75°C. Dry type transformer shall preferably be mounted inside the drive system panel. The impedances of converter input transformers with more than one secondary winding for minimum 18 pulse systems shall be selected to ensure equal load / current sharing

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between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

- b) The transformation ratio, impedances, taps and secondary voltage shall be chosen by the drive vendor to optimize system performance.

1.4.5 DC link reactor

- a) Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- b) Unless otherwise specified, the reactor shall be dry type, air cored, air-cooled or fan cooled type located within the panel.
- c) Reactor shall be suitable for withstanding earth fault continuously and for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.
- d) Noise level shall not exceed value specified in NEMA TR-1

1.4.6 Output filter

- a) VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance free and self-healing type.
- b) The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

1.4.7 Protection, Control, Metering, Indication and Annunciation

- a) The Bidder shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

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- b) Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.
- c) Protective Relays:
For details on protective relays used, refer to Technical Specifications on MV Switchgear
- d) Operator Control Panel
- i. Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to start/Stop, Local/Remote, auto/manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
 - ii. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
 - iii. Operator console shall have facility /port to connect external hardware such as Lap-Top etc. Console shall have facility for upload and download of all parameter settings from one drive to another identical drive for start up and operation.
 - iv. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing up stream breaker after all required process parameters are achieved.

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- v. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.
 - vi. Suitable interface with DCS to be provided for control and status signals of VFD.
- e) Local Motor Control Station
- i. The local motor control station shall be installed near the motor. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
 - ii. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current.
 - iii. Requirement of controls and indications required in the Local Control Station shall be as specified in the data sheet.
- f) Protective Features:
- The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:
- i. Incoming line surge protection
 - ii. Under / Over voltage protection
 - iii. Phase loss, phase reversal protection.
 - iv. Programmable Over current protection and under load protection.
 - v. Motor differential protection for motor rated above 1000 kW
 - vi. Inverter Fault.
 - vii. Over frequency operation.
 - viii. Ventilation loss,
 - ix. Over temperature of equipment.
 - x. Over speed of motor.

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- xi. Specific motor protection, including motor winding, bearing temperatures, over-current, overload, negative phase sequence, locked rotor and earth fault protections etc.
- xii. System Earth fault protection.
- xiii. Excitation system protection for synchronous motor
- xiv. Over and under frequency, rotor earth fault, field failure protection for synchronous motor
- xv. Additional protection for drive system

g) Control features

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

- i. Start/Stop
- ii. Speed control (Raise/lower)
- iii. Forward/Reverse(if Specified)
- iv. Auto/Manual /test mode
- v. Local/remote
- vi. Emergency stop
- vii. Start/stop for by pass starter (where specified)
- viii. Trip-Remote Breaker
- ix. Excitation control system for synchronous motors
- x. Sequential switching of filters

h) Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- i. Input AC Current
- ii. Input AC voltage
- iii. Input AC frequency
- iv. Output voltage
- v. Output current VFD / Bypass
- vi. Output frequency
- vii. Motor thermal state

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- viii. Drive thermal state
- ix. Motor speed
- x. Motor energy meter
- xi. DC Link voltage
- xii. Hour Run
- xiii. Voltage and current meter for excitation system for synchronous motor.
- xiv. KVAR, power factor meter for synchronous motors
- xv. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

i) Indications

Bidder shall provide indications as required for normal operation and for easy maintenance, which shall not be limited to the following indications both at local and at plant DCS.

- i. Motor running
- ii. Motor stopped
- iii. VFD System Fault
- iv. System ready to start
- v. AC mains ON
- vi. Motor over speed
- vii. Rectifier output 'ON'
- viii. Motor zero speed
- ix. Remote breaker trip
- x. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e., door mounted keypad or through hardwired indicating lamps/LEDS.

Potential free contacts of items i- iv shall be wired separately for remote indications in DCS.

j) Audio-visual annunciations

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- i. The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter, output transformer etc.
- ii. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.
- iii. Audio-visual window annunciations shall be provided on the front of the panel All annunciations as required for normal and satisfactorily operation of the drive system shall be included as per Bidder standards. These annunciations can be part of operator console panel or separately mounted type.
- iv. Bidder shall include audio-visual alarm as required for normal operation and maintenance of the system but not be limited to the following,
 - Rectifier fuse failure
 - Main AC failure
 - Inverter fuse failure
 - Inverter overload
 - Inverter high temperature
 - Cooling system failure
 - Motor failed to start
 - Transformer failure
 - Excitation system failure for synchronous motor
 - Battery monitoring healthiness
 - Communication and measurement system un healthy
 - Motor temperature high
 - Harmonic filters monitoring
- i. Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminals of DCS I/O panels for remote alarm and monitoring.

k) Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available for a period of minimum 4 days (96 hours) after a shut down even though no supply

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would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

1.4.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle lamps (CFL) etc. shall operate on 240 volts single phase AC.

All control circuit shall operate at voltage of 110V AC or 220V DC.

Bidder shall include supply of all control transformers, protective devices, required accessories etc. and any other control supply voltage as required for the system.

1.4.9 Maintenance features

The controller design shall incorporate the following maintenance features:

- a) Modular construction
- b) All components shall be easily accessible.
- c) Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

1.4.10 Painting

- a) All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.
- b) After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be as per manufacturer's standard, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

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- c) All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

Final paint shade shall be light gray and dove gray 631 and 632 as per IS-5 for indoor and outdoor equipment respectively unless otherwise specified

1.5 Tests

The Routine and Type Tests to be performed on the drive system in the presence of the purchaser or consultant shall be as follows:

1.5.1 Type Tests

For each rating and type of VFD, the Bidder shall submit for Owner's approval, the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

All type tests shall be conducted as per relevant standards and test certificates of similar panels conducted within last 5 years shall be furnished.

1.5.2 Routine tests

- a) Visual Inspection
- b) It involves checking of the various equipments/components fault diagnostic unit, Wiring, Terminals, earthing ratings etc. in line with the approved drawings and visual inspection shall not be limited to the following:
- c) Insulation Test
- d) Light Load and Functional Test
- e) Load characteristics test
- f) Load duty test
- g) Checking of Auxiliary Devices
- h) Checking the properties of the control equipment

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- i) Checking the Protective Devices
- j) Checking of control and functional requirements
- k) High voltage test
- l) Leakage and pressure test for cooling water system where provided
- m) Shaft current/bearing insulation
- n) Automatic restart/re-acceleration

Additional tests on switchgears and dry type transformers shall be carried out based on the requirement defined in the technical specification.

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data and Manuals

The engineering services scope and the documentation to be issued with the bid are described hereafter. The list shows the minimum requirements for the documentation, so that any additional documentation considered as necessary will be added to this.

- a) Engineering, manufacturing, delivering and test schedule
- b) Sub-Supplier lists.
- c) General arrangement drawings(plan, elevation, section view) with dimensions
- d) Foundation drawing including loading data.

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- e) Technical Data sheets.
- f) Electrical and control wiring diagram.
- g) Terminal arrangement drawing, interconnection wiring diagram.
- h) Cross sectional drawing.
- i) Inspection and test plan.
- j) Manufacturing Quality Plan.

1.7 Ratings and requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table 2.0

Sl. No	Technical Parameters		
		6.6 kV	415 V
1	Manufacturer Name	[By Bidder]	[By Bidder]
2	Model No.	[By Bidder]	[By Bidder]
3	Application		
4	Quantity		
5	Enclosure Protection Rating	IP-31	IP-31
6	Output Current Rating at ambient temperature	[as per requirement]	[as per requirement]
7	% derating considered for specific ambient	As per IEC	As per IEC
8	Rated Voltage (volts) Input	6.6 kV AC ± 10%, 3-phase	415 V ± 10%, 3-phase

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Sl. No	Technical Parameters		
		6.6 kV	415 V
9	Output Frequency Range (Hz)	[By Bidder]	[By Bidder]
10	Number of Phases and Frequency (Hz)	3 Phase, 50 Hz (+ 3% to -5%)	3 Phase, 50 Hz (+ 3% to -5%)
11	Rectifier type & Design	[6/12/18 Pulse Diode Bridge]	[6/12/18 Pulse Diode Bridge]
12	Inverter type & Design	[as per requirement]	[as per requirement]
13	Min/Recommended / Max switching frequencies (kHz)	[as per requirement]	[as per requirement]
14	Filters	[as per requirement]	[as per requirement]
	Line Side	[as per requirement]	[as per requirement]
	Load Side	[as per requirement]	[as per requirement]
15	Output Modulation Method	PWM	PWM
16	Speed Accuracy (+/ - %)	[as per requirement]	[as per requirement]
17	Response time (speed)	< 5ms with nominal Torque	< 5ms with nominal Torque
18	Response time (Torque)	[By Bidder]	[By Bidder]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
19	Type of cooling	[Natural/forced/water] cooled	[Natural/forced/water] cooled
20	Whether VFD is suitable for outdoor installation	No	No
21	Drive Control Capabilities		
	Start/Stop Push button	ON/Speed Increase/Speed decrease From DCS	ON/Speed Increase/Speed decrease From DCS
	Modbus control	Yes	Yes
22	Load parameters at rated voltage & frequency		
	Output Frequency (Hz)	[0 to ± 120Hz]	[0 to ± 120Hz]
	Full Load current (Amp)	[By Bidder]	[By Bidder]
	VFD Heat dissipation (w)	[By Bidder]	[By Bidder]
23	VFD Efficiency		
	At Full rated Torque	[Approx 98% (Only drive)]	[Approx 98% (Only drive)]
	At 75% of full load torque	[By Bidder]	[By Bidder]
	At 50% of full load torque	[By Bidder]	[By Bidder]
24	Drive Power factor range		
	At rated speed, Torque	[≥ 0.98 (Fundamental)]	[≥ 0.98 (Fundamental)]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
25	DC Voltage	[1.35 times of supply voltage]	[1.35 times of supply voltage]
26	Fundamental power factor	≥ 0.98(At nominal Load)	≥ 0.98(At nominal Load)
27	Switching Frequency	[By Bidder]	[By Bidder]
	Drive Dimensions	[By Bidder]	[By Bidder]
	Length	[By Bidder]	[By Bidder]
	Height	[By Bidder]	[By Bidder]
	Depth	[By Bidder]	[By Bidder]
	Weight	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-II, PART-C
DETAILED TECHNICAL SPECIFICATION- I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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1 GENERAL

This specification is intended to provide the technical guidelines for the fully coordinated Control & Instrumentation (C & I) system for the Coal Handling C&I and its Auxiliaries of [210/215/220/250] MW, Coal fired Subcritical Thermal Power Plant.

The technical specification shall serve as the guide specification for the proprietary controls of coal Handling System and its Auxiliaries, equipments as also various stand alone system controls included as part of sub-packages, as in case of system auxiliaries.

The requirements enumerated in this specification are based on typical configuration of the plant. It shall be responsibility of bidder to offer the control and instrumentation system to meet the actual functional requirements of the coal handling system offered by bidder.

It is to be noted that where equipment or system for the Coal Handling system and its auxiliaries are described, it shall be understood that the quantities described are per unit basis, i.e., identical sets to be furnished for each of the units (If plant have multiple units). Where equipment or systems for common facilities are described, it will be understood that the quantities described are the total quantities required.

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2 SYSTEM DESCRIPTION

I&C system of coal handling system shall consist of all local instruments Viz. Pressure Gauge, Temperature Gauge, limit switch, Pull cord switch, Belt Sway switch, Electronic Zero speed / Under speed switch, Bunker level switch/ indicator, other field sensors, Local panel & push button station, CHP Local control room equipment, as required erection hardware & interconnecting cables required for the control & monitoring of the entire Coal handling Plant along with control of track hopper & Stacker-Reclaimer as turnkey basis.

The Control and Instrumentation system for the Coal Handling System shall be designed to ensure safe, efficient and reliable operation of the plant under all regimes of operation namely start up, shutdown, normal operation and under emergency conditions.

The following equipments of the coal handling system shall be operated and controlled from CHP control room:

- Conveyers, flap gates, scoop type fluid couplings, crushers and screens.
- Stacker cum Reclaimer
- Complete Dust Suppression System
- Ventilation System (group/individual control as required)
- Inline magnetic separators (ON/OFF control with indications)
- Metal Detectors (ON/OFF control with indication)
- In line Belt Weigh Scale (ON/OFF control with indication)
- Vibration Monitoring System (VMS) For HT Drives

A PLC based control system shall be provided for operation, control, interlocking, tripping of the entire Coal Handling Plant and all associated equipment whenever required under specified abnormal conditions.

All 6.6 KV drives shall be provided with fluid coupling temperature/ bearing Temperatures measurement & shall be measured with Duplex RTD. Temperature Measurement sensor shall be provided for all bearing temperature measurement. Stator winding temperature measurement element shall be duplex type and all temperature measuring points shall be connected to PLC. Winding temperature high alarm will be generated in the PLC system. 6.6 KV drives shall also be provided with vibration monitoring devices and shall be connected with PLC.

2.1 General Requirements

1. The control and instrumentation system for Coal handling Plant shall be designed and constructed to meet all the specification requirements. All

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instruments/ equipments offered shall be capable of satisfactory operation for prolonged period of time and shall perform accurately and safely under the environmental & operating conditions described in the specification.

2. All equipment, and accessories furnished under the specification shall be from the latest proven control and instrumentation product range of qualified manufacturers whose successful performance has been established by a considerable record of satisfactory operation in power stations. C&I devices & systems shall employ latest state-of-the art technology to guard against any obsolescence. In any case, it shall be required to ensure supply of spare parts for lifetime of the plant.
3. Each item included in this specification shall be inspected and tested by the Bidder in his works for full compliance with specification requirements, completeness, proper assembly, satisfactory operation, cleanliness and state of physical condition as applicable.
4. Full details regarding all equipment and systems including complete Bill of Materials, drawings, data, information, technical literature and other details required to fully establish the capability and performance of the equipment and systems offered shall be provided as a part of the contract.
5. To ensure smooth and optimal maintenance, easy interchange ability and efficient spare parts management of various C&I items, it shall be ensured that each C&I item is of same make, series and from same family of hardware (as far as practicable).
6. All plants and equipments which needs regular operation and monitoring shall be provided with remote operation/ monitoring facilities, at respective control rooms/centers. Automatic control facilities to be incorporated wherever applicable.
7. Operation & Control Philosophy: The operation and control shall be through the PLC based system for the entire Coal Handling Plant (CHP) covering the total functional requirement of sequence control, interlock & protection, monitoring, alarm, data logging.
8. The design of the control system and related equipment shall adhere to the principle of fail safe operation of all system levels i.e, the failure of signal, failure of power or failure of any component should not cause a hazardous condition and at the same time prevent occurrence of false trips and provide reliable and efficient operation of the plant under dynamic condition.
9. The PLC system shall be an integrated control and data acquisition system for providing control & monitoring of coal handling plant equipment from CHP Control Room. The control room operator shall be provided with colour

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graphic displays of the Coal Handling Plant and with sufficient details to allow proper control & monitoring of the plant functions.

10. All plant and equipments which needs regular operation and monitoring shall be provided with remote operation/ monitoring facilities, at respective control rooms/centers. Automatic control facilities to be incorporated wherever applicable.
11. Belt Weigher, ILMS, Dust suppression, Dust extraction, Ventilation system, will have local control panels mounted near the equipment. Redundant remote I/O cables shall be provided from local control room to CHP control room for interfacing with CHP PLC.
12. Local start/stop facility for conveyors/ travelling trippers/ Paddle feeders other equipment shall also be provided for maintenance requirements for those which are remote operated.

2.2 PLC system

PLC system shall be redundant with respect to Power Supply, Processor and Communication. Redundant Input card shall be used for measurement of Critical points related to protection of the equipment. All output commands to MCC/ SWGR shall be provided through interposing relay .The control panel shall be IP 55 protection class.

The control system shall have hooter with required hardware and driven from PLC output. Test, Accept and Reset Push Button shall be connected to the PLC system and programmed for alarm annunciator.

A table top mounted PC loaded with editable programming software and HMI shall be provided and placed on a table located on the side of the control panel. There shall be facility of operation from LCD based Operator's station.

2.3 Interfacing With Plant DCS

Facility of interface shall be provided for interface requirements with plant DCS. CHP PLC shall be linked with plant DCS through redundant Unidirectional OPC link in addition to some hardware interface signals. Any device/ software required for the same shall be included. Proper co-ordination shall be maintained with the DCS vendor in achieving the successful & complete interface.

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3 DESIGN PHILOSOPHY

This section covers the design philosophy which shall be used for all control & instrumentation system for Coal Handling System & its auxiliaries.

1. Control System for coal handling plant shall be Programmable Logic Controller (PLC) based or shall be implemented through micro-processor based distributed control system (DCS) covering total functional requirements of sequence control, interlock & protection, monitoring, alarm and data logging. Remote I/O cabinets shall be provided wherever required depending upon distance/location.
2. It shall be possible to select any coal flow path from the Operator's work station located in the CHP control room viz.
 - Wagon tippler/ track hopper to coal bunkers
 - Wagon tippler/ track hopper to crushed coal storage via stacker cum reclaimer
 - Wagon tippler/ track hopper – one stream to crushed coal stockpile and other stream to coal bunkers
 - From crushed coal stockpile to coal bunkers via stacker cum reclaimer
 - From crushed coal stockpile to coal bunkers via emergency reclaim hoppers
3. Entire CHP shall be controlled from following points:
 - CHP control room consisting of Operator Work Station (OWS) and Large Video Screen (LVS) for the control of entire CHP. Some I/O may be located remotely in Wagon tippler MCC room and on bunker floor.
 - OWS/LCP for the control of stacker cum reclaimer.
 - OWS/LCP for the control of wagon tipplers/track hoppers.
 - Dust extraction/suppression system shall be operated from the respective control panel provided locally with the equipment/system. Dust extraction/suppression system shall operate when the coal conveying system is in operation and bunker ventilation systems shall operate round the clock. DE / Dust suppression system shall be provided with remote operation from main CHP control room except for Bunker floor DE operation which will be local.
 - Control system for stacker cum reclaimer, wagon tipplers, dust extraction /suppression system shall be interfaced to the CHP control room.

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- Local start/stop push button stations, de-interlock switches to be mounted near each equipment for start/stop during maintenance of the system through Local/remote selection from respective SWGR/MCC.
4. The flow stream path is then selected by positioning different flap gates/shuttle feeders at the desired position from monitor to select the conveyors. After the selected path is in operation the movement of the path selector shall not have any effect on the system. The system shall be in operation with a time delay and with a hooter sound. If selection is wrong, PLC shall generate an audio-visual warning.
 5. The control system shall be designed for "Auto" & "Manual" operation of the conveyors in the selected path. Auto/Manual selection shall be done from faceplate in HMI.
 6. Auto Mode: In the "Auto" mode, the conveyors and related equipment shall start sequentially when the "System Start" is activated. During stopping, when the "System Stop" is activated, all conveyors shall stop sequentially (in the reverse sequence) allowing time delays for clearing the materials on conveyor.
 7. Manual Mode: In Manual Mode, the operator shall start the conveyor system in the same sequence as in Auto mode by pressing individual "Start" buttons on OWS/LCD. The operator shall also stop the conveyor system, by pressing "System stop" or individual "Stop" buttons in the reverse sequence.
 8. During 'sequence start' in both auto and manual modes, first the required number of hooters shall be energized simultaneously for a preset time of 1 minute or so (adjustable) as per the program. After the preset time, the hooters shall stop and a preset time of two minutes (adjustable) shall be allowed for the movement of the personnel and for the permissive of the conveyor system operation. This condition shall be indicated on the HMI as 'SEQUENCE START'. The starting permissive shall be available for a period of 5 minutes. In the event the last conveyor /equipment is not started within this preset time of 5 minutes, the start command for equipment not activated shall be withdrawn. The system shall not be started again unless the 'sequence start' command is again provided and the hooters sound again, as described before. Those conveyors and equipment, which have already started, shall continue to run.
 9. After a conveyor / equipment are started, the status indications against that conveyor / equipment on HMI shall change to steady glow indicating that it is running.
 10. Graphic display status indicators associated with a particular motor /equipment shall flicker fast in case of fault / trip.

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11. In addition, emergency stop push button for immediate shut down of complete plant shall be provided in the control desk.
12. Vibration monitoring shall be provided for all HT drives such as crusher.
13. Crusher vibration limit shall be as per ISO 2392. r.m.s. velocity limit shall be 4.5 mm/sec.
14. The degree of protection for the motor enclosure shall be IP-55. The terminal boxes shall be provided with at least IP-55 degree of protection. For single core cable termination, gland plates shall be of non-magnetic material. All motors located in hazardous area shall have flame proof design.
15. All MV/HV motors shall be provided with vibration pads for mounting vibration detectors.
16. For 415V motors, maximum double amplitude vibrations upto 1500 rpm shall be 40 microns and 15 microns upto 3000 rpm.
17. Maximum noise level measured at a distance of 1.0 meter from the outer surface of the motor shall not exceed 85 db (A).
18. Pressure indicators shall be used wherever indicating type Pressure transmitters are not envisaged. The applications include:
 - a) Suction and discharge lines of pumps, including header section, if two or more pumps are employed for the same service.
 - b) All input and output lines of process equipments.
19. Pressure Switches shall be avoided as far as possible and in place, smart pressure transmitters with soft limit value monitoring in control system shall be used. The applications shall include the following:
 - a) On all process lines / Equipments where parameter abnormality / status including pre trips alarms to be communicated to the operator in control room.
 - b) For all permissive and protection conditions governed by safety operation of the equipments. e.g. pressure adequate, pressure very high / very low conditions.
 - c) For all interlock conditions, governing starting of standby equipment or subsequent equipments for safety operation of the system.
 - d) Inlet and outlet of filters / strainers.
20. Temperature Elements: RTDs shall be used for casing metal temperature monitoring and bearing temperature monitoring of HT drives/motors.
 - a) Six nos. (2 nos. per phase) Resistance temperature detectors (RTD's) shall be used for all HT motors, for winding temperature monitoring. Each

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element shall be 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to coal Handling Control system.

- b) 1 no. duplex PRT-100 type RTD shall be used for each bearing of HT equipment and its driving equipment (motor).
 - c) All RTDs shall be PRT-100 type with each element being 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Coal Handling Control system.
 - d) Temperature measurement shall have upscale / down scale protection features not to cause major process upset in case of sensor failure.
21. Level gauges shall be used on all tanks and the maximum length of one gauge glass shall not exceed 1 meter. The gauge glasses shall be stacked to cover the complete height of the tanks including over flow level. There shall be an overlap of minimum 100mm, when more than one level gauge is required.
22. Level switches: The instrument shall be used for the following applications:
- a) On all equipments (storage vessel) where parameter abnormality/status has to be communicated to the operator in the control room.
 - b) All permissive, interlock and protection conditions governed by the safe operation of the equipment.
 - c) The instrument shall be external cage type with SW connection with isolation facility for surface mounted tanks and top mounted with still pipe for all sumps. Still pipes shall be used with adequate supports.
 - d) Radar type level switches shall be used for bulk material bunkers/hoppers.
23. Level Transmitters Stubs with impulse pipes, root valves for mounting Level transmitters shall be used on process equipments where continuous remote monitoring and/or control of level is envisaged. Wherever necessary standpipes or float chambers and also makeup line shall be used for filling up the constant level vessel.
- a) The instrument shall be differential pressure type or torque tube type for other applications.
 - b) Radar type level transmitter shall be used for bulk material bunkers/hoppers.
 - c) Admittance or Radar type shall be for sludge and slurry applications.
24. Solenoid Valves shall be used for all pneumatic control valves hooked up with process interlock requirements and where direct tripping is involved. All

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solenoid valves shall be uniformly rated for 24V DC or 220V DC. The number of ways for solenoid valve shall be used as indicated below:

- a) On line two (2) way solenoid valves shall be used, where process line of less than 2 inch with low pressure & temperature application is involved.
- b) Three (3) way solenoid valves shall be used commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder. E.g.: Pneumatic operated spray water block valve.
- c) Four (4) way solenoid valves shall be used for operating double acting cylinders (If applicable). E.g.: Pneumatically operated on-off type dampers.
- d) Dual coil, latch, unlatch type Solenoid valves shall be supplied for equipment trips/critical applications.

25. Electro-Pneumatic positioners shall be used for all pneumatically operated control valves, power cylinders etc., for converting controller output of 4-20 mA to appropriate pneumatic signal

26. Air Filter Regulators along with gauges shall be used in each of the:

- a) Air supply line to valve positioner/power cylinders
- b) Air supply line to pneumatic interlocked block valves

27. Interposing relay for interface to the following:

- a) Solenoid valve (if output module cannot directly drive SOV) - Relays with contact rating of minimum 2 Amps.
- b) DC Starter (if output module cannot directly drive) - Relays with contact rating of minimum 0.2 Amps.
- c) Hardwired signal exchange – as required.

28. For all HT rotating equipment bearings provision for mounting vibration probes shall be used.

29. Junction Boxes/Field termination cabinet: All JBs /FTCs shall be FRP. Junction Boxes shall be used for:

- a) Termination of all sensors located equipment wise.
- b) Termination of Duplex RTDS
- c) Termination of limit switch, torque switch, position transmitter and control demand, independently for each valve/device.
- d) Area wise or Elevation wise bunching of cables.

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30. Instrumentation & control cables and Prefabricated Cables with Anti-Rodent treatment shall be used to:

- a) Connect field instruments to field junction boxes/Local Panels. For switches, both the SPDT contacts of switches shall be wired up to the J.B.
- b) Connect limit switches, torque switches and position transmitters to their respective field junction boxes.
- c) Compensating cable shall be supplied for connection between the element and the respective junction boxes / system cabinets as per guidelines.
- d) Prefabricated cable for connecting between system cabinets, marshalling cabinet to system cabinet, system cabinet to Relay Rack, system cabinets to engineering work stations etc.
- e) Entire C&I cable within the battery limits.

31. All field instruments including electronics located outside control room areas shall be tropicalized and shall be designed to work in site specific atmosphere/climatic conditions and enclosed in dust tight, waterproof and weatherproof enclosures. In general, transmitters and switches installed at outdoor location shall be mounted in closed type transmitter enclosure. For other areas (indoor), open type racks may be used for installation of transmitters and process switches.

32. All alarm shall be displayed in the control system HMI/LCD. However where local panels are used for local operation/monitoring, PLC driven alarm annunciation system with LED type lamps for local panel shall be used.

33. Spring-loaded/ Cage clamp type terminals shall be used for termination of instrumentation cables at field JBs, FTCs and local panels.

34. Signal Exchange Between Coal Handling Equipments/System and control System

- a) All the signals required for interlock/alarm/SER purpose (to be implemented in the control System) shall be hardwired.
- b) All binary outputs provided to local panels/sensors for connection from control System shall be potential free contacts with a rating of 0.2 amps at 220 V DC or 2 amps at 24 V DC or 5 amps at 240 V AC. All check backs to control System shall only be potential free contacts.
- c) All analog outputs provided to local panels/sensors for connection from control System shall be isolated 4-20 mA DC.

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- d) Command outputs from control System to motorized valve actuator shall be logic level signal (24 V DC) and necessary interposing relays suitable to accept 24 V DC logic level command signal shall be used in MCC module for MOV actuator.

35. All indication lamps shall be LED type.

36. All interposing relays shall be Plug in type with screw type base & LED for status indication. Relay modules/boards etc. are not acceptable.

37. All Limit Switch shall be Non-Contact type. If there is constraints because of process conditions/space, mechanical lever actuated Limit switch may be used.

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4 DESIGN CRITERIA

This section covers the general design criteria to be adopted in designing the Control & Instrumentation system for the Coal Handling System Package.

4.1 General Requirements

Ambient Conditions

Instruments, devices and equipment for location in outdoor / indoor / air-conditioned areas shall be designed to suit the environmental conditions indicated below and shall be suitable for continuous operation in the operating environment of a coal fired Power plant and also during periods of air conditioning failure without any loss of function, or departure from the specification requirements covered under this specification.

Table 4.1
Protection Class Requirement

Ambient Temperature (outside temperature)	Pressure	Relative Humidity	Atmosphere	Required Protection class of panels /cabinets /desks
Outdoor Location				
55 °C max	Atmosphere	100%Max	Air (dirty)	IP 65
4 °C min	Atmosphere	5% Min	Air (dirty)	IP 65
Indoor Location				
55 °C max	Atmosphere	95% Max	Air	IP 54
4 °C min.	Atmosphere	5% Min	Air	IP 54
Air-conditioned Area				
24 +/- 2 °C normal	Atmosphere	95% Max	Air	IP 44
50 °C Max.	Atmosphere	5 % Min	Air	IP 44

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Ambient Temperature (outside temperature)	Pressure	Relative Humidity	Atmosphere	Required Protection class of panels /cabinets /desks
<p>a) For Ventilated enclosures, protection class shall be IP 42.</p> <p>b) For hazardous areas the protection class shall be in accordance with the requirements of the relevant NEC code for the location.</p> <p>c) For PCs, OWS, EWS, Servers, Printers and other peripherals, maximum temperature limit shall be 35 °C, For LCD the same shall be 25 °C & for UPS the same shall be 40 °C</p>				

4.2 Codes & Standards

All equipment, system and service covered under this specification shall comply with the requirements of the latest statutes regulations and safety codes as applicable in the locality where the equipment/systems shall be installed.

The equipment, systems and services furnished as per this specification shall conform to the codes and standards mentioned in this section. However in the event of any conflict between the requirements of two standards or between the requirements of any standard and this specification, all equipments under this specification shall be given tropical treatment for the climatic conditions prevailing at site as described under project data. Tropical protection shall conform to IS-3202 or any other applicable international standard for protection of Electrical power equipments against climatic conditions.

Reference Codes and Standards

The design, manufacture, inspection, testing, site calibration and installation of all equipment and systems covered under this specification shall conform to the latest editions of codes and standards mentioned below and all other applicable ANSI, ASME, IEEE, NEC, NEMA, ISA, DIN, VDE and Indian Standards and their equivalents.

Temperature Measurement

- Instrument and apparatus for temperature measurement ASME PTC 19.3(1974)
- Temperature measurement by electrical resistance thermometers – IS: 2806.
- Thermometer-element-platinum resistance-IS-2848 / DIN 43760/ IEC 751

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Pressure Measurement

- Instrument and apparatus for pressure measurement - ASME PTC 19.2 (1964)
- Bourdon tube pressure and vacuum gauges - IS 3624 – 1966

Flow Measurement

- Instrument and apparatus for Flow measurement – ASME PTC 19.5 (1972) Interim supplement, Part-II
- Measurements of Fluid flow in closed conduit – BS 1042 / ISO 5167.

Electronic measuring Instruments & Control hardware

- Automatic null balancing electrical measuring instruments - ANSI C 39.4 (Rev. 1973)
- Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5 - 1974.
- Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1 - 1975.
- Dynamic response testing of process control instrumentation - ANSI MC 4.1 (1975): ISA-S26 (1968).
- Surge withstand capability (SWC) tests - ANSI C 37.90a (1974) IEEE Std. 472 (1974). IEC - 254.1.
- Printed circuit boards - IPC TM-650, IEC 326 C
- General requirements and tests for printed wiring boards - IS 7405 (Part-I) - 1973
- Edge socket connectors - IEC 130-11.
- Requirements and methods of testing of wire wrap terminations DIN 41611 Part-2.
- Dimensions of attachment plugs & receptacles ANSI C73-1973.
- Direct acting Electrical Indicating Instruments: IS-1248-1968.

Electronic Cards, Subassemblies & Components

1. Unpackaged

- Vibration IEC 68.2.26
- Shock IEC 68.2.27
- Drop & Topple IEC 68.2.31

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2. Packaged

- Vibration, Drop & Static Compression – NSTA

3. Electromagnetic Compatibility

- Electrical Fast Transient – IEC 801.4
- Surge Withstand – IEC 255.4
- Radiated Electromagnetic Field – IEC 801.3
- Electrostatic Discharge – IEC 801.2
- Electromagnetic Emissions – VDE 0871, Class B

Instrument Switches and Contacts

- Contact rating - AC services NEMA ICS Part-2 125, A600
- Contact rating - DC services NEMA ICS Part-2-125, N600.

Enclosures

- Types of enclosures - NEMA Std. ICS-6-110.15 through 110.22 (Type 4 to 13).
- Racks, panels, and associated equipment - EIA: RS-310-B (ANSI C83.9 - 1972)
- Protection Class for Enclosure, Cabinets, Control Panels and Desks - IS-13947, 1993 & IEC 529.

Apparatus, enclosures and installation practices in hazardous areas

- Classification of hazardous area - NFPA Art. 500, Vol.70-1984.
- Electrical Instruments in hazardous dust locations - ISA-RP 12.11
- Intrinsically safe apparatus - NFPA Art.493 Vol.4.1978
- Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Art. 496 1982.

Annunciator

- Specifications and guides for the use of general purpose annunciator - ISA RP 19.1-1979.
- Surge withstand capability tests - ANSI C.37.90a - 1974 and IEEE std. 472-1974

Interlocks, Protections

- Relays and relay system associated with electric power apparatus - IEEE std.3.13.

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- Surges withstand capability tests - ANSI C.37.90a - 1974 and IEEE Std. 472 - 1974.
- General requirements & tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I) 1973.
- Boiler safety interlocks - NFPA Section 85B, 85D, 85E, 85F, 85G.

Control Valves

- Flow Equation for Sizing Control Valves – ISA S39.2, 1972
- Control Valve Seat Leakage – ANSI / FCI 70.2
- Face to face Dimensions of Control Valves – ANSI B16.10, ISA – S75.03 & ISA – S75.16
- Steel Pipe, Flanges & Flanged Fittings – ANSI B16.34
- Control Valve Capacity Test Procedure – ISA – S75.02
- Industrial Process Control Valves - IEC 534

Process Connection and Piping

- Codes for pressure piping power piping ANSI B31.1
- Seamless carbon steel pipe ASTM A-106.
- Forged and Rolled Alloy steel pipe flanges, forged fittings, valves and parts - ASTM A-182.
- Material for socket welded fittings - ASTM A-105.
- Seamless Ferritic alloy steel pipe - ASTM A-335.
- Pipe fittings of wrought carbon steel and alloy steel - ASTM A-234.
- Composition bronze or metal castings - ASTM B-62.
- Seamless copper tube, bright annealed ASTM B-168.
- Seamless copper tube - ASTM B-75.
- Dimensions of fittings - ANSI B-16.11
- Valves flanged and butt welding ends - ANSI B16.34.
- Nomenclature for Instrument tube fittings ISA-RP-42.1 - 1982.

Cables

- Colour coding of single or multi-pair cables - ICEA S-61- 402. (Third edition) NEMA WCS-1979.

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- Guide for design and installation of cable systems in power generating stations (insulation, jacket materials) - IEEE Std. 422 - 1977.
- Requirements of vertical tray flame test - IEEE 383 - 1974.
- Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B-33 - 81.
- Oxygen index and temperature index test - ASTM D-2863.
- Smoke generation test - ASTM D-2843 and ASTM E-662.
- Acid gas generation test - IEC-754-1.
- Swedish chimney test - SEN - 4241475 (F3)
- Instrumentation cables and internal wiring IS-1554 (Part-I, 1976) and IS: 5831(1984).
- Mono-mode Fibre – ITU-T G.652 for Optical Fibre Cable
- IEEE 1138, 1994 / IEC 1089 / EIA-455 B for Optical Fibre Cable

Cable Trays, Conduits

- Guide for the design and installation of cable systems in power generating station (cable trays, support systems, conduits) - IEEE Std. 422, NFPA-70-1984.
- Guide for the design and installation of cable systems in power generating station (Cable trays, support systems, conduits) Test Standards, NEMA VE-1 - 1979.
- Galvanizing of Carbon steel cable trays - ASTM A-386-78.

4.3

Power Supply

All instruments and control devices shall be designed to operate on power supplies as follows:

- Electric:
- 230 volts AC, 50 hertz, single-phase for low torque drives with guaranteed satisfactory operation when equipment is continuously energized at any voltage from 216VAC to 264VAC.
- 24V DC for PLC.
- 24 VDC, 110VAC or 230 VAC for Field Instruments.
- Pneumatic: Clean, dry, and oil free instrument air at 4.2 to 8.6 bars gauge.

4.4

Standard Ranges of Analog Signals

The ranges of analog signals shall normally be as follows:

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- (a) Electric -- 4 to 20 mA dc.
- (b) Pneumatic -- 0.2 to 1.0 kg/cm².

The use of any signal range other than the above shall not be acceptable.

4.5 Contact Ratings

The ratings of all instrument contacts used for alarms and interlocks shall be as follows:

Table 4.2
Contact Ratings

	Voltage Rating (volts)	Continuous Rating	Switching Rating (break)
a)	240 AC	480 volt-amperes	1200 volt-amperes
b)	220 DC	60 watts	200 watts
c)	24 DC	12 watts	25 watts

The ratings of all microprocessor-based controller or programmable controller output contacts shall be as required by the controlled devices. Where necessary for higher current ratings or isolation, interposing relays shall be used.

4.6 Reliability and Availability

- (a) Each component and system shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
- (b) Detailed reliability calculations shall be used for each system/ equipment (with the help of a schematic of various sub-system connected in series or in parallel as the case may be and MTBF & MTTR values for the various equipments). Availability calculation shall be as per IEEE Standard-P1046 or equivalent.
- (c) When more than one device uses the same measurement or control signal, the transmitter and other components/ module shall be fully equipped to provide all signal requirements. The system shall be arranged so that the failure of any monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.

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- (d) To ensure availability, adequate redundancy in system design shall be used at hardware, software and sensor level to satisfy the availability criteria. For the protection system, independent sensing device shall be used to ensure adequate safety of plant equipment.

4.7 Standardization & Uniformity of Hardware

To ensure smooth and optimal maintenance, easy interchange ability efficient spare parts management of various C&I instruments, ensure that all instruments/devices (Processor modules, input/output modules, power supply modules etc.) are of the same family of hardware. For example, all 4-20 mA electronic transducers, control hardware, control valves, actuators instruments/ local devices etc. being furnished shall be manufacturer specific.

4.8 Redundancy

1. Reliability of the Control System shall be established by judicious incorporation of redundancy. In general all critical parts shall have hot standby feature to render the system immune to any single failure.
2. Measurement system (MS), Closed Loop Control System (CLCS) and Open Loop Control System (OLCS) shall all be configured with redundancy at processor modules, communication modules, data bus and power supply modules.
3. Both CLCS & OLCS shall be configured with I/O channels redundancy for each sensor/signals. Where redundant sensors are provided redundant I/O channels shall be used for each sensors/signals.
4. Two out of three measurements philosophy shall be adopted for the control of all closed and critical open loop variables for reliability of operation. The control system shall select the median value for the normal control purpose.

4.9 Operability & Maintainability

1. The design of the control systems and related equipments shall adhere to the principle of 'Fail Safe' operation wherever safety of personnel / plant equipment is involved. 'Fail Safe' operation signifies that the loss of signal or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips are avoided / minimized.
2. The types of failure which shall be taken into account for ensuring operability of the plant shall include but not be limited to:
 - Failure of sensor or transmitter,
 - Failure of main and/or redundant controller/other modules,

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- Loss of motive power to final control element,
 - Loss of control power.
 - Loss of instrument air
3. The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:
- Standardization of parts.
 - Grouping of functions.
 - Interchangeability.
 - Malfunction identification facility/self surveillance facility.
 - Easy modular replacement.
 - Fool proof design providing proper identification and other features to preclude improper mounting and installation.
 - Appropriate derating of electronic components and parts.

4.10 Metering Bases of Units

The following system of units shall be followed throughout the specification unless otherwise mentioned.

Table 4.3
Metering Bases of Units

S.No	Parameter	Unit
1	Pressure	Kg/sq. cm
2	Differential pressure	mm of H ₂ O column or Kg/sq. cm
3	Draught	mm of H ₂ O column
4	Vacuum	mm of Hg
5	Temperature	Degree Celsius
6	Flow	Tonnes / hr or Kg/hr
7	Flow (Air / Gas)	Tonnes / hr or N. Cu. M /hr
8	Density	gm / c.cm
9	Level	mm or M

4.11 Grounding System

All panels, desks, cabinets shall be used with a continuous bare copper ground bus. The ground bus shall be bolted to the panel structure on bottom on both sides. The bolts shall face inside of panels.

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The system ground shall be isolated from the panel ground with suitable isolators. All internal component grounds or common shall be connected to the system ground, which shall be fabricated of copper flat (size 25 mm x 6 mm min, length as applicable).

Shield on instrumentation cables shall be grounded on panel side. When shielding termination is required in cabinets furnished under this specification, suitable terminals shall be furnished on copper flat forming system ground. System and shield ground shall be connected to earthing strip at 0.0 meter level using suitable size of cable.

4.12 Drive Control Philosophy

The Drive control & measurement philosophy for the project is detailed in this section.

1. Bi-directional drives (inching or open/close)
 - (a) All bi-directional drives shall be operable from Remote i.e. from CR.
 - (b) Remote manual operation of all drives shall be carried out from OWS.
 - (c) Remote Open/Close commands, generated in control system shall be issued to MCC module through interposing relays located in respective MCC module in the MCC room. Latching of commands shall be used in control system logic which shall be reset by Limit/Torque switch feedback. The Limit/Torque switch feedback from drive shall be directly wired to Control System.
 - (d) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
 - (e) Following signal exchange shall be envisaged between Drive & Control system:
 - Open Limit Switch (Both NO & NC contacts)
 - Close Limit Switch (Both NO & NC contacts)
 - Open Torque Actuation
 - Close Torque Actuation
 - Position feedback (4-20 mA, two wire electronic type) for inching drive
 - (f) Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in/near MCC room):
 - Switchgear available
 - Switchgear disturbance
 - Open Command
 - Close Command

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2. Unidirectional LT drives

- (a) Unidirectional LT drives shall be operable only from Remote i.e. from CR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays.
- (d) Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
- (e) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
- (f) Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives greater than 90 KW. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules.
- (g) Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in MCC room):
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Start Command
 - Stop Command
- (h) All Numerical relays/Intelligent controllers for LT drives shall be interfaced to Control System through IEC 61850 protocol.

3. Solenoid Operated drives

- (a) Solenoid operated drives shall be operable only from Remote i.e. from CR.
- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Open/Close commands shall be generated in Control system & shall be issued to the Solenoid through interposing relays.
- (d) Necessary process interlocks shall be realized in Control system.
- (e) Following signal exchange shall be envisaged between solenoid drive & Control system:

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- Open Limit Position
- Close Limit Position
- Open Command
- Close Command

4.13 HT drives

1. HT drives shall be operable only from Remote i.e. from CR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
2. Remote manual operation of all drives shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
5. Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
6. Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules
7. Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in MCC room):
 - Switchgear available
 - Switchgear disturbance
 - Master Trip relay Operated
 - On Feedback
 - Off Feedback
 - Trip Feedback
 - Emergency stop feedback
 - Start Command
 - Stop Command

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- Current Feedback
8. All Numerical relays/Intelligent Controllers for HT drives shall be interfaced to Control System through IEC 61850 protocol.

4.14 Variable Frequency Drives (VFD)

1. VFD shall be operable from Remote i.e. from CCR/LCR & from VFD Local Display unit. In addition, Local pushbutton shall be used only for emergency stopping of drive.
2. Remote manual operation of VFD shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to VFD Panel through interposing relays located in VFD Panel.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided in the field. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to VFD panel.
5. Necessary Electrical protections shall be realized at VFD module whereas process interlocks & protections shall be realized in Control system.
6. Following signal exchange shall be envisaged between VFD & Control system:
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Trip Feedback
 - Emergency stop feedback
 - Start Command
 - Stop Command
 - Current Feedback
 - Speed feedback
 - Speed Setpoint
7. The VFD shall also be interfaced with control system via Modbus soft link.

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5 COAL HANDLING CONTROL SYSTEM

5.1 General

The instrumentation and control system shall cater to the requirements of coal handling system (CHS) consisting of the following major systems:

- Coal Unloading System
- Stacker Cum Reclaimer (SCR) System
- Coal Transport/Storage/Reclaim System
- Dust Control System
- Electrical Controls Related to Coal Handling System (For Details Refer Electrical Section)
- Vibration Monitoring System for HT Drives

The coal handling system instrumentation shall include the bunker level monitoring system, PLC based control system along with UPS, complete I&C cabling, etc. All necessary field instruments such as Pull Chord Switches, Belt Sway Switches, Zero Speed Switches, RTDs, Ultrasonic level instruments (switches, indicators or transmitters), pressure switches etc and instruments required for auxiliary systems like Compressed Air System, Dust Suppression system etc shall be included.

The design of the control system and related equipment shall adhere to the principle of "fail safe" operation at all system levels (i.e.) loss of signal, loss of power or failure of any component should not cause a hazardous condition; and at the same time prevent occurrence of false trips and provide reliable and efficient operation of the plant under dynamic conditions and attainment of maximum station availability.

For operation and control of the Coal Handling Plant, Bidder shall provide Microprocessor based Programmable Logic Controller based control and instrumentation system which shall cover the total functional requirements of the plant which includes sequence control, interlock & protection, monitoring, alarm, data logging, fault analysis etc. The bidder shall provide all the integral instrumentation for monitoring, Protection and smooth operation of all the Plant and machineries.

5.2 Coal Unloading Control System

5.2.1 Wagon Tippler (wherever applicable)

Coal unloading operation of Wagon Tripler hopper shall be operated/ managed from "Wagon Tripler Control Room" located adjacent to the Wagon Tripler. Wagon tippler control room shall have MMI of the PLC, mimic panel etc shall be air conditioned. Wagon tippler shall be operated and controlled from the Remote IO of CHP PLC located in Wagon tippler control cabin. An

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OWS shall be provided in wagon tippler control cabin for operation of wagon tippler.

5.2.2 Apron Feeder & Dribble Feeder (wherever applicable)

Apron Feeder & Dribble Feeder shall be operated and controlled from Remote IO of CHP PLC located in Wagon Tippler Control cabin.

5.2.3 Paddle Feeder (wherever applicable)

Local Control Panel shall be provided for paddle feeder control. However running status of paddle feeder along with stop facilities shall be available from CHP PLC. Suitable indication of paddle wheel rpm shall be provided on the paddle feeder local control panel and flow rate indicator of belt weigh scale shall also be duplicated on local control panel of paddle feeder. Paddle feeder shall be equipped with end travel switch.

5.2.4 Travelling Tripper

Local Control Panel shall be provided for travelling tripper control. However running status of travelling tripper shall be available in CHP PLC. Travelling tripper shall be equipped with end limit switch.

5.2.5 In Motion weigh bridge system

1. One (1) no. In motion pit less type Weigh Bridge complete with Weigh Bridge Platform with Load Cells, Digital Weight Indicator & Totalizer for measurement of gross weight and tare weight shall be provided. Weighbridge shall have its 22" LCD HMI; printer etc. with built in diagnostics and suitable weight management software. Weigh bridge terminal shall be located in the wagon tippler control room or any other location found suitable by the bidder. The weigh bridge control room shall be air conditioned. All cabling shall be armoured with braided stainless steel to protect against corrosion and rodents. The railway track shall be straight and levelled up to at least 100 meters upstream and downstream of each weighbridge. The weighbridge shall be designed to operate in dusty environment.
2. The Accuracy and Least Count of the Weigh Bridge shall be as below:
 - Overall system accuracy : $\pm 0.02\%$ of F.S.
 - Least Count : 10 kg
 - 7 segment LED, self checking, for weight display in tonnes/kgs, with 16 to 20 mm high characters.
 - Continuous self test with selectable automatic analog test and automatic check of components during warm-up.
 - Automatic Zero tracking calibration circuits and zero lock facility as anti fraud measure.
 - Communication ports for interfacing with main computer of plant to enable further processing of data, as and when required.

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- Micro controller based System
- Standard RS232 serial interface for PC & Printer
- Standard RS422 / RS485 port
- Ethernet Connectivity
- Customized & user-friendly Windows based Software for generating reports / slips with parameters like date, time, vehicle no., supplier, material, net and gross weights etc. The relevant file can be printed on a printer.
- High Stability, Accuracy and Repeatability
- Automatic zero maintenance and asymmetric load compensation.
- Auto zero maintenance feature, eliminating the need of frequent zero setting.
- Built in high degree of protection against all forms of electromagnetic & radio frequency interference.
- Diagnostic test facility.
- Multilevel password protection to maintain data security.
- Surge protection - Surge protection for protection of weighing system should be built in (system electronics, PC, load cell etc.) against electrical surges.
- In-built Lightning Protection System
- Self check features for cable breakage etc.

5.3 Stackers Cum Reclaimer (SCR) System

The SCR shall be provided with following minimum instruments for operational interlocks & equipment protections:

1. Radar type level devices to detect stockpile height
2. RF switches for the detection of stockpile surface to protect equipment.
3. Limit switches with backup switches shall operate before device travel limits are exceeded to prevent movement beyond zone of normal operation. The backup switches shall be arranged to directly disconnect power to travel drive motors.
4. Zero speed switches for conveyor under speed detection protection.
5. RF switch for blocked chute detection on each feed chute
6. Audible alarms/sirens to operate before starting of any long travel, luffing, slewing or conveying shall be provided.
7. Anemometer for Wind speed measurement with trip contact for high wind speed.
8. Position measurement for Luffing & slewing.

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9. CCRD for hardwired interlocks with CHP PLC.

5.4 Coal Handling System (Storage/Transport/Reclaim System)

5.4.1 Metal Detector

1. It shall be possible to start the conveyors only after energizing the metal detector and metal detector is in 'reset' condition. Once the metal is detected, the corresponding conveyor shall trip. It shall be possible to restart the conveyors, after local resetting of metal detector & putting back the marker bag in position. Metal detector ON/OFF facilities shall be provided in the OWS.
2. In case of tripping of conveyor system, metal detector shall de energize after a time lag.
3. Following individual indications shall be provided on Local Control panel:
 - Metal Detector 'ON'
 - Metal Detected
 - Metal Detector 'reset'
 - Metal Detector Faulty

5.4.2 In Line Magnetic Separator

1. It shall be possible to start the conveyor only after energizing the magnet of ILMS. Further, if conveyor system trips magnetic separators shall de-energize after a time lag. Also if drive motor of cleated belt of ILMS trips, Magnetic separator shall not get de-energized, but conveyor system shall trip and audio-visual annunciation shall appear at CHP control room.
2. Following individual indications are provided on Local control panel
 - Magnetic separator ON.
 - Incoming supply ON
 - Under current relay operated.
 - Cleated belt motor ON/OFF/TRIP.
 - Oil temperature high

5.4.3 Conveyor System

1. The starting sequence of the conveyors shall follow a direction opposite to that of flow of material.
2. Interlocking of yard conveyor with stacker & reclaimer's boom conveyor shall be provided.
3. Once a conveyor trip, flap gate directing Coal from this conveyor shall change over its position with a time delay and shall come back to the original position again, to prevent jamming of gate.

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4. Any individual equipment (belt conveyor etc.) should not be allowed to start unless the equipment immediately following the same in the direction of flow of Coal is already in operation.
5. Stop / tripping of any equipment from running condition shall trip all preceding equipment in the system, but shall not effect succeeding ones which shall continue to operate except crushers. Interlocking of various conveyors shall be achieved with limit switches and zero speed switches.
6. Adequate no. of Pull cord switches at 30m intervals shall be provided along the length of each belt conveyor, which shall enable the respective conveyor to be stopped immediately. Belt Protection switches, Pull Chord Switch & Belt Sway Switch, shall be identified/addressed by a specific number in the Control Room.
7. Means shall be provided to pre-warn personnel working nearby when starting any conveyor /Stacker/ Reclaimer by providing Sirens.
8. Interlocking of various conveyors shall be achieved with Flap gate & Flow Dividers via Limit switches & Zero speed switches.
9. Crushers shall be provided with fluid coupling oil temperature, speed and vibration monitoring instruments. Crushers shall trip in case fluid coupling oil temperature/ speed / vibration are going beyond set limits of design.
10. Wherever Scoop type coupling provided for HT motors, the coasting time of respective conveyor, thruster brake, actuator selection and the chute size shall be so selected such that there is no spillage of Coal from any downstream conveyors during next start.
11. For maintenance purpose local operation of the conveyor shall be provided through LPBS located near the Drive. The interlock/de-interlock selector switch shall be provided for enabling the local operation. The required status indication shall also be provided.

5.4.4 Flap gates/Flow Dividers

All flap gates / Flow Dividers / Diverter gates shall be motorized and remote controlled from the control room. Their position shall be indicated on the OWS/LCD of control room. Once a conveyor trips, flap gate directing coal from the conveyor shall change over its position with a time delay and shall come back to the original position again to prevent jamming of gate.

5.4.5 Coal Sampling Unit

1. Coal sampling unit shall be controlled through standalone PLC based Local Control Panel. Control & interlocks for complete sampling system including sampler, crusher, belt feeders & sample collector system shall be implemented in PLC.

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2. Only one start/stop push button for coal sampling system shall be provided for automatic operation of complete coal sampling system. Local push button stations shall be provided for all individual equipment of coal sampling system near the equipment.
3. The necessary controls for automatic control of coal sampling system shall be designed in accordance with the requirements of ASTM-D-2234.
4. All local instruments like limit switches, proximity switches, emergency stop PB, Belt sway switches, zero speed switches etc. required for the CSU shall be provided.

5.4.6 Bunker Level Measurement

1. Radar type or ultrasonic type level transmitter shall be provided for each Coal bunker. Level of coal in the bunkers shall be indicated in a local panel mounted on the bunker floor of each unit. High & Low level audio-visual alarms shall be provided as a minimum requirement for local operation.
2. Local display and annunciation shall be provided for High and Low level signals on the instrument and level reading shall be available for operator at Control Room by means of 4-20mA.
3. In case of level high in bunker level, the feeding conveyor shall be stopped. Bunker level shall be continuously displayed with low, lowlow, high and high-high indications on the HMI.

5.4.7 Bunker filling system

1. Bunker filling shall be interlocked with bunker level through bunker level transmitter. However for manual Operation of Tripper Level Indicators Shall be provided.
2. The shuttle feeder/Tripper shall be provided with optical encoders for positioning on bunkers.
3. Required Proximity type & mechanical limit switches for over travel protection shall be provided. The over travel limit switch shall be wired directly to MCC.
4. The bunker filling operation shall be provided with manual as well as automatic mode. In automatic mode the bunker filling sequence shall be decided based on the level of bunkers. In addition to this the facility shall be available on OWS for selecting the sequence of bunker filling.
5. Local control panel shall be provided for local operation with status indications & annunciation windows.

5.5 Dust Control System

5.5.1 Dust Suppression System

1. The DSS shall be started or stopped automatically from the coal handling system PLC. The DSS shall be tripped automatically when the main conveyor

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/ equipment in that particular Junction Tower is not operating in order to prevent flooding of discharge chutes/conveyors. Necessary flow activation station with local push buttons for maintenance purpose and pressure regulating units with start, stop PBs, indication lamps, control wiring, interlocks, contactors, instrumentation etc. shall be provided.

2. The Coal stockyard DSS water supply pumps located in the coal handling system pump house shall supply water for stockyard DSS only, when stacking and / or reclaiming is taking place. Hence when either stacking or reclaiming or both are taking place in a preselected section of a particular stock pile and or a different stock pile, these pumps shall automatically start supplying water to a set of sprinklers located on either side of the particular stock pile and or a pre-selected section of a particular pile. When stacking and/or reclaiming shifts to another section or to another stockpile, water supply shall also get shifted automatically to those particular set of sprinklers located in the new areas. In the section(s) of the stockpile where stacking and/or reclaiming was taking place earlier, water supply shall be cut off automatically.
3. The fixed nozzles spraying water on to Coal at the discharge of various conveyors, shall be energised only when the respective conveyors are operating.

5.5.2 Dust Suppression System Pumps

1. The DS System pumps shall be operated from CHP control room.
2. Following individual inputs shall be provided to PLC for alarms / indications:
 - Motor On, Off & Trip
 - Discharge water pressure low
 - Water level is low in tank
 - Water level is high in tank
3. Pressure switch shall be provided in the delivery line to maintain the minimum set pressure during the operation. If the pressure falls down below the set pressure the standby pumps shall start automatically after time delay. Even after the pressure is not healthy inside the system the pump shall trip automatically after certain predetermined set time.
4. The control logic should be designed to meet the following minimum interlocks.
 - Both pumps cannot run together. Only one at a time in any mode.
 - Pumps should not be started when the water level is lowest in the tank.
 - Low contact of Level switch to be interlocked.
 - After starting the pump if the pressure is not built within the specified time the running pump should be stopped and other pump shall be tried.

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If it is the same case with other pump too then the system should stop and announce the alarm.

- Differential pressure switch in the duplex strainer shall give the filter clogged signal. This No contact shall be used for "FILTER CLOGGED" alarm.
- Along with the above interlocks regular motor protection shall be used in the logic.

5.5.3 DS System Compressors

1. The DS air system shall be provided with microprocessor-based control system for each compressor and shall be fully automated, using the manufacturer's standard control package, with single button system start/stop from the CHP Control room and with status/alarm information provided to the operator via the CHP PLC.
2. Local control units with display shall be provided for the compressors to allow local operation & monitoring. All common logics for compressors such as selection, auto change over, duty cycle etc. shall be implemented.
3. The control equipment shall be interfaced with the CHP PLC through Modbus/suitable communication, such that the operator can monitor the operation of the compressors and be aware of problems as and when they occur.
4. The control scheme shall be suitable for operating the compressors such that all the compressors shall be equally loaded and ensures power consumption is also optimized.
5. Any of the compressors may be selectable for "shut down ", "working " or "standby" duty.
6. An electrically operated automatic valve shall be provided on cooling water supply line of each compressor (if applicable) which shall automatically shut of the cooling water supply, in case any of the compressor is not running for more then set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor.
7. All necessary instrumentation and field sensors for control and operation shall be provided which shall include:
 - Indication of suction pressure after suction air filters for each compressor.
 - Indication of temperature of compressed air after intercooler & after after-cooler.
 - Indication of pressure of lube oil after oil filter.
 - Indication of differential pressure across lube oil filter.
 - Oil Level of Indication of lube oil sump.

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- Indication of cooling water pressure to compressor cooling circuit.
 - Indication of Flow measurement at the common discharge airline
 - Indication of Air pressure of individual compressor discharge header and on each air receiver.
8. The dual type control system shall permit operation of each compressor in either of the following way :
 - Continuous Variable Load/unload regulation
 - Automatic Start/Stop control.
 9. The compressed air system shall be provided with automatic data logging system-integrated with/through CHP PLC, automatically furnishing and recording the following important parameters.
 - Compressor status like Ready, Run, Stop, Trip, Remote, Alarm, Fault etc
 - Number of hours of operation of compressor.
 - Energy consumption, pressure, and any other related parameters.

5.5.4 Coal Stockyard Spray water system

1. Sprinkler type dust suppression system envisaged for Coal stockpiles.
2. The operation of the sprinklers for stock piles shall be automated by CHP PLC.
3. Two solenoids of opposite side sprinklers shall be made as pair and they should get ON together. Bidder to decide the no. of sprinklers required to be switched ON together depending on the site requirement.
4. There shall be two modes of operation for spray water system:

Manual Mode:

Solenoid pairs shall be switched ON/OFF by using Push Buttons at the Solenoid box. Any sprinkler switched ON in manual mode shall continue in ON status till it is switched off/mode is changed. The indicator shall glow in the panel when any solenoid is ON.

Auto Mode:

In auto mode control of the sprinklers shall be through relay panel. Switching the first relay shall energise Solenoid 1 and 2. Similarly each relay energization shall energise the other solenoids in pairs, covering the entire length of the stockpile. The relay contact shall be latched & till the relays are energised solenoids should remain in energised state. Sprinkler ON time and sequence shall be programmed as per the site requirement. The no. of relays to be energised at a time.

5. The sequence logic & pumps control/interlocks shall be implemented in CHP PLC & operation shall be monitored through OWS/LCD.
6. The failure of sequence or tripping of pumps etc. shall be alarmed at the CHP control room.

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5.5.5 Dust Extraction System

1. The following sequence shall be followed for starting the DE system:
 - Start Screw conveyors of bag filter & cyclone outlet
 - Start RAV of Cyclone & bag Filter
 - Power to sequential controller
 - Start Centrifugal Fan Motor
 - Open motorized damper of fan inlet
2. The equipments shall be interlocked with following instruments for normal operation of DE system:
 - DPS shall energize at pre set pressure and shall issue command to sequential controller for solenoid valve energization.
 - After air purging in sequence of solenoid valves through sequential controller with pre set pause and on time the DPS shall be de-energized at fixed differential set pressure.
 - Sequential controller shall stop output to solenoid valve if air pressure at compressed air line falls below the set pressure. In that case the whole system shall shut down immediately.
3. ZSS shall be provided for detecting rotation of rotating part of the RAV during running Condition. If any RAV of cyclone, Bag filter fail to run then the whole system shall shut down immediately.

5.6 Vibration Monitoring System

5.6.1 General

Bidder shall supply a programmable on-line Vibration Monitoring System (VMS) that shall automatically acquire data related to the mechanical health of rotating equipment such as crushers. The VMS shall exchange data with the PLC of CHP system for viewing, trending, alarming of machine parameters.

The system shall be complete including transducers, transmitters, monitors, relay modules, networking hardware, power supplies, special cables etc. for measurements, protective alarm and trip etc. The system shall have inherent feature to suppress false alarm / tripping due to defective transducers, power supply failure etc.

No failure of a single component shall lead to the trip of the machine. Critical alarm and trip relay output shall be configured in as required for the machine criticality. All the alarm and trip relay contact shall be hardwired to the respective control system. Potential free wired contact shall be available for the same.

The system shall have the following sub systems:

- Field Transducers

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- Process data Interface sub system
- PLC interface

Vibration level of equipments at bearings shall not exceed the following limits for different equipment. Vibration levels shall conform to the limits specified below and shall be measured as per VDI 2056 / BS 4675. Equipment Peak to peak limit:

Table 5.1
Vibration Limits

S.N	Description	Vibration Limits
1	At the bearing of drive pulley, motor and gear box for the following equipment:	
	i) Boom conveyor of stacker/ Reclaimer:	115 microns
	ii) All other equipment/ : Conveyors/feeders etc.	75 microns
2	On the floors and columns of junction towers, Crusher house and conveyor, Gallery walkways	200 microns
3	Crusher	160 microns for speed of 750 rpm

For rating ≥ 6.6 KV motors, vibration sensors/ transmitters in X,Y direction with both raw and 4-20mA outputs for motor and gear box shall be provided by the bidder. For raw signals cabling upto junction box & 4-20 mA signal shall be taken to CHP PLC.

5.6.2 System Requirement of VMS

1. The system shall comprise of Instrument rack, dual power supply modules, monitoring modules, relay modules, interface modules, communication modules and necessary software to convert and process raw transducer signal.
2. Failure of single power supply shall not affect system functioning.
3. Monitoring modules shall allow "hot" insertion or removal. All dynamic monitoring modules shall have each channel's buffered transducer signal available on the front of the monitor through BNC connectors. This will enable the buffered output to be used for connecting portable test and diagnostic equipment.
4. Vibration monitors shall have four channel input capability and be fully software configurable for the radial vibration measurement; the monitor should return direct, gap, 1X amplitude and phase, and 2 X amplitude and phase, not 1 X, and Smax data.

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5. Removal and replacement of module shall be possible to be carried out in system power on condition.
6. Process variable monitors shall have the capability to receive 4-20 mA DC process data in addition to machine transducer data.
7. Relay modules shall be programmable or hardwire connected to perform Boolean operation.
8. The system shall be supplied with necessary configuration and HMI software for configuring.
9. Racks shall be connected in a network. Networking shall be made through OFC / Ethernet data highway cable.
10. Input supply to the system shall only be taken from the UPS system in the nearby area.
11. System shall be capable of operating from 0 to 50 °C and at 95% non-condensing moisture.
12. The monitoring / protection system should be compliant to API 670.

5.7 Operation and Control Philosophy

1. The operation and control of the Coal Handling Plant (CHP) and associated systems shall be performed from it's own dedicated PLC located in the Coal Handling Plant Local Control Room through two nos. (2) Operator Stations and one (1) number Engineering/Operator Work Station. The two (2) Nos. 52" LCD shall be configured to display alarm and also serve normal operation.
2. One (1) no. A3 size dot matrix printer shall be provided which shall be connected to the data highway and One (1) no. A4 size Colour Laser jet printer shall be provided which shall be connected directly to the engineering work station. The required furniture such as operator desk, chairs, etc shall be provided by the bidder. The CHP PLC shall be interfaced to DCS through redundant OPC link by fibre optic cable as well as some signals shall be hardwired to DCS for monitoring purposes.
3. The Stacker & Reclaimers shall be controlled through Dedicated PLC.
4. SCR local PLC shall be interfaced with the CHP PLC over the redundant radio communication network. Wireless Ethernet modem with necessary transmitter-receivers shall be used. Necessary process graphics, alarms, status shall be provided on the CHP PLC for monitoring. Failure of the communication links shall be annunciated in the HMI.
5. The frequency spectrum shall be as per statutory norms. The frequency shall be high to avoid interruption / interference due to building and trees. Necessary structures shall be provided for mounting of the antenna tower. The telemetry license shall be in bidder's scope.

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6. The SCR PLC shall be programmed for various operating modes as:
 - Local/Auto – manual mode: for operations from SCR cabin
 - Local/Maintenance mode: for maintenance purpose
 - Remote mode: for operation from CHP control room through Telemetry (only in case of emergency)
7. The operator interface for the SCR control desk shall have a HMI directly mounted on to the panel with fully shielded industrial key-board and mouse. In addition to this the control desk shall be provided with push buttons and joy sticks for operator control.
8. Minimum information shall be made available in the local control room as given below:
 - Flow diagram of coal handling system
 - Position of flap gates
 - Operating / non operating equipment indication.
 - Position of flow dividers – 0 to 100% from the reference.
 - Quantity of coal flow in each chute from each position of FD
 - Belt weigh scale capacity in TPH – quantity of coal conveyed on the conveyor in one hour, one shift, one day, one week, one month and one year
 - Fault annunciation of each equipment
 - Down time of each equipment, reasons for break down. Total down time of each equipment in a day, week, month & year.
 - Availability of each equipment % - availability in a year.
 - No. of hours of operation of each equipment in a shift, day, week, month and year.
 - Loading pattern of each conveyor – graphical representation
 - Healthiness of each belt weigh scale, calibration date previous and next due date
 - Major parameters of each equipment
 - Position of each tripper
 - Level of coal in each bunker % fill and height (signal to be taken from the level monitoring system supplied by coal handling vendor)

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- Alarm for normal / high level of coal in bunker, low level and low low level shall be derived from the level indicators.
- Local / remote selection facility for operation of tripper.
- Current drawn by motors
- Power consumed by equipment
- All electrical faults
- Vibration and temperature alarms for HT motor and gear boxes.

5.7.1 Interlock & Protection

Safety interlocks to be taken care for conveyors and other equipment as a minimum are:

A. Conveyors

- Pull chord switch – not operated
- Belt Sway switch – not operated
- Motor protection - not tripped.
- Local stop PB – reset.
- Chute Block switch – not operated.
- Brakes for conveyor - not operated.
- Trip circuit – healthy.
- Temp of fluid coupling oil - not high
- Zero speed switch – closed at 90% of belt conveyor speed

B. Magnetic Separators / Metal Detectors/Suspended Magnets

- O/L / fault relay - not tripped
- Local Stop PB - reset
- Metal detector - reset

C. Vibrating Screens/Grizzly Feeders

- Motor O/L - not tripped
- Local stop PB – reset
- Respective Crusher – on
- Respective Belt Feeder – on

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D. Crusher

- Zero Speed – not operated
- Motor Protection – not tripped
- Vibration level –not high
- Temp of fluid coupling oil – not high
- Local stop PB – reset

E. Flap Gates/ Rack & Pinion Gates

- End of travel limit switches - reset
- Torque limit switches - reset
- Local stop – reset

F. Paddle Feeders (wherever applicable)

- Paddle Feeder Down conveyor - running.
- Local Stop - reset.
- Stop PB in main CHP control room - reset.
- All limit switches - reset.
- Motor O/L - not tripped.

G. Travelling Tripper

- Bunker Conveyor - running.
- Local Stop - reset.
- Motor O/L - not tripped.
- Limit switches – reset.
- Bunker Level Low

H. Apron Feeder (wherever applicable)

- VFD - healthy.
- Trip conditions - healthy.
- Local stop PB – reset.
- Any of the succeeding conveyors - running.
- Dribble Feeder - on.

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I. Dribble Feeder (wherever applicable)

- Trip conditions - healthy.
- Local stop - reset.
- Pull cord switch - not operated.
- Any of the succeeding conveyors - running.

H.T. motors shall continue to run on no load by disengaging the fluid coupling in the event of failure of any process interlock. The H.T. motors shall however be tripped in the event of any motor fault like O/L, high motor winding temperature etc.

All conveyors and equipment shall have local push buttons. Belt scale shall be started when relevant conveyors are started. The dust suppression systems shall be energized as soon as the conveyors at the transfer points are energized.

5.7.2 Annunciation Requirements

1. Each of the Coal handling system equipment shall have status and alarm indicated in HMI. Operating stop and trip condition of each of the equipment shall be indicated as per the approved color code. Similarly energized, de-energized and trip conditions of magnetic separators shall be indicated on the HMI. The trip indication shall be flashing under trip conditions until accept button is pressed.
2. Individual point Annunciation shall be provided for each of the following in HMI as a minimum:
 - Annunciation for trip of individual belt conveyors
 - Annunciation for Fault in individual conveyor Hydraulic drives / crusher motor, screen motor trip on O/L / fault of HT motors.
 - Annunciation shall be provided for all belt conveyors except trunk conveyors of Stacker cum Reclaimer and belt feeders including shuttle feeders, to annunciate the tripping due to each of the following conditions separately.
 - Pull cord switch operated.
 - Belt sway switch actuated.
 - Zero speed switches actuated.
 - Emergency Switch operated.
 - Thrust Brake Fault in HT Drives
 - Chute Position disturbed.
 - Chute Jam detector
 - Any other causes

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- Annunciation for trip of individual crusher, screen and feeder.
- Crusher Vibration Monitor Alarm (for each)
- Annunciation for trip of feeder / conveyor Hydraulic drive due to overload / fault on LT motors / core balance relay /under voltage relay / bi-metal relay
- Annunciation for motor trip due to high bearing temperature and winding temperature.
- Annunciation for operation of low speed switch of crushers, screens.
- Wagon Rack arrived.
- Annunciation for trip of conveyor due to metal detection by metal detector.
- Stacker Reclaimer Tripped - for each.
- Wagon Tippler Tripped - for each (wherever applicable).
- Apron Feeder tripped (wherever applicable).
- Annunciation for Paddle Feeder (wherever applicable)
- Annunciation for Travelling Tripper
- Individual annunciation for each Conveyor for the tripping due to following:
 - Belt sway switch actuated
 - Pull chord switch operated
 - Zero speed switch actuated
 - Emergency switch operated
- Individual annunciation for the following conditions of the electrical power system:
 - Main DC supply feeder failure.
 - Switchgear Incomer and Bus coupler auto trip.
 - 415V switchgear / MCC trouble.
 - Transformer Alarm and Trip.
 - Motors bearing, winding temperature high alarm.

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6. PROGRAMMABLE LOGIC CONTROL (PLC)

6.1 General Technical & Design Requirements

Programmable Logic Controller (PLC) shall be microprocessor-based system. The PLC shall be versatile, expandable, user friendly and latest state of art technology. The system shall be envisaged for the purpose of sequential operation, protection and interlock, data acquisition system, alarm functions, closed loop control and data archiving for fully automatic operation. Logic controller shall be used with adequate and reliable protection safeguard for various equipments and to assist the operator for easy safe and efficient starting and stopping of various drives in the process. The system shall be designed by selecting high-grade components of proven quality and proper design of system electronics. The system shall be able to operate satisfactorily with reference to the specified environmental conditions as indicated in the specification.

1. The system shall be modular in construction and expandable in future by adding additional electronic modules, which shall be easily accessible for maintenance and repair. The modules shall preferably be Rack/Rail mounted. The types of modules shall be kept to minimum possible in order to have interchangeability and spares inventory.
2. The system shall have extensive self-diagnostic hardware and software features for easy and fast maintenance of the PLC. Safety barriers shall be used for intrinsically safe input / output circuits.
3. The PLC shall have very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and electromagnetic disturbances expected in a power plant.
4. The system shall be programmed as per the logic requirements required for the functioning of the systems and equipment.
5. Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.
6. On-line replacement of any module shall be possible in such a way that the removal and addition of the module shall be possible without de-energizing the system or causing any interruption in the system while replacing a faulty module except for the inputs /outputs which are being handled by that module. However, in case of triple modular redundant or dual PLC configurations, there shall not be any process upset while replacement.
7. PLC shall be used with 20% hard wired installed spare I/O Channels.
8. The system shall be capable of handling the long-term storage of data for 15 days and retrieval.

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9. The system shall be used with programming. PLC shall be used with one no. Laptop of latest configuration with programming software & communication cable.

6.2 PLC System Configuration

The Coal Handling System shall be operated, monitored and controlled through a centralized and dedicated PLC, located in the Coal Handling Plant control room.

The PLC shall be redundant and operated through PC based station (OWS, EWS). A large video display (LCD type) is also shall be envisaged. PLC with work station and the large display shall be located in the control room of CHP. Additionally an OWS (per unit) is envisaged to be installed in the Central Control Room for monitoring. Operation and control shall also be possible from this OWS under predetermined conditions.

Remote Input-Outputs (RIO) concept shall be envisaged. RIO shall be located at different geographical locations and shall communicate to the CHP PLC located in the CHP control room, through dual redundant fibre optic cable links.

PLC shall be networked with the Plant DCS by dual redundant communication link –based on Ethernet TCP/IP using bidirectional OPC connectivity, on fibre optic cable. The data network shall be extended using redundant link on fibre optic cable up to central control room for installation of one operator workstation at the central control room.

6.3 Input/output Sub system

1. I/O subsystem shall be suitable for accepting discrete inputs, BCD inputs and analog inputs. The I/O modules shall be mounted in the I/O racks.
2. Each I/O shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 V DC.
3. Each module shall have LED for each digital I/O channel to indicate the status of each input / output. Redundancy in I/O level shall be maintained as per the process requirement.
4. PLC inputs shall be used with potential free dry contacts. All the inputs shall be double ended i.e., two wires per input and not common return for all inputs. The contact interrogation voltage for input contacts shall be 24V DC minimum. Each input channel shall be protected by separate fuse.
5. Output contacts from the PLC shall be potential free dry contacts. Each output shall be short-circuit proof and protected by fuse.
6. Visual indication of fuse blown must be provided for each input and output channel.

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7. There shall be at least 20% spare capacity available on input & output modules, over and above the system requirement.
8. All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
9. PLC shall have the following monitoring features:
 - Power supply monitoring.
 - Contact Bounce filtering.
 - Optical isolation between input and output signals with the internal circuits.
 - In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode.
 - Further, keying-in of individual wire connectors shall be used to ensure that only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs.

6.4 Processor Sub system

1. The processor sub system shall include CPU, memory, power supply, communication interface etc.
2. Dedicated PLC's shall be envisaged for each Auxiliary system. The processor shall have capability to implement all the control functions required. The processor shall have sufficient memory for storage of the program instructions as applicable to the logic requirements. CPU shall be of 32/64 bit or upgraded version of microprocessor.
3. Memory shall be non-volatile, preferably EEPROM type. However, in case volatile memory is provided, battery backup shall be used for a minimum of three months to keep the stored program intact. A battery drain indication shall be used at least one week before the battery gets drained. Memory shall be used with adequate capacity with 40% spare capacity under worst loading condition.
4. The healthiness of processor hardware and software shall be continuously monitored by watchdog timer.
5. PLC's shall be used as a minimum with dual redundant processor subsystem including CPU, memory and power supply. Redundancy shall be used such that, in case of failure of the main processor, the standby processor shall take over automatically and vice - versa. The changeover shall be bumpless and shall not result any process or system upset.
6. In case of failure of complete processor system i.e., both processors, outputs shall take fail safe state automatically.

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7. The scan time of programmable controller shall be of the order of 100 milliseconds or better. Scan time of PLC is defined as the cycle time taken by the system to read input, process input executing logic and update control output for all the logics configured within the system. Other activities like diagnostic routines, output / dump of data to peripherals, or any other activity which consume processor time shall also be accounted while computing scan time.

6.5 Communication Sub system

1. The communication subsystem shall provide reliable and high speed data transfer between the processor subsystem, I/O subsystem, PLC console and other devices connected to the system.
2. Redundancy in communication subsystem shall be used, such that on the failure of the active device, communication link or bus, the redundant device communication link or bus shall take-over automatically without interrupting the system operation. The communication bus shall be of coaxial / Fiber optic type.
3. Information about the failed device shall be displayed locally as well as on the PLC console. It shall be possible to manually switch-over the communication from main bus device to redundant bus device without interrupting the PLC functions.
4. The PLC shall have provisions of communication interface facility with Plant DCS system in order to make the entire system operational from CCR. Bi-directional, Redundant soft links shall be used in the PLC for the connectivity with the Plant DCS.
5. Following shall also included in the system:
 - Cables required for interfacing with DCS.
 - Implementation of Tags and establishing the Link.
 - Any other software/hardware required.

6.6 System Power Supply

1. For PLC system, redundant 24 V DC power supply shall be used. The required power supply cable shall be used from the UPS DCDB & ACDB for Coal Handling control system
2. For separately mounted I/O racks, separate power supplies shall be used. Power supply module shall be of ample capacity to supply all modules. In addition 20% spare capacity for future shall be used. All the drives shall be switched ON/OFF through 24V DC coupling relays to be provided in HT/LT SWGR panels.
3. For the Operator Stations and Engineering Station the power supply shall be from the 230 VAC UPS system.

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6.7 PLC Console

1. PLC Console or operating panel/display panel shall be used as operator Interface station for control and monitoring of the plant. This shall be done through dynamic mimic displays and control displays.
2. PLC console shall also be used for program storage, display, fault diagnostic and alarm monitoring. It shall be possible to modify, add or delete the application program on-line without affecting the outputs. It should be possible to modify or create new displays from PLC Console.
3. Isolation shall be used between programming terminal and related subsystems, if there is any possibility of high voltage from TFT being transmitted to other subsystems.
4. The PLC system shall have provision to shift the Operator Station/ Engineering Station to the CCR in future with third party interactive communication facility.

6.8 Displays

The system shall be capable of reading the status of equipments, acquiring the analog signals, displaying the status in the form of mimic diagram, video trend, bar graph, periodic display, alarm display, alarm overview display, logs such as hourly/shift/daily logs, alarm logs etc.

Displays include plant mimic diagrams, which shall include the complete auxiliary plant system indicating each major components of the system and the operating status of individual equipment and devices

6.9 Alarms

1. The system shall display history of alarms in chronological order of occurrence on the Operator Station LCD. At least three (3) levels of alarm priority shall be available which shall be displayed in different color. It should be possible to display and print alarms. System shall have all alarm related functional keys like acknowledge, reset etc. Other design features like set point / dead band adjustment, alarm priority, manual and automatic inhibition based on predefined logic etc. shall be used.
2. The alarm display shall be built bottom up with the most recent alarm at the top of the list. When a point returns to normal, the associated alarm line shall change color suitably and on acknowledgement, the line shall be blanked out.
3. The alarms below the blank lines shall move upward to fill the empty lines. If the capacity of the OWS display page is exceeded, alarm history shall be stored in memory to accept the over- flow. This alarm history shall be displayed upon operator demand.

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4. When a point goes into an alarm state and appears on the alarm screen, the time of alarm shall flash until acknowledged by the operator. Acknowledgement by the operator shall cause the time to stop flashing. All alarm initiations and return to normal, shall be logged on a printer.

6.10 System Software

1. Complete licensed software for PLC based system including the communication software system shall be supplied and implemented to meet completely the specification requirements.
2. Application software shall be built based on approved logic diagram, graphics etc and shall include controls, graphics, logs, trends, history, report generation etc.
3. The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics.
4. Diagnostic software shall have the capability to provide information about the failed module / system either in the form of a system configuration display or provide information in the form of a statement.
5. The software's shall not be machine specific. All software licenses shall be valid for the continuous service life of the plant and equipment.
6. Password security shall be used in order to ensure security level to the plant operation.

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7. UNINTERRUPTED POWER SUPPLY (UPS)

Redundant, 230 VAC Uninterrupted Power Supply (UPS) System for CHP control system consisting of 2x 100% capacity static inverters, 2 x 100% capacity static switches, Manual by-pass switch, 1x 100% capacity float-cum-boost chargers, Battery with accessories, Step-down transformer, Voltage Stabilizer, AC Power Distribution Boards etc. shall be provided. UPS shall be provided with all interconnecting cable between UPS equipment and battery, UPS system cabinets and enclosures etc.

UPS shall be provided with all equipment and accessories required for completeness of the system including any feeder distribution as required for protecting UPS equipment and connected inputs and outputs shall be furnished in line with the specification.

7.1 Technical requirements

1. The equipment furnished under this subsection of the specification shall meet the requirements of all applicable codes and standards including ANSI, NEMA, IEEE, NEC and IS.
2. The UPS equipment and the complete system shall have Surge Withstanding Capability (SWC) to meet the requirements of ANSI C 37.90a - IEEE Standard 472-1974.
3. The UPS shall be provided to cater to all the loads for systems, equipment and instruments supplied by the Bidder requiring UPS supply. Spare feeders of at least 10% of the total number of feeders shall be built in.
4. The selection and selective coordination of all the protecting devices including fuse free circuit breakers/ fuses shall conform to the requirements of National Electric Code NEC –1984 and other applicable codes and standards. The selectivity ratios of the fuses shall be such that there is a sufficient margin between the total electric energy of the upstream fuse. The selectivity ratio shall not be less than 2:1 in any case.
5. The following general requirements shall be met for ensuring proper branch and circuit protection.
6. The feeder fuse ampere rating and feeder conductor ampacity must be at least 100% of the non continuous load plus 125% of the continuous load as calculated per Article 220 (220-10 G) of NEC Code- 1984. The feeder conductor must be protected by a fuse not greater than the conductor ampacity.
7. Each ungrounded service entrance conductor shall have a fuse in series with a rating not higher than the ampacity of the conductor.
8. If secondary fuses are sized not greater than 125% of transformer secondary current, individual transformer fuses are not required in the primary,

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provided, the primary feeder fuses are not larger than 250% of the transformer rate primary current.

9. The UPS system shall be suitable for operation at ambient conditions indicated in the specification.

7.2 Functional requirements

1. The Uninterrupted Power Supply (UPS) system of continuous duty shall supply regulated, filtered and uninterrupted 230V, 50 Hz, single-phase power, within specified tolerances. Each of the UPS loads shall receive one feeder each from the AC Distribution Board of Inverter A& B. However, each inverter shall supply only 50% loads under normal conditions.
2. Each UPS System component shall be compatible for satisfactory and well coordinated operation with other related components as well as with the input and output systems. The Bidder shall be responsible for fully meeting this requirement by proper design and co-ordination of UPS system with other related input/output systems and by furnishing all required equipment for interface and completeness as applicable.
3. The KVA rating of the UPS shall be guaranteed at 230VAC, 50 Hz, single phase output at 50 deg C ambient temperature and load factor of 0.8 lagging. In case, the Bidder's standard UPS rating are applicable at an ambient temperature lower than 50 deg C, the Bidder shall consider derating factor of at least 1.5 % / deg C. The Bidder shall demonstrate the above stated capacity at 500 Deg C during shop testing.

7.3 Normal Operation

1. During normal operation, UPS loads shall be supplied by both 100% capacity inverters each working at 50% load. The inverters shall receive power from DC source (Charger/Battery) and their static switches shall be in the respective "Inverter" position. In this mode the two inverters shall act as hot standby for each other.
2. Necessary paralleling networks shall be included to ensure equal load sharing by both inverters. The rating of the paralleling device / circuit shall be such that it does not act as a limiting factor on the fault clearing capability of the inverters individually and when working in parallel. Load sharing network details shall be provided to establish all functionalities including fuse clearance.
3. One inverter shall act as "Master", working on its internal oscillator and the other inverter shall follow by using the synchronising signal from master inverter for automatic control of its output frequency.

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7.4 Emergency operation

In case of failure of any inverter, the static switch shall automatically transfer the UPS loads of faulty inverter (say Inverter-"A") to the healthy Inverter-"B" which shall start working at 100% capacity. Thus the feeding of UPS power is continued automatically to all loads connected to both inverters despite the failure of one inverter and the quality power supply to all UPS loads connected to both inverters shall be maintained without interruption. Isolation of faulty inverter shall be automatic and achieved in less than 4 mille seconds.

On inverter failure, the plant AC source is automatically brought in as the standby source to healthy Inverter working at 100% capacity. In this mode, the healthy Inverter shall get the synchronizing signal from the standby AC source.

Operation on internal oscillator and transfer/retransfer to standby source shall be as follows :

1. The output frequency of the healthy inverter shall be automatically synchronised with the plant stand-by AC source supplied through step down transformer and voltage stabliser using synchronising signal from the standby source. If the frequency of the standby source is beyond these limits, the inverter frequency control shall be automatically disconnected from stand-by synchronising signal and the inverter shall maintain the output frequency at 50 Hz within + 0.1 percent under all conditions of load and input voltage by working on its own internal oscillators.
2. During operation on its own internal oscillator, the inverters shall continuously monitor the frequency of standby source. Upon restoration of proper frequency conditions of stand-by source, the inverter shall automatically start using stand-by source frequency as the synchronising signal for inverter output frequency control.
3. During the operation of any inverter on its internal oscillator due to synchronising frequency being beyond the specified limits, the transfer of static switch from "Inverter" to "Standby source" shall be inhibited.
4. While one of the inverters (healthy) is feeding 100% load and the AC source is acting as standby, and in case this invertor also fails, the 100% load shall be automatically transferred from invertor to standby AC source through static switch, provided the standby source is synchronised to the invertor (synchronous transfer). However, such transfers shall be inhibited during operation of invertor on its internal oscillator due to standby AC source frequency being beyond the synchronisation limits. Asynchronous transfer of invertor loads to standby AC source with a beak, on invertor failure will have to be provided by the Bidder.

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5. Retransfer of loads from standby AC source to inverter shall be automatic or manual as pre selected by the operator and shall be accomplished only after synchronism of the inverter output with the standby source has been automatically accomplished.
6. The manual bypass switch shall have the provision for fully by-passing the UPS system and connecting all UPS loads to the standby AC source.

7.5 Static inverters and auxiliary equipment

The static inverters shall be solid state type employing silicon controlled rectifiers or power transistors and other solid state devices to convert direct current power to essentially sinusoidal alternating current power as per this specification. Ferro resonant type inverters shall not be acceptable. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, surge suppression network, automatic synchronisation etc. as specified herein. Inverter shall be of continuous duty. Natural convection or forced cooling using redundant fans shall be used. Equipment shall be designed for operation with full load even with cooling fans failure / non-availability.

7.5.1 Inverter Capacity

Each static inverter shall have the following minimum capabilities.

Continuous full load rating: meeting specification stipulations

Over load capacity: 125% of full load rating for 10 minutes and 200% for 10 seconds minimum and 300% for 4ms minimum for all specified input voltages.

The inverter shall have sufficient I²t capability to clear a slow acting HRC fuse having a continuous current rating equal to at least 20% of the continuous full load current rating of the inverter, while feeding 100% rated loads of the inverter.

Voltage regulation: $\pm 1\%$ for 0-100% load at all input voltage and all power factors.

Step load pick up: Upon transfer of full load, the inverter output voltage shall not drop below 85% of nominal voltage during the first half cycle after transfer and 90% of nominal voltage in the next half cycle. The recovery to within $\pm 1\%$ of voltage shall be in less than 50 milliseconds.

7.5.2 Input / Output Voltage

The inverters shall be fed from Battery and chargers which do not feed any other loads. Input voltage shall be nominal DC output voltage of battery and charger of range from final voltage after discharge of battery to maximum

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DC bus voltage during equalize charging of battery. The inverter shall also be capable of working satisfactorily meeting all specification requirements with only the chargers connected to its input without battery in circuit. Filtering on the input of the inverters shall be furnished as required to operate with the output ripple of the chargers furnished by the Bidder. Each inverter shall include equipment necessary to protect itself from damage resulting from excursions, loss or restoration of DC input voltage and synchronizing voltage. The inverter output voltage shall be 230V AC, 50 hz, single phase. Total harmonic content shall be 4% (max) and harmonic content of any single harmonic shall not exceed 3%. The inverter efficiency at 100% load and 0.8 pf shall be minimum 85% and at 50% load and 0.8 pf shall be minimum 80%.

7.5.3 Over loads, Short Circuits and Load loss

1. The inverters shall be provided with suitable fuses at the input and output which shall permit proper co-ordination with other protective devices and at the same time protect the inverter against damage due to internal faults. All necessary equipment shall be provided to protect the inverters against over loads, short circuits and 100% loss of load. The inverter shall be self protecting against damage if energized with full load connected. All the fuses used in inverter power & control circuits shall be fast acting type, operating in less than 5 ms.
2. The inverter shall be provided with current limiting circuitry which shall limit the output current to a value which will not damage the inverter or blow its fuses.
3. The inverter shall have sufficient I^2t capability to prevent damage to itself until short circuit conditions on the output are cleared.
4. Each inverter shall be capable of operation with non linear loads. Bidder shall furnish details of non linearity for the loads. Output waveform of the inverters) shall remain within specified limits when operating with non linear loads at 100 percent rated load.
5. The inverters shall be self protecting against all AC and DC transients, voltage surges and steady state abnormal voltages and current likely to be encountered in utility power station.

7.5.4 Automatic Synchronization

1. Inverter equipment shall include stable solid state oscillator devices designed to automatically maintain the inverter output in phase and in synchronism with the standby AC source. The frequency regulation shall be automatic within $\pm 0.1\%$ for all conditions of inputs, loads and temperature occurring simultaneously or in any combination.

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2. Facility shall be provided for automatic transfer to internal oscillator operation when the standby source frequency is not within the synchronisation limits.
3. Provision shall be made for step less adjustment of synch disconnect frequency range from 50 Hz +/- 0.5 Hz to 50 Hz +/- 2 Hz.
4. Automatic adjustment of phase relationship between inverter output and standby AC source shall be gradual, at a controlled slew rate which shall not exceed one Hz per second.
5. The inverter shall normally work on the internal oscillator with either of the two invertors as master synchronizer and the other following it. Suitable selector facility shall be provided to select the master. When any one inverter fails the healthy inverter gets the synchronizing signal from the standby A.C. source.

The DC input current shall never exceed the full load current except for a short circuit within the inverter. This limitation applies to transient as well as steady state currents and includes inrush currents upon initial energisation of the UPS, load energisation, short circuits external to the inverter etc. For any value of the load and load power factor drawn by the equipment served, the inverter shall not impose on DC source any voltage oscillations in excess of 5 volts (RMS total, all frequencies) or any current oscillations in excess of 3 percent (RMS total, all frequencies) of the DC current at full load.

7.5.5 Static inverter auxiliary equipment

In addition to the inverter equipment specified above, auxiliary equipment shall be furnished with each static inverter as follows:

1. Output ammeter, Output voltmeter, Output KVA meter, Input voltmeter, Frequency meter, Power factor meter, Inverter ON-OFF switch, Alarm Reset Push Button etc. of one number each shall be provided on the front panel of the inverter enclosures.
2. Indicating lights shall be furnished on front of the UPS panels. For those abnormal conditions which could be of a momentary nature, the indicating lights shall remain energized and the contact remain closed until cleared by a reset push button on the panel.
3. The following indications shall be provided as a minimum i.e. DC voltage to the Inverter Low/ High, Loss of DC input to the inverter, Inverter output voltage High/ low, Inverter failure, Standby AC source failure, Inverter synchronized with standby AC source in case of failure of the other inverter, Inverter feeding 100% UPS load, Standby AC source feeding 100% UPS loads, Fan failure and temperature high etc.

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4. In addition to the above indications, the Bidder shall furnish electrically independent, potential free contacts for each of the above conditions. These contacts shall be rated for 0.5 Amps, 220 Volts DC and shall be wired to the terminal blocks.
5. The Bidder shall furnish 4-20 m A signals for Inverter A & B output voltages, output currents, output frequency etc.

7.5.6 Static transfer switches and auxiliary equipment

The static transfer switches shall be provided to perform the following functions

1. To transfer the load automatically between the Inverter to the standby inverter as described under automatic synchronisation.
2. To transfer UPS load under manual control from standby AC source to inverter when placing the UPS System in service and from inverter to standby AC source when taking the UPS out of service.
3. The static transfer switches shall have two modes of operation namely automatic and manual.
4. The static transfer switches shall use silicon controlled rectifiers and other static devices required for automatic transfer of load from Inverter" to Standby" source and vice versa.
5. The static switches shall be provided with the requirements specified herein including the following:

- | | | |
|----|-----------------------------|---|
| a) | Capacity(continuous) | Continuous full load capacity of the inverter. |
| b) | Capacity (overload) | As per overload capacity of inverter indicated in the specification |
| c) | Capacity (Peak) | 1000% of continuous rating for 5 cycles. |
| d) | Transfer Time | 1/4 cycle maximum. (The transition shall be "make before break". Voltage failure shall be sensed at the output of static switch |
| e) | Voltage Rating (Nominal) | 230 Volts, 50 Hz, single phase. |
| f) | Transient Voltage Tolerance | 340 Volts peak above the normal line voltage. |
| g) | Ambient temperature | 50 deg C max. |
| h) | Cooling | Natural or forced circulation, using redundant fans. |
| i) | Duty | Continuous |

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6. The transfer of static switch from normal "Inverter" position to "Stand-by" position shall be initiated by Inverter failure and UPS system trouble, Static switch output voltage failure, over current or manual push button operation.

The UPS bus shall be monitored by two voltage detectors. One fast acting circuit shall be used for detecting a complete and instantaneous voltage loss while the other slower acting averaging circuit with adjustable trip level shall be employed to detect voltage deviation beyond selected limits. Both voltage detector circuits shall automatically initiate operation of static transfer switch.

UPS bus current shall be continuously monitored by a current monitoring detector. This detector shall operate the static transfer switch when the load current exceeds the overload rating of any inverter. The detector shall rest when the load current falls below the rated current of the inverter resulting in retransfer of static switch with inverter position.

The static switch shall automatically transfer the load from inverter to stand-by AC source when the maximum I_{2t} capability of the inverter is reached or when the inverter output voltage drops below 90%.

Over current transfer limit shall be continuously adjustable from inverter continuous rating to inverter current limit rating.

7. Transfer Inhibit of static switch shall be under the following conditions:

Automatic or manual synchronous transfer of load from inverter to stand-by AC source or vice versa, shall be inhibited when the inverter frequency is not synchronized to the alternate source. However, asynchronous transfer facility under such condition shall be provided.

Transfer resulting from overload shall be inhibited when the standby AC source is not available. In this case the load fed by the inverter shall be automatically disconnected.

8. Static transfer switches shall be provided with necessary protective devices (circuit breakers) both in "Normal" as well as "Stand by" position.

9. The static switches shall be furnished with contacts to alarm failure of the alternate source or opening of any fuse protecting the static switches.

10. Auxiliary equipment for static transfer switch

11. Following auxiliary equipment shall be furnished with each static transfer switch a minimum:

- Red indicating Light to indicate switch in "Normal" position, Green indicating Light to indicate switch in "Standby" position, White indicating Light to indicate "Normal" and "Standby", power sources in synchronism, Push-button to simulate normal AC UPS power failure (sensed at static switch output) to test the satisfactory working of static switch, transfer labeled "Transfer Test", Push-button for manual retransfer of static switch to "Normal" position, Push-button for manual transfer from normal to

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alternate source, Light to indicate standby AC source voltage deviation high, Light to indicate voltage transfer enabled, Light to indicate voltage transfer disabled etc shall be provided on the front of the enclosure.

- Two (2) number each of NO contact for static switch transfer to "Standby" position and standby source voltage deviation $> \pm 2\%$ from normal shall be provided within the static transfer switch enclosure.

A. Manual by-pass switch

- The manual by-pass switch shall be used to isolate any static switch from its load and stand-by power supply and to take the static switch out of service without power interruption to the load. In doing so, the manual by-pass switch shall connect both load buses to a single inverter. The manual bypass switch shall provide the facility for by passing the entire UPS system during the operation of the UPS in the option of the operator.
- The manual bypass switch shall have "make before break" contacts to ensure continuous supply to UPS loads during the operation of the same.
- The manual bypass switch shall be rated for 600 Volts, 50 Hz, single phase operation. It shall have continuous load carrying capacity equal to full load inverter current and necessary short term load carrying and interrupting capacity to meet the requirements of the UPS system.
- An other bypass and disconnect devices shall be provided, as required for orderly start up, shut down and maintenance of UPS system and system components.
- The manual by-pass switch and required disconnect devices shall be furnished duly mounted and wired in enclosure.

B. Float-cum-boost chargers and auxiliary equipment

- Two 100% capacity chargers shall be furnished for the UPS system. Each charger shall confirm to the following requirements.
- Each charger furnished for UPS system shall be adequately rated to ensure that any one shall meet full DC load of UPS system operating at 100 % rating plus recharge the fully discharged UPS batteries within 8 hours.
- The chargers shall be served from a 415 volt, 50 Hz, 3 phase system. The chargers shall maintain the output voltage within plus and minus 0.5 % from no load to full load, with an input power supply deviation in voltage level of $\pm 10\%$ and input power supply deviation in frequency of $\pm 5\%$ and with both deviations present in any combination.
- In addition to supplying DC power for inverters, the chargers shall be designed to charge a fully discharged battery without over loading or causing over voltage or without causing interrupting operation of AC or DC circuit breakers for the entire range of intended operating regimes. Suitable solid state

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electronic circuits shall be provided to ensure that the charging current is voltage regulated and current limited. After the battery is recharged the charger shall maintain the battery at full charge until the next emergency operation when the UPS battery is again required to provide DC power.

- e) In addition to supplying DC power for inverters, the chargers shall be designed to charge a fully discharged battery without over loading or causing over voltage or without causing interrupting operation of AC or DC circuit breakers for the entire range of intended operating regimes. Suitable solid state electronic circuits shall be provided to ensure that the charging current is voltage regulated and current limited. After the battery is recharged the charger shall maintain the battery at full charge until the next emergency operation when the UPS battery is again required to provide DC power..
- f) Float and equalising controls shall have an adjustment range of +/- 5% continuous (without steps).
- g) The chargers shall be self-regulating, solid state, silicon controlled, full-wave rectifier type designed for single and parallel operation with the battery specified. The chargers shall be designed for automatic load sharing during parallel operation.
- h) The charger shall be current limited at 125% of full load to reduce output voltage for charger circuit protection and for protection of battery from overcharge. The current limit shall be continuously adjustable from 80% to 125%.
- i) All necessary equipment and devices shall be provided to protect the charger from short circuits, transient voltages, surges, load and supply fluctuations including sudden loss of input or load.
- j) The charger shall have a slow walk-in circuit which shall prevent application of full load DC current in less than 10 seconds after AC power is energised.
- k) The minimum full load efficiency at nominal input and float output shall be 90% or better. The output regulation, ripple content and power factor shall meet the requirements of UPS system offered.

7.5.7 Battery Charger Auxiliary Equipment

Following auxiliary equipment shall be furnished for battery charger a minimum:

AC Voltmeter, DC Voltmeter, AC Ammeter, DC Ammeter, Charger On-Off push buttons, Potentiometers (one "Float Voltage Adjust" and one "Equalising Voltage Adjust", both with manual adjustment knobs, the settings of these knobs, shall be independent of each other), Selector Switch for float charge / Equalising charge, Charging rate setter, Selector switch and lights for ground fault detector, Indicating lights with proper actuating

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devices, Circuitry and legend etc shall be furnished on the front of the panel of the charger enclosure.

Indications such as Failure of input AC supply, Charger failure, System on battery operation, Battery equalise timer 'on', Low battery voltage, DC ground fault, Redundant fan failure and temperature high (if provided), Charger fuse failure, Low DC output voltage, High DC output voltage etc.

One set of independent potential free contacts rated for 0.5 amps, 220 volt DC shall be furnished for the alarms above and wired to terminal block for use of alarm annunciation system.

7.5.8 Ground Detector System

Each charger shall be furnished with a ground detector system consisting of a relay and a centre tapped resistor. The resistor shall be connected between the positive bus and the negative bus. The relay coil shall be connected to resistor and ground. The relay shall be furnished with one normally open and one normally closed contact wired to terminal blocks for connection to external circuits.

Two indicating lights and one three position spring return to centre selector switch mounted on front of charger cabinet shall be provided for each ground detector system.

7.5.9 UPS Battery

1. The battery shall be heavy duty Nickel-cadmium type and shall have sufficient Amp-hour capacity to supply 100% full load current of UPS for 30 min. The Ni-cd battery shall conform to IS: 10918 and shall be sized according to IEEE Std. 1115.
2. The battery shall be high discharge performance type to withstand discharge/charge cycles throughout life without loss of capacity. In battery sizing calculation, Bidder shall also take into account a minimum voltage drop of 2.5 volts from battery room to the inverter input.
3. Bidder shall furnish battery sizing calculations, supporting curves/data etc. with the proposal to demonstrate that the proposed battery capacity meets the above specification. Bidder shall take into account various correction factors such as capacity factor, temperature derating factor (at a minimum electrolyte temperature of 4°C), design margin as per data given below:
 - a. Temperature derating factor (At : (Td)
an electrolyte temperature of :
40C)
 - b. Design margin : 20% = 1.2
 - c. Capacity factor (KT) (For : AH capacity of chosen cell
discharge duration of 1 hr. & /(discharge current in amp for

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- end cell voltage of 1.1 volts) chosen cell Corresponding to 1 hour) x Float correction factor.
- d. The UPS battery shall be furnished as specified herein and shall meet following requirements.
- i) iNominal Voltage : As per the requirement of nominal DC voltage level at the input of the inverters.
- ii) Ambient temperature : 50 ° C max.
- iii) Specific gravity, full charge : 1.19 ± 0.01
- iv) Voltage per cell
- Nominal : 1.2 V
- Floating : 1.40 V to 1.42V
- Boost : 1.53 V to 1.67V
- End cell voltage : 1.1 Volts

7.5.10 Battery Accessories:

2 nos of Hydrometer along with syringes suitable for vent holes in different cells, Thermometers, Specific gravity correction chart, Wall mounted type holder made of teak wood for hydrometer & thermometer, Cell testing voltmeter (3-0-3V), Acid/Alkali mixing jar 2 nos, Rubber apron, Rubber gloves, Set of spanners, Goggles (industrial) Instruction Card, Variable metallic resistor & shunt, Inter cell connectors, Suitable terminal lugs for cables, Two tier teakwood battery rack, Jack for lifting the cells etc shall be provided as accessories and fittings of the Batteries and auxiliaries.

7.5.11 Step-down transformer & voltage stabiliser

One 415 Volt, 3 phase to 240 Volt, single phase transformer along with associated voltage stabilizer shall be furnished.

This transformer and stabilizer combination shall convert 415 Volt +/- 10% plant auxiliary AC supply to 230V, +/- 2% single phase standby AC Power, which shall serve as UPS system back up supply source.

The transformer and stabilizer shall be sized for 100 % UPS load and shall co-ordinate with the largest branch circuit protection device for feeder short circuit current without sacrificing voltage regulation. The voltage stabilizer shall employ silicon solid state circuitry and shall maintain a stabilized voltage for 0 -100% load with input voltage variations as indicated above.

The stabilizer shall meet the following characteristics as a minimum. Fast rate of correction - within 5 cycle; Output distortion - less than 5% under worst conditions; Efficiency shall be better than 94%; No load losses less than 5%.

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7.5.12 AC Distribution Boards

Panel boards for distribution of continuous AC power to essential loads shall be dead-front type panel boards rated for 600 V, AC service. Sheet steel thickness shall be 3 mm for load bearing member and 1.6 mm for other members. The hinged panel board front shall cover the fuses and wiring gutter but not the switch handles. The hinged front and switch handles shall be covered by the enclosure-door.

Each panel board shall be constructed for 2 wire, single phase distribution with solid neutral bar. Phase and neutral bars shall be of copper. Rating of the main lugs shall be equal to the rated continuous full load current of each inverter. Type of enclosure shall be IP 42 as a minimum.

Each panel board shall have one fused disconnect switch of adequate rating for incoming feeder for AC Bus and requisite single pole, suitably rated disconnect switch branch circuit devices. Fused switches shall be equipped with arc quenchers, visible blades and quick-make quick-break operating mechanisms. The number of feeders and rating of each feeder shall be to suit the individual load requirements.

The AC distribution board and components thereof shall be from the latest proven product range of a qualified. However, 25% spare feeders with fuses of each rating shall be provided.

Wiring and interconnections

All interconnections required from input to output terminals or outgoing inverter, transfer switches and distribution board equipment shall be provided within the enclosures in accordance with the manufacturer's proven practice, applicable international standards and good engineering practice. Internal wiring in factory pre-wired electronic systems cabinets may be installed according to the Bidder's standard as to wire size, insulation and method of termination on internal equipment. Wiring for external circuits including all alarm contacts shall be brought to grouped terminal blocks located for convenient connection for external circuits entering from top or bottom.

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8. FIELD INSTRUMENTS & FINAL CONTROL ELEMENTS

8.1 Belt Weigher

1. The electronic belt weigher for measurement of Coal flow rate and quantity shall be provided at specified locations.
2. The belt weighers shall be complete with load cell type sensing element, weigh idler & suspension system, digital speed sensor, local panel with rate of flow indicator and digital totalizer, remote transmission, special cables, etc. The electronic belt weigher shall be designed for continuous automatic weighing.
3. The frame of Weigh Bridge shall house pivot & link mechanism, weigh idler and all other required items. This shall be made of structural steel. This shall be made of structural steel through angles, self gauging pivots, self aligning bearings and lateral checking by flexure plates, such that entire arrangement is floating.
4. The weigh section shall be fully temperature compensated, and protected against dust, shock and vibration. The load cells shall be suitable for working in the dusty environment prevailing in the CHP area.
5. Min. weighing accuracy shall be $\pm 0.25\%$ and on instantaneous capacity for the full range of 20% to 120% of conveyor design capacity. The weigher shall have 250% overload protection for the structure.
6. All necessary facilities for calibration like weigh-chain, chain reeling drum etc. to be provided along with the belt weigher. Provision for auto-calibration also to be provided.
7. Suitable provision shall be made for indication of the following to the Operator at CHP control room.
 - Daily & cumulative Coal conveyed to crusher house.
 - Daily & cumulative Coal sent to stockpile
 - Daily & cumulative Coal sent to boiler bunker.
 - Amount of Coal available in the stock pile
8. Fully automatic zero and span calibration facility shall be provided.
9. Test chain shall be two (2) idlers longer than the weighing length of the weighers, and shall be complete with chain reset equipment with weight adding reels of adequate size.
10. Provision shall be provided in local panel to retain the totalizer reading during power failure. All necessary battery back-up shall be provided.

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Table 8.1
Specifications for Belt Weigher System

S.NO	Features	Minimum Requirements
1	Type	Microprocessor based.
2	Accuracy	+/-0.25 % of Full Scale
3	Weigh Span	4 idler length
4	Belt width	
5	Belt speed	
6	Capacity	
7	Load cell	7 Load cell
a)	Construction	SS encapsulated
b)	Protection	IP-67 or better
c)	Sensitivity	4mV/V or better
d)	Overload	150% of rated capacity/ Ultimate 300% of Rated Capacity
e)	Type	S-type
f)	Rating	weatherproof
g)	Capacity	As per system requirement
8	Belt speed sensor	
a)	Type	Digital
b)	Mounting	Bracket mounting on Return belt
c)	Pulse frequency	200 Hz or more for nominal belt speed
d)	Housing	SS 316
e)	Protection Class	IP-65 or better
9	Power supply	230 V, 50 Hz
10	Communication port	Modbus RS 485
11	Output	4-20 mA for Flow Rate & Pulses for Totalizer
12	Calibration	Automatic Zero & Span Calibration
13	Display	16 digit two line LCD display for Flow Rate & Total Flow.

8.2 Pull chord Switch

Pull chord type (manually reset type) emergency stop switches shall be located on both sides of belt conveyors along the walkways for the entire length of conveyors for emergency stopping of conveyor at spacing of 30 Meters. The location of switches shall start from 4.0 meters from drive pulley / tail pulley. It shall have a separate terminal box with a separate

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hinged cover which shall be totally sealed from main box containing actuating mechanism / limit switch etc. Local pull chord actuation shall be provided by means of mechanical flap. Each switch shall have two NO and two NC contacts, which shall be wired out to the terminal block. One contact of the switch shall be used in BMU & other contact shall be serially wired to PLC. The trip contact of the BMU shall be wired directly to switchgear. The terminal block shall have facilities of cable looping. Adequate length of rope and all accessories shall be furnished.

Table 8.2**Specifications for Pull Chord Switch**

S.No	Features	Minimum Requirements
1	Type	Heavy-duty, addressable type
2	Design	Dust & vermin proof design
3	Sensor module	To be housed inside
4	Protection	Conforming to IP-65 or better class of enclosure
5	No. of Contacts	2 N.O. + 2 N.C contacts
6	Contact rating	5 A at 230V A.C
7	Terminals	Suitable to receive 2.5 Sq. mm wires
8	Enclosure material	Aluminium alloy LM6 or cast iron
9	Operation	Bi-directional with two ropes fitted to it from opposite directions terminating with a spring at the anchor points. The spring shall operate the switch in the event of rope breakage.
10	Reset	Manual

8.3**Belt Sway Switch**

Belt sway switches of self resetting type shall be furnished one pair at 50 meter intervals on both sides of conveyor along the conveyor and at the head end, tail end, horizontal bends/ curvature, either side of horizontal bends / curvature etc. to limit belt sway to permissible extent. The location of switches shall start from 15 meters from drive pulley / tail pulley. It shall have a separate terminal box with a separate hinged cover totally sealed from the main box containing actuating mechanism/ limit switch etc. Each switch shall have two NO and two NC contacts, which shall be wired out to the terminal block. One contact of the switch shall be used in BMU & other contact shall be serially wired to PLC. The terminal block shall have facilities for cable looping. The contacts of the switches shall be rated for at least 5 Amps. breaking at 230 VAC.

Table 8.3

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Specifications for Belts Way Switch

S.N	Features	Minimum Requirements
1	Type	Heavy-duty, addressable type
2	Design	Dust & vermin proof design
3	Sensor module	To be housed inside
4	Protection	Conforming to IP-65 or better class of enclosure
5	No. of Contacts	2 N.O. + 2 N.C contacts
6	Contact rating	5 A at 230V A.C
7	Terminals	Suitable to receive 2.5 Sq. mm wires
8	Enclosure material	Aluminium alloy LM6 or cast iron
9	Cable Entry	4 Nos. ½ " NPT conduit threaded to accept Flameproof cable glands rope breakage.
10	Reset	Self

8.4

Belt Monitoring Unit (BMU)

- One number Belt monitoring unit shall be provided for each Conveyor to give a trip signal in case any of the conveyor switches is actuated and for identifying the switch which has acted.
- Switches of different conveyors shall not be combined in one monitoring unit.
- The addressable sensor module of all pull cord switches of one conveyor shall be connected in series to the BMU. Similarly the addressable sensor module of all belt sway switches of one conveyor shall be connected in series to the BMU.
- If the numbers of switches of one conveyor are more than the identifying capability of one BMU, the switches shall be divided into further groups.
- It shall be possible to identify whether PCS or BSS has acted and which switch has acted and shall be displayed on the BMU / local panel.
- The trip contact of the BMU shall be independent for PCS and BSS and shall be instantaneous without any delay.
- An additional serial output shall be provided by the BMU for connecting to PLC for indication of the type of switch and number of the switch which has acted.
- The trip contact of the BMU for PCS shall be wired directly to switchgear.
- The supply for the BMU shall be from UPS.

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8.5 Zero Speed Switch

Zero speed switch shall be non-contact (proximity) type electronic switch. Mounting arrangement/ location shall be such that operation, effective sensing distance, sensitivity etc. shall not be effected by accumulation of dust on rotating part or surface of probe. Adequate mechanical protection by means of non-metallic shields shall be provided on top of the switch to prevent any damage due to falling coal / metallic pieces etc. In built initial start up delay and nuisance, tripping delay through timers shall be provided. Each switch shall have two NO and two NC contacts wired out to the terminal blocks. A separate terminal box with a separate cover, which shall be totally sealed from main box, shall be provided. Terminal blocks shall be suitable for terminating 1.5 mm sq. standard copper cable.

Table 8.4
Specifications for Zero Speed Switch

S.N	Features	Minimum Requirements
Sensor Probe		
1	Type	Proximity, 2 wire, NAMUR type, cylindrical
2	Supply	8.5 V DC (approx.)
3	Effective sensing distance	10 mm (min)
4	Protection	IP 65 or better
5	Material of enclosure	SS
6	Sensor cable	2 metres (min)
Monitoring Electronic Unit		
1	Type	Microprocessor-based, programmable
2	Supply	230 V AC
3	Output contacts	2 Change-over / 2 NO + 2NC
4	Contact rating	2 A at 240 V AC
5	Speed range	Configurable
6	Switching Hysteresis	+/- 5% or better or configurable
7	Speed setting	Configurable, with push buttons / key pad
8	Time delay	Configurable from 1 to 20 seconds
9	Protection	IP 65 or IP 20 if mounted inside IP 65 JB/Panel

8.6 Under belt switch

These switches shall be installed under the belt for detecting the presence of material on the belt whose contacts shall in turn be used for operating

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solenoid valves of dust suppression system. The switch and its operating arrangement shall be suitable for working in dusty areas. The minimum degree of protection of switch shall be IP-65. The switch shall be capable of detecting three events simultaneously as follows:

- Belt loaded
- Belt running at more than preset speed.
- Preset initial start delay.

8.7

Chute Blockage Switch

One no. chute blockage switch of proven type. Chute blockage switch shall trip the feeding conveyor in case of Chute blockage and protect the feeding conveyor and shall be provided at a suitable height on each leg of the conveyors equipment.

The switch and its operating arrangement shall be suitable for working in dusty areas. Local indication of chute blockage switch actuation shall also be provided. Location of chute block switch shall be such that washing/cleaning of chute by pipe / rod does not affect it.

Table 8.5
Specifications for Chute Blockage Switch

S.N	Features	Minimum Requirements
1	Type	RF Type
	Sensing Probe	
1	Material	SS 316
2	Mounting	Flange type
3	Enclosure Housing	Cast Aluminium or better
4	Enclosure Protection	IP-65 or better
5	Temperature	200 Deg C
	Electronic Controller	
1	Relay output	2 Nos. of potential free change-over
2	Supply	230 V AC
3	Contact Rating	5 A at 230 VAC
4	Local Indication	LEDs for Normal, Alarm levels, Probe
5	Enclosure Housing	Cast Aluminium
6	Enclosure Protection	IP 65 or better
7	Accessories	RF signal cable from sensing probe to

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8.8 Electromechanical Type Limit Switch

Table 8.6

Specifications for Electromechanical Type Limit Switch

S.N	Features	Minimum Requirements
1	Sensor / Lever	Heavy duty, high impact operation with robust construction and capable of withstanding repetitive operations
2	Protection	Weatherproof
3	Contacts	Making and breaking arrangements shall be reliable and having high mechanical endurance
4	No. of contacts	Minimum 2 NO + 2 NC adequately rated for handling inductive currents in the circuit
5	Housing	Aluminium alloy LM6 of robust construction
6	Enclosure	IP 65 or better
7	Roller / Lever	High grade, wear resistant material with provision for roller lever to be adjustable and mounted in steps.

8.9 Proximity Type Limit Switch

The normal travel end / intermediate position limit switches shall be 2-wire proximity type. The Proximity switches shall be suitable for detecting the metals without contact and indicate their presence by providing a switched signal.

Table 8.7

Specifications for Proximity Type Limit Switch

S.N	Features	Minimum Requirements
1	Type	2 wire, Inductive type
2	Shape	Rectangular (preferred)
3	Sensing range	15 to 30 mm
4	Control supply	24 V DC
5	Output Logic	NO / NC (selectable)
6	Switching frequency	100 Hz max.

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S.N	Features	Minimum Requirements
7	Mounting position	suitable for operating in any mounting position
8	Design	Suitable for operating under high mechanical and ambient stress (i.e. high temperature, dust etc.) conditions
9	Ambient Temperature	50 Deg C
10	Indication	LED for indication of operating status
11	Terminal box / Enclosure	IP-65 or better
12	Cable Entry	½ " NPT (F)
13	Terminals	Suitable for 1.5 Sq. mm wire connection

8.10

Resistance Temperature Detector (RTD)

Table 8.8
Specifications for RTD

S.N	Features	Minimum Requirements
1	Type	3 / 4 wire , Pt-100 (100 ohm at 0 deg C) (as per DIN 43760)
2	No. of Element	Duplex
3	Housing/Head	IP-65/Diecast Aluminium. Plug in connectors are to be provided for external signal cable connection
4	Sheathing of RTD	Metal sheathed , mineral insulated, ceramic packed
5	Calibration and accuracy	As per DIN-43670 Class-A for RTD
6	Stability	Zero & span drift within 0.1% of span for a 6 month period.
7	Characteristic	Linear with respect to temp, within $\pm 1/2$ percent of top range value
8	Standard	As per DIN-43670 for RTD & ASME PTC-19.3 for Thermowell
9	Accessories	a) Adjustable Nipple-Union-Nipple with thermo well connection / plug in connectors
		b) Compression fittings / unions
		c) Flanges etc.
		d) Thermowell as per requirement

- RTDs shall be of duplex, platinum three / four wire type with a nominal resistance of 100 ohms at 0°C and conform to DIN 43760 / BS 1904.

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2. Stability of RTD over full range shall be better than 0.05 ohms and the repeatability figure shall be better than 0.02 ohms. Accuracy shall be of the order of 0.15% or better and response time shall be less than 20 seconds with thermo well.
3. The protective-sheath material shall be SS 316, seamless tubes using compacted magnesium oxide packing for insulation. The insulation resistance at 540°C shall not be less than 5 mega-ohms.

8.11

Temperature Gauge

Table 8.9
Specification for Temperature Gauge

S.N	Feature	Minimum Requirement
1	Type	Mercury filled
2	Sensing Element material	Bourdon AISI 316 SS
3	Movement Materials	AISI 304 SS
4	Case Material/Protection class	SS / IP65
5	Capillary Armouring	SS Flexible
6	Capillary	SS 316 (5 mtr. Length for Local & 15 metre for panel Mounting)
7	Bulb/Stem Diameter	12 mm
8	Dial Size	150 mm
9	Window	Shatterproof glass
10	Scale	Black lettering on white background in 270 °C arc
11	Adjustment	Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
12	Pointer	Externally Adjustable
13	Range Selection	Normal Process Temperature – approximately two third of Temperature range.
14	Stop at Max. Reading	Shall be used
15	Over range Protection	150% of FSD
16	Instrument Connection	Bottom connection for local mounting, back connection for panel mounting.
17	Process Connection	½ " NPT with Thermowell
18	Performance :-	
a	Accuracy	+/-1.0% of full scale or better
b	Repeatability	Less than 0.5% of full range
c	Response Time	30 seconds (max.) with Thermowell and 15 seconds Bare.

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S.N	Feature	Minimum Requirement
15	Operating Ambient Temperature	50 °C (Max. continuous)
16	Accessories	Mounting brackets, Bolts, Nuts, Gaskets / SS Tag plate, SS Thermowell etc.

1. Temperature gauges shall be dial thermometers (liquid spring / metal expansion thermometer), either rigid stem or capillary tube depending upon application; if this is not possible for design reasons, industry type liquid – in – glass thermometers shall be used.
2. Case shall have back or bottom connection with adjustable gland to permit adjustment of thermometer into the thermo well.
3. Thermometer stem adjustable gland with union connection and bushing shall be suitable for ½ inch NPT connection.
4. Bi-metallic type dial thermometer, if used, shall be hermetically sealed, back or bottom connection type, with 150 mm dial.
5. The gauges shall be used with automatic ambient temperature compensation.
6. Scale ranges shall be selected so that normal process temperature in middle two – third of full scale range

8.12

Pressure/ Differential Pressure Switch

Table 8.10

Specification for Pressure/DP Switch

S.N	Feature	Minimum Requirement
1	Type	Piston for high pressure application Bellow/Diaphragm for low pressure application
2	Sensing Element material	AISI 316 SS
3	Wetted Parts material	AISI 316 SS
4	Case Material	Epoxy coated Die Cast Aluminium
5	Setter Scale	Black graduation on white linear scale. Graduation 0 – 100% with red pointer for set points.
6	Over range for Pressure / Vacuum Switch	150% of maximum pressure
7	Set Point	Adjustable throughout switch operating range.
8	Static Pressure for Differential Pressure Switch	Maximum Line Pressure or Static Pressure on either side without permanent deformation or loss of accuracy.
9	Adjustments	Internal – set point

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S.N	Feature	Minimum Requirement
		Differential adjustable feature
10	Process Connection	½ " NPT(M) bottom connected
11	Switch Configuration	2 SPDT / 1 DPDT
12	Switch Rating	230 V, 5A AC / 220 V, 0.25 A DC/24 V, 2A DC
13	Switch Type	Snap acting, shock and vibration-proof
14	Cable Connection	½ " ET conduit connections or compression gland
15	Enclosure Class	Weather proof as per IP 65 with corrosion resistance coating.
16	Accuracy	1% of span up to 3Kg/cm2 0.5% of span for more than 3 Kg/cm2.
17	Repeatability	0.5% of span
18	Accessories	
a)		Snubber for pulsating fluid application.
b)		Tag Number, service engraved in SS tag plate
c)		Teflon back-up sheath protection, as required.
d)		i) Remote diaphragm seal with SS 316 armored capillary for typical application. MOC of seal material shall be as per process fluid requirement. ii) Silver coated diaphragm for corrosive services like chlorinated water.
e)		Retention ring and screws for surface mounting.
f)		3-way Gauge Cock (SS 316) for PS / 5-Valve Manifold (SS 316) for DPS.
g)		mp for 2 " pipe, bolt & nut.

1. The pressure switches shall have sensing elements made of copper alloy or stainless steel sealed diaphragm and piston actuated for high pressure service and bellows for low pressure / vacuum service.
2. Low differential pressure switches for low static pressure ranges shall be diaphragm type with snap action switch elements.
3. Low differential pressure switches for high static pressure shall be elbows and torque tube type and snap – action switch elements and metric scale dial indicators.
4. For corrosive, viscous process fluids diaphragm sealed with completely filled inert liquid shall be used. Material of diaphragm and wetted parts shall be selected considering the nature of process fluid.

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5. The sensing elements shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand at least 150 % the full scale pressure without any damage or permanent deformation.
6. Actuation set point, dead band shall be internally adjustable throughout the range with tamper proof facilities.
7. Electrical connection for the switch devices shall be suitable for plug in type connection.
8. Process connection shall be ½ inch NPT. Process piping connections shall include necessary union, nut, nipple, tail pipe, isolation valve and test connection to permit servicing, testing, calibration and removal of the instrument device.
9. Pressure switches shall be tested as per BS – 6134.

8.13

Guided Wave Radar Type Level Transmitter

Table 8.11

Specification for Guided Wave Radar Type Transmitter

S.N	Feature	Minimum Requirement
1	Application	Level measurement of vessel under vacuum or low pressure application
3	Type	Guided wave radar
4	Principle	TDR (Time domain reflectometry)
5	Probe Material	SS 316
6	Accuracy	5 mm or better
7	Resolution	+/- 0.1 % of range or better
8	Signal Output	4 – 20 mA DC with 600 ohms load with HART compatibility
9	Power Supply	24 V DC + / - 10 %
10	Display	Integral
11	Mounting	External cage type
12	Transmitter housing Protection Class	IP-65 with corrosion resistance coating
13	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

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8.14 RF Type Level Switch

Table 8.12

Specification for RF Type Level Switch

S.N	Feature	Minimum Requirement
1	Application	Solids
2	Particle size	Fine dust to 400 mm
3	Process Temperature	0 – 100°C
4	Vessel pressure	up to 60 bar
5	Insertion length	As required
7	Mounting	Side or top or top vertical at $\pm 15^\circ$
8	Process connection	40 NB thread or flanged
9	Protection Class	IP 67
10	Electronics	Remote
11	Cable connection	½ "NPT cable gland Plug-in cable connector

8.15 Speed Probe

Table 8.13

Specification for Speed Probe

S.N	Feature	Minimum Requirement
1	Type	Proximity type (inductive / NAMUR)
2	Frequency Response	0-10 KHz
3	Housing	SS 316/ Polyurethane tip
4	Sensing distance	10 mm minimum (2mm for embedded type)
5	Enclosure class	IP67
6	Power supply	24 V DC/8 V DC (for NAMUR)
7	Cable	Integral Cable 6 mtr.
8	Mounting	Flush with check nut
9	Accessories	Flexible conduit, Non-conductive mounting plates etc.

8.16 Speed Transmitter

Table 8.14

Specification for Speed Transmitter

S.N	Feature	Minimum Requirement
1	Type	Microprocessor based Programmable
2	Enclosure Protection	IP-67
3	Accuracy	+/- 1 RPM

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S.N	Feature	Minimum Requirement
4	Power Supply	24 V DC
5	Range	Programmable
6	Resolution	0.1 RPM
7	Output	4-20 mA
8	Input signal	Pulse Input from Proximity Probe
9	Display	LCD display

8.17

Solenoid Valves

Table 8.15

Specification for Solenoid Valves

S.N	Feature	Minimum Requirement
1	Operating Principle	Electromagnetic (noiseless), Pilot operated
2	Coil Voltage Rating	24 V DC (in general)/220 V DC/230 V AC/ 110 V AC as required
3	Ways	3 ways in general others as required
4	Port size	¼ " NPT all ports
5	Body	SS Bar stock/Brass
6	Trim	AISI 316 SS
7	Manual Operation	In built
8	Duty	Suitable for continuous Energisation
9	Sealing	Airtight & leak proof
10	Coil Enclosure	SS 316/Moulded type
11	Insulation class	Class H
12	Coil Casing	IP-67
13	Mounting	Suitable for mounting On pipe or in panel
14	Cable connection	½ " NPT Cable gland
15	Accessories	Mounting Bracket, nuts, bolts etc.
16	Other Features	LED Indication

8.18

Vibration Monitor

Table 8.16

Specification for Vibration Monitor

S.N	Features	Minimum Requirements
1	Sensitivity	100 mV/mil or better
2	Frequency Response	User Programmable
3	Accuracy	+/- 5% of full scale

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4	Transducer Supply	24 V DC (typical) Voltage
5	Alarm Adjustment	Digitally Adjustable over full scale to alert danger set points
6	Power Supply	240V AC, 50 Hz

8.19

Vibration Sensor

Table 8.17

Specification for Vibration Sensors

S.N	Features	Minimum Requirements
1	Type	Seismic type(Piezoelectric accelerometer)
2	Mounting	The Probe shall be mounted Outside the machine case using protective housing with adjustable sleeves (stingers) that shall be extended to the shaft surface.
3	Frequency Response	0-10 KHz
4	Linear Range	Begins at 10 mils from probe face.
5	Linearity	within ± 1 mil of a straight line
6	Sensitivity	100Mv/mil +/- 10% or better
7	Temperature Sensitivity	3% of span for 600C change or better
8	Ambient Temperature	0-80 deg C
9	Relative Humidity	95% non-condensing
10	Case Material	SS 316
11	Enclosure Class	IP-65
12	Power Supply	24 VDC from monitoring units
13	Accessories	i. Non conductive mounting plates for housing. ii. Extension cables (S.S armored) iii. Suitable junction boxes etc.

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9. INSTRUMENTATION CABLES & ACCESSORIES

9.1 Specifications of Instrumentation Cables

a) Common Requirements

Table 9.1

Specification of Instrumentation Cables- Common Requirement

S.N	Property	Requirement
1	Voltage grade	600 V (Peak Value)
2	Codes and Standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6 , VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification
3	Continuous operation suitability	At 70 deg. C for all types of cables, while 205 deg C for Type-C cables
4	Progressive automatic on-line sequential marking of length in meters.	To be provided at every one meter on outer sheath.
5	Marking to read 'FRLS'	To be provided at every 5 meters on outer sheath except for type-C cable.
6	Allowable Tolerance on overall diameter	+ /- 2 mm (maximum) over the declared value in data sheet.
7	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8	Ovality at any cross-section	Not more than 1.0 mm

b) Specific Requirements

Table 9.2

Specification of Instrumentation Cables- Specific Requirement

S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
A.	Conductors				
i.	Cross section area				
ii.	Conductor material	ANSI type KX	ANSI type SX	High conductivity annealed tin coated copper	ANSI type KX
iii.	Colour code	Yellow-red	Black-Red	As per VDE-0815	Yellow-red
iv.	Conductor Grade	As per ANSI MC 96.1		Electrolytic	As per ANSI MC 96.1
v.	No. & dia. of strands	7x0.3 Sq. mm (nom)			

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
vi.	No. of Pairs	2, 6	2	4, 8, 12, 16, 24, 48,	2
vii.	Max. conductor resistance per Km (in ohm) at 20 deg. C	As per ANSI MC 96.1		73.4 (loop)	As per ANSI MC 96.1
viii.	Reference Standard	As per ANSI MC 96.1		VDE 0815	As per ANSI MC 96.1
B.	Insulation				
i.	Material	PVC type YI 3 with FRLS properties			Teflon (i.e. extruded FEP)
ii.	Thickness in mm (Min/Nom/Max)	0.25 / 0.3 / 0.35			0.4 / 0.50
iii.	Volume Receptivity (Min) in ohm-cm	1x10 ¹⁴ at 20 deg. C & 1x 10 ¹¹ at 70 deg.			---
iv.	Voltage rating	1100 V peak operating voltage			
v.	Reference Standard	VDE 0207 Part 4			VDE 0207 part 6 & ASTM D 2116.
vi.	Core diameter above insulation	Suitable for cage clamp connector			
C.	Pairing & Twisting				
i.	Max. lay of pairs (mm)	50			
ii.	Single layer of numbered binder tape on each pair provided	Yes			
iii.	Unit formation of four pairs with printing of no. of Unit provided	NA		Yes	NA
iv.	Conductor / pair identification as per VDE0815	NA		To be provided	NA
D.	Shielding				
i.	Type of shielding	Al-Mylar tape			
ii.	Individual pair shielding	No		To be provided for Type-F cable	No
iii.	Minimum thickness of individual pair shielding	No		28 micron	No
iv.	Overall cable assembly shielding	To be provided			
v.	Minimum thickness of overall cable assembly shielding	55 micron			
vi.	Shielding coverage	100% with at least 20% overlap			
vii.	Drain wire provided for individual shield	NA		Yes (for F-type) 7 -strand	NA

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
				20 AWG (0.51 mm ²) annealed Tin coated copper	
viii.	Drain wire provided for overall shield	Yes (for F-type) 7 -strand 20 AWG (0.51 mm ²) annealed Tin coated copper			
E.	Fillers				
i.	Non-hygroscopic, flame retardant	To be provided			
F.	Outer Sheath				
i.	Material	Extruded PVC compound YM1 with FRLS properties			Teflon (i.e. extruded FRP)
ii.	Minimum thickness at any point	1.8mm			0.4 mm
iii.	Nominal Thickness at any point	> 1.8mm			0.5mm
iv.	Color	Blue			
v.	Resistant to water, fungus, termite & rodent attack	Required			
vi.	Oxygen index as per ASTM D-2863	Not less than 29%			NA
vii.	Temperature index as per ASTM D-2863	Not less than 250 deg. C			NA
viii.	Acid gas generation by weight as per IEC-60754-1	Maximum 20 %			NA
ix.	Smoke Density rating as per ASTM D-2843	Maximum 60% (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as ASTM D-2843)			NA
x.	Reference Standard	VDE 207 part 5			VDE 207 Part 6 & ASTM D 2116
xi.	Armour	Galvanised steel wire armoured type conforming to IS-3975			
G.	Electrical Parameters				
i.	Mutual capacitance between Conductors. At 0.8KHz (Max.)	200 nF / Km		120 nF / Km for F type 1000 nF / Km for G-type	200 nF / Km
ii.	Insulation resistance (Min.)	100 M ohm / Km			
iii.	Cross talk Figure (min.) at 0.8 KHz	60 dB		60 dB	NA
iv.	Characteristics impedance (Max) At 1 KHz	NA		320 ohm for F type 340 ohm for G type	NA
v.	Attenuation Figure at 1 KHz	NA		1.2 dB / Km	NA

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
H.	Complete Cable				
i.	Complete Cable assembly	Shall pass Swedish chimney test as per SEN-SS 4241475 class F3.			NA
ii.	Flammability	Shall pass flammability test as per IEEE-383 read in conjunction to this specification			NA
I.	Accessories				
i.	Cable accessories of flame retardant quality	Yes. (Accessories such as harnessing components, markers, bedding, cable jointer, binding tape etc.)			
J.	Cable Drum				
i.	Type	Non-returnable wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.			
ii.	Outermost layer covered with waterproof paper	Yes			
iii.	Painting	Entire surface to be painted			
iv.	Length	1000m + 5% for up to & including 12 pairs 500m + 5% for above 12 pairs			

c) Type Test

Table 9.3
Type Test Requirement for Cables

S.N	Item	Test Requirement	Standard
1	Conductor	Resistance Test Diameter test Tin coating test (drain wire)	VDE – 0815 IS – 10801
2	Insulation	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
3	Inner sheath	Loss of mass Heat shock Hot deformation Shrinkage Cold bend / Cold impact test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
4	Outer sheath	Loss of mass Ageing in air ovens Tensile strength & elongation	VDE – 0472 VDE – 0472 VDE – 0472

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S.N	Item	Test Requirement	Standard
		test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming Colour fastness to water Cold bend / Cold impact test Oxygen Index test Smoke Density test Acid gas generation test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831 IS – 5831 IS – 5831 ASTM D – 2863 ASTM D – 2843 IEC – 754 – I
5	Filters	Oxygen Index test Smoke Density test Acid gas generation test	ASTM D – 2863 ASTM D – 2843 IEC – 754 – 1
6	AL-MYLAR Shield	Continuity test Shield thickness Overlap test Noise interference	
7	Overall cable	Flammability	IEEE 383 & IEC – 332
8		Noise interference Dimensional checks Cross talk Mutual capacitance HV test Drain wire continuity	IS – 10810 VDE – 0472 VDE – 0472

d) Routine Test

To be carried out by supplier during various stages of manufacture.

1. Insulation & jackets: All tests as per IS – 5831 except insulation resistance, voltage & spark test shall be as per BS – 5308, Part II (1986)
2. Armor test as per IS – 3975
3. Conductor resistance
4. Cable capacitance and L/R ratio.

e) Acceptance Test

These following tests shall be carried out as acceptance test:

1. Continuity test
2. Voltage test as per BS – 5308 Part II (1986)
3. Conductor resistance and drain wire resistance

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4. Cable capacitance and L/R ratio test.
5. Tests for uniformity of galvanization of armor as per IS – 2633
6. Oxygen and temperature index test as per ASTM D – 2863
7. Dimensional checks for overall diameter and under armour / over armour diameter.
8. Checking of drum length & overall length tolerances.

Immediately after completion of electrical tests, the ends of the cable shall be sealed to prevent ingress of moisture with suitable PVC / Rubber caps

9.2 Specifications of Optical Fibre Cables (OFC)

1. OFC shall be installed on cable tray, duct bank, cable trench installation as necessary. For outdoor applications the cable shall be armoured with Poly Ethylene sheathing. In all cases cable shall be routed through suitable grade HDPE permanently lubricated protection pipe as per IS-4984, IS-12235 & TEC.G/CDS-08/01 of suitable size @ 53% fill factor.
2. The optical fibre core shall be of ultrapure fused silica glass coated with UV cured acrylate suitable to withstand temperature of about 80 deg. Centigrade continuously.
3. OFC shall be 4 / 8 / 12 core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor / indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multi-mode fibres on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties & to be identified with the manufacturer's name, year of manufacture, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
4. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. steel central member, Loose buffer tube design, 4 fibres per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly or better material etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile 1000 N minimum. The compressive strength of cable shall be 3000N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 DegC to 70 DegC.
5. The splicing loss of any two fibres in any case shall not exceed 0.10 db/splice.
6. The total additional attenuation above the nominal attenuation due to regular splices, repair splices, connectors, temperature variation, ageing etc. shall be indicated.

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7. Fibre coloring shall conform to EIA/TIA-598. The color-coding shall be permanent thus withstanding normal handling; e.g., during termination, testing, or cable relocation. Refer to EIA – 359 for color identification and coding.
8. Cables shall be designed & tested in accordance with ISO 11801, TIA-568 & ICEA 596 and Performance specifications shall be measured in accordance with the Fibre Optic test procedures(EIA/TIA -455 documents) test procedures of IEC-60793 & IEC-60794
9. The OFC shall generally conform to the following specifications

Table 9.4A
Specifications for Single Mode Optical Fibre

S.N	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@1310 nm	0.4 dB/km
		@1550 nm	0.3 dB/km
2	Mode field Diameter	@1310 nm	9.2 ± 0.4 µm
		@1550 nm	10.4 ± 0.8 µm
3	Maximum Cable Cut-off Wavelength		1260 nm
4	Maximum Zero Dispersion Wavelength		1321.5 nm
5	Minimum Zero Dispersion Wavelength		1301.5 nm
6	Maximum Zero Dispersion Slope		0.092 ps/nm ² ·km
7	Maximum Polarization Mode Dispersion		0.2 ps/√km
8	Gigabit Ethernet Length 1000BASE-LX		2-5000 mtrs.
9	Ten Gigabit Ethernet Length	10GBASE-LX	2-10000 mtrs.
		10GBASE-LX4	2-10000 mtrs.
10	Maximum Core/cladding Concentricity Error		0.5 µm
11	Cladding Diameter		125.0 ± 1.0 µm
12	Cladding Non-circularity		1 %
13	Coating Diameter		245 ± 5 µm
14	Maximum Coating Concentricity Error		12.5 µm
15	Temperature Dependence (-60 to + 85C)		0.05 dB/km
16	Temperature & Humidity Cycling (-10 to + 85C, 4 to 90% RH)		0.05 dB/km
17	Minimum Proof Test		100 kpsi

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S.N	Feature	Minimum Requirement
18	Bending Induced Attenuation (100 turns, 75mm diameter)	0.5 dB

Table 9.4B
Specifications for Multi Mode Optical Fibre

S.N	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@850 nm	3 dB/km
		@1300 nm	0.7 dB/km
2	Overfilled Launch Bandwidth	@850 nm	200 MHz·km
		@1300 nm	500 MHz·km
3	Gigabit Ethernet Length	1000BASE-SX	2-300 mtrs.
		1000BASE-LX	2-550 mtrs.
4	Ten Gigabit Ethernet Length	10GBASE-SR	2-33 mtrs.
		10GBASE-LX4	2-300 mtrs.
5	Numerical Aperture		0.275 ± 0.015
6	Core Diameter		62.5 ± 3.0 µm
7	Maximum Core Non-circularity		6 %
8	Maximum Core/cladding Concentricity Error		3 µm
9	Cladding Diameter		125.0 ± 2.0 µm
10	Cladding Non-circularity		2 %
11	Coating Diameter		245 ± 10 µm
12	Maximum Coating Concentricity Error		12.5 µm
13	Temperature Dependence (-60 to + 85C)		0.2 dB/km
14	Temperature & Humidity Cycling (-10 to + 85C, 4 to 90% RH)		0.2 dB/km
15	Minimum Proof Test		100 kpsi
16	Bending Induced Attenuation (100 turns, 75mm diameter)		0.5 dB

10. The cables shall be supplied in non-returnable strong wooden (or alternatively steel) drums provided with lagging of adequate strength, constructed to protect the cable against any damage and displacement during transit, storage and subsequent handling and stringing operations in the field.

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11. Test on Fibre optic cable:

Table 9.4C
Type Test Requirement for Fibre Optic Cables

S.N	Test Requirement	Standard
A	Optical Characteristics of Fibres	
1	Attenuation	IEEE Std. 1138 IEEE STD. P1222 (EIA/TIA – 455-61,78A) (IEC 793-1-C1A,B,C)
2	Cut off wavelength	IEEE STD. 1138 IEEE STD P1222 (EIA-455-80, 170) (IEC-793-1-C7A,B)
3	Fibre Dispersion	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-168A,169A,175A) (IEC-793-1-C5A,B,C)
4	Frequency Response	IEC-793-1-C2B
5	Mode Field Diameter	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-164A,165A,167A) (EIA-455-174) (IEC 793-1-C9A,B,C,D)
6	Temperature Cycling	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-69A) (IEC 793-1-D1)
B	Mechanical Characteristics of Fibres	
1	Abrasion	IEC 793-1-B4
2	Core Concentricity	IEC 793-1-A3
3	Macro Bending	EIA/TIA-455-62A (IEC 793-1-C11)
4	Micro Bending	IEC-793-1-C3
C	Proof Test	IEC-793-1-B1
D	Strippability	IEC 793-1-B6
E	Visual Examination	EIA/TIA-455-13 (IEC 793-1-B5)

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9.3 Instrumentation Cable Interconnection & Termination Philosophy

The cable interconnection philosophy to be adopted shall be such that expensive grouping of signals by large scale use of field mounted Group Junction Boxes (JBs) at strategic locations. (Where large concentrations of signals are available, e.g. valves limit and torque switches, switchgear) is done and consequently cable with higher number of pairs are extensively used. The details of termination to be followed are mentioned in the following Table:

Table 9.5
Instrumentation Cable Interconnection
& Termination Philosophy

S.N	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
1.	Limit, Torque switches of valves / dampers / drives (integral junction box)	Marshalling cubicle / Marshalling cum Termination Cubicle / Local group JB	Plug-in connector	Posts mount cage clamp type	G
2.	Transmitters, process actuated switches mounted in LIE / LIR	Integral junction box of LIE / LIR	Plug-in connector	Cage clamp (rail mount)	F, G
3.	RTD heads	Local junction Box	Plug-in connector	Cage clamp (Rail mount) type	F
5.	Other Field Mounted Instrument	Local JB / Group JB	Plug in connector	Screwed, Cage clamp (Rail mount) type	F (For analog signals) G (For Binary Signals)
7.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Group JB	Cage clamp (Rail mount) type	Cage clamp (Rail mount) type	F, G
8.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Marshalling Cubical / Marshalling cum termination Cabinet	Cage clamp (Rail mount) type	Posts mount cage clamp type	F, G
9.	Marshalling Cubical / Termination Cabinet	Electronic system cabinet	Cage clamp post mounted type	Plug-in connector / Other System as per manufacturer's Standard	Internal Wiring

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Notes:

1. Normally 10% spare cores shall be used when the numbers of pairs of cables are more than four pairs.
2. For analog signals, individual pair shielding & overall shielding & for binary signals only overall shielding of instrumentation cables shall be used.
3. * For high temperature applications only.
4. Instrument Cabling for instruments / equipment of specialized / proprietary Control System shall be as per manufacturer's standard.

9.4

Terminal Blocks

1. All terminal blocks shall be rail mounted/post mounted, cage clamp type with high quality non-flammable insulating material of melamine suitable for working temperature of 105 deg. C. The terminal blocks in field mounted junction boxes, temperature transmitters, instrument enclosures/racks, etc. shall be suitable for cage clamp connections. The terminal blocks in Control Equipment Room logic / termination / marshalling cubicles shall be suitable for the post mounted cage clamp connection at the field input end. The terminal blocks for Coal Handling control system Input/ Output connections from/to SWGR/MCC, shall be used with built in test and disconnect facilities complete with plug, slide clamp, test socket etc.
2. All the terminal blocks shall be used complete with all required accessories including assembly rail, locking pin and section, end brackets, partitions, small partitions, test plug bolts and test plug (as specified above for SWGR connections), transparent covers, support brackets, distance sleeves, warning label, marking , etc.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams. At least 20% spare unused terminals shall be used everywhere including local junction boxes, termination/marshalling cabinets, etc. All terminal blocks shall be numbered for identification and grouped according to the function. Engraved labels shall be used on the terminal blocks.
4. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
5. Internal wiring in factory pre-wired electronic equipment cabinets may be installed according to the applicable standards as to wire size and method of termination or internal equipment. Terminal blocks for connection of external circuits into factory pre-wired electronic equipment cabinets shall meet all the requirements as specified above.

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9.5 Internal Panels, Cabinets, System Cabinet Wiring Philosophy

1. Internal panel/cabinet wiring shall be of multi-stranded copper conductor with FRLS PVC insulation without shield and outer sheath meeting the requirements of VDE 0815.
2. Wiring to door mounted devices shall be done by 19 strand copper wire provided with adequate loop lengths of hinge wire so that multiple door opening shall not cause fatigue breaking of the conductor.
3. All internal wires shall be used with Tag identification of printed type (partex labels) at both ends. All wire directly connected to trip devices shall be distinguished by one additional red color.
4. All external connection shall be made with one wire per termination point. Wires shall not be tapped or spliced between terminal points.
5. All floor slots of desk/Panels/cabinets used for cable entrance shall be used with removable gasketed gland plates and sealing material. Split type grommets shall be used for prefabricated cables.
6. All the special tools as may be required for solder less connection.
7. Tag identification for internal wires shall be printed (partex labels)
8. Wire sizes to be utilized for internal wiring shall be as per following table.

Table 9.6
Wire Size for Internal Wiring

S.N	Application	Wire Size
1	Current (4-20mA), low voltage signals (48 V)	0.5 Sq. mm
2	Ammeter/ Voltmeter circuit, control switches etc. for electrical system.	1.5 Sq. mm
3	Power supply and internal illumination.	2.5 Sq. mm minimum (shall be as per load requirement)

9.6 Cable Installation & Routing

1. All cable assigned to a particular duct/conduit shall be grouped and pulled in simultaneously using cable grips and suitable lubricants. Cables removed from one duct/conduit shall not be reused.
2. Cables shall be segregated as per IEEE Std. 422. In vertically stacked trays, the higher voltage cable shall not be in higher position and instrumentation cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other system shall be as follows:
 - From 11KV/6.6KV/3.3KV tray system - 900 mm
 - From 415KV tray system - 600 mm
 - From control cable tray system - 300 mm

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3. Cables shall terminate in the enclosures through cables glands. All cable glands shall be properly gasketed. Fire proof sealing (to prevent ingress of dust entry and propagation of fire) shall be used for all floor slots used for cable entrance. Compression cable glands (double for armored and single for other cables) shall be used.
4. All cables shall be identified by Tag. Nos. provided in approved format at both the ends as well as at an interval of 5 meters.
5. Line voltage drop due to high resistance splices, terminal contacts, insulation resistance at terminal block, very long transmission line etc. shall be reduced as far as practicable.
6. The cables emanating from redundant equipment/devices shall be routed through different paths. The above segregation of cables & wiring for redundant equipment / devices shall be in accordance with IEEE-Std-422

9.7

Cable Laying

1. Cable shall be laid strictly in line with cable schedule. In general, the cable routing from the local instrument to JB shall be such that the cable go away from the hot zone.
2. Identification tags for cables.
Indelible tags to be provided at all terminations, on both sides of wall or floor crossing, on each conduit/duct/pipe entry/exit, and every 20 m in cable trench / tray.
3. Cable tray numbering and marking.
To be provided at every 10m and at each end of cables way & branch connection.
4. Joints for less than 250 Meters runs of cable shall not be permitted.
5. Buried cable protection
With concrete slabs; Route markers at every 20 meters along the route & at every bend.
6. Road Crossings
Cables to pass through buried high density PE pipes encased in PCC. At least 300 mm clearance shall be used between.
 - HT power & LT power cables,
 - LT power & LT control cables,
 - LT control & instrumentation cables,
 Spacing between cables of same voltage grade shall be in accordance with the derating criteria adopted for cable sizing.
7. Segregation (physical isolation to prevent fire jumping)

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- a) All cable associated with the unit shall be segregated from cables of other Units.
- b) Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire.

8. Cable clamping

All cables laid on trays shall be neatly dressed up & suitably clamped/tied to the tray. For cables in trefoil formation, trefoil clamps shall be used.

9. Optical fibre cables inside conduits shall be laid on cable trays wherever available and feasible. In areas where the same are required to be buried, the same shall be buried in separate trench approx. 1.6 meter depth, to be laid in 2" GI/rodent proof HDPE conduits covered with sand, brick and soil along the pipe line route.

10. While crossing roads- to be laid in GI/rodent proof HDPE conduits with sand filling at bottom and sand, soil filling at top with cement concrete;

While crossing canals/river- to be laid in GI/rodent proof HDPE conduits within Hume pipe.

9.8

Cable Accessories

1. Cables, which terminate in cabinets of draw out sections, shall have sufficient cable coils in the bottom of the cabinet to permit full withdrawal of draw out sections without disconnecting the cables. When prefabricated cables with factory connectors on both ends are longer than required, the excess cable shall be coiled in the bottom of one or both termination cabinets.
2. No splices shall be made in conductors for instrument and control circuits except where required at connections to devices equipped with factory installed pigtails. Such splices shall be made only in approved splicing boxes of fitting with removable cover. The splices shall be made with sufficient slack left in the wire to permit withdrawal of the splice from the splicing boxes for ease of future disconnection of the splices. All exposed conductor or connector surfaces shall be covered with a minimum of three half-lapped layers of all weather vinyl plastic electrical tape. Taping shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the other insulation or connections requiring insulation.
3. Proper grounding of all equipments shall be done. Further, proper termination of cable shield shall be verified and the grounding of the same shall be coordinated so as to achieve grounding of all instrumentation cable shields at same potential. This shall be completed prior to system tests.
4. Take full care while laying/installing cables as recommended by cable manufacturers regarding pulling tensions and cable bends.

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9.9 Cable Conduits

1. Conduits shall be generally used for interconnecting cables from field instruments to Local JB's. All unarmoured cables shall be installed in conduit. All rigid conduits, couplings and elbows shall be hot dipped galvanized rigid mild steel in accordance with IS: 9537 Part-I (1980) and Part-II (1981). The conduit interior and exterior surfaces shall have continuous zinc coating with an overcoat of transparent enamel lacquer or zinc chromate. Flexible metal conduit shall be heat resistant lead coated steel, water leak, fire and rust proof. The temperature rating of flexible conduit shall be suitable for actual applications. The flexible metal conduit shall be constructed with interlocked corrosion resistant steel & manufactured in accordance with UL1 & NEC Article 348.
2. All grounding bushings within all enclosures shall be wired together and connected internally to the enclosure grounding lug or grounding bus with 8 AWG bare copper conductors. Conduit runs to individually mounted equipment shall be grounded to the cable tray grounding conductor with 12 AWG bare copper conductors.
3. All rigid conduit fittings shall conform to the requirements of IS: 2667, 1976. Galvanized steel fitting shall be used with steel conduit. All flexible conduit fittings shall be liquid tight, galvanized steel. The end fittings shall be compatible with the flexible conduit supplied.
4. All individually mounted equipment and devices shall be connected to the supply conduit, using not more than one meter of flexible conduit adjacent to the equipment or device. Flexible conduit shall be installed in all conduit runs, which are supported by both building steel and structures subject to vibration or thermal expansion.
5. Special areas, such as Control Rooms in which external noise is to be minimized, shall have flexible conduit in conduit runs where the runs cross from the main building framing to the Control Room framing.
6. Conduit supports shall be furnished and installed in accordance with these specifications. Support material shall comply with the requirements.
 - a) Hanger rods shall be 12 mm diameter galvanized threaded steel rods.
 - b) Single conduit support shall be one-hole cast straps and clamp backs. Multiple conduit bank supports shall be constructed of special galvanized support channels with associated conduit clips.
7. Conduit sealing, explosion proof, dust proof and other types of special fittings shall be used as required by these specifications and shall be consistent with the area and equipment with which they are installed. Fittings installed outdoors and in damp locations shall be sealed and gasketed. Hazardous area fittings and conduits sealing shall conform to NEC requirements for the area classification.

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8. Double locknuts on all conduit terminations shall be used. Water tight conduit unions and rain tight conduit hubs shall be utilized for all the application which shall be exposed to weather. Moistures pockets shall be eliminated from conduits.
9. Conduits shall be securely fastened to all boxes and cabinets.

9.10 Cable Sub Trays & Support

1. The cable sub-trays and the supporting system, to be generally used between Local/Group JBs and the main cable trays. It is the assembly of section and associated fitting forming a rigid structural system used to support the cable from the equipment or instruction enclosure up to the main cable trays (trunk route). The material of cable tray shall be GI.
2. The covers on the cable sub-trays shall be used for protection of cables in areas where damage may occur from falling objects, welding spark, corrosive environment, etc. & shall be electrically continuous and solidly grounded. The cable trays shall not have sharp edges, burrs or projections injurious to the insulation or outer sheath of the cables.
3. The supporting arrangement of cable tray system shall be able to withstand the weight of the cable and cable tray system. The supporting interval shall not be more than the recommended span for the above loading for the type of cable tray selected. The tray shall not overhang by more than one meter from the support at the dead end. As far as practicable the cable sub-tray system shall be supported from one side only, in order to facilitate installation and maintenance of cables.
4. Install the estimated quantities and size of sub trays / troughs including all required fittings and adaptors on as required basis.

Table 9.7
Specifications for Cable Tray

S.N	Feature	Minimum Requirement
1	Material	Mild Steel as per IS-2062
2	Thickness	Not Less than 2 mm
3	Finish	Hot Dip galvanised as per IS-2629, 2633 & Zinc Coating as per IS-4579
4	Length	2.5 Mtr. +/- 10 mm
5	Width	W +/- 3mm
6	Inward Bend	25 mm
7	Coupler Plate	Thickness 2 mm, length 100 mm, Width 50 mm
8	Coupler plate material	MS with Hot dip galvanised
9	Nuts, Bolts, washer etc.	As required/ Hot dip galvanised

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S.N	Feature	Minimum Requirement
10	Cover	Dome Fixed type, Thickness 1.2 mm (Minimum)
11	Cover Material	Hot dip galvanised MS sheet

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10. SYSTEM CABINETS, PANELS & JUNCTION BOX

10.1 General Requirements

1. All control panels, system cabinets, local panels and local instrument enclosures, racks shall be furnished fully wired with necessary provision for convenience outlets, internal lighting, grounding, ventilation, space heating, anti-vibration pads and accessories as per IS:5039-1969 as required for completeness of the system.
2. All panels & cabinets shall be free standing type and have bottom entry for cables unless otherwise specified. The bottom of panels, cabinets, enclosures shall be sealed with bottom plate, compression cable glands and fire proof sealing material to prevent ingress of dust and propagation of fire. The Cabinets shall be designed for front & back access to components, terminals and wiring.
3. The cabinets shall be used with bottom glanding plate which shall be removable from inside and shall be used with sufficient no. of knockouts. All knockouts shall be used with pluggable grommets.
4. The cabinets shall be of max. 2200mm height including base channel. The base channel shall be of 100 ISMC. All cabinets shall be of same height. Construction shall be modular.
5. System & non-system cabinets shall have "look alike" appearance.
6. All electronic system cabinets shall be designed for 50 deg C operating under maximum ambient temperature without air conditioning system in service. Further cabinets, panels shall be so designed that temperature rise due to heat load does not exceed 10 deg. C above ambient temperature under all operating conditions. Necessary louvers, fans, limited packing density, adequate spacing between instruments, devices etc. shall be used to maintain temperature rise within permissible limits.
7. Panels, cabinets enclosures wiring shall be arranged to enable the removal of modules/instruments and devices without unduly disturbing them.
8. All panels, cabinets, enclosures interiors shall be illuminated with rapid start fluorescent strip fixtures with door actuated switches. Door switch terminals shall be shrouded. All illuminated lights shall be used with isolation switch in addition to door switch for maintenance & switching off when not required. Illumination light shall be used on both front & back sides if both sides are provided with equipments/instruments/terminal blocks requiring maintenance.
9. Sufficient number of power receptacles with disconnect switches shall be installed within panels, enclosure and racks.
10. The local instrument enclosures/racks shall be used locally for mounting of electronic transmitters and switches, etc.

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11. Exterior steel surface shall be sand blasted, ground smooth, filed, primed, sanded and smooth enamel painted to give a good finish subject to minimum paint thickness of 65-75 microns for sheet thickness of 3 mm and 50 microns for sheet thickness of 2mm. Minimum 2 coats of primer and two sprays of final finish colour shall be applied to all surfaces.
12. The colour of the panel's interior shall be brilliant white. External colour of the panels will be as RAL 7032 for LIE/ LIR and RAL 7035 for control room system cabinets.
13. All panels, enclosures, system cabinets, marshalling cabinets shall be used with a minimum of 20% spare terminations and system cabinets shall be used with spare space for 20% additional modules fully wired with connectors etc. in excess of the total requirement of the system design when the cabinets are delivered. The spare space capacity shall be distributed evenly throughout the cabinets.

10.2

System Cabinets

Table 10.1
Specifications for System Cabinets

S.N	Features	Minimum Requirements
1	Application	For housing Signal conditioning cards, input/output cards, processor cards, power supply units etc.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Anti vibration pad	Required, 15mm
9	Painting	Interior- Brilliant White Exterior- RAL 7035
10	Cabinet Dimension	As per Standard Practice
11	Grounding	M6 earthing stud shall be used
12	Ventilation	Fans & louvers with brass mesh required
13	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
14	Lifting arrangement	Removable lifting eyebolts shall be used

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1. Beacon Lamps shall be used in each cabinet to indicate panel having fault condition.
2. The racks in system cabinets shall have provision along with plug in sockets/back plane to house accommodate the spare slots/modules as specified elsewhere.
3. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots & details of the card type/service shall be inscribed on this metal tag.
4. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
5. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
6. All cabinets shall have common key for locks.
7. Door shall have concealed type of hinges with 120 degree swing.
8. Door latches shall be of the three-point type to ensure tight closing.
9. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material.

10.3 Marshalling Cabinets

Table 10.2
Specifications for Marshalling Cabinets

S.N	Features	Minimum Requirements
1	Application	For termination of all cables originating from field.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Terminal Blocks	Rail mounted cage-clamp suitable for conductor size up to 2.5 mm ² & fused type with LED indication for power supply (24 VDC, 230 V AC, 110 V AC etc.) for instruments & equipments.
9	Anti vibration pad	Required, 15mm

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S.N	Features	Minimum Requirements
10	Painting	Interior- Brilliant White Exterior- RAL 7035
11	Cabinet Dimension	As per Standard Practice
12	Grounding	M6 earthing stud shall be used
13	Ventilation	Fans & louvers with brass mesh required
14	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
15	Lifting arrangement	Removable lifting eyebolts shall be used

1. Separate Marshalling cabinets for the system shall be supplied for terminating all cables originating from the field and for distributing the signals to different functional panels and cubicles.
2. The terminal blocks shall be cage clamp type. Fused terminal blocks hinged at one end to facilitate easy isolation shall be used wherever necessary. All cabinets shall be used with spare terminals for the spare inputs/outputs as specified elsewhere in the specification. The type of terminals for terminations from cabinets/panels shall match with the pre fabricated cables and pins supplied.
3. The terminals for field cables shall be arranged in a logical order of equipment/system wise.
4. The marshalling cabinets, the terminal blocks, the terminals and the electronic hardware if any, shall have identification numbers.
5. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
6. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
7. All cabinets shall have common key for locks.
8. Door shall have concealed type of hinges with 120 degree swing.
9. Door latches shall be of the three-point type to ensure tight closing.
10. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material.

10.4

Local Junction Box

Table 10.3
Specifications for Junction Box

S.N	Features	Minimum Requirements
1	No. of Ways	32 (2X16) with 20% spares terminals

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S.N	Features	Minimum Requirements
2	Material & Thickness	3 mm thick FRP
3	Protection class	IP-65 for outdoor/ IP 55 for Indoor
4	Cable entry	Bottom
5	Mounting	Suitable for Wall/column/structures mounting
6	Terminal Blocks	Rail mounted cage-clamp type suitable for conductor size up to 2.5 mm ²
7	Grounding	M6 earthing stud shall be used
8	Gland plate	Removable type
9	Door	Single Lockable door with gasket, able to open sideways, turnable hinge based, latch type lock without handle with common key.
10	Accessories	Tag plate, clamps, fixtures, bolts (SS), nuts (SS), Gasket (Neoprene), cable glands (SS), Lugs (Brass), Fire proof compound for sealing.

1. All JB's for outdoor application shall be used with individual canopies to prevent ingress of water.
2. All JB' shall have provision to add 10% additional TB's.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams.
4. Separate Terminal blocks shall be used for Analog & Digital Signals & also for signals with different voltage levels.
5. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
6. Separate shield bus shall be used with screw connection for terminating cable shields.
7. All spare cable entries shall be used with plugs.
8. All wires in JB shall be neatly dressed & ferruled.
9. Double deck type terminal block shall not be used.

Table 10.4
Specifications for Cable Glands

S.N	Features	Minimum Requirements
1	Type	Double compression
2	Entry Thread	½ " NPT
3	Material	Brass

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S.N	Features	Minimum Requirements
4	Finish	Cadmium Plated
5	Protection	IP-54 or better
6	Accessories	Neoprene gasket, Locknut, Reducer etc.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-II, PART-D
DETAILED TECHNICAL SPECIFICATION-CIVIL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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	Section-II	Part-A	Detailed Technical Specifications - Mechanical
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1 CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

1.1 Introduction

This specification covers the design, preparation of general arrangement, construction as well as fabrication drawings, supply of all labour as well as materials and construction of all civil, structural as well as architectural work on EPC basis for Renovation and Modernisation of Coal handling Plant and associated structures for the existing [Name of project...] Thermal Power Project of [210/215/220/250] MW capacity. Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope shall be as per Volume-II, Section-I, CIVIL SCOPE OF WORK.

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2 [BUILDINGS & STRUCTURES]

Design and construction of new buildings, structures, foundations etc. as well as repairing / retrofitting of existing buildings, structures, foundations shall take into account requirement for operation and maintenance of all equipments and its users. The buildings will have good architectural features. The surrounding areas shall be properly micro levelled and graded. The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials fittings and finishes.

- *Due consideration shall be given for adequate natural lighting and ventilation for both plant and non-plant buildings.*
- *Retrofitting / repair works / new constructions shall not cause damage to the existing structures. The temporary supports shall not be allowed on the existing structures for any of these works unless the loads are minor and may not cause any damage to any existing structure. However in such a case Bidder shall take approval from the Owner/Consultant prior to initiating the work.*
- *Internal finishes shall be provided with latest available materials approved by Owner/Consultant with due consideration of the functional aspect of the area.*
- *External finishes shall be provided with latest materials approved by Owner/Consultant for improving the aesthetics.*
- *The orientation of the important buildings shall be in line with the existing site condition and function as such.*
- *Each building shall have its own identity. However, a total homogeneity shall be maintained in the design of all buildings.*
- *Adequate frontage shall be provided to all important buildings to create a better visual impact.*
- *All other civil and structural buildings shall be developed in conjunction with the above aspects.*

All Civil, Structural and Architectural works of the following systems shall be covered under this package.

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- a) *Track Hopper*
- b) *Wagon Tippler*
- c) *Stockpile*
- d) *Stacker cum Reclaimer foundations*
- e) *Conveyor Galleries and Trestles*
- f) *Screen cum Crusher Houses- (Primary and Secondary Crusher)*
- g) *Junction Houses*
- h) *Reclaimer Hopper Pits and Shed*
- i) *Compressor cum pump house*
- j) *Tunnels, Pent houses and Transfer Houses*
- k) *CHP Switch Gear cum Control Room Building*
- l) *Dust Suppression, Dust Extraction and Ventilation System Structures*
- m) *Any building inadvertently left out in the above list, however required for proper functioning of the power plant as per system requirement stipulated under Mechanical & Electrical section of this specification shall also be included.]*

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3 DESIGN REQUIREMENTS

3.1 Location

Geographical location of the plant site is approximately between [...]°[...]′[...]″ N] to [...]°[...]′[...]″ N], Latitude and [...]°[...]′[...]″ E] to [...]°[...]′[...]″ E], Longitude.

3.2 Ground Condition

Subsurface condition: The natural ground surface level approximately varies from [...] m to [...] m] from MSL.

[The soil profile in the plant area can be broadly classified into 3 layers namely laterite, cemented sand and cemented silt in general as per detail soil investigation report. Top soil upto a depth ranging from 0.4 m to 0.75 m is entirely non-uniform. The underlying layer is laterite whose depth varies from 4.0 m to 5.5 m followed by deep layers of cemented silt and cemented sand].

The ground water table (GWT) at finished ground level shall be considered for foundation design purposes.

The detailed soil investigation report conducted for plant shall be made available to Bidder for required replacement / refurbishment / retrofitting of Foundations, if any.

Bidder is advised to carefully study the content of detailed Soil investigation report for the existing type of foundations and design of new ones.

The type, size, depth of the foundation shall be based on the detail soil investigation report provided by OWNER.

3.3 Climatic Condition

a) Temperature

Maximum : [...] °C

Minimum : [...] °C

For design purpose, maximum temperature to be considered: [...] °C

minimum temperature to be considered: [...] °C

b) Rain fall

Minimum : [...] mm in May]

Maximum : [...] mm in October]

Peak hourly rain fall: [...]mm] (corresponding to 50 years return period)

[Note: Maximum per day rainfall as per weather report has been considered conservatively as peak hourly rain fall which will be used for drainage system design etc.]

Annual average: [...] mm to [...] mm & average [...] mm]

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3.4 Seismic Zone

The site is located in [Zone III] as per IS: 1893-2002. Zone factor shall be [0.10]. Importance factor shall be considered as [1.75].

3.5 Wind Zone

The site is located in wind speed zone [50 m/s] as per IS: 875 (Part 3)-1987.

3.6 Loads and Load Combinations

All new structures shall be designed and old structures requiring modification shall be checked for the most critical combinations of dead loads, imposed loads, equipment loads, wind loads, seismic loads, temperature loads, forces developed due to differential settlement and any other loading conditions which can occur during the design life of the facility.

(a) Dead Loads

Dead loads consist of the weights of the complete structure with finishes, fixtures, partitions, wall panels and all existing / modified / replaced equipments of semi-permanent nature including storage structures partitions, roofing, piping, cable trays, bus ducts etc. The content of storage structures etc. shall be measured at full capacity for this purpose.

The piping loads (for empty, operating and test conditions), cable tray loads and the contents of the storage structures shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing load for uplift.

The following unit weight of material shall be considered for computation of loads. Loads given in IS: 875 (part-I) shall be made use of for material not listed below.

Table 2.1
Weights of Material

Material	Unit weight (kN/m ³)
Plain cement concrete	24.0
Reinforced cement concrete	25.0
Structural steel	78.5
Brick work	19.0
Cement plaster	21.0
Floor Finish	24.0
[Coal]	11.0

(b) Superimposed Live Load (SILL)

Listed below is the minimum SILL for the areas involved. Floors and supporting members subjected to heavy equipment live loads shall be designed on the basis

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of the equipment loads specified by vendor or specifically defined SILL whichever is greater.

The specific minimum floor SILL is listed below:

**Table 2.2
Superimposed Live Load (SILL).**

S.No	Description	SILL Value
a)	Roof	
	Flat accessible roof	1.5 kN/m ²
	Flat accessible roof with HVAC equipments, etc.	5 kN/m ²
	Flat inaccessible roof	0.75 kN/m ²
	Sloped Roof	As per code IS: 875 (Part-2)
b)	All building floors & Stairs	5 kN/m ²
c)	Walkways of Conveyor Galleries	5 kN/m ² or Concentrated Load of 3 kN at centre which ever is critical
d)	M.C.C. Floor	10 kN/m ²
e)	Equipment Load	As applicable
f)	Culverts & its allied structures including Concrete pipes	Class "A" / Class "70R" as per IRC standard whichever is higher / load due to bull dozers
g)	Underground basement,	Surcharge of 10 KN/m ²
h)	Vehicular traffic	Surcharge of 20 KN/m ²
i)	Covers for Channels	Surcharge of 10 KN/m ²
j)	Pump Houses	
	Operating Floor Slab	15 KN/sqm or as required by equipment supplier whichever higher
	Workshop	10 kN/m ²
k)	Other areas:	
	• RCC floors (Offices, laboratories, conference rooms and general floors)	5 kN/m ²
	• Balconies	5 kN/m ²
	• Chequered plate / gratings	5 kN/m ²
	• Walkways	3 kN/m ²
	• Toilets	2 kN/m ²

- In addition to LL, Hung loads for electrical, ventilation & air conditioning minimum of 0.5 kN/m² shall be considered.

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- Load of 1 kN/m² shall be considered as hung load for piping unless otherwise mentioned. However, the actual loads will be as furnished by the supplier. The stringent most will be followed.
- For other areas LL shall be considered as per IS: 875 (Part-2).

(c) Seismic Load

The proposed plant is located in Seismic [Zone-I] as per IS: 1893, Seismic force on the structures will be considered accordingly.

(d) Wind Load

The proposed plant is located in Wind Speed Zone of [50 m/s] as per IS: 875 (Part 3). The wind force on the structures will be considered as follows:

Table 2.3
Wind Speeds

Description	Wind Speed
Basic Wind Speed V _b (at 10m above mean ground level)	[50 m/sec]
Risk coefficient K ₁ (for 100 years)	[1.07]
Category of terrain	[Category 1]
Factor K ₂	As per IS: 875
Topography factor K ₃	As per IS: 875

For the design of structures, wind force on Equipment, supported on frame including all fixtures, piping, staircase, ladder, etc, shall be considered.

Design of structures shall be checked for the condition of wind load with gust factor.

(e) Earth Pressure Loads

For earth pressure the worst condition with dry / submerged and active, passive or at rest shall be considered. The pressure coefficient shall be adopted as recommended in Soil Report or for the backfill material used.

(f) Temperature Loads

The total temperature variation shall be considered as 2/3rd of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the average between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50 % of the total considered temperature variation with temperature load applied with positive and negative sense.

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For design purpose average maximum annual variation shall be taken as $[+50^{\circ}\text{C}]$ to $+5^{\circ}\text{C}$.

Coefficient of thermal expansion of steel shall be taken as per IS: 800 where the value is given as $12 \times 10^{-6}/^{\circ}\text{C}$. Coefficient for thermal expansion for concrete shall be taken as per IS: 456.

(g) Thermal Loads (during operating condition)

When thermal loads (such as produced by temperature changes in piping, equipment and structures) results in friction between equipment and supports (exchangers) or piping and supports, the friction force will be taken as the operating load on the support multiplied by the applicable friction coefficient given below:

Table 2.4
Thermal Loads

Description	Value
Surfaces	Friction coefficient
Rolling supports	0.05
Steel to steel	0.30 (longitudinal) and 0.10 (lateral)
Concrete to steel	0.30

(h) Equipment Loads

Static and dynamic loads of major existing / modified / replaced equipments shall be based on the manufacturer's data of the specified equipments and shall be considered in design in addition to the live load.

Equipments to be tested for hydraulic test, tanks and piping design loading shall include hydraulic test loading. Weight of equipments, ducts, tanks, pipes, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads applicable.

(i) Cranes, Hoists, Monorail and Elevator loads

All lifting beams and monorails shall have their design loads increased for impact factor. Loads for overhead cranes, hoists, monorails and elevators shall be taken as per IS: 875.

100 % of the lifted load including elevator live load plus the cab weight shall be considered for the elevator support beam design. Pedestals in elevator pits shall be designed assuming impact factor as per IS codes.

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(j) Vibration and Noise

The design shall ensure that vibrations from any moving machinery transmitted from its immediate foundations to adjacent buildings or areas of the same building shall be suppressed in accordance with the recommendations of relevant codes of practice.

(k) Other Loads

- Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance loads, creep and shrinkage shall also be considered in design of all structures.

- Dust loads

All buildings / structures shall be designed for a dust load of 1 kN/m² for flat roof and 0.5 kN/m² for sloped roof.

- Construction /Erection/Maintenance Loads

The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing as far as possible. However, construction or access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

- Future Loads

Loads from future expansion shall be considered when so directed by the Owner/Consultant. Future loads may include any of the loads listed above.

- Surge Loads

Surge loads may occur in some vessels or equipment. In such cases, the magnitude and direction of the load shall be given by the equipment supplier.

(l) Basic Load Cases

Following basic loads shall be considered for analysis and design:

Dead load	:	DL
Superimposed dead load	:	SIDL
Self weight of permanent equipment	:	EL
Steam piping (Static & Dynamic) & other piping loads	:	PL
Cable loads	:	CL
Live load on floor / walkway	:	LL
Superimposed live load	:	SILL
Live load on roof	:	LLR
Seismic load	:	SL

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Wind load	:	WL
Load due to soil pressure	:	SP
Load due to surcharge	:	SCL
Load due to hydrostatic pressure	:	HP
Load due to temperature	:	TL
Hoist, monorail loads	:	MR1
Crane Loads	:	CRL
Special loads	:	SPL

(m) Load Combinations

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load combinations shall be taken as per IS: 456, IS: 800 & IS: 875 (all parts) and other relevant IS codes.

Wind and seismic forces shall not be considered to act simultaneously.

Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loading.

(n) Load Combinations for underground structures

- For the design of sub structure only liquid pressure from inside and no earth pressure and ground water Pressure and surcharge pressure from outside (applicable only to the Structures which are liable to be filled with water or any other liquid) shall be checked.
- For the design of sub structure combination of earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside shall be applied.

(o) Coal Handling System (CHS)

In addition to the loads specified in (b) above, following additional loads shall be considered for design of various structures of CHS.

Flat roof	:	
Accessible	:	0.50KN/sq. m dust load
Non accessible	:	1.25 KN/sq. m dust load
Inclined roof	:	0.50KN/sq. m dust load
Building floors	:	5KN/sqm or equipment load whichever is high + 1KN/sqm spillage load (Where

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equipment is located)

Load due to material on belt : 1.6 times design weight of the material on belt

Spillage load

Gallery walk way : 1KN/sq. m

Seal plate : 1KN/sq. m

Belt tension for twin conveyors : One belt at starting condition and one in running condition

Impact factor for drive machines : 1.50

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4 EARTHWORK AND ROCKWORK

4.1 General

This section applies to all earth and rockwork required for the replacement / refurbishment / retrofitting of existing foundations or construction of new buildings foundations (if any), any types of structure and burying service lines in the ground.

The Bidder shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the detailed soil investigation and of the available information and instruction given in writing by the Owner/Consultant.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Owner/Consultant. All necessary precautions shall be taken to cause the minimum possible alteration or disturbance to the other existing foundations, material lying under and adjacent to the excavation final lines.

4.2 Fill Materials

The fill materials used and source are to be examined and approved. Excavation materials can be used if they fulfil the requirements.

a) Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials, which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas etc.

b) Ordinary fill shall have the following properties:

- Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.
- The intention is to use ordinary fill for non-built areas.

c) Special fill:

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- Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks.

4.3 Excavation

The works shall be excavated either by hand or by use of excavating plant and tools acceptable to the Owner/Consultant.

Last 300 mm shall be excavated by hand tools only to ensure that natural conditions of soil at foundation level should not be disturbed. In case if over excavation has been done, the depth of soil over excavated shall be filled with M10 Grade concrete and no earth filling shall be allowed to fill over excavated earth.

Also excavation by hand may be required close to existing installations, existing foundations and/or underground services, but subject to special instruction of the Owner/Consultant.

The Bidder shall carry out all kind of earth and rockwork for the following particular works as defined hereafter (where applicable):-

- i) Clearing and grubbing
- ii) Excavation of topsoil
- iii) Open cut excavation
- iv) Backfilling
- v) Safety precaution during earthwork
- vi) Mining or underground excavation (if required)
- vii) Grading
- viii) Replacement of material
- ix) Trench excavation for service lines
- x) Embankments
- xi) Archaeological findings

4.4 Safety Precautions

The Bidder shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc shall be to the Bidder's debit. The additional moving of soil resulting from such damages will not be paid for.

4.5 Over Excavation

Bidder shall ensure that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

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4.6 Stockpiles and Disposal

Excavated material from the works selected by the Owner/Consultant for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on site as directed by the Owner/Consultant.

The Bidder shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Owner and shall not be permanently deposited elsewhere. The Bidder shall trim and form the edges of spoil to profiles and levels as directed by the Owner/Consultant.

Distance of stockpiling of excavated material from the pit edge shall be minimum 1.5 meters or half of the depth of the pit whichever is higher.

The placing of materials within the waste disposal areas shall be made in layers not exceeding 0.50 m in thickness in order to obtain an appreciable degree of compaction by means of transportation equipment and/or if required by appropriate compaction equipment.

All traffic to or from the waste disposal areas shall run over the surface of such areas in order to achieve compaction.

4.7 Preparation of Foundation

All earth surface against which concrete is to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Owner/Consultant and then protected by means of a lean concrete layer, 7.5 cm or PCC thickness as shown in the design drawings, whichever is greater. No concrete is to be poured until formation is inspected and approved by the Owner/Consultant. No structural concrete shall be poured against earth surface. Shuttering shall be used at sides and PCC shall be provided below foundations.

4.8 Backfilling

Foundations and structures shall be backfilled with approved material compacted in layers not exceeding 150 mm by suitable equipment upto the required designed levels.. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Owner/Consultant.

Density requirements as per standard Proctor Test shall be in accordance with relevant parts of IS: 2720 and all tests shall be made by/on under the supervision of Owner/Consultant at Bidder's own expenses, at optimum moisture content:

- a) Backfilling of foundations and under grade slabs - 98%
- b) Under roadways and parking areas - 98%
- c) Embankment - 95%

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The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Owner/Consultant after compaction tests have been made.

Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the sub-grade.

Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Owner/Consultant.

4.9 Soil Replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange. The suitability of soil for its use for filling shall be as per provisions of Indian Standards.

Prior to the commencement of work, three samples shall be taken from the anticipated borrow area and tested in respect of IS: 2720 or Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

These three samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of not more than 15 cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for watering of soils.

The fill material shall be compacted by vibratory roller (min. weight 20T.). However for small compaction works such as small patches etc., comparatively low weight compactors or other compaction methods may be used after taking approval from Owner / Consultant. The minimum required degree of compaction should be as defined under "Tests and Properties". One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Owner/Consultant. Bidder shall make suitable arrangements for carrying out all the necessary quality tests or he shall co-operate with an experienced soil testing laboratory, subject to the approval of the Owner/Consultant.

Filling work may be continued in case all tests performed show satisfactory results.

4.10 Protection of Existing Utilities and Services

During modification/rehabilitation of existing structures or construction of new structures, the Bidder shall provide all protection for existing utilities and services as may be required by his modification and construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Owner/Consultant.

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In addition to the requirements as specified, herein the Bidder shall comply with the following requirements:

- a) Use all necessary precautionary and protective measures required to maintain existing structures, utilities, services and appurtenances that must be kept in operation. In particular, the Bidder shall take adequate measures to prevent undermining of existing structures and utilities/services presently in service.
- b) Protect existing or new utilities and services where required by the Bidder's operations and/or as directed by the Owner/Consultant. The Bidder shall be responsible for bracing and supporting existing structures, utilities and services to prevent settlement, displacement or damage.

4.11 Dust Control

The Bidder shall use all means necessary to control dust on roads, dismantling/demolition and modification areas, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

4.12 Dewatering during Construction

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the detail soil investigation and/or information given in writing by the Owner/Consultant.

Ground water control for keeping the construction pits dry shall be included in the Bidder's scope of work.

The method and technique shall be based on the IS: 3764.

The scope of supply includes removal of all equipment, plants, pipes, machinery, etc for modification /rehabilitation of existing foundations and re-installation of all equipment, plants, pipes, machinery, etc and its removal after completion including operation & maintenance of the equipment during the construction period.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that alterations and extensions can be made at any time throughout the operating time, if necessary. Reserve units shall be kept ready for service when failure of any of the installed units occurs.

The Bidder has to consider the possibility of a temporary failure of any pump, diesel engine and/or the electric power service and shall install emergency

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power units with sufficient capacity to feed the necessary power to the installed unit at the moment of failure. The Bidder shall submit to the Owner/Consultant, the detailed method of the envisaged pumping system for dewatering, the pump capacity and the standby reserve units. The Bidder shall adjust the system if required by the Owner/Consultant.

The Bidder must ensure that any dewatering works will not cause any interference to his own work and to those of other Bidders working elsewhere on site. Any damage occurring during the above mentioned period should then be made good by the Bidder at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least *[0.50]* m below the foundation level.

4.13 Equipments

All equipments, instruments, machineries, tools, pipelines, etc required for execution of the water control shall be kept in good working condition throughout the operation period.

4.14 Execution

The Bidder shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to the Owner/Consultant for information and checking every working day. For that purpose, the lowering of the water table shall be controlled by piezometers. The numbers and position of them shall be submitted to the Owner/Consultant's approval. The Bidder shall provide and maintain these piezometers at his own expenses during the dewatering works or as long as the Owner/Consultant requires it.

Pump operations shall not be stopped nor pipes, channels and equipment for dewatering and water control removed or altered in any way, except with the express permission of the Owner/Consultant. The Owner/Consultant will stipulate the time of removal. Until then, the pumps and water drainage facilities shall be kept in proper working order without extra payment being granted.

Pump sumps and channels:

Provision of pump sumps and channels of the dimensions required for each particular case shall include all necessary excavation of any kind of soil above and under water, backfill and consolidation, sheeting, bracing, stiffening, sealing, scaffolding accesses, as well as the disposal of water and all auxiliary works.

Routing of channels or pipes for discharge water shall be such as not to impede or obstruct any of the other works and/or operations.

The same shall be applicable for pump sumps. Prior to the determination of any arrangement of pump sumps, the Owner/Consultant's approval shall be obtained.

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Routing and location of water discharge lines shall be submitted to the relevant authorities and to the Owner/Consultant's approval.

Difficulties during dewatering:

The Bidder shall consider all difficulties and additional work due to the presence of unexpected ground water during subsequent construction work. Where it is possible to keep off or divert such water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from Owner/Consultant has been obtained.

Ready for service condition:

The Bidder shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by the Owner/Consultant in this matter shall be carried out immediately.

Leakage:

Blockouts and pipe connections through structures and their closure, proper grouting of joints, etc or repairs in the event of leakage shall be the responsibility of the Bidder.

Piezometers:

The ground water lowering effect is to be checked by piezometers in unfavourable positions (e.g. in the middle of the building pit) before starting the excavation. The piezometers are to be installed at unfavourable positions or in more permeable layers (in stratified sub-soil) below the bottom of the excavation. They serve to check whether or not the water pressure (head) has been sufficiently reduced in those layers below the bottom of the excavation, which are more permeable. Security against hydrostatic uplift is to be demonstrated by calculation.

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5 REINFORCED CONCRETE STRUCTURES AND FOUNDATIONS

5.1 General

All structures, building foundations, machines / equipment foundation, water retaining structures, trenches, pits, etc. shall be checked / designed as per latest relevant IS codes in general. Construction in general shall follow provisions of IS: 456 and IS: 3370 for normal and water retaining structures respectively.

5.2 Design Methodology

a) General

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456.

IS: 11384 shall be followed for design of steel concrete composite beam.

For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

b) Foundation and Underground Structures

Type of foundation system, i.e. isolated, strip, raft shall be decided based on the loading arrangement, load intensity and soil strata. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

Foundation system adopted shall ensure that settlement / relative settlement is as per provision of IS: 1904 and other Indian Standards. However, the settlement shall be restricted to a lower value, if necessary as per the system requirement.

All foundation including machine / equipment foundations shall be of RCC construction. All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian standards IS: 2974 and IS: 456. Raft foundations shall be designed as per IS: 2950.

All foundations shall be treated as per the guidelines prescribed in IS 456: 2000 against sulphate/other aggressive chemicals if found present in soil or as per the requirements of detail Geotechnical Investigation Report.

For design of underground structures, subsoil water level shall be assumed at Finished Ground level. All underground pits, tunnels, basements, cable and pipe trenches, etc. shall be designed as leak proof RCC structure, where depth of ground water table so warrants. In case of leakage in the above structures injection grouting method shall be applied to repair the structure according to

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the requirement of IS: 6494. Effects of uplift and reduction in bearing capacity due to underground water table shall also be considered.

For Subsoil conditions, Average ground water table, Foundation system, Earth Pressure Coefficient, refer to detail geo-technical investigation report of the site.

The soil conditions met during the foundation works especially in the foundation level are to be checked by the Bidder's soil Engineer, recorded and compared with previous known or investigated results. If essential differences occur, which could be detrimental to the structures, the Bidder has to inform the Owner/Consultant and to propose further measures. Foundation works in such areas are to be continued only after approval of such measures by the Owner/Consultant

If there is any doubt about the soil quality or if discrepancies appear with regard to the previous decisions or investigations stated by the Owner/Consultant, then additional measures are to be taken after consulting the Owner/Consultant (e.g. additional excavation and lean concrete fill)

Allowable settlements, elastic plus consolidation, shall be limited as follows: -

- i) Total settlement : 38 mm
- ii) Differential settlement : 6 mm

Foundations for equipment shall be designed to meet the total and differential settlement established by the equipment manufacturer if they are more stringent than the allowable settlements listed above. Foundations for buildings shall be designed to meet the total and differential settlement as required for the building function if they are more stringent than the allowable settlements listed above.

c) Movement and Expansion Joints

Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS: 8009 – "Code of Practice for calculation of settlement of foundation".

d) Foundations at Different Depths

Foundations at different levels should be based beyond a load-spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure) of the higher-level structures on the lower ones must be taken into consideration.

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e) Replacement

If unsuitable soils are encountered below the grade slabs or basement floor, they are to be replaced by suitable layer wise compacted material down to the good bearing soil.

Materials and compaction method as well as quality control are described in clause 'Earth and Rockworks' of this section. Selected fill is to be employed below all grade paving and basement floors.

f) [Liquid Retaining Structures]

RCC water retaining structure like storage tanks shall be leak proof and designed as un-cracked section in accordance with IS: 3370 (Part 1 to IV) by working stress method. However the parts of such structures not coming in contact with liquid may be designed according to IS: 456.

Water channels and substructure of pump houses shall be designed as cracked section with steel stresses as per IS: 3370 (Part 1 to IV) by working stress method and limiting crack width to 0.2 mm.

All water retaining / storage structures shall be designed assuming liquid upto the height of wall irrespective of provision of any over flow arrangement. No pressure relieving devices shall be permitted in underground structures.

In all liquid retaining structures, PVC water bar shall be provided at each construction / expansion joint. The sequence of construction shall also be specified on drawings showing construction joints.

The walls shall be designed for a surcharge load of 2000 Kg/m² or actual whichever is higher.

Liquid Retaining Structure shall be checked for two loading conditions. With water inside up to operating level and no earth fill outside or water in one compartment and no water in the other compartment (where two compartments are provided).

Base slab / raft of all liquid retaining structure shall be designed to withstand the uplift pressure.]

g) Modification of the existing foundation (as required) for the new equipment supplied

The new equipment shall be supported on an RCC deck which in turn shall be supported over steel helical springs and viscous dampers. The steel helical springs and viscous dampers shall be supported over structural steel beams which in turn shall rest over columns. The columns shall be supported over foundation. The modification of existing foundation may involve partial to full dismantling and reconstruction of new foundation as per design & constraints of space.

Precautions shall be taken not to disturb the basic building structure & other foundation and it shall be ensured that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to

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adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

The contractor shall be responsible for maintaining all safety norms including the stability of existing structures. Any propping, shoring and under pinning required to this effect shall be put in place before the dismantling work is undertaken.

Wherever any existing concrete member is required to be partially dismantled, a coat of epoxy paint shall be applied to the exposed reinforcement and the cut surface of concrete shall be built up by providing 40 mm thick concrete with wire mesh.

h) Machine Foundations

General

Design of equipment foundation for block type machine foundation (if any) shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in mind the existing structural arrangement and space limitation.

The design of machine / equipment foundation shall be as per IS: 456 and IS: 2974. The provisions of DIN 4024 shall also be followed for machine foundations. All machine / equipment foundations and structures subject to vibrations shall be suitably proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

For the foundations supporting minor equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining part of building and other foundations. Joints at floor/ slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitable to ensure integral action.

The extent of foundation shall be based on the general arrangement of the equipment and the design requirement. However minimum width of any foundation shall not be less than one meter. Water table has to be considered at finished ground level for design of all foundations.

Suitable arrangement shall be made for prevention of transmission of vibration from the proposed foundation to the nearby structure/ foundation/ paving slab.

All design calculations and drawings shall be submitted to Owner for approval.

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In case any modification to any existing nearby structural steel bracing/support system/ concrete work is required, the contractor shall check the adequacy of the design of the existing structures for the new loads. Suitable modification to the existing structure as required shall be carried out by the contractor.

Loose pockets if any found below the foundation shall be removed and filled up with PCC of grade M10.

Loads

All static and dynamic forces / loads which equipment supplier considers applicable shall be considered for analysis and design of machine foundations.

Foundation Sizing

The outline plan dimensions of foundations as given by the machine supplier will be adopted. The height of foundation will be selected after taking into consideration soil strata and operating level of the machine. The eccentricity of common CG of machine and foundation with respect to the centroid of base area should not exceed 5 % of the corresponding base dimensions of foundation. Partial contact between the foundation and soil strata shall be considered wherever applicable. The footing will be checked for minimum contact area of 80 % and maximum bearing pressure will be calculated for the actual contact area only.

Analysis and Design

The minimum grade of reinforced cement concrete shall be M25, unless specified otherwise.

The analysis and design of machine foundations will be carried out to ensure the following:

- Compliance with the manufacturer's requirements and relevant standards
- No resonance phenomenon of a disturbing nature to machine operation should exist at the normal running speed
- Calculations to be performed for dynamic as well as static cases for reinforced concrete block type pedestal
- Soil bearing capacities
- Deep foundation capacities
- Lateral earth pressures
- Allowable settlements
- Structure, equipment and environmental loadings
- Equipment performance criteria
- Access and maintenance requirements
- Temporary construction loadings

The foundation will be designed for the most critical combinations of forces and moments, resulting from all possible combinations of the various loading from the equipment system. The foundation sections will be sized and reinforced adequately for bending moments and shear stresses and uplift.

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The foundation shall be checked for overturning, sliding and uplift as per relevant IS Codes. The foundation will be checked for overturning with minimum and maximum vertical loads.

For analysis of machine foundation following data will be furnished by the equipment manufacturer:

- Loading diagram showing static and dynamic loads and points of application of loads
- Operating speed of machine
- Weight of rotating parts, maximum eccentricity of rotating mass from the geometric axis of rotation
- Location of C.G. of machines in all three axis
- Mass moment of inertia
- Allowable amplitude / velocity of vibration at machine bearing points
- Temperatures at various areas during operation

While designing following aspects shall also be taken care of:

- All dynamic foundations shall be isolated from building foundations. The isolation gap shall be of minimum 25 mm.
- Natural frequencies of structures and components shall be away from running speed of equipment by at least 20 % generally but for important ones it shall be away by at least 30 %.
- For design of foundation of large fans etc., provision shall be kept in the foundation for addition of mass / area for retaining of the foundations if required at a later date
- However following minimum factor of safety shall be followed:
- Factor of safety against overturning due to wind, seismic or other lateral loads shall be 1.5
- Factor of safety against sliding shall be 1.5
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5. Uplift check shall be carried out during construction stage also.

Specific requirements for machine foundations

- Crusher Foundation

The crusher shall be supported on M30 grade RCC deck slab mounted on vibration isolation system comprising springs and viscous dampers, which in turn will be supported on RCC beams. The vibration isolation shall be done by providing inertia block with anti vibration pads. These pads shall be suitably procured with respect to crusher manufacturer's specifications.

Alternatively crushers shall be mounted independently on ground-supported RCC frame structure. The crusher foundation shall be made isolated from building & this should suit to process requirements. Crusher foundations shall be kept isolated by providing 75 to 100 mm gap all around at crusher floor level as per process requirements.

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Detailed dynamic analysis shall be done for top deck of coal crusher together with springs & dampers and natural frequencies & amplitudes of vibration shall be determined. A mathematical model of top deck shall be formulated with three dimensional beams, plate, and finite elements for the purpose of analysis with the spring idealized with vertical and horizontal stiffness. The mass of the machine together with that of the top deck shall be considered for the analysis. Natural frequencies up to at least 10% above the operating speed shall be determined and three frequencies shall be checked against the design criteria. Forced response dynamic analysis shall be carried out for the unbalance forces generated during operating condition using a sinusoidal forcing function. Unbalanced forces as given by the manufacturer shall be used for this purpose.

Ultrasonic pulse velocity (UPV) test shall be carried out for crusher foundation to ascertain the homogeneity and integrity of concrete. Testing shall be done as per IS: 1331 (Part-1). The defects shall be rectified by using cement / epoxy grout etc.

- **Miscellaneous Machine Foundation**

For miscellaneous machines, most suitable type of foundation shall be provided. Foundation for pumps, and minor rotating equipment etc., are usually in the form of solid block foundations, resting on the ground or on a floor of the building. At such machine supports, floor may be thickened and extra reinforcement may be provided. Also the machines, which are almost vibration free, light to moderately heavy, may be supported in the above manner. Rubber or neoprene pads under some of these machines to reduce transmission of vibrations to the supporting floor will be provided if required.

All block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456. Suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining foundations.

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25°C when placed. For maintaining the temperature of 25°C in the top decks of machine foundations, crushed ice shall be used in mixing water.

Non-Shrink Grout for Equipment Foundations

Special non-shrinking grout of approved make shall be provided in strict accordance with the manufacturer's instructions / specifications. Ready mix

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non-shrink grout of GP2 brand or equivalent, of approved make shall be used for base grouting of major rotating equipments.

i) Increase in Stresses

Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

Bearing capacity of the soil shall be allowed to be increased by 25 % under seismic/ wind load condition.

j) Elevated Foundations

Design of all equipment foundations shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in view the existing structural arrangement and space limitation. Adequacy of the design of the existing structures, for the new loads shall be, checked by the contractor. Suitable modification as required shall be carried out by the Contractor and complete design for the same shall be furnished to owner for approval. Where ever new columns/foundation is required the same shall be designed and constructed by the contractor as per relevant Indian Standard Code.

For the foundations of the all equipments details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic forces as per IS:1893. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Design of RCC foundations/as well as structures, checking of design of existing structure shall be carried out by working stress method. A fatigue factor of 2.0 shall be considered for dynamic forces.

The foundation general arrangement shall be such that the spring units are placed over the structural steel beams. The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The vibration amplitudes at the bearing locations shall not exceed the limits as per VDI 2060 or limits specified by the machine supplier whichever is more stringent. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

The grade of concrete for the top deck shall be M35.

k) Steel Helical Springs and Viscous Dampers

The supporting structural beam and columns shall be designed for the loads transferred through springs and all other loads such as piping loads, seismic loads as per IS:1893. The stiffness of the beams supporting the springs shall be at least 10 times the stiffness of the springs supported over it along both vertical and horizontal direction.

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The scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implied for the successful completion of the work for which these specifications are intended.

Scope of work of the bidder shall include manufacturing, testing, supply, transport to site, pre-stressing, erection, supervision of erection, release of pre-stress, alignment, commissioning etc of Steel helical springs and viscous dampers:

- Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
- Frames for pre-stressing of spring elements.
- Suitable hydraulic jack system including electric pumps, high- pressure tubes etc. required for the installation, alignment etc, of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.
- Any other items which may be required for the complete installation and satisfactory commissioning of the spring system.

Supervision of complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

The steel helical springs and viscous dampers supplied should be of proven make. The bidder or his sub-contractor should have designed spring supported machine foundations, manufactured, supplied and installed steel helical springs and viscous dampers (conforming to DIN 2096 & DIN2089) and viscous dampers (providing damping resistance in all three planes) for not less than 2 (two) machine foundations of heavy rotating machine systems.

The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of units.

All design calculations and drawings shall be submitted to Owner for approval.

5.3 Stability of Structures

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like underground storage tanks, pits, trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For the purpose of calculating downward load due to any

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overburden, only the mass located vertically above the projected area of the base slab shall be taken in to consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS: 456 and other latest relevant IS codes. However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum
- Factor of safety against sliding shall be 1.5 minimum
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In cases where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

5.4 Minimum Thickness of Concrete Structural Elements

The following minimum thickness shall be followed:

Table 2.5
Minimum Thickness of Concrete

S.No	Description	Thickness, mm
a)	Suspended floor / slab / walkways /canopy slabs, etc.	125
b)	Ground floor slab (non-suspended)	150
c)	Water Retaining slabs / walls	200
d)	Cable/pipe trenches/underground pits/Laundry walls and base slab	125
e)	All footings (including raft foundations)	300
f)	Parapets	125
g)	Sunshades	75 at edge
h)	Precast louvers / fins	50
i)	Precast trench cover slabs / floor slabs / louvers	75
j)	Paving	100
k)	Basement walls and base slab	200
l)	Bin walls	150
m)	Underground tank: Below ground water table	200

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S.No	Description	Thickness, mm
	Above ground water table	150

From fire resistance point of view minimum cover to reinforced concrete members shall be as per Table 16A of IS: 456.

5.5 Minimum Heights for Pedestal of Steel Columns

Pedestals to Steel Columns for building structures:

Top of RCC foundations (pedestals) shall normally be kept at a minimum *[250 mm]* above finished floor level (FFL) unless specified otherwise. Foundation levels for columns shall be decided to accommodate underground services, pits, trenches, etc.

Stair and ladder pedestal shall be kept *[200 mm]* above the finished floor level.

Pedestals to Steel Columns for Equipment structures:

a) Equipment in open area : as required *[(300 mm min)]*

b) Equipment in covered area : as required *[(150 mm min)]*

c) Structures and equipment

Supplied by vendor : as per vendor's data subject to minimum as specified above.

5.6 Minimum heights for encasement of steel columns

In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following:

a) Open area : *[300 mm]* above paved level

b) Covered area : *[150 mm]* above FFL

5.7 Concrete Works

i) General Description, Proportions and Mixing

Mix Design

At the commencement of the contract the Bidder shall make preliminary tests to determine the proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling and placing and when concrete hardens, it shall have the required strength, durability and surface finish. The Bidder shall get approval of Owner/Consultant to such proportions before he starts concreting. However, such approval shall not relieve the Bidder of his

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responsibility to produce concrete having compressive strengths as laid down in the foregoing Table.

No departure from the approved proportions will be permitted during the works unless and until the Owner/Consultant gives written authorisation for any change in proportion. The Owner/Consultant shall have authority at any time to check whether the mixing of concrete is being carried out according to the approved proportions.

For the all major and important R.C. works and for all special works, the design of mixes shall be made by the Bidder at his own cost, for each grade of concrete as well as for various workability. The design of mixes shall be made according to I.S. 10262 or any other approved standard methods.

The concrete made by designing the mix is termed hereinafter as "Design Mix Concrete".

The cement content for various grades of concrete shall be based on design mix. However, irrespective of requirement of cement found out from design mix, cement content of concrete shall not be reduced below the quantities specified as under.

Grade of concrete	Minimum cement content per Cu.m finished concrete
M-15	290 kg
M-20	320 kg
M-25	380 kg
M-30	not less than 400 kg
M-35	not less than 400 kg

Water Cement Ratio

Where a particular water cement ratio is stipulated in the design or drawing along with the characteristic grade of concrete the design of mix shall be carried out by adjusting the other variable factors to obtain the characteristic strength of concrete with stipulated water cement ratio.

In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, such as water retaining structures, basements, underground premises, tunnels, pump houses, pre-stressed structure, thin precast members etc. the water cement ratio shall be kept low and preferably not exceeding 0.45.

The water cement ratio, as achieved in the Mix Design, or as specified in the drawings shall be adhered to strictly and shall not be varied without the permission of the Owner/Consultant.

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Workability

The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling & placing so that after compaction it becomes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

The workability of fresh concrete at the place of batching/mixing shall be measured by compacting factor test and at the place of disposition by means of slump test. During the finalisation of Trial Mixes, the relationship between compacting factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS: 1199.

Normally, in the condition of low water cement ratio as well as for medium/high workability, the workability shall be achieved by increasing the cement content, in consistent with added water.

In cases where the cement content is to be limited to reduce the heat of hydration, and the water/cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of plasticiser or air entraining agent. In such cases the method of mixing and dosage of the plasticiser/air entraining agent shall be according to the manufacturer's specification and with the approval of the Owner/Consultant.

The usual limits of consistency for various types of structures are given below:

Limits of consistency

Degree of Workability	Slump in mm with Standard - Cone		Use for which concrete is suitable as per IS : 1199
	Minimum	Maximum	
Very low	0.0	25.0	Large mass concrete structure with heavy compaction equipment, roads and the like.
Low	25.0	50.0	Uncongested wide and shallow R.C.C structures
Medium	25.0	75.0	Deep but wide R.C.C structures with congestion of reinforcement and inserts
High	75.0	125.0	Very narrow and deep R.C.C structures with congestion due to reinforcement and Inserts

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Durability

The durability of concrete, depending on the exposure condition, is to be taken into account while designing the mix. For given aggregates, the cement content should be sufficient to make sufficiently low water cement ratio and Appendix A of IS: 456 shall be taken as guideline for durability considerations.

Minimum fire rating of 2 hours shall be considered where fire hazard is expected and accordingly minimum cover shall be taken as per Table 16 A of IS: 456. For structures below ground level which are exposed to sulphate attack, requirement of cement shall be as per Table 5 of IS: 456. Intermixing of different grades of concrete in the same structure shall not be allowed in a particular element.

Mix design concrete shall be used for all areas other than plain concrete work used for lean concrete, screeds and backfill.

The following minimum grades of concrete as per IS: 456 shall generally be used for the type of structures noted against each grade.

Table 2.6
Grades of Concrete

Concrete mix/Grade	Type of structure
1:5:10	Fill concrete
1:4:8	Blinding layer below foundations, trenches and underground structures, foundation below brick wall, etc. Minimum thickness of layer shall be 75 mm
M15	Plinth protection work around buildings
M25	Base plate encasement, encasement of structural steel work, all RCC paving work, ground floor slabs, cable and pipe trenches, precast concrete work etc.
M30	All RCC structures and equipment foundations, super structure, grade beams, columns, roof slabs and all underground RCC structures, cable and pipe rack foundation, pedestals etc.

Inter mixing of different grade of concrete in the same structure shall not be allowed normally.

ii) Trial Mixes

- Before concreting commences, the Bidder shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation. Only materials which the Bidder intends to use for concreting (including all admixtures) shall be used in the trial mixes.

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- Test cubes from trial mixes shall be made and tested in accordance with IS: 516.
- As per IS: 456 and IS: 516, three separate batches of concrete should be made, workability of each batch determined and three test cubes shall be made from each batch for each age (e.g. for 7 and 28 days) at which tests are required. The strength shall conform to target mean strength as per IS: 456 – Requirements for design mixes.
- The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength and if the average strength of the nine cubes is not less than recommended by IS: 456 and IS: 516, trial mixes.

iii) Quality and Testing

Not more than 5% of the test results may fall below the 28 days specified strength. Making and curing of test specimens shall be in accordance with relevant IS: 456, IS: 516 and IS: 1199.

All mixes can only be placed following approval by the Owner/Consultant. The mean strength shall exceed the characteristic strength by a margin of 1.65 times the standards deviation expected from the batching plant. However, no standard deviation less than 3.5 N/mm² shall be used as a basis for designing a mix.

iv) Trial Mixes and Field Tests

Sufficient laboratory trial mixes shall be prepared to show that concrete complies fully with the specified performance criteria. The following tests are to be included:

- Air content < 1%
- Slump: Piles 170 + 25 mm, regular work 80 + 20 mm as per IS: 1199
- Fresh and hardened concrete densities
- Field trial mixes shall be carried out under full-scale site conditions as per IS: 4925 (for structural concrete only).
- Where directed by the Owner/Consultant, concrete incorporating reinforcement details shall be cored to assess stratification of mixes. Cores of 150 x 200 mm (diameter and length) shall be used.
- Each trial mix shall have 9 x (150 x 150 x 150 mm) cubes taken to measure 24 hours/7 days and 28 day compressive strengths. These trials shall be run for three consecutive days (for structural concrete only).
- At least 3 x sets of field trials shall be tested according to the provisions laid down in laboratory testing.

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- The average 28 day characteristic strength for trial mixes shall be as per IS: 456.. Failure to comply shall result in the mix having to be re-designed.
- All test results shall have to be complied before approval can be given.

v) Consistency of Concrete

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests measured in accordance with IS: 1199 and shall not exceed the values given in clause 7.1 of IS: 456-2000.

vi) Mixing of Concrete

- The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way and shall comply with the requirements of IS: 456, IS: 1791 and IS: 12119.
- The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than 2 (two) minutes after all the materials and water are in the drum.
- Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

Bidder shall make suitable arrangements for carrying out all the necessary quality tests and ensure that testing work shall be carried out in compliance with the standards.

5.8 Strength of Concrete

i) Testing of fresh concrete by means of test cubes

- a) All test cubes shall be made and tested for compressive strength in accordance with IS: 456, IS: 516 and IS: 1199.
- b) The minimum required strength for different classes of concrete shall be as shown in clause "General description and proportions and mixing" here above.
- c) The grade of concrete required will depend partly on the particular use and the characteristic strength needed to provide the structure with adequate ultimate strength and partly on the exposure conditions and the cover provided to any reinforcement.

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- d) A minimum of four test samples (of six test cubes each) shall be taken on each concreting day (from the same mix) and for at least each 40 m³ of concrete mixed. At least one sample shall be taken for each shift.
- e) For columns, beams and cantilevers seven (7) cubes for every 15 m³ of concrete poured shall be taken. The concrete for test samples shall be taken directly from the concrete mixer and shall be handled (vibrated etc) under similar conditions to those prevailing during the construction. The moulds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.
- f) The strength level of each type and each strength concrete will be evaluated separately and the concrete strength will be considered satisfactory if:
 - Compressive strength: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-
 - The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column 2 of table 11 of IS: 456.
 - Any individual test result complies with the appropriate limits in column 3 of table 11 of IS: 456.
 - Flexural strength: When both the following conditions are met, the concrete complies with the specified flexural strength:-
 - The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm².
 - The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm².
- g) If the results are less than those specified, the Owner must suspend all concreting work and order further tests. Any concrete found not to comply with the specification shall be broken out and replaced to the satisfaction of the owner.
- h) The Bidder shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

ii) Testing of concrete in structures

- a) The types of tests described hereinafter are applicable to the finished parts of the structures. They may be used in routine inspection and for quality control.
- b) Type of tests:
 - Cutting cores: The procedure used shall comply with the requirements of IS: 516 or an approved equivalent standard.
 - Gamma radiography: The testing shall be carried out in accordance with the requirement of IS: 13311, part 1 or equivalent.

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- Ultrasonic test: Such tests may be used to obtain approximate indications of the strength of the concrete in the structures (IS: 13311, part 1).
 - Electromagnetic cover measuring devices: Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design (IS: 13311, part 1).
 - Rebound hammer test: Such tests may be used to obtain approximate indications of the strength of the concrete (Ref. IS: 13311, part 2).
 - Load tests of structures or parts of structures: If the results of the above mentioned check tests show that the quality of the materials is inadequate or if other defects are revealed, the owner may require a loading test to be made.
- c) For the purpose of testing floors, roofs and similar structures and their supports, the test load shall be equivalent to the sum of the characteristic dead load and one-and-a quarter times (1.25 times) the characteristic imposed load for a period of 24 hours which the works or part thereof to be tested have been designed.
- d) Wherever certain procedures for testing of parts in structures are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Owner/Consultant.
- e) If within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under superimposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.
- f) If the result of the test is not satisfactory, the Owner/Consultant shall instruct that the part of the works concerned be taken down or cut and reconstructed to comply with this specification. The Bidder shall at his own cost take down or cut out and reconstruct the defective work.
- g) The Owner/Consultant may require other tests to be made. Number of samples, tests and types will be as per Owner requirements.
- h) All the costs for the above mentioned tests shall be borne by the Bidder.

5.9 Materials

a) Storage of materials

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Storage of materials shall conform to IS-4082 "Recommendation on stacking and storage of construction materials and components at site". Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Bidder.

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b) Cement

OPC/PPC Cement of reputed make conforming to relevant codes, shall be used for all Concreting works and the certificate of manufacturer shall be furnished with each batch. Cement used shall be ordinary Portland cement unless the chemical nature of the soil warrants special cement for structures below ground level.

Sampling and Testing of Cement

- All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties as required by relevant IS: 8112 for grade 43 and IS-12330 for sulphate resistant cement.
- The manufacturer's test certificate will normally be accepted as proof of compliance with the specification, but the Owner may order further tests of a character specified in the appropriate Indian standards. The confirmatory tests are to be conducted by a recognized quality control organization. The Bidder shall bear all expenses required for the preparation, dispatch, and tests of the samples. In case the results of such tests show any sample to be inferior to specifications, the whole consignment from which the sample was taken shall not be used and shall be immediately removed from the site.

Delivery and Storage of Cement

- The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture, date of original loading, destinations en-route, date of unloading, intended date of delivery to site.
- The Bidder shall obtain and provide to the owner the manufacturer's average test certificate for each consignment of cement to the works.
- The certificates shall be provided before the consignments are required for use and shall show the chemical composition and physical properties determined in accordance with the relevant standard.
- Samples shall be taken from each consignment of cement and tested as directed by the owner in an approved independent laboratory.
- Consignments shall be used in the order in which they were delivered.
- Bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the owner before any cement is delivered to site.
- Each consignment of cement shall be separately stored for ease of access, identification, inspection and sampling. Sufficient stocks shall be maintained on site to ensure the proper progress of the works and the stock holdings shall be to the approval of the owner.

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- No cement from any consignment shall be used in permanent works without the approval of the owner.
- Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter or which has been contaminated or is otherwise unsatisfactory in the opinion of the Owner/Consultant will be rejected and shall be removed from site without delay.
- The Bidder shall be responsible for satisfying himself that the performance characteristics of cement are not such as to necessitate excessive cement content or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete notwithstanding apparent compliance with this specification.

c) Reinforcing steel

General

Reinforcing steel used in reinforced concrete shall comply with the following standards:-

Deformed bars shall be of grade Fe500 and conform to IS: 1786.

Mild steel shall conform to IS: 432.

Mesh reinforcement shall conform to IS: 1566.

Binding wire

Binding wire for general use shall be annealed wire 16/18/20 BWG conforming to IS 280. The number of strands shall be as per IS specification.

Reinforcement supports

- Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing; supporting, and fastening the reinforcement.
- Spacers shall be cast from concrete of the same quality as that in which they will be embedded.
- Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.
- Binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the Bidder shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

Certificates

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analyzed and the date of such tests and analyses and that such tests and

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analyses comply in all respects with the standards. The following tests shall be carried out on reinforcement:-

- Cast analysis
- Carbon equivalent value
- Tensile strength, yield stress, elongation
- Bend test
- Bond classification
- Chemical analysis

Stock of reinforcing steel

In order to ensure due progress of the works, the Bidder shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted as satisfactory by the Owner/Consultant.

Rejection

The owner at his discretion may order random testing of the reinforcement steel and in the event of any failed test reject the entire lot notwithstanding the manufacturer's or coating applicator's certificates.

The Bidder shall remove all rejected reinforcing steel from the site without delay at his own expense.

Storage

All bars for reinforcement and steel fabric reinforcement shall be stored on the site under cover on timber or concrete supports suitably spaced and of sufficient height to keep the steel not less than 150 mm clear of the ground.

Bar-bending Schedules

The Bidder shall prepare bar bending schedules based on the detailed reinforcement drawings. These shall be presented to the Owner/Consultant for review. The Bidder is fully responsible for their completeness and correctness in every way nor shall any claim for extra cost or time be allowed on the grounds of errors or discrepancies which may arise between drawings and schedules.

d) Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. pH value of water shall not be less than 6.

Only potable water shall be used. Tests and quality of water shall be in accordance with IS: 456 or equivalent.

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e) Aggregates

General

The aggregates for concrete shall be crushed natural rock subject to Owner's approval.

The aggregate to be used in the work shall be supplied from an established pit or quarry.

The concrete supplier shall obtain from the aggregate producer, or otherwise provide current test, examination, and inspection reports performed and certified by an approved laboratory for submittal to the Owner/Consultant.

As a minimum, this information shall include the following items:-

- **Item 1**

A comprehensive description, with current photographs of the pit or quarry, including but not limited to, identification by name and location, type of deposit, age, potential reserves, primary products by size including average gradation based on previous six (6) months production and the range for each sieve size; mining methods, process equipment, quality control organization and laboratory; the primary and alternate means of product transportation; listing of primary and secondary users of the product.

- **Item 2**

Petrographic examination in accordance with IS: 2386 (Part-8) and ASTM C-295 performed by a qualified concrete aggregate petrographer. This report shall be based on material produced and examined within the previous six (6) months and must be representative of the current production.

- **Item 3**

Coarse aggregate shall be sampled from current production in accordance with IS: 2386 (Part 1 to 8). Three [20 mm, 10 mm & 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:

IS 2386(Part 1): Methods of test for aggregates for cement: Part 1
Particle size and shape (Amendments 3)

IS 2386(Part 2): Methods of test for aggregates for concrete: Part 2
Estimation of deleterious materials and organic impurities (Amendment 1)

IS 2386(Part 3): Methods of test for aggregates for concrete: Part 3
Specific gravity, density, voids, absorption and bulking

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- IS 2386(Part 4): Methods of test for aggregates for concrete: Part 4 Mechanical properties (Amendments 3)
- IS 2386(Part 5): Methods of test for aggregates for concrete: Part 5 Soundness
- IS 2386(Part 6): Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregates (Amendments 2)
- IS 2386(Part 7): Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity
- IS 2386(Part 8): Methods of test for aggregates for concrete: Part 8 Petrographic examination
- ASTM C-295 Standard guide for petrographic examination of aggregates for concrete

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the Owner/Consultant shall meet the requirements of IS: 383 and IS: 456.

Testing is to be carried out at the following intervals:

Table 2.7
Grades of Concrete

Type	Coarse Agg.	Fine Agg.
Grading	Daily	Daily
Specific Gravity	7 days	7 days
Magn Sulphate soundness	30 days	-
Clay, Silt and dust content	Daily	Daily
Shape (elongation and flakiness)	3.5 days	-
Los Angeles Abrasion	Initial stage only	Initial stage only
Moisture content	2 days	Daily
Drying shrinkage	Initial only	Initial only
Organic impurities	30 days	30 days
10% fines value for concrete	7 days	-

Combined grading shall also be done on a daily basis.

Storage and handling of aggregates

- Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent wind blown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.

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- Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect against wind blown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.
- Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.
- Rescreening Coarse Aggregate: Rescreening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If rescreening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.
- Natural or manufactured sand shall be allowed to drain until it has reached somewhat uniform moisture content before it is used.

Fine Aggregate

Fine aggregate source shall be manufactured crushed stone or river sand, excluding fines, which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone nor 4% for natural sand.

The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

Crushed Stone Sand

- i) Concrete subject to abrasion 1% by weight
- ii) All other concrete 3% by weight

There shall be no clay or fine silt present.

The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on an IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS: 383.

The grading of the aggregates should be such as to produce a concrete of the specified proportions, which will work readily into position without segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

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A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of silt adhering to the aggregate is found to be unacceptably high.

Coarse Aggregate

Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The unit weight of the coarse aggregate shall not be less than 2.5 t/m³. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm² when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

Samples of aggregates shall be submitted to the Owner/Consultant, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the Owner/Consultant have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

f) Concrete additives

Use of Concrete Additives

Concrete additives approved by the Owner/Consultant shall be used to improve consistency, workability, quality and strength of the concrete.

Chemical admixtures manufacturer shall provide certified test reports from qualified independent laboratories showing actual test results indicating material that complies in all respects with the applicable specification.

Admixtures used in concrete shall conform to the appropriate specification and requirements as indicated below:-

- Air entraining admixtures shall conform to IS: 9103.
- Water reducing and retarding admixtures shall conform to IS: 9103. Accelerating admixtures shall not be used.

High range water reducers shall be naphthalene-sulfonated polymer based material. No admixtures containing chlorides shall be used.

- Chemical admixture suppliers shall provide certified test reports with each shipment indicating compliance with the appropriate specification. The test reports shall include the chloride content of the admixture, specific gravity and solids content.

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- Fibers: Polypropylene fibers shall be collated, fibrillated polypropylene fiber of approved manufacture.
- Admixtures used in production of concrete shall be the same as used in establishing the required concrete mix and shall be used in accordance with the manufacturer's directions.
- Liquid admixtures shall be stored in such a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations

Accelerating and Retarding Additives

Such additives shall only be used in case of necessity and after obtaining the written approval of the Owner/Consultant.

Plasticizers and Air entraining Additives

Plasticizers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Owner/Consultant and in accordance with the manufacturer's instructions.

5.10 Dismantling/Demolishing and Modification in PCC&RCC

- The dismantling implies, carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of a structure. This includes chipping work, cutting of reinforcement, making holes/opening etc. in concrete members, according to the required shape, size and profile at all elevations.
- The term demolition implies, taking up or down or breaking up of a structure/member, in part or full, as specified or shown in the drawings or as directed by Engineer.
- In a structural member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as directed by the Engineer.
- All material obtained from the demolition/dismantling work shall be property of the Owner, unless otherwise specified.
- All serviceable materials obtained, shall be separated out and stacked properly upto a lead of [500 meter] or shall be returned to OWNER's stores and all unserviceable materials, rubbish etc., shall be disposed off as directed by the Engineer, upto a lead of [2kms].
- The dismantling / demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process or work.
- Necessary propping, shoring and under pinning shall be provided for safety of adjoining work or property which is to be left intact, before dismantling/demolishing work.

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- All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall be taken to keep the dust nuisance down. Safety requirements stipulated in IS: 4130 shall also be followed.
- As and where necessary, the dismantled/demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Engineer. Wherever required, temporary enclosures shall be erected to minimize the dust or moisture infiltration.
- Wherever fresh concrete is laid over old concrete, to ensure proper bond between old concrete and fresh concrete, the surface of old concrete shall be thoroughly cleared by removing all loose particles and coat of epoxy paint shall be applied.

5.11 Minimum Cover to Foundation Bolts

Minimum distance from the centre line of foundation / anchor bolt to edge of pedestal shall be the maximum of the following:

Clear distance from the edge of base plate / base frames to the outer edge of the pedestal shall be minimum 50 mm

Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm

Clear distance from the edge of sleeve or anchor plate to the edge of pedestal shall be 75 mm

5.12 Miscellaneous Requirements

Fillets at the junction of roof and vertical walls shall be provided with cast in-situ cement concrete 1:2:4 (nominal mix) followed by 12 mm thick 1:4 cement mortar.

A screed layer not less than 100 mm thick of cast in-situ concrete of nominal mix 1:3:6 shall be provided below all water retaining structures. A sliding layer of craft paper or bitumen paper shall be provided over the screed layer to destroy the bond between screed and base slab.

Plywood formwork shall be used for all water retaining / conveying structures and for all over ground concrete works. For other areas steel/ plywood formwork shall be used.

Unless specified 20 mm and down graded aggregates shall be used for all structural concrete works. However 40 mm and down graded aggregates may also be used under special conditions for foundation.

Tolerance for formed and concrete dimension shall be as per IS: 456.

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5.13 Major Equipment Foundation

Special requirements for concreting of major equipment foundations shall be as given below:

Coarse Aggregates

Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali aggregate reaction. Materials, which contain high percentage of reactive silica, shall not be used. In exceptional cases of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations, which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundations).

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25° C when placed. For maintaining the temperature of 25° C in the top deck of machine foundations, crushed ice shall be used in mixing water.

Admixture

Plasticizer cum retarder/accelerating type admixture shall generally be added to the concrete for promoting workability in addition to retarding / accelerating setting time for mass concreting work. The Bidder shall submit the mixing proportion/report after conducting the design mix as per the relevant codes and standards. The slump of concrete shall generally be in the range given below:

Block foundation	: 100mm to 150mm
Column	: 100mm to 150mm

Formwork

Plywood formwork shall be used for the top deck of all machine foundations. Any other type of formwork required to be used may be permitted subject to prior approval of the OWNER/CONSULTANT after submission of the required data.

Scheme for Concreting

Batching plants shall be mobilized for all RCC works. Concrete pump shall be mobilized for all foundations. Arrangements for stand-by Plant and Equipments shall also be made.

Placing of Concrete

Base mat as well as top deck of machine Foundations shall be cast in a single pour. However the BIDDER shall submit method statements for various structures and shall get the prior approval from the OWNER/CONSULTANT before placing the concrete.

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Ultrasonic Testing

Ultrasonic pulse velocity test shall be carried out for the top deck of all machine foundations to ascertain the homogeneity and integrity of concrete. In addition, additional cubes (at the rate of one cube per 150 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values. Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the BIDDER shall rectify the defects suitably using cement / epoxy grout etc.

5.14 Transport of Concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods, which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The Concrete shall be transported by transit mixers of adequate capacity. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Owner/Consultant.

The Bidder shall obtain permission well in advance of any concrete pour.

5.15 Concreting Operations

Inspection prior to Concreting

All concreting methods shall be subject to the approval of the Owner/Consultant.

Concrete placing shall not be started until the Owner/Consultant has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

Placing of Concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The Bidder shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

The temperature of concrete shall not exceed 40°C measured at discharge into the works.

The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable differential temperature between any two points in the same element is 15°C. Additional temperature control measures during

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construction (such as the use of insulated formwork) will be required. Bidder to prepare a process control chart and method statement verifying measures to achieve these requirements.

Temperature monitoring of concrete work is required where:

The minimum dimension of any casting is 0.8 metres or more, or otherwise instructed by the Owner/Consultant.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours time shall be subject to the same treatment as the construction joints.

Concrete shall not be dropped into place from a height exceeding 1.5 metres. Trunking and chutes to Owner/Consultant's approval shall be used for any concrete to be deposited from a height exceeding 1.5 m.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

5.16 Compaction and mechanical vibration of concrete

As concrete is being placed it shall be compacted by mechanical vibrators complying with IS: 2505, IS: 2506, IS: 2514 & IS: 4656, to obtain a dense material free from honeycombing, free from water and air holes.

The Bidder shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation/bleeding caused, but complete compaction of the concrete is achieved.

5.17 Finish of concrete

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

5.18 Construction, expansion and contraction joints

Construction joints

The number of construction joints should be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

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Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subject to agreement between the Owner/Consultant and the Bidder before any work commences. Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Concrete should not be allowed to run to a featheredge and vertical joints should be formed against a stop board.

The top surface of a layer of concrete should be level and reasonably flat unless design considerations make this undesirable. Joint lines should be so arranged that they coincide with features of the finished work.

If a kicker (i.e. a starter stub) is used it should be at least 70 mm high and carefully constructed. The kicker must be incorporated with the previous concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

The maximum horizontal length of wall to be poured in one operation in any one direction is 7.5 metres. A period of 7 days to be allowed between adjacent pours except where water stops are provided when this can be reduced with Owner/Consultant's approval. Alternatively a gap of 600 mm width shall be left between adjacent pours and filled after 7 days from the date of formation subject to Owner/Consultant's approval.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible a vibrator should be used.

Where the Owner/Consultant considers that special preparation is necessary, i.e. for an in-situ structural connection, preparation should be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush, which is sufficient to remove the outer mortar skin and expose the larger aggregate. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking of hardened surfaces should be avoided.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

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Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.

Joints shall be straight and vertical, except where otherwise specified, and concrete surfaces on both sides of the joint shall be flush. Where necessary, water stoppers of a type approved by the Owner/Consultant shall be embedded in the concrete. The water stopper should be made of high quality material, which must obtain its resilience through the service life of the structure for the double function of movement and sealing. The surface of water stoppers should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints the water stopper should be provided with anchor parts. The cross-section of the water stoppers should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

All joints between structural steel and concrete parts shall be sealed by a suitable permanent flexible compound.

5.19 Concreting at night

When approval is given to carry out concreting operations (under control of the Owner/Consultant) at night or in places where daylight is excluded, the Bidder has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

5.20 Protective measures for concrete

In general, the cover of rebars shall be as per IS: 456 taking into account the site conditions. However, the minimum concrete cover shall not be less than:

Concrete parts above ground (external surface)	: 40 mm
Concrete exposed to underground & groundwater	: 50 mm
Isolated footings	: 50 mm
Raft	: 75 mm
Slabs	: 25 mm
Beams	: 25 mm
Columns	: 40 mm

Immediately after the compaction of the concrete has been finished, the Bidder shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constant moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Owner/Consultant. Where formwork cannot be removed within

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24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Owner/Consultant's approval to the use of a particular curing compound and to the method of application will only be given after the Bidder has completed satisfactory site trials and a sample panel has stood for at least 28 days.

Where large sections of concrete are poured, special precautions to the approval of the Owner/Consultant shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete.

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind, however light, shall be allowed on concrete which has not properly set and the Bidder shall prevent any load to be imposed on the concrete structures until it has been declared by the Owner/Consultant to be ready to carry loads.

5.21 Concrete with Special Properties

General requirements

The pre-condition for obtaining concrete with special properties is that it should be made with the appropriate composition, that it is placed in such a way that segregation does not occur and further that it is fully compacted and given appropriate curing.

Waterproof concrete

This concrete must meet the provisions of IS: 3370. Waterproof concrete must be sufficiently dense (impermeable).

Waterproofing and protection of underground concrete structures

Water aggressive to concrete should be kept away from the fresh concrete.

Concrete, which is exposed for a prolonged period to "very severe" chemical attack, must be protected against direct access of the aggressive substances.

The protection, which is to be laid as protection to all concrete surfaces in contact with the ground, shall consist of an approved waterproofing membrane. The membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane.

Such membranes shall be PVC sheets of minimum 0.35 mm thickness with knobs of Maxlock.

The waterproof membranes shall be installed in strict accordance with manufacturer's instructions.

The membranes shall extend 15 cm above ground level.

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When setting forms and reinforcing steel caution shall be exercised to avoid damage to the impervious membrane. The surface of the impervious membrane extending outside the forms shall be protected during subsequent operations.

Any puncture or damaged areas shall be cleaned and patched according to manufacturer's instructions.

Concrete with high wearing resistance

Concrete which is exposed to severe mechanical action, e.g., due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, should possess high wearing resistance and correspond at least to grade M30.

The aggregate upto 4 mm size should consist predominantly of quartz or materials of at least equal hardness; the coarser particles should consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action, it will be necessary to use special hard materials. The particles of all types of aggregate should have a moderately rough surface and be of compact shape. The combined aggregate should be as coarsely graded as possible.

Furthermore, the concrete should be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete should be kept moist for at least 7 days after placing.

Finishing of formed surfaces

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that shall be covered with earth backfill. Exterior surfaces that shall be exposed above grade and all interior surfaces, except those not usually exposed to view shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed. The resulting recesses shall be cleaned, wetted, and filled with patching mortar. Patches on rubbed surfaces shall match the texture of the adjacent concrete.

Finishing of unformed surfaces

No surface treatment shall be required for buried or permanently submerged concrete. As a minimum, unformed surfaces shall be finished by screeding and floating. Surfaces requiring a trowelled finish shall be finished by screeding, floating, and trowelling.

Float finished and screeded surfaces shall be finished to provide a flat profile within a 6 mm deviation as measured from a 3 m straightedge. Trowel finished

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surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 3 mm when measured from a 3 m straightedge.

Screeding

Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

Floating

The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and colour.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

Trowelling

The exposed portions of the tops of equipment bases, tops of interior curbs, and the surfaces of interior slabs not receiving a separate finish shall receive a steel trowel finish. Trowelling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Trowelling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

Surfaces to be covered with neoprene-hypalon coatings shall be lightly trowelled but not burnished.

Brooming

Brooming shall follow the float finish for exterior surfaces where a nonslip surface is required. Brooming shall be done with an acceptable steel or fiber broom not less than 450 mm wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1.5 mm and 3 mm deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

Aggregate Exposure

Surface mortar shall be removed and the aggregate exposed from surfaces that shall be covered with mortar, concrete, or grout at a later time.

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Edging

Unless specified otherwise, exposed edges of floated or troweled surfaces shall be edged with a tool having a 6 mm corner radius.

Finishing mortar

Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 102 kilograms of concrete sand to one sack of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 50 mm.

Separate finishes

Certain slabs surfaces shall be finished with a separate concrete finish or floor covering.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances. Low areas shall be filled. High spots shall be ground slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 3 mm from a 3 m straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the drawings or a float finished surface set 3 mm low and levelled with trowel finished fill material.

Surfaces that receive a mortar set quarry tile, ceramic tile, or vitrified finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 6 mm as measured from a 3 m straightedge.

5.22 Formwork

Design and construction

For stability and type of formwork and support framing used, IS: 14687 is to be observed.

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section) "Dimensional Tolerances".

The Bidder shall submit in sufficient time in advance for the approval of the Owner/Consultant the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Particular attention must be paid to the formwork supports and braces to avoid any slip when the concrete is poured.

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Materials for formwork

Forms shall be constructed from steel or from sound timber well seasoned and free from shakes. Plywood lining for forms shall be of timber, which is resin-bonded and water repellent.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete. Where a slope exceeds 1 V: 2 ½ H, formwork shall be provided for the top of the concrete faces and anchored to prevent flotation.

The details of fair-faced concrete facades have to be to the satisfaction of the Owner/Consultant. The concrete surface for facades has to be absolutely stainless and all efforts have to be taken to achieve this. All the proposed formwork shall be properly designed before its usage.

Grading of formwork and of finished concrete surfaces

Quality of formwork, materials to be used and treatments of surface are graded according to the finish of the concrete surface as given in IS: 14687.

The type and treatment of the formwork lining (plywood, metal, plastics, etc) should be appropriate to the grade of concrete finish required.

Preparation and inspection of formwork

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces, which are not oiled, shall be wetted thoroughly to prevent warping.

Erection and placing of formwork

All formwork shall be erected and placed in accordance with the construction drawings approved by the Owner/Consultant. Shuttering shall be true to line and braced and struttred to prevent deformation under weight and pressure of the wet concrete, live loads, wind and other forces. The deflections shall not exceed 3 mm.

The formwork for beams and slabs shall be erected so that the form on the sides of the beams and of the soffits of slabs can be removed without disturbing the beam soffit.

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If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Wherever necessary, panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc shall be fixed to the formwork carefully.

Panels shall be put together to ensure a perfect fit at the joint and fixed in both directions.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on the drawings as "Fair-faced Formwork".

Where concrete surfaces are covered (non-exposed surfaces), the formwork shall be referred to and marked as "Sawn Formwork".

Internal spacers and ties, if any, shall be so arranged that after removing of the forms no holes shall extend through the concrete, in the case of watertight concrete or to be closed by plastic plugs and epoxy mortar in all other cases.

All formwork will be inspected and approved by the Owner/Consultant before concrete placing commences but this shall not relieve the Bidder of any of his responsibilities under the contract.

Striking of formwork

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

In accordance with IS: 456 clause 11.3.1, the striking period for cast in-situ concrete under certain conditions may be taken as follows: -

**Table 2.8
Formwork**

Type of Formwork	Minimum period before striking formwork
Vertical formwork to columns, walls, beams	16 to 24 hours
Soffit formwork to slabs (props to be refixed)	3 days

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Type of Formwork	Minimum period before striking formwork
immediately after removal of formwork)	
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs:	
1) Spanning upto 4.5 m	7 days
2) Spanning over 4.5 m	14 days
Props to beams and arches:	
1) Spanning upto 6 m	14 days
2) Spanning over 6 m	21 days

Special care is necessary in the case of components, which have to carry nearly the full-calculated load as soon as the formwork is struck.

Columns, piers and walls are to be struck before the beams and slabs supported by them. Scaffolds, formwork supports and self-supporting floor formwork are to be carefully lowered by releasing the devices.

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

To keep deflections through creep and shrinkage to a small amount, auxiliary supports should be left in place or immediately repositioned after striking.

5.23 Water stoppers

Water stoppers shall be of PVC or equivalent and shall be eye-letted with a minimum 25 cm width. Type and manufacturer shall be submitted to the Owner/Consultant's approval.

All intersection pieces shall be prefabricated by the manufacturer and only welding of butt-joints in running lengths will be allowed to be carried out on the site.

The site welding of butt-joints shall be executed by using the manufacturer's purpose-made electrically heated jig and work shall be done by competent and trained personnel only. The manufacturer's instructions shall be carefully observed.

The wings of the water stoppers shall be formed with corrugations or bulbs to achieve a good bond. Moreover, the water stoppers shall conform to the following requirements:-

- The tensile strength not less than 10 N/sq.mm when tested.
- The ultimate elongation shall not be less than 22% when tested.
- The tear resistance shall not be less than 2 N/sq.mm when tested.
- The material shall not crack when tested.

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- Under accelerated elongation, the tensile strength shall not be less than 8 N/sq.mm and the ultimate elongation shall not be less than 200%.

The water stoppers shall be installed so that they are securely held in position during the placing of concrete, which shall be fully and properly compacted around the water stoppers to prevent voids or porous areas. Adequate clearance between the reinforcement and all the water stoppers shall be kept to permit proper compaction of concrete.

No holes or nailing shall be made through any water stopper for fixing purposes. Jointing by lapping two pieces of water stoppers shall not be permitted.

The free edges of water stoppers shall at all times be protected from direct sunlight.

5.24 Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed and if required the concrete may be protected for few more days as per the design mix / approved methodology.

Trowelled surfaces except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane-curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

Water curing

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water may be interrupted for surface rubbing. The concrete surface shall not be permitted to dry.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap and kept saturated for the remainder of the curing period.

Membrane curing

Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at coverage of not more than 7.4 sqm/litre. Membrane curing shall not be used on surfaces that shall be covered at a later date with mortar, concrete, damp proofing, tile, or any coating. Membrane curing shall not be used on cast-in-place concrete bases for field-erected tanks. Membrane curing will be permitted only after prior approval of the OWNER/CONSULTANT.

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Floor sealer

All concrete floors shall be given two coats of clear floor sealer in addition to that applied as membrane curing compound. The first coat shall be applied at the end of the curing period before any traffic is permitted on the floor. The second coat shall be applied after the floor has been cleaned in preparation for the final inspection. Floor sealer shall be applied in strict accordance with the manufacturer's recommendations.

5.25 Waterproofing/Damp proofing

A waterproofing seal shall be provided for all below grade structures where applicable by external tanking with PVC sheets of 1.0 mm thickness with knobs for membrane type waterproofing. In addition, joints in deep underground structures shall be provided with structural waterproofing.

Damp-proof course 40 mm thick, consisting of cement concrete 1:2:4, with admixture of approved water-proofing compound shall be laid at plinth level for walls of all buildings for protection of super-structure against moisture and dampness.

5.26 Repair of damaged and defective concrete

Concrete after its final setting shall be inspected by the Owner/Consultant and any cracks, honeycomb areas, segregations, etc shall be marked. No repairs shall be carried out until directed by the Owner/Consultant.

Surface defects in formed concrete shall be repaired to the satisfaction of the Construction Manager within 24 hours. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 25 mm shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the concrete is placed.

Defective concrete shall be replaced within 48 hours after the forms have been removed.

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6 PRESSURE GROUTING

The work shall consist of drilling grout holes, exploratory holes and check holes, pressure testing, pressure washing, and injecting suspension grout under pressure, and shall include furnishing of all materials, labor, and equipment as described and specified.

6.1 Materials

a) Cement

Portland cement shall be contains less than 0.6 percent alkali.

b) Aggregate

Aggregate shall be non reactive and shall be washed before use. When sources of aggregate are changed, test reports shall be provided for the material from the new source prior to commencing grout work. Fine aggregate shall be sand or crushed stone.

c) Admixtures

Admixtures shall be compatible with the grout and shall comply with the manufacturer's recommendations. Admixtures shall be added to the grout mix separately.

Water Reducing Retarder: Water reducing retarder shall comply with relevant Indian standard or as approved by Owner.

Lubricant: Lubricant additive for cement pressure grouting shall be Intrusion Prepakt Intrusion Aid, Sika Intraplast N, or as approved by Owner.

d) Water

Waste for washing aggregate, for mixing and for curing shall be potable, shall not contain more than 1000 mg/l of chlorides as Cl, nor more than 1300 mg/l of sulfates as SO₄, and shall not contain impurities which may change the setting time by more than 25 percent or a reduction of more than 5 percent of the compressive strength of the grout at 14 days when compared to the results for grout made with distilled water.

e) Grout

Drypack Grout

Drypack grout shall be a mixture of approximately one part cement, 1.5 parts sand, water reducing retarder and sufficient water to make a stiff workable mix, branded Dry Pack or approved equal.

Cement Grout

Cement grout shall be a mixture of one part cement, two parts sand proportioned by volume admixtures for pressure grouting and sufficient water to form a workable mix.

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Nonshrink Grout:

- Non-shrink expansive flowable grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticiser admixture shall be added in the grout. For grouting of base of machine foundation high strength ready mixed non-shrink flowable grout shall be used.
- Type and grade of grouting for structural columns and equipment bases shall be as indicated. Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M 30.
- Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipment. For secondary posts, stair and ladder base, etc. grouting shall not be less than 25 mm thick.

Special grout, where specified on the drawings, shall be provided in strict accordance with the manufacturer's instructions/specifications. Pre-mixed Grout Conbextra GP-2 of 'FOSROC' make or equivalent of crushing strength 650 kg/cm² for major equipment foundations and Conbextra GP-1 or equivalent having crushing strength of 450 kg/cm² for other foundations where concrete grade M30 or higher is provided

- Forms and shims used to obtain adequate clearance shall not be removed and the anchor bolts shall not be tightened for at least three days after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and edge of the foundation shall be finished smooth to allow drainage away from the base. Attachment of interconnecting piping of machinery and complete load transfer of machinery shall not be done before the bolts are tightened. During this period, grouting work shall be properly cured using rags/gunny bags.

In view of extremely small proportion (about 0.01% by weight of cement) of the aluminium powder required, it is necessary to take all precautions to ensure thorough mixing. It is advisable to mix the blend of aluminium powder thoroughly with sand and cement before water is added because aluminium powder has a tendency to float on water.

- Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement: 1 admixture: 1 sand), or as per manufacturer's instructions.

Pre-mixed non-shrinking grout shall be used as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

Epoxy Grout for Crack Repair and Dowel Anchorage

Except for applications involving pressure grouting or crack injection, epoxy shall be a high modulus, moisture insensitive, two components, 100 percent solids, thermosetting modified polyamid epoxy compound. The material shall

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equal which is capable of not sagging in horizontal or overhead anchoring applications.

Epoxy for applications involving pressure grouting or crack injection, shall be a high modulus, moisture insensitive, two components, injection grade, 100 percent solids blend of epoxy resin compounds. The material shall equal which is capable of achieving complete penetration of hairline and larger cracks.

Polymer Concrete for Resurfacing and Patching

Polymer concrete shall consist of a liquid binder and dry aggregate mixed together to make a flowable mortar. The liquid binder shall be a chemical and oil resistant, stress relieved, low modulus, moisture insensitive, two component epoxy resin compound. The binder material shall equal with a consistency similar to light weight oil for proper mixing with the aggregate. The aggregate shall be oven dry, kept in sealed packages until the time of mixing and be of size and consistency compatible with recommendations of the manufacturer of the liquid binder for the intended application.

Adhesive Resin for Dowel Anchorage:

Pneumatically operated caulk gun and automatically mixed at nozzle. Subject to compliance with one of the following: HIT RE500-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-2322), HIT-HY 150 MAX-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-3013), SET-XP Adhesive Anchoring Systems, Simpson Strong-Tie Co. (ICC ESR-2508).

6.2 Pressure Grouting Equipment

Pressure grouting equipment shall include a mixer and holdover agitator tanks designed to place grout at pressures up to 0.345N/mm^2 (50 psi). Gauges indicating grouting pressure shall be provided and the mixer shall be equipped with a meter capable of indicating to within 0.003 m^3 the volume of grout placed.

6.3 Execution

Bonding compounds for use with grout is to be provided and installed per the manufacturer's recommendations.

a) Drypack Grout

Drypack grout is to be used for built-up surfaces, setting miscellaneous metal items and minor repairs.

Surfaces required to be built-up with drypack grout are to be roughened by brushing, cleaned and coated with the bonding compound before application of grout. The grout is to be applied to the required thickness.

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b) Cement Grout

Cement grout is to be used for filling nonbearing portions of equipment pads and pressure grouting.

Except for the specialized requirements for pressure grouting, grout is to be mixed and placed in the same manner as cast-in-place concrete. Grout is to be mixed for at least one minute and diluted grout is to agitated until placed.

c) Non-shrink Grout

Nonshrink, nonmetallic aggregate grout is to be used under equipment, bearing plates and column base plates. Nonshrink, metallic aggregate grout is to be used under rotating equipment where high strength and fatigue are of concern, to grout anchor bolts and to grout reinforcing steel. Grout is to be placed and cured in accordance with the manufacturer's recommendations.

Holes required for grouting shall be blown clean with compressed air and are to be free of dust or standing water. Horizontal holes for grouting are to be drilled at a slight downward angle and with the inserted dowel or bolt bent to match.

d) Epoxy Grout

Epoxy grout shall be used for repairing cracks by pressure grouting or gravity, repairing structural concrete and may be used for setting dowels or bolts in holes. Concrete is to be primed in accordance with the grout manufacturer's recommendations.

The use of epoxy grout must comply with the following restrictions:

- Limited to areas where exposure, on an intermittent or continuous basis, to acid, chlorine gas or to machine or diesel oils, is extremely unlikely.
- Limited to applications where exposure to fire or to concrete temperatures above the product heat deflection temperature or 120 deg F (40 deg C)(whichever is less) is extremely unlikely. Overhead applications are not allowed.
- Holes for the anchors shall be drilled (not cored), shall be blown clean with compressed air and shall be free of dust or standing water.
- The anchor type, size and embedment depth shall be as shown on the drawings and the anchor must be installed in accordance with the manufacturer's recommendations.
- The anchor must not be loaded until after the full curing period has elapsed.

e) Pressure Grouting

Prior to grouting, cracks and holes to be grouted shall be washed clean. Washing is not required for grouting soil voids. Once started, grouting shall be continuous until completed. In case of a mechanical failure or other stoppage of the work, the grout equipment shall be washed out sufficiently to ensure that fresh only grout is pumped when the work is restarted.

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After grouting is completed, the Contractor shall remove the grouting plant and all related parts, equipment, and supplies from the site, including unused materials and waste.

6.4 Field Quality Control

- Bidder shall make suitable arrangements for carrying out all the necessary quality tests and ensure that testing work shall be carried out in compliance with the standards.
- Testing of grout mixes for conformance to manufacturer's specified strength: The independent testing laboratory shall take four test samples of each day's grout mix and test grout mix samples at 7 and 28 days. Test reports shall be submitted to the Owner for review.
- Test 25 % of reinforcing steel dowels installed with adhesive resin on a given day in tension using pullout procedure. Test to 80% of specified yield strength of the dowel with special inspection. Dowels specifically noted on the drawings as "No test required" do not require tension testing.
- If the failure rate of dowels exceeds 10 percent, testing will be increased to 100 percent of that day's installation of similar anchors or dowels. Testing will be reduced to 25 % of that day's installation when the failure rate is reduced to 10 percent or less. Failed dowels will be replaced at no additional cost to the Owner. The Contractor will produce daily reports of all testing activities; copies of daily reports will be submitted to the Owner in a timely manner.

6.5 Submittal

- Manufacturer's data shall be provided for bonding compounds, dry pack, non-shrink, pressure grout, retardants, epoxy grout, polymer concrete.
- Test reports, accompanied by a manufacturer's statement that previously tested material is of similar type, quality, and manufacture as that which is proposed for use on this projects, shall be submitted for Cement, Aggregates, Retardants, Bonding compounds and Epoxy resin
- The testing laboratory shall provide evidence of correction of deficiencies noted in the inspection report before materials specified in this section are delivered to the job site.

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7 RETROFITTING WORKS

7.1 General

- a) The Work shall, in general, conform to other works/items specified in this Specification.
 - If the specifications for any item are not available in in this Specification cited above, relevant BIS Specifications should be followed.
 - In case BIS Specifications are also not available, the decision of Engineer-in-Charge given in writing based on acceptable sound engineering practice and local usage shall be final and binding on the contractor.
- b) The work will be carried out in accordance with the architectural and structural drawings to be approved by Owner. The structural and architectural drawings shall have to be properly correlated before executing the work.
- c) For items where so desired, samples shall be prepared before starting the particular items of work for prior approval of the Owner and nothing extra shall be payable on this account.
- d) Materials brought at site of work shall not be used in the work before getting satisfactory Mandatory test results.
 - Equivalents for the various materials and the materials of approved make shall be got approved from the Owner in writing before using them on the work.
- e) The contractor shall submit the required documents regarding the genuineness of materials used such as manufacturer's certification that the firm has manufactured the supplied materials.
- f) The contractor shall get approved from the Owner the storage space for epoxy/polymer/patented/other manufacture of materials to ensure that the storage temperature is maintained between 5° C and 38° C unless recommended otherwise by the manufacturer.
- g) Contractor shall comply with manufacturer recommendations so as to comply with environmental conditions under which the repair materials may be applied.
- h) The contractor shall employ Principal Technical Representative & skilled site workers who shall have adequate qualifications and experience for the proper execution of such works and already performed works of this kind with success.
- i) Contractor shall advise all workers working with epoxies to avoid contact with eyes and skin, inhalation of vapours, and ingestion. Necessary protective and safety equipments in the form of hand gloves, welders' goggles, shall be provided by the contractor and used on site.

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- j) Care shall be taken to ensure that vibrations are well within acceptable limits for structural safety and users of the building.
- k) For the execution of protection and repair works, properly maintained plant and equipment permitting adequate treatment of the concrete substrate, proper execution of the work and determination of the required properties of the construction materials and construction measures must be present on the construction site.
- l) To ensure efficient and effective functioning, all plant and equipment must be checked on-site and at field material testing laboratory prior to first use and at appropriate intervals thereafter.

7.2 Chipping of Unsound/Weak Concrete Material

a) Purpose

To remove weak, loose or carbonated concrete over an area from its surface with pneumatically operated or power driven tools by chiselling, chipping etc.

b) Materials and Tools & Plants (T&P)

Power or pneumatically driven chisel, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator (0.2% phenolphthalein solution) with pH range at least up to 10.5 and clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support to relieve the structural member of stress and strains.

Step-2: Scaffolding, if necessary for the exterior members, shall be done for working upon the area.

Step-3: Working Platforms for interior members, if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if necessary.

Step-5: Mark off the area to be repaired using straight lines between corners. The marked area shall have 90° corners with the sides parallel or normal to the direction of the reinforcement. The marked boundaries for the repair area should be a minimum of 50 mm outside the perimeter of the spall. For a single spall, the repair area should have a minimum width of 100mm in any direction. If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair.

Step-6: Cut shall be made along the marked boundary, normal-to-the surface. It should be made with a diamond cutter blade. However, when diamond cutting is not practical, the normal cut can be made with a power driven chisel. Minimum depth of cut shall be 10 mm. In situations where the diamond saw could cut

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into the reinforcing steel due to inadequate concrete cover, the boundary edge should be formed manually by means of chisel and impact hammers. A cover meter could be used to estimate the depth of cover.

Step-7: Chipping to remove all the unsound and weak concrete material shall be done carefully from the damaged portions of structural members by adopting mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

e) **Tolerance**

The chipping tolerances shall be ± 5 mm.

f) **Chiselling**

Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer. Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm Mechanical Milling (single drum, rotary cutter head with Tungsten-carbide bits) is applicable for large areas where the concrete cover is to be removed. Care must be taken to avoid contact with the reinforcing steel as both the reinforcement and the cutter drum could be damaged. Rounded And Feathered Edges should be hand cut to form normal-to-the-surface boundaries. All the edges and cavities shall be square shouldered.

Step-8: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on concrete in contact and in the immediate vicinity of reinforcement soon after its chipping. As otherwise, chipped concrete surface in contact with air is likely to get carbonated soon after its coming in contact with atmospheric carbon dioxide.

Step-9: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, in case the concrete in contact and in immediate vicinity of the reinforcement is carbonated.

Step-10: Inspection and soundness testing, after concrete removal & cleaning, for weaknesses and delamination of exposed surfaces shall be visually carried out. If required, additional removal will be done.

Step-11: Cleaning of debris and dust shall be carried out from within the chiselled/ chipped area and its disposal as per direction of the Engineer-in-Charge.

7.3 Removing concrete all around reinforcement including from its behind

a) **Purpose**

To create an average clear air gap equal to nominal size of coarse aggregate plus 5 mm all around embedded reinforcement, in contact with carbonated concrete for rust removal & passivating its surface with fresh alkaline passivating coat and concrete/ mortar.

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b) **Materials and T&P**

Power or pneumatically driven chiselling, abrading, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator i.e. 0.2% solution of phenolphthalein indicator for pH range preferably up to 11.5 or at least up to 10.5, clinical injection syringe.

c) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

d) **Procedure**

Step-1: Prop and support, if not done already, to relieve the structural member of stress and strains.

Step-2: Scaffolding & working platforms for the exterior members, if not already done and if necessary, shall be erected for working upon the area.

Step-3: Working Platforms for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if not already done and if necessary.

Step-5: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on freshly chipped concrete in contact and in the immediate vicinity of reinforcement.

Step-6: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, if the concrete in contact and in immediate vicinity of the reinforcement is carbonated. The concrete around reinforcement shall be removed so as to have a near uniform air gap of about 5 mm plus the nominal size of coarse aggregate to be used in repair concrete/mortar. However, the air gap shall not be less than 15 mm in any case. Power/pneumatic driven tools/chisels shall be used for such portions of carbonated concrete around reinforcement, which could not be removed manually, to achieve a near uniform required air gap all around including behind the reinforcement. Power Driven Chisels/Hammers are normally applicable for chiselling smaller depths up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger depth in excess of 50 mm.

Step-7: Cleaning of debris and dust shall be carried out from within the chiselled /chipped area and its disposal as per direction of the Engineer-in-Charge.

7.4 Rust cleaning from reinforcement Steel

a) **Materials and T&P**

Chiselling, abrading, chipping, hammering, wire brushes, paint brush, abrading cloth, etc hand tools complete with accessories, tested and approved chemical rust remover.

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b) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

c) **Procedure**

Step-1: Cleaning by manual method-

Remove the rust manually from all round the surface along the length of reinforcement, using hand tools like chisels, hammers, wire brushes, abrading cloth/paper, etc. This shall be continued manually along the length of the rusted reinforcement till such time that the steel surface is cleared of all rust that could be removed manually.

Step-2: Cleaning by chemicals –

Remove the Rust by using tested chemicals, if directed by Engineer-in-Charge, due to unsatisfactory results of manual rust removal. Chemical rust remover shall be brush applied over the reinforcement surface thoroughly all around the circumference and along the full length of rusted reinforcement. After 24 hours (or as prescribed by manufacturer) of its application, the surface shall be cleaned with wire brush and all loose particles removed. It shall be washed with water thoroughly and allowed to dry.

7.5 Cleaning Reinforcement and exposed concrete surface of loose and foreign material by means of sand blasting

a) **Purpose**

Clean the prepared concrete surface of all-loose, lightly sticking materials including the foreign materials, loose concrete, aggregates etc to provide a good bond with the applied repair material and clean the reinforcement surface of any minor rust remaining after manual and chemical cleaning to achieve shining bright metal.

b) **Materials and T&P**

Coarse sand conforming to Zone I or II as per IS: 383, Air compressor of a minimum 35 Kilowatt capacity, spray gun for sand, all related accessories for sand blasting, hand tools like wire brushes, chisels, etc

c) **Testing of Materials and T&P**

The sand shall be tested to conform to the specification.

The air compressor shall be tested to perform to the required standards as laid down in specifications of shotcreting.

d) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

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e) Procedure

Step-1: Specified tested coarse sand shall be collected at site in required quantity for sand blasting.

Step-2: Make available mechanical power driven air compressor in working condition at site with all required accessories for carrying out sand blasting as well as air blasting operations.

Step-3: Coarse sand shall be sprayed under pressure over the exposed surface so as remove all loose and foreign material and to cause an intense abrading of the reinforcement and removal of rust from entire surface of reinforcement to achieve shining bright surface. The sand blasted surface shall be subsequently cleaned with oil free air blast.

7.6 Providing drilling and inserting nipples along crack lines

a) Purpose

To fix injection nipples and seal the remaining portion of honey combed or cracked concrete /masonry for grout injection.

b) Materials and T&P

12 mm diameter approved PVC/aluminium /Galvanised Iron nipples, Chisel, hammer, power driven tool for chase cutting & drilling, hand operated blow out pump, sealing putty of polyester/epoxy/polymer modified mortar etc. and all related accessories and materials.

c) Testing

The sealing putty and the nipples shall be tested to conform to the manufacturers specifications. The power driven tools shall be test driven and their drill/cutting bits shall be tested for effectiveness before taking up the repair operation.

d) Procedure

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Personnel, Supervision, Product delivery, Storage and Handling etc.

Step-2: Identify the Cracks and mark the area for injection grouting.

Step-3: Prop & support the structural member, if required, to relieve it of stress and strains.

Step-4: Open up cracked surface by making 'V' notch or groove of size 12 mm x 12mm.

Step-5: Remove plaster, if required, to identify and mark the honey combed area.

Step-6: Drill holes at least 25 mm diameter and 40mm deep along crack lines at spacing of 300 mm or thickness of the structural member, whichever is less. In

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honey combed area @ 9 nos per sqm. as directed by Engineer-in-Charge and up to 30 mm to 40 mm depth.

Step-7: Remove coarse debris and dust in opened up cracks and drilled holes by blowing oil free compressed air, if available with air compressor, otherwise with hand operated blow out pump. Concrete surfaces required to be grouted shall be free from all loose and unsound materials by means of mechanical abrasion using stiff wire brushes, after removing all loose areas with chisel and hammer. Area shall be made free from any deleterious materials, such as oil dust dirt etc. by means of oil free jet of compressed air. All prepared concrete surfaces shall be thoroughly inspected and got approved by the contractor.

Step-8: Insert 12mm dia specified injection nipples in holes drilled along crack lines and fix them by sealing only its sides with epoxy or polymer modified mortar.

Step-9: Seal the crack or the honey combed surface between the nipples by polymer modified mortar as may be approved by Engineer-in charge. The polymer used shall be of approved grade and applied as per specifications mentioned separately elsewhere. The polymer-modified mortar shall be moist cured for 1-3 days and allowed to gain strength before actual grouting commences.

7.7 Sealing of cracks by injection of advance grout

a) Purpose

To inject the specified grout into honeycombed or cracked concrete/ masonry

b) Materials and T&P:

Cement, sand. Water and admixture for cementitious grout shall be as per clause 5 of this specification.

Polymer: It shall be as specified and shall conform to ASTM-C-1059.

Hand/power operated grouting pressure pump/gun with pressure gauge. The grouting equipment shall be capable of supplying, mixing, stirring and pumping grout to the satisfaction of the Owner. The equipment shall have the capacity to inject grout at a pressure upto 7 kg per square centimeter measured at the grout connections. It shall be capable of mixing and pumping of cement sand grout 1:2 with water cement ratio ranging from 0.5 to 1.

Air compressor with all related accessories for carrying compressed air to the required location. Hand operated blow out pump may be allowed by Owner for small crack depths/areas.

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing, Spray equipment/brush for application of polymer modified/ bonding cement slurry

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c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured material (e.g. specified resin, hardener, polymer, cement, etc as may be required) shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: If directed by Owner, collect random samples of materials for test and send to approved laboratories so as to ensure that they satisfy the physical and mechanical properties. The grout pump and the pressure gauge shall be tested before taking up the repair operation.

Step-4: Identify the Cracks and mark the area for injection grouting.

Step-5: Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

- Prop & support the structural member to relieve it of stress and strains.
- Provide grouting nipples.

Step-6: Blow the compressed air followed by washing with water through nipples located at the highest level and downwards to ensure removal of even fine dust particles from the cracked surface, which could obstruct the free flow of grout material and impede its bonding with cracked surface (and drying with air blast wherever epoxy injection grout is to be used).

Step-7: Saturate the cracked surface in the vicinity of crack/honeycombed concrete/ masonry with water (but without excess water), only if the cementitious grout is to be injected. Otherwise, this step may be skipped.

Step-8: Prepare the injection grout as specified under clause 5 of this specification.

Step-9: Inject the approved & specified grout into the cracks by means of suitable gun or pump at a pressure of 1- 2 kg./cm² for epoxy grout and 4-7 kg./cm² for cementitious grout. In case of vertical cracks injection shall be started at the lowest nipple and continued until the injected grout begins to flow out at the next higher nipple. Whereas in other cases of horizontal locations, the injection shall be started from one nipple and continued until the injected grout begins to flow out at the other nipple.

The first nipple shall then be closed off and injection continued at the second until the grout flows out at the third. The process shall be repeated until the whole of the crack has been sealed. As soon as the system is cured, the nipples shall be cut.

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In case of Honeycombed Area, each grout hole shall be grouted individually. Grouting pressures to be used in the work will vary with the conditions encountered and different areas and the pressure used shall be between 1 to 4 kg/cm². The sequence of injection shall be as per the direction of Engineer-in-Charge.

7.8 Providing and inserting shear key bars

a) Purpose

Shear key bars are used for providing a structural connection of the applied repair material with the substrate/parent surface for transfer of forces occurring at the interface.

b) Materials and T&P:

Epoxy cartridges and specified lengths and diameter of steel reinforcement.

Standard Power driven drilling/hammering equipment, Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

c) Procedure

Step 1: Mark the locations of shear keys and get the same approved for structural connection from the Owner.

Step 2: Drill holes to specified depth and diameter in concrete at marked locations for the specified dia of shear key bars.

Step 3: The drilled hole in dry state shall be cleaned with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump.

Step 4: Inject epoxy from the foil pack with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards.

Step 5: Insert the reinforcing bar and allow the epoxy adhesive to cure.

7.9 Reinforcement for RCC works etc.

a) Purpose

To provide reinforcement in repair concrete for structural purposes, controlling effects of thermal variation or holding shotcrete/gunite material in position. The reinforcement material may comprise specified grade and quality with or without zinc coating.

b) Material & T&P:

Specified reinforcing material, necessary hand or power driven tools for cutting, bending, binding, transportation, handling and placement etc. Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

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c) Procedure

The general requirements, placing in position, measurement etc. shall be generally followed as in clause 4 of this specifications excepting those specifications provided in the following clauses.

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Testing of Material: The requisite number of test specimens of specified reinforcing material shall be collected from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements before use on the work.

Step-3: Execution:

The required reinforcement as per approved detailed drawings in the form of round bars or welded wire fabric in such a way so as to cause the least interference with placement of repair material.

d) Overlaps:

Lapped reinforcing bars shall not be tied together. They shall be separated by at least 50 mm wherever possible. Wire mesh shall be lapped by 1-1/2 squares in all direction. Minimum requirement of lap length of bars shall be as specified in I.S. 456.

e) Clearance around reinforcement:

Sufficient clearance shall be provided around the existing exposed and additional reinforcement to permit complete encasement with sound repair material.

f) Cover:

Minimum cover to reinforcement shall be as specified under clause 4 or as per I.S. 456. As far as possible the bars shall be arranged so as to permit shooting from opposite side.

g) Fixing:

Reinforcement shall be fixed to existing shear key bars and depth gauges driven into the concrete with wires and secured rigidly so that the vibration resulting from the deposition of repair material shall not impair or displace them.

h) Where Gunite /shotcrete to be done in more than one layer

In such cases, the additional reinforcement should be so fixed that it is encased in succeeding layer. No additional reinforcement is required to be fixed in first layer of gunite.

Mesh reinforcement shall be fixed in the manner so that it is firmly held at least 12 mm away from the parent concrete surface as well as from the final finished surface. It shall be ensured that it is stiffened enough and cannot belly out during the guniting / jacketing / concrete overlays with consequent lack of cover. It shall be done by tying with parent concrete surface through shear key

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bars or depth gauges. GI-wire mesh fabric will add sacrificial "Zinc" coating & shall reduce corrosion process in the reinforcement. The wire mesh spacing shall be as specified in the drawings.

7.10 Alkaline Passivating bond coat over Reinforcement

a) Purpose

To protect steel reinforcement with a passivating alkaline layer provided all around its circumference along the length with strong adhesive to bond with applied repair concrete or mortar.

b) Materials and T&P:

Specified alkaline passivating & bonding materials e.g. CPCC material, epoxy, epoxy phenolic IPN-RB or specified polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, mechanical mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882.

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

Patented materials e.g. CPCC or epoxy-phenolic IPN-RB as per licensee's specifications

c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: Prepare the surface for treatment.

Step-4: Thoroughly inspect all the concrete surfaces prior to applications of passivating/ bond coat and get approved from the Engineer-in-Charge.

Step-5: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-6: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),

Mechanical blender for mixing

Brush for application of specified and approved passivating/bond coat.

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Step-7: Material Mixing: Components of the passivating/ bond coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-8: Material Application: The alkaline passivating & bonding material shall be applied to prepared reinforcement substrate after tying in new reinforcement wherever specified in the form of bars or welded wire fabric. It shall be applied to reinforcement surfaces by stiff nylon bristle brush. The coating material shall be worked well all round the periphery and along its exposed length using a stiff brush ensuring that no pinholes are remaining. The second coat, if required, the same shall be applied as per manufacturer's recommendation after the first coat is touch dry.

7.11 Bonding coat for hardened concrete with repair concrete/shotcrete/cement mortar

a) Purpose

To provide adequately strong adhesion of parent concrete with applied repair concrete or mortar.

b) Materials and T&P

Specified bonding materials e.g. epoxy or polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, spray gun, mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

c) Execution

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer- in-Charge Full quantity shall be worked out as theoretically required for consumption in the whole work

Step-3: Prepare the surface for treatment.

Step-4: Saturate the surface with water but shall be free of excess surface water, debris and dust, where cementitious bond coat is to be applied. Otherwise, surface to remain dry and clean of debris and dust.

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Step-5: Thoroughly inspect all the concrete surfaces prior to applications of adhesive and get approved from the Engineer-in-Charge.

Step-6: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-7: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing Spray equipment, brush for application of epoxy, polymer modified, bonding cement slurry.

Step-8 Bond Coat Mixing: Components of the bonding coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-9 Bond coat application for jacket concrete/ shotcrete/ Mortar placement: The specified adhesive shall be applied to concrete surface at atmospheric temperatures below 40°C for epoxy adhesive and below 30°C for polymer modified cement or cement-sand slurry adhesive. Bonding coat shall be applied by spray equipment or stiff nylon bristle brush as approved by Engineer-in-Charge. The bonding material shall be worked well into the surface of the parent body ensuring that no pinholes are visible.

Polymer modified bonding cement slurry shall be applied to a thickness not in excess of 2 mm.

If necessary, a second coat shall be applied at right angles to the first to ensure complete coverage and absence of pin holes.

All concrete surface shall be well protected beyond limits of surface receiving adhesive against spillage.

Step-10 Repair Material Application: Fresh plastic concrete/ shotcrete/ mortar shall be applied while adhesive is still tacky and well within the pot-life/ setting period. If adhesive cures to the extent of losing its tack or has set before plastic concrete/shotcrete/mortar is placed, the same shall be removed or slightly abraded and second coat of adhesive applied. Freshly placed plastic concrete shall be thoroughly consolidated to ensure full bonding of new concrete with the substrate.

d) Bond of repair with parent concrete:

Evaluate bonding of fresh concrete/ shotcrete/ mortar to existing concrete after the fresh material has cured for not less than 7 days by sounding and tapping fresh concrete with a blunt metal instrument to the satisfaction of Engineer-in-charge. Suspect inadequate bonding, if a hollow sound is detected in any area.

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In case of conflicted location contractor shall extract one core from the repaired surface area at the end of 28 days.

Conduct one core test at random for checking the bond, for every 100 square metre or part thereof. The contractor shall core each area after 28 days of application of concreting/ shotcreting/ repair mortar application for determination of bonding adequacy.

Core drilling shall be done through applied repair material and into the existing concrete. Core diameter shall be not less than three times the nominal size of the coarse aggregate used in repair material or as required by the Engineer-in-Charge. Length of cylindrical cores shall preferably be twice the core diameter or twice the thickness of applied repair material or as instructed by Engineer-in-Charge but in any case not less than the dia of the core.

Cores shall be visually inspected by Engineer-in-Charge for evidence of poor workmanship.

Cores shall be tested in tension to evaluate the quality of bond between new concrete/shotcrete/mortar and the parent concrete. If the failure is in the parent concrete the bond of new repair material shall be deemed to be satisfactory.

Failure at the bond line or in the repair material shall be concluded as lack of proper bond or inadequate strength of repair mortar

Dismantle such areas of work failed in bond or repair material and re-prepare the surface after chipping off new concrete/mortar work and abrading the epoxy/polymer/cement slurry interface. Nothing for testing concrete for bond between old and new concrete shall be paid separately.

7.12 Curing of RCC Surfaces etc

a) Purpose

To ensure satisfactory hydration of cement by retaining or replenishing the mixing water lost due to natural drying and evaporation process for a specified period through exposed cementitious surfaces of the freshly placed cement mortar/ concrete.

b) General

Importance of wet curing to all items of work involving use of cement can not be over emphasised. Any surface experiencing discontinuity of dampness of surface with any patch having dried out during the specified period of curing, it shall be prominently marked with lime or other suitable prominent colour.

c) Materials and T&P:

Curing compound, brush or hand operated spraying gun and all other related accessories for application on Concrete/Plastered Surface.

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d) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified manufactured material shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out theoretically for consumption in the whole work.

Step-3

- **Moist Curing:**

Cover all exposed surface of concrete, when the concrete begins to harden i.e. two to three hours after compaction with moist gunny bags or any other material approved by the Owner.

Keep the exposed surfaces continuously damp after its final setting (i.e. after a maximum of 8 hours of concreting) by ponding with a sheet of water or by covering with a layer of sacks, canvass, hessian or similar water absorbent materials constantly kept wet by water sprinkling for at least 7 days, where ordinary portland cement is used and 10 days, where portland pozzolana cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as per manufacturer's recommendations or as directed by the Owner.

- **Using Curing compound:**

Testing of Materials:

It must be ensured that curing compound should neither affect the strength nor the surface of concrete. It shall not leave any undesirable stains on surface to affect the bond of plaster or other finishes to be applied later. It should be soluble in water, so that it can be removed by splashing or washing with water without scrubbing the surface.

Test for Efficacy:

The testing of curing compounds shall be done from each lot of curing compound received at site by casting two sets of 15 cm cubes with each set having 6 cubes. One set shall be moist cured by covering with damp gunny bags and subsequently by immersing under water and the other set by applying curing compound on top after 2 to 3 hours of casting and subsequently on de-moulding apply on the remaining faces all around. The cubes shall be kept in an environment similar to which the actual structure is exposed for a period of 7 days after its casting. Three concrete cubes each from both sets shall be tested after 7 days for their crushing strength as per standard test procedure. The average crushing strength of cubes cured with curing compound shall be not less than 95% of the crushing strength of cubes cured under damp or immersion curing.

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Test for Staining:

The set of three sample cubes applied with curing compound, remaining after 7-day cube crushing strength test, shall be washed with water with soft brush scrubbing with nylon bristles and allowed to dry for a period of seven days in an atmosphere with relative humidity not exceeding 40% at ambient temperature. The other set of three cubes cured for seven days under damp or immersion conditions shall also be kept for another seven days under identical humidity and temperature conditions. The surface of the two sets of such cubes shall be compared by closely observing for any visible stain and texture that may detrimentally affect its bond with subsequently applied plain plaster or aesthetic appearance. Such observations shall be recorded in three categories as no effect, slight effect and moderate effect. The curing compound shall be considered as acceptable in the 'no effect' category and unacceptable in the 'moderate' category. The decision of Engineer-in-Charge, which shall be final and binding, based on the likely use of finished surface of concrete/plaster shall determine the acceptability of the 'slight effect' category.

Concrete curing compounds, after testing satisfactorily for efficacy, may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing within two to three hours of casting and well within an hour of removal of formwork.

7.13 Engineered Steel Tubular double Scaffolding System

a) Purpose

To provide a scaffolding system with adjustable working platforms on the exterior of the building for the workmen to work upon any part of the area to be accessed safely and with ease for surface preparation, application of repairs and construction activity.

b) Materials

The standard proprietary tubular double scaffolding system of repute with all accessories, working platforms etc.

c) Design

It shall be designed for all the incidental dead, live and wind loads as per IS: 875 in steel tubular sections as per general design considerations governed by IS:800. The design of the scaffolding system shall cater to the safety features for the workmen.

d) Fabrication and Erection

Fabrication and erection shall be done as per the design brief and installation instructions of the proprietary firm. It shall be maintained in functional condition for the work duration.

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7.14 Temporary barricading using angle iron verticals and sheet panels

a) Purpose

To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work.

b) Materials

Available Corrugated G.I. Sheet minimum 24 G thick; Framing structural material at least MS Angle iron of size [40x40x5mm] or equivalent.

c) Fabrication & Erection

Size of framing panel shall be decided depending upon site conditions and these could be approximately 2.0 metres long with height as 1.8 metre.

It shall be made up at least of two verticals, each with additional length of about 600 mm for fixing in to ground firmly and two horizontals equal to the length of panel.

It shall be made up by cutting the structural sections to size, shear punching holes in verticals and horizontals for nuts and bolts or making other suitable provision for receiving CGI sheet or other specified panelling material and connection of panel with adjoining panels.

Fabrication of frame of an individual panel shall be by welding at corners, welding MS plate at base of verticals or any other acceptable practice approved by Engineer-in-charge.

G. I sheet or other specified panelling material shall be suitably fixed. It shall preferably be done by means of nuts and bolts at its ends spaced at about 300 mm c/c transversely and at about 600 c/c longitudinally along corrugations. The corrugations of CGI sheet shall run along the shorter span of the panel.

In case of newly fabricated panels, these shall be painted with red oxide zinc chromate primer on steel work and approved primer on other material and at least one coat of paint of approved shade. In case of used panels, one coat of paint of approved shade shall be applied over the existing paint. The portion of verticals to be embedded in ground shall be suitably protected against rusting by painting it with bitumen or other suitable paint.

The fabricated panels shall be suitably fixed vertically and firmly in to the ground to the satisfaction of Engineer-in charge by maintaining a uniform height of about 1.8 metres above GL and connecting each panel with the adjoining panels with nut and bolts or other suitable means.

Suitable provision of frame/posts in the openings provided in barricading shall be made for receiving door shutter at locations as approved by Engineer-in-Charge.

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7.15 Temporary protective fabric screens

a) Purpose

To protect passersby from falling debris and also to protect the workmen and structure being repaired against direct exposure to sun.

b) Materials:

For screening purpose jute cloth, woven PVC cloth, geo-textile or wire-mesh as specified and approved by Engineer-in-Charge shall be used, which shall conform to their relevant BIS Code. Screen materials shall be fixed by suitable means comprising of M.S.Flats/ J-bolts /nails/clamps, etc with washer or any other suitable means on frames of existing scaffolding etc.

c) Procedure

Scaffolding, if required, comprising of verticals, horizontals and diagonal bracings of steel tubes shall be fixed over ground which is payable separately.

One end of the screening material, brought to site in looms/rolls, shall be properly fixed over top horizontal member with suitable means and suspended so as to cover the required area.

The vertical fall of screen shall be suitably fixed/firmed up at intermediate levels so as to keep it in position during the work duration.

Next strip of the screening material shall be fixed with its sides stitched or suitably jointed or lapped with the previous ones as approved by Engineer-in-charge.

Spacing of frame member of scaffolding shall be so selected that the sagging of screen shall not hinder the repair process.

The contractor shall maintain the protective screens in acceptable conditions for the entire work duration as required by the Owner.

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8 CONCRETE RETROFITTING METHODS

In selecting the retrofitting method, the current status of the existing concrete structure as determined through inspection, the performance of the structure, the performance required of the structure after retrofitting, the conditions for retrofitting construction work, the ease of maintenance, economy and other factors shall be considered.

At the stage of selecting the retrofitting method, the current status of the existing structure and its performance shall be obtained, and the performance required for the structure after retrofitting and the conditions for retrofitting work shall be determined. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors.

Various retrofitting methods listed below shall be used for retrofitting objective:

8.1 Retrofitting of concrete members

a) **Continuous fiber reinforced plate bonding construction method:**

Bonding continuous fiber reinforced plates to the surface of the existing structure to restore or improve load-carrying capacity

b) **Continuous fiber reinforced plate jacketing construction method:**

Jacketing with continuous fiber reinforced plates around the periphery of the existing structure to restore or improve load-carrying capacity and deformation characteristics

c) **Prestressed concrete jacketing construction method:**

Placing pre-stressing wires and pre-stressing stranded steel wires in place of lateral ties around the periphery of existing member sections and using mortar and concrete to bond them in order to reinforce the structure. To increase the restraining effect of the inner concrete, the pre-stressing steel is generally stressed during placement.

d) **Pre-stressing introduction (internal cable) construction method:**

Using internal cables for the existing concrete members to provide pre-stressing and restore or improve the load-carrying capacity of the members.

e) **Repaving method:**

Replacing some or all of the existing concrete members with new members through the use of precast members or concreting on site to restore or improve load-carrying capacity.

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8.2 Retrofitting as a structural body

a) Beam (girder) addition method:

Adding beams between the main girders of the existing reinforced concrete deck to reduce the deck span and restore or improve the load-carrying capacity of the reinforced concrete deck.

b) Seismic wall addition method:

Placing new reinforced concrete walls between existing reinforced concrete rigid-frame bridge piers and bonding them to form a continuous unit in order to restore or improve the load-carrying capacity as a structural body.

c) Support point addition method:

Supporting the intermediate sections of the beams and other existing concrete members with new members to reduce the span of the members in order to restore or improve the load-carrying capacity as a structure.

d) Seismic isolation method:

Using seismic isolation bearings and the like to reduce the seismic energy applied to the structure in order to improve its various performance values during an earthquake.

8.3 Foundation retrofitting

a) Underground wall (beam) addition method:

Connecting the foundations with cast-in-site diaphragm walls and underground connecting beams to distribute stress and ensure the stability of the entire system.

b) Pile/footing addition construction method:

When pile foundations are damaged or there is residual displacement, adding piles or footings to increase the load-carrying capacity of the foundation.

c) Foundation improvement method:

Improving the ground around the foundation with cement improvement materials to improve the ground bearing capacity and horizontal foundation resistance. Also prevents excessive pore water pressure and liquefaction.

d) Steel sheet-pile coffering construction method:

Placing sheet-piles around the periphery of the footings and bonding them to the footings to improve bearing capacity and horizontal resistance.

e) Foundation compacting method:

When insufficient foundation bearing capacity is a concern due to scouring or the like, using concrete or the like to compact the ground around the foundation in order to restore bearing capacity.

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8.4 Repair of cracks and missing sections

a) **Cracks fill method:**

Forcing low viscosity resin and ultra-fine cement into the cracks in existing concrete members to seal the cracks.

b) **Fill method:**

Filling cracks, rock pockets, cavities, peeling and other small-scale missing sections in existing concrete members with resin and mortar to repair sections.

c) **Section repair method:**

Removing deteriorated or damaged portions of existing concrete members and then restoring these members to their original sectional status using materials with excellent bonding to existing concrete.

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9 SHORING AND UNDERPINNING

9.1 Material and Equipment

- a) The contractor shall furnish all materials, tools, equipment, facilities and services as required for providing the necessary shoring and underpinning work and facilities. Jack and jacking equipment shall be more than adequate for the imposed loads and shall be provided with calibrated gauges.
- b) Shoring and bracing materials
Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles, and accessories as required.
- c) Lagging and sheeting material
Provide heavy timber boards, planking or sheeting as required. Lagging board shall be secured in place by steel H-piles, with boards inserted between the H-flanges.
- d) Underpinning Pier
An excavation pit, provided generally by manual excavation, which is carried to a pre-selected bearing surface and then filled with concrete to provide supplementary foundation support for the underpinning structure.
- e) Concrete
Refer clause 4 of this specification for concrete requirements.
- f) Grout
Refer to Clause 5 of this specification for Non-Shrink Grout requirements.
- g) Structural Steel
Refer to Clause 9 of this specification for Structural steel requirements

9.2 Execution

- a) Detection of Movement
 - For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding improvements to be monitored. Settlement markers shall be capable of being read to an accuracy of 1.52mm.
 - Take and record readings not less than once per week during performance of the work until the permanent structures is complete to the ground level.
 - Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.
 - Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks or longer if movement persists, and report the results to the Engineer.

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- The detection of movement shall be performed by a qualified licensed land surveyor or civil engineer.

9.3 Shoring and Underpinning

- Existing footings, foundations, pile caps, grade beams, retaining walls, or pavement which may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement.
- Provide soldier piling, lagging and sheeting, tie-backs, slurry diaphragm wall, and cementitious grouting, as required, to hold back earth at excavations and as required to prevent cave-ins and earth sloughs.
- Footings, foundations, pile caps, grade beams, retaining walls, or pavements which have been undermined by earthwork and pile-driving operations shall be filled and supported with concrete extended to undisturbed bearing earth or bedrock.
- Concrete may be placed as a stiff mix of minimum slump (dry pack), or concrete may be pneumatically placed (shotcrete), or concrete may be placed by conventional methods with concrete formed to hold it in proper position.

9.4 Concrete Piers, Walls and Pile caps

- Install concrete underpinning piers, walls, and pile caps as indicated, with the bottom at the indicated or bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed.
- Where earth forms are indicated, install waterproof building paper or board between the earth and concrete to prevent water loss from the fresh concrete.
- Do not remove support of existing structure until concrete piers, walls, or pile caps have attained design strength.

9.5 Piles and Caissons

- Install pipe pile shells or drilled shafts at locations indicated, and extend from underside of existing footings to indicated elevations, plus additional penetration if required to develop the design working load of the pile or caisson.
- Distribute jacking reactions over the existing structure in a manner that will not overstress or deflect the existing structure.
- Weld splices where indicated. Provide watertight welds capable of developing the full strength of the pile or caisson. Align splices to ensure the

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straightness of the pile from top to tip. Use outside sleeves and backup rings as necessary.

- Where the pile tip is below the ground-water table, maintain the elevation of the water inside the shell at approximately the elevation of the ground-water table during installation of the shell.
- After installation of the shell, apply the full design-working load to the empty pile shell and maintain until there is no measurable settlement over a one hour period.
- Maintain the excavation within the pile shell approximately 12 inches above the tip during driving, and dewater pile shells prior to filling with concrete in a manner which will prevent loss of earth or soil at the tip. An earth plug may be left in the pile tip or a concrete plug may be placed and cured prior to dewatering pile shells.
- After load testing to the design load, dewatering, and inspection of the shell by the Engineer, fill accepted pile shells with concrete in the presence of the Engineer. Keep an accurate record of the volume of concrete deposited in each pile. Deficiencies revealed by comparing the volume of the inside of the pile with the volume of placed concrete will be cause for rejection of the pile or correction of the deficiency.
- Securely wedge in place with steel wedges those piles that have satisfied the load-testing requirements. Weld and encase in concrete all wedges, plates, wedging struts and piles, as indicated or required.
- Following completion of load transfer of underpinned structures, fill the underpinning pits with concrete as indicated. Provide reinforcement, shear keys, dowels, and water stops as indicated or required. Place concrete to within 3 inches of the underside of the existing foundation. After three days, dry pack the space between the foundation and concrete.

9.6 Load testing of piles and acceptance criteria

- After the concrete within the pile or shaft has set for at least 24 hours, test each pile or pier by jacking to a load equal to 150 percent of the design-working load of the pile. Maintain the load until there is no measurable settlement of the pile over a one-hour period.
- Load-test piles in sequences and groupings that will minimize or eliminate eccentric loadings on the existing foundation and piles.
- Piles will be rejected and shall be retested if, in the opinion of the Engineer, there is a danger of unequal loading.
- Should the existing structure fail to furnish sufficient reaction to installed underpinning piles to the test loads specified, provide additional reaction to prevent damage to, and movement of, the structure during installation of piles, and to obtain specified underpinning test loads. The additional reaction shall not detrimentally affect the structure.

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- Maximum out-of-plumb tolerance for installed piles: two percent.
- Maximum offset of top of pile from the design center: 3 inches.

9.7 Fill and backfill

Provide engineered fill and backfill in accordance with Clause 3 of this specification, after acceptance of the underpinning by the Owner.

9.8 Temporary Supports

Install temporary supports where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work.

9.9 Restoration

Restore existing structures to conditions equivalent to those existing prior to the start of shoring and underpinning work, including repair of any settlement-related damage.

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10 STRUCTURAL STEEL WORK

Design of structural steel work shall include generally but not be limited to the steel constructions listed below:

- Steel building structure and open structures including beams, columns, bracings, supporting structures for floors, roof slabs, cladding etc.
- Hoist & monorail supporting beams etc.
- Coal conveyor galleries, trestles, transfer house, pent house, crusher house, wagon Tippler, Track hopper etc.
- Platforms and walkways
- Ladders, staircases, handrails, etc.

10.1 Design

(a) General

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However where large cut outs are to be provided in the floor slabs horizontal floor bracing shall be provided. Grating / Chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support and horizontal bracing shall be provided as required in such cases.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimize vibration, avoid resonance and maintain alignment and level.

(b) Design of structure

The Design of steel structures shall be done by Working stress or Limit state method, in accordance with the provisions of IS: 800 and other relevant IS codes as applicable to specific structures. Basic consideration for structural framing shall be stability, rigidity, building usage, ease of fabrication / erection and overall economy. Additional bracings / moment connections shall be used to assure stability of structures. Structure shall be designed such that the surfaces of all parts shall be accessible for inspection, cleaning, painting and maintenance. Most of steel superstructure shall be designed as simple space frame structures. Simple space frame design utilizes single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Large span built-up girders shall be single web plate girders of welded construction with bearing and intermediate stiffeners. For lifting / monorails beams ISMB sections shall be preferred and the bottom flange of all beams shall be checked separately for distortion and reinforced suitably if required.

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Columns shall be designed to support the load combination which results in maximum interaction ratio. Exterior columns shall be designed to resist moments due to wind & seismic. Columns shall also be designed to resist moments caused by discontinuous vertical bracing or non-concentric bracing work points. Column base can be fixed or pinned. Lateral forces shall be resisted by rigid jointed moment connections in rigid frame design. For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension, etc.) use 90 % of the column dead load and no live load. Uplift forces from vertical bracing and Wind uplift on the roof shall be included where applicable.

Permissible stresses for different members shall not be allowed to exceed by 33.33 % under wind and seismic conditions. However, members who shall be designed primarily to resist wind load such as bracing members, no increase in permissible stresses will be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. All anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself. No anchor pockets in foundation shall be allowed. Design of base plates shall be based on design pressure on foundation which shall not exceed the following:

Pedestal in concrete grade M30 7.50 N/mm²

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A coefficient of friction of 0.30 shall be used in conjunction with the minimum column load. If the horizontal shear force exceeds the frictional resistance force or if the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Anchor bolts are not assumed to resist any horizontal shear force. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Static analysis of overhead conveyor galleries upto a span of 24 m is allowed. However dynamic analysis shall be carried out for overhead conveyor galleries exceeding 24 m span.

For equipments, the bolt shall be either embedded or placed inside the pedestal and grouted with non-shrink grout.

The following criteria shall be followed for posting loads on the design drawings. For vertical beam reactions, the load shall be posted whenever the value exceeds the maximum allowable uniform distributed load. For axial loads in floor beams, the actual horizontal load which the beam end connection must resist shall be posted for each end of the beam. Note that this value may be different for opposite end of the same beam. For truss members, only one member force shall be noted for each member.

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(c) Permissible deflections

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

• **Vertical deflection**

a) For beams supporting dynamic equipment	Span / 500
b) For beams supporting floors / masonry	Span / 325
c) For beams supporting pipes (pipe racks)	Span / 400
d) For roofing and cladding components	Span / 250
e) For gratings and chequered plates	Span / 200 subject to a maximum of 6 mm
f) Coal conveyor gallery bridges	Span / 450

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

For manually operated cranes and monorails : Span / 500

For electric overhead cranes

- i) Up to 50 t capacity : Span / 750
- ii) Over 50 t capacity : Span / 1000

• **Horizontal deflections**

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	Height / 325
b)	Multistoried building (without crane load)	Height / 500
c)	Pipe rack columns	Height / 200
d)	Open Structures	Height / 200
e)	Crane gantry girder due to surge	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail due to action of crane surge load only	Height / 2500 limited to level maximum of 10 mm
g)	Open gantry columns at crane rail level due to action of crane surge load only	Height / 4000 limited to maximum of 10 mm

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h)	Coal handling trestles	Height/1000
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Provisions of IS: 800 and relevant latest IS Codes shall be followed for limiting deflections of structural elements not listed above.

(d) Minimum thickness and size of steel elements

• **Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgement in each instance.

Trusses, purlins, girts and bracing	6 mm
Columns and beams	8 mm
Gussets	8 mm
Stiffeners	8 mm
Base plate	10 mm
Chequered plates	6 mm o/p
Grating flats	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc shall be 6 mm.

• **Minimum Sizes**

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

(e) Slenderness and depth ratios

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

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Truss	1 / 10
Rolled beams and girders for Ordinary floors and rafters	1 / 24
Supporting floor beams for vibrating Machines / equipments	1 / 15
Roof purlins and girts	1 / 45
Gable columns	1 / 30

(f) Design of Connections

Welding will be done in accordance with the recommendations of IS: 816 and IS: 9595.

Shear connections will be designed for 75 % of section strength for rolled sections and 80 % of section strength for built up section or rolled section with cover plates. Designed shear force shall be more than actual shear. Moment connections between beam and column will be designed for 100 % of moment capacity of the beam section.

All butt welds will be full penetration butt welds.

Size of fillet weld for flange to web connection for built up section will be as follows:

- i) Able to take full shear capacity or actual shear whichever is more for box section
- ii) Able to take 80 % of full shear capacity or actual shear (if indicated in drawings) or shall be 0.5 times of the web thickness whichever is more. For I-section Weld will be double fillet
- iii) All welds will be continuous. The minimum size of the fillet weld will be 6 mm as per relevant IS code

Connection of vertical bracings with connecting members will be designed for full tensile capacity of the bracings. The connection between top flange & web of built-up girder will be full penetration butt weld & for bottom flange, connection may be fillet weld.

Connection of base plate & gusset members with the columns will be done considering that total load gets transferred through weld.

Splicing

All splicing work will be full strength. Field splicing will be done with web / flange cover plates. For, exceptional cases the field splicing will be designed for 50 % of load carried by the cover plates and remaining 50 % load through full penetration butt weld. Shop splicing for all sections other than rolled will be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections will be carried out using web and flange cover plate. For design efficiency of site weld shall be considered as 80 %.

Insert plates

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Insert plates shall be designed / checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall also be checked. Lugs using steel bars shall preferably be fillet welded to the plate to transfer full strength of the lug.

10.2 Fabrication

(a) General

Fabrication drawings shall be prepared according to the provision of IS: 800, IS: 813, IS: 816, IS: 9595, IS: 1367 and IS: 9178.

The work to be provided by the Bidder, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following:

- i) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on design drawings submitted by the Bidder and approved by the Owner/Consultant.
- ii) To submit revised design with calculations and detailed fabrication (drawings in case any substitution of the designed sections are to be made.
- iii) To submit design calculations for joints and connections developed by the Bidder along with detailed fabrication drawings.
- iv) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding \ electrodes for field connections. The field connection materials supplied by the Bidder shall be to the extent of actual requirement plus 10 % (ten percent).
- v) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- vi) Suitably mark, bundle and pack for transport all fabricated materials.
- vii) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

(b) Conformity with Design

Except where the standard connection details are furnished, the Bidder shall design all connections, supply and fabricate all steelwork and furnish all connection materials, Shear connectors / shear lugs on the beams in accordance with the approved drawings and / or as instructed by the Owner/Consultant Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and / or as approved by the Owner/Consultant. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

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(c) Quality control

The Bidder shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work shall be performed in accordance with this specification. In addition to the Bidder's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Owner/Consultant. As far as possible, all inspection by the Owner/Consultant shall be made at the Bidder's fabrication shop whether located at Site or elsewhere. The Bidder shall co-operate with the Owner/Consultant in permitting access for inspection to all places where work shall be done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Bidder.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

- a) Steel Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
- b) Bolts, Nuts Manufacturer's certificate, dimension & Washers checks, material testing.
- c) Electrodes Manufacturer's certificate, thickness and quality of flux coating.
- d) Welders .Qualifying Tests
- e) Welding sets Performance Tests
- f) Welds Inspection, X-ray, Ultrasonic tests
- g) Paints Manufacturer's certificate, physical Inspection reports
- h) Galvanizing Tests in accordance with IS: 2633 and IS: 4759.

(d) Materials

If desired by the Owner/Consultant, Test Certificates of materials supplied by the Bidder in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Owner/Consultant, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

Materials for main and secondary members shall be selected in line with good engineering practice and shall be arranged within any structure with due regard for maintenance of the structure and Plant and Equipment supported or sheltered by the Structure and also with regard to corrosion.

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pitting, rusts, etc. that may impair their strength, durability and appearance.

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All rolled steel shall conform to the requirements of the Indian Standards.

- i) Structural Steel will conform to IS: 2062 Grade-A for rolled steel members or plates up to 20 mm thickness.
- ii) For plates above 20 mm thickness and welded construction, steel conforming to IS: 2062 Grade-B will be used.

(e) Workmanship

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of IS: 800 and other relevant Indian Standards or equivalent.

Straightening Material

Rollled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed as per IS:1852. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

Cutting

Cutting shall be affected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Owner/Consultant.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

Planning of Edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Owner/Consultant.

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Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end, but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

Bolted construction

All bolts and nuts shall conform to the requirements of IS: 1367.

Field connections shall preferably be bolted connections unless specified otherwise. Weld connections at site shall be avoided.

High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter unless designated otherwise. High strength bolts shall be installed as bearing type joint except where loads are reversible. Bearing Type connection (H.T. bolts Grade 8.8) shall be used for all removable type connections. Bolts will be tightened to develop the required pre-tension during their installation.

All erection bolts shall be of minimum 16 mm diameter of property class 4.6 conforming to IS: 1367 unless specified otherwise.

Holes for bolts shall not be more than 1.5 mm for bolt of diameter equal or lesser than 25 mm and shall not be more than 2 mm for bolt of diameter greater than 25 mm.

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

Assembly

Drifting to enlarge un-matching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall

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be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted nor damaged and shall be so prepared that the specified cambers, if any, are maintained.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Owner/Consultant.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or locknut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

Welded Construction

Welding shall be in accordance with relevant Indian Standards. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817. All shop connections shall be welded type.

Preparation of Material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears, Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than 20C.

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to

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other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Owner/Consultant, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Consultant.

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding shall be started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

No welding shall normally be done on parent material at a temperature below (-) 50C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 50C and 00C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 200C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

Submerged arc welding process shall be used for welding longitudinal fillet welds (connecting flanges with web) and longitudinal / transverse butt joints for fabrication of columns, framing beams and all other built up members unless manual arc welding is specifically required. All electrodes, flux, bare wire etc will be procured from approved manufacturers. All butt welds in beams, girders & columns will be of full penetration. All butt welds will be radio-graphically or ultrasonically tested as per relevant IS codes and standard practice. The base

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wire electrodes for submerged arc welding will conform to IS: 7280. The combination of wire and flux will satisfy requirements of IS: 3613.

Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the Owner/Consultant.

Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-buttressed over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2 mm.

Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

Miscellaneous

- Lacing bars

The ends of lacing bars shall be neat and free from burrs.

- Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

- Bearing Plates

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Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

- Architectural Clearances

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

- Shop Connections
 - i) All shop connections shall be welded as specified on the Drawings.
 - ii) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Owner/Consultant for convenience of erection and the Bidder will have to make the desired changes at no extra cost to the Owner.
- Shop Erection

The steelwork shall be temporarily shop-erected complete or as directed by the Owner/Consultant so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

(f) Shop Painting

All fabricated steel material, except those galvanized or to be embedded in concrete, shall receive paint coatings as specified below. All paints shall be of approved brand and shade as per the Owner's requirement.

Steel surface, which is to paint, shall thoroughly be cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by wire brush & if required by sand blasting prior to actual surface preparation. The surface shall be cleaned to grade ST-2.5 as per SIS05-5900 or as per IS: 1477 (Part -I).

All steel structures shall receive two primer coats and two finish coats of painting. After fabrication the first coat of primer shall be immediately given over the prepared steel surface. The second coat of primer shall be applied over the dried first primer coat. Two finish coats shall be applied over the primer coats before dispatch of structure at site.

Primer paint shall be red oxide zinc chromate conforming to IS: 2074. Dry film thickness of each coat shall be 50 microns. Adequate care should be taken such that the surface does not possess a slick finish to which paint may not adhere properly. Top coat shall consist of two coats of HB Synthetic enamel of approved shade and colour with glossy finish and DFT as 75 microns (total). Thus the total DFT of painting including that of primer coats shall not be less than 175 microns.

Following care shall be taken while painting:

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- i) Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.
- ii) Surfaces inaccessible after assembly shall receive two coats of primer prior to assembling.
- iii) Surfaces inaccessible after erection, including top surfaces of floor beams supporting gratings or chequered plate, shall receive one additional coat of finish paint over and above number of coats specified above before erection.
- iv) Portion of steel member embedded / to be encased in concrete shall not be painted.
- v) Areas / Surfaces subjected to chemical attacks shall be painted with acid resistant paint.
- vi) Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

(g) Inspection, testing and acceptance criteria

Unless specified otherwise, inspection to all work shall be made by the Owner/Consultant at the place of manufacture prior to delivery. The Owner / Consultant shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification. The Bidder shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Owner/Consultant to carry out inspection and / or tests in accordance with the Contract.

The Bidder shall guarantee compliance with the provisions of this Specification.

The Bidder shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Bidder shall get the specimens tested in a laboratory approved by the Owner/Consultant and submit to the Owner/Consultant the test results in triplicate within 3 (three) days after completion of the test.

Steel

All steel supplied by the Bidder shall conform to the relevant Indian Standards, except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Owner/Consultant, random samples of materials will be taken from each unidentified lot of 50 ton or less of any particular section for tests to

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conform to relevant Indian Standards. Cost of all tests shall be borne by the Bidder.

All material shall be free from all imperfections like mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

All raw steel plate of thickness more than 20 mm supplied by the Bidder shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Owner/Consultant:

- i) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.
- ii) If the results of the tests in (i) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (i) or as directed by the Owner/Consultant.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Owner/Consultant requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Bidder. If the plates in the fabricated item are found to be laminated, the component will be rejected.

Welding

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Owner may ask for at least one test-destructive or non-destructive including X-ray, ultrasonic test or similar, the cost of which shall be borne by the Bidder. In the event of further tests as may be desired by the Owner. The cost of such test shall be borne by the Bidder if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Owner / Consultant shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

Bolts, nuts and washers

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Owner/Consultant and shall conform to the relevant Indian Standards. If desired by the Owner/Consultant, representative samples of these materials may have

- i) Name of the Bidder
- ii) Number and date of the Contract

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- iii) Name of the office placing the contract
- iv) Nomenclature of stores
- v) A schedule of parts or pieces, giving the parts or piece number with
- vi) Tolerance

The tolerance on the dimension of the individual rolled steel components shall be as specified in IS: 1852. The tolerances on straightness, length etc. of various fabricated components (such as beams, girders, columns, etc) of the steel structures (other than steel railway and road bridges structure) subjected to dynamic loading (like wind, seismic etc.) and thin walled constructions (like box girders) shall be as specified in IS: 7215.

10.3 Erection

(a) General

The work to be provided for by the Bidder, unless otherwise specified in the Bid, shall include but not be limited to the following:

- i) The Bidder shall provide all transport equipment, lifting equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- ii) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Bidder shall pay all demurrage and / or wharfage charges etc. on account of default on his part.
- iii) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the Owner/Consultant. If necessary, suitable temporary approach roads to be built for transportation of fabricated steel structures.
- iv) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Owner/Consultant. The Bidder shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- v) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Owner/Consultant.
- vi) Touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Bidder free of cost to the Owner.
- vii) All minor modifications of the fabricated steel structures as directed by the Owner/Consultant including but not limited to the following:

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- Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
- Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
- Reaming of holes for use of higher size bolt if required.
- Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Owner/Consultant.
- Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
- Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
- Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
- Carry out tests in accordance with this Specification if directed.

(b) Conformity with design

The Bidder will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and / or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and / or the instructions of the Owner/Consultant. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and / or the instructions of the Owner/Consultant.

(c) Storage of materials

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site.

(d) Yard

The Bidder will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access, trailers and other heavy equipments. The yard shall be fenced all round with security / arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

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The Bidder should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. All of which shall be carried out by the Bidder at his own cost as directed by the Owner.

(e) Covered Store

All field connection materials, paints, etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Bidder.

(f) Workmanship

Erection Plant and equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Owner/Consultant.

Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Owner/Consultant. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

Temporary bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure Installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Bidder in respect of temporary bracings and guys shall cease when the structural steel is once located plumbed levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Owner/Consultant.

The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Bidder to take out the materials from 'the project site. The Owner may remove and return the materials in good condition to the Bidder without any charge if they have been left in place under other agreed arrangement.

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Temporary floors for buildings

It shall be the responsibility of the Bidder to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and / or by-laws of state, Municipal or other local authorities.

Setting out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Owner/Consultant. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Bidder shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations.

He shall remain responsible for correct positioning. For heavy columns, etc. the Bidder shall set proper screed bars if desired by the Owner/Consultant, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

Drifting

Correction of minor misfits of bolts will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

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(g) Testing and Acceptance Criteria

General

Loading tests shall be carried out on erected structures, if required by the Owner/Consultant, to check adequacy of fabrication and / or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract of either fabrication or erection of steelwork whoever is responsible for it and no payment towards the cost of the dismantled portion and any connected work shall be made to the Bidder, unless it is proved that the deficiency is due to reasons beyond the Bidder's scope. If any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Bidder responsible, to the satisfaction of the Owner/Consultant. The cost of the tests specified hereinafter shall be borne by the Owner. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed. The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated below. The method of testing and application of loading shall be as approved by the Owner/Consultant.

Stiffness Test

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 % of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 % of the maximum increase in strain or deflection recorded during the second test.

Strength Test

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours. In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

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Structure of same design

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure when a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Owner/Consultant. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20 % of the maximum strain or deflection recorded at similar load in the test on the prototype.

Repair after inspection tests

An actual structure which has passed the "Strength Test" as specified above herein before and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' above.

10.4 Requirement for specific structures

Coal Handling System Structures

Toe guards shall be provided on sides of conveyor gallery, toe guard shall have a minimum size of 65 x 6 mm.

In case the inclination of the conveyor is more than 10°, walkway shall be given with steps.

For the design of conveyor gallery, load due to cables, light fittings and pipes as well as effect of gravity take up loads shall also be considered, in addition to dead load, wind load and imposed load.

Lattice girders supporting the conveyor shall be suitably braced at top and bottom chord levels to transmit the wind load to the end portals connected to trestles. Roof purlins and walkway runners shall also be suitably braced at both ends.

In the case of galleries, temperature expansion joint shall be introduced at intervals less than 180 m to divide the galleries into temperature block. In each block at least one four legged rigid support guaranteeing stability of structure in the longitudinal direction shall be provided. This shall also to take care of all longitudinal forces in the given block. Effect of wind load acting on 2-legged trestle shall also be considered while designing the 4-legged trestle.

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Base plates for trestles shall be designed as gusseted base with shear lugs to transfer horizontal forces. Anchor bolts shall be designed only for uplift forces.

Conveyor galleries and trestles having two conveyors belt shall be designed for both conveyors working together.

Chute loads on floors of houses shall be considered plugged with material for the entire height of the chute.

In case chequered plates are used as floor covering the thickness of plate o/p shall be 8 mm. Suitable plan bracings shall be provided 75 mm from top of steel to transfer all the horizontal forces.

Anchor fasteners shall not be used for supporting equipment imparting dynamic forces.

Bracing patterns and locations shall be so planned such that they do not hinder movement of personnel and movement of equipment during maintenance. When floor beam forms part of vertical bracing system, additional loads from the floor beams transferred to the bracing shall be taken into account.

Angle section shall not be used as flexural members except for purlins, side girts and walkway runners. Minimum angle size used shall be L50x50x6.

All foundation bolts shall be provided with double nuts.

End connection for rolled beams and channels shall be designed for a minimum of 60% of their shear capacity and built up beams for 80% of their shear capacity in addition to axial load.

Dynamic analysis shall be carried out for beams supporting screens, vibrating feeder, rotating equipment and conveyor supporting beam in conveyor gallery.

To admit proper light into the conveyor gallery perspex sheet shall be provided at the rate of one square metre per metre length of gallery on the roof and 0.2m² per metre length of gallery per side on the sides of conveyor gallery.

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11 ARCHITECTURAL WORKS

The architectural design concept of buildings shall be evolved considering the functional, technical and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes. To achieve above objective Bidder shall employ a qualified architect / architectural firm to carry out all designs and hold all other architectural responsibilities for the project.

The Bidder shall obtain and be conversant with all laws, by-laws and regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The Bidder shall provide the drawings and documents for such statutory approvals.

11.1 General

The architectural services shall cover finishing work of new buildings and modernised existing buildings/structures, included under the specification starting from masonry work, partition walls, cladding walls, roof protection, finishing of walls, floors and ceilings, false ceiling as required potable water system, sanitation etc.

During execution of the contract, the Bidder shall take approval from the Owner, for all building materials and finish items (e.g. floor tiles, doors, and windows, paints etc.) to be used for the contract by submitting samples and/or product literature as appropriate.

Finishing works including material used for renovation/modernisation work shall be matched with the finishing of existing structures to make similarity in architectural view of new and existing structures.

11.2 Finishes

All exposed surfaces shall be clean and smooth and members shall be sized to give a pleasing appearance. The Finishes for all Structures and Buildings shall meet the functional requirements and shall be as per the approved Finishing Schedule. However, the finishing schedule shall be pre-approved by the Owner/Consultant.

11.3 Design Requirements

(a) Architectural Concepts

- All buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to all

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buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

- Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipments, exposed structural elements, piping, trestles, bus ducts and other service elements.
- Overall emphasis shall be on developing an eco-friendly architecture, merging with the nature with its own sustainable energy management systems.
- The scheme shall be conceptually finalized in totality including that of equipments so that the proper co-ordination with other agencies can be taken up at appropriate time.

(b) Architectural Design

- Natural light shall be used to the maximum extent. For adequate light and ventilation, National Building Code recommendation shall be followed.
- Entrance canopies, chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.
- All the buildings shall be architecturally designed to meet the National Building Code.
- Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect Statutory requirement and any clearances from local authority may be required to be met with, wherever essential. The Architect Consultant shall be of national - International repute having experience in similar kind of works. The consultant shall evolve the design philosophy and shall present it in the form of presentation drawings, prospective views, 3-D Models & detail drawings.
- A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving plant technology and architectural & civil engineering for a smooth control hierarchy and man machine interface.

The Bidder shall develop the architectural layout of all the buildings listed in this document as per the final approved equipment disposition and other layout considerations indicated elsewhere in this specification. These drawings shall need the approval of the Owner/Consultant before construction. The Bidder shall also have to submit perspective views if so desired by the Owner/Consultant at no expenditure to the Owner. Approval from statutory authorities, e.g. Factories Inspector, Explosives Inspector, Loss Prevention Association of India / Tariff

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Advisory Committee etc. shall be the responsibility of the Bidder without any obligation of the Owner.

The entire complex shall have an architectural character and style of its own and shall be visually and functionally integrated with the existing landscape. The Bidder must visit the site and have a feel of the overall environment, so that a harmonious as well as integrated architectural concept of the proposed phase of development is achieved. Special care must be taken to enhance the visual and technological quality of development by adopting updated technology, materials, finish etc.

11.4 Guideline for Architectural Works

11.4.1 Roof Insulation and Ventilation

Wherever required the roof of buildings shall be insulated with foam concrete. For ventilation requirements relevant section of the specification shall be referred.

11.4.2 Roof Waterproofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size 230x230x18 mm laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

11.4.3 Brick/stone masonry and parapet wall

All masonry works shall be designed in accordance with IS: 1597, IS: 1905, IS: 2212, IS: 4326 and other relevant IS codes as applicable. Structural design of load bearing and non-load bearing walls constructed with solid or perforated burnt clay bricks or concrete blocks shall be in accordance with criteria specified by National Building Code of India.

All walls shall be non-load bearing infill panel walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change rooms, first aid rooms and toilets, which may be half brick thick.

Minimum 50 kg/sq.cm compressive strength brick shall be used for non-load bearing super structure brickwork. Cement sand mortar 1:6 for one brick thick wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided to reinforce the wall where required.

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All brickwork shall be plastered as per specification.

Even where metal cladding is specified, for initial [3 m] height from the ground level, minimum one brick thick masonry wall shall be provided.

All up stands and parapet walls on roof shall be of RCC construction, minimum height of parapet walls shall be [1050 mm] and a minimum thickness of [125 mm].

11.4.4 Cement based polymer modified mortar

a) Purpose

To carry out structural repairs to prepared patches of spalled concrete with an alkaline impervious repair material comprised of polymer admixed cement-sand mortar.

b) Materials and T&P

Polymers in emulsion or powder forms as may be specified conforming to ASTM C1059, Ordinary Portland Cement of 43 grade conforming to relevant BIS code, Sand conforming to Zone-II or Zone-III grade of IS: 383, Mixing water conforming to IS: 456-2000, mortar mixer with mechanical water dozer, spatulas, trowels, etc.

c) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified polymers shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 Testing of Material: The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less). These are to be tested for conformance to the specified requirements before use on the work. Polymer modified cement mortar with cement: sand proportion by weight as (1:3) shall have the following properties

Minimum compressive strength -20N/sq.mm after 28 days at 27oC

Step-4: Identify and mark the area for Polymer modified mortar repair.

Step-5 Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

Prop & support the structural member to relieve it of stress and strains.

Removal of existing surface plaster/treatment shall be done.

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Chipping unsound/weak concrete material shall be done.

Removing concrete all around embedded rusted reinforcement shall be done.

Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done.

Sealing the cracked or honeycombed concrete with injection grouting shall be done.

Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate, which may also be used as depth measuring gauge.

Additional fresh reinforcement, if required, shall be tied with required overlaps or welded.

The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically.

Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done.

Step-6: Clean the dust and saturate the prepared surface of concrete and reinforcement with a clean oil free air blast and water fit for construction.

Step-7: Inspection of concrete surface prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-8: Alignment & thickness Control- Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-9: Apply Passivating & bonding coat over the cleaned existing and new reinforcement.

Step-10: Apply bond coat on the cleaned concrete substrate.

Step-11: Mix and Prepare Polymer Modified Mortar to have a uniform consistency and texture by adding cement sand and polymer as weigh batched ingredients of the design mix, a specified proportion of water through water dozer.

Use of prepacked ready to use components supplied by manufacturers in containers may be allowed subject to approval of Owner. In case where prepacked ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

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Plastering with cement based polymer modified mortar shall be done immediately after applying the bonding slurry to the prepared surfaces, preferably in coats of approximately 10mm thickness as greater thickness may lead to delamination/collapse. However, coats shall be applied in fairly rapid successions within 15 to 30 minutes. After applications of mortar the surface shall be finished using a wooden float.

Step-12: Moist cure the polymer modified mortar surface for 1-3 days followed by air curing at ambient temperature or as per manufacturer's specification, if specified otherwise. Use of flowing water or ponding of water shall not be done for curing. Steam curing shall not be permitted.

Step-13: Test the Surface of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

d) Inspection & Quality control

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing stoppage of work during low temperatures (minimum working temperature being 8°C in most of the polymer modified mortar or as per manufacturer direction) and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 28 days of mortar application. The cores shall be examined for evidence of poor workmanship by the Owner, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall dismantle such areas of work as required by the Owner and re-do the same after re-preparing the surface by chipping off mortar work and abrading the bonding slurry interface.

11.4.5 Partition Wall

All intermediate walls shall be full brick thick wall in 1:6 cement sand mortar. Half brick thick wall in 1:4 cement: sand mortar with [2 nos. 6 mm] diameter rod in every fourth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area.

11.4.6 Metal cladding

a) Permanent colour coated sandwiched insulated metal cladding system

Trough zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 180 gm / sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film

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Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanised M.S. sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanising shall not be less than 180 gm / sq. m.

The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanised steel sheet of grade 375 as per IS: 277. Inner sheet shall be fixed at the rate not more than 0.75 m centre to centre to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS: 8183, having a density of 32 kg / cu. m for glass wool & 48 kg / cu. m for rock wool.

b) Permanent colour coated (non-insulated) metal cladding system

Trough zinc-aluminium alloy coated not less than 180 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability.

c) Flashings, Cap, Trim Closures etc.

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

11.4.7 Plastering

On the exterior wall & rough side of interior brick wall [18 mm] thick minimum with cement-sand mortar in two layers shall be applied. Where external finish will require rich plastering for special finish plaster shall be of 1:4/1:3.

Interior wall: [12 mm] thick with 1:4 cement-sand mortars

Ceiling: [6 mm] thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

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11.4.8 Removal of plaster manually from masonry or concrete surface using chisel and hammer and disposal of debris etc

a) Purpose

For removal of all type of loose /delaminated /damaged/weak cement plaster from surface of masonry or concrete.

b) Procedure

Step-1: Safety shall be ensured in accordance with contract conditions and specifications.

Step-2: Provide double scaffolding, protective screens etc.

Step-3: Existing plaster to be identified for removal by tapping all areas and its boundary shall be marked with a colour marking (in an optimal rectangular shape), which shall be approved by Engineer-in-Charge.

Step-4: Make a cut normal to the surface all along the boundaries with power driven cutters. The depth of cut shall not exceed the thickness of plaster.

Step-5: Remove the plaster manually with the help of chisel and hammers to completely expose the parent masonry or concrete surface, so as not to have any traces of such plaster left behind.

11.4.9 False ceiling and under deck insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the under side of the roof / floor slab of the air-conditioned areas based on the functional requirement. Aluminium false ceiling system shall comprise of [84 mm] wide [12.5 mm] deep closed type plain panels of approved colour, roll formed out of [0.5 mm] thick corrosion resistant aluminium alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, AC ducts etc. Suitable M.S channel (minimum ISMC100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc.

Bidder shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire detectors, fire protection sprinklers etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the Owner approves the layout. Under deck insulation shall comprise of [50 mm] thick resin bonded mineral wool insulation mat conforming to IS:8183. This mat shall be backed with [0.05 mm] thick aluminium foil and [24 Gx25 mm] wire mesh netting. These shall be fixed to ceiling or wall as the case may be with [100x50x6 mm] slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at [600 mm c/c and 14 G] steel wire drawn through slots and fixed to wire netting.

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11.4.10 Doors

- Generally hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas.
- Solid core factory made wooden flush doors in hard wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.
- Special areas like control rooms and other special area shall be provided with minimum 15 micron pre-coated Le. colour anodised aluminium glazed partitions with air lock facilities having two sets of doors.
- Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard and also to all fire exists as per TAC requirement.
- Doors shall be provided at appropriate location to prevent dust ingress from outside.
- FRP Doors with FRP Frames shall be provided for all the toilet doors.
- Weather stripping shall be provided to all outside doors as well as air-conditioned areas and all other doors where dust-free environment is required.

11.4.11 Rolling shutters

Rolling steel shutters conforming to IS: 6248 will be used for large openings where frequent use is not envisaged. Unless noted otherwise, main entry doors of width and height to suit the requirements. Rolling shutters with area up to 8 m² shall be pull and push type hand operated, while above 8 m² shall be pull and push type with ball bearings (Electrically operated) as per IS specification.

11.4.12 Windows & Ventilators

In all buildings, full glazed windows and ventilators in minimum [15 micron] colour anodized aluminium window frame shall be provided with [4 to 6 mm] thick (depending on the size of panel) clear float glass and [6 mm] thick clear wired/laminated glass where required from safety point of view. Structural glazing may be considered as an important facade element.

The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Glass thickness and member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Bidder before execution.

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11.4.13 Plywood Covering Panels to Cover Windows etc. During repairs

a) Purpose

To protect the finished items against their spoiling/damage to finishes during the process of carrying out repairs in a building. The items could include finished windows, doors, glass curtain wall or other such items.

b) Materials:

Wooden Battens of size 50mm X 50mm (approximately) or as approved by Engineer-in-charge, free from warping, cracks etc. made from locally available timber.

Plywood of suitable thickness preferably 6 mm thick as approved by Engineer-in-Charge.

Nails, screws etc. as per requirement.

c) Fabrication:

Size of covering panels shall be more than the size of windows etc. to be shielded/ protected, enough to be fixed to the walls without damaging the windows etc.

Wooden battens shall be cut approximately to the size of panels of windows etc. to be protected. The joints of the wooden framework shall be lap joint or as approved by Engineer-in-Charge.

Where the panel size is more than 2 square metres or as specified by the Engineer-in-Charge, the stiffening shall be done with batten backing to impart stiffness enough to provide rigidity against undue deflection due to impact of falling debris, self load, etc.

Plywood shall be fixed with nails/screws over the batten frames. The spacing of nails/screws shall be about 300mm c/c or as may be required at site.

d) Fixing:

The plywood covering panel shall be suitably fixed without damaging the windows etc. being protected by such panels with nails/screws fixed in walls strong enough to resist the forces likely to be imparted during repair work. It shall be done in such a manner that it can be removed with ease without damaging the covered windows etc. after completion of repairs.

e) Removal:

After completion of work, the covering panels shall be removed carefully, so as not to cause any damage to windows etc. covered. The damages, if any, shall be made good.

11.4.14 Facilities in Buildings

Adequate toilet and drinking water facilities shall be provided for personnel working in each building. Each building shall have toilet facilities both for Gents

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and Ladies. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.

However minimum 1 Water Closet, 1 washbasin, 1 urinal shall be provided in each toilet.

Each floor shall have drinking water facility connected through water purification system like Aquaguard or similar approved make.

11.4.15 Glazing & Glazed Partition

- Glazing in Control room between AC. and non-AC. areas shall be insulating glass consisting of [two 6 mm] thick toughened float glass sheet hermetically sealed and separated by [12 mm] gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.
- [4 mm] thick ground glass shall be provided for toilets.
- Glazing between two AC. areas shall be with 6 mm thick clear float glass.
- All glazing shall be in aluminium frame.
- [6mm] thick Wired / laminated glass shall be used for windows / ventilators at higher level for safety.
- [24mm] thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with [12mm] air gap & hermetically sealed shall be mounted on [15 micron] coloured anodised aluminium frame suitable for structural glazing system.

11.4.16 Sealant

Silicon sealant or polyurethane sealant shall be used in all expansion joints exposed to weather. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water-lightness.

11.4.17 Damp Proof Course

[40 mm thick 1:1.5:3] concrete with waterproofing admixture. Water proofing compound shall be of Zydex, SIKa, or similar approved.

11.4.18 Plinth Protection

Minimum [1000 mm] wide and minimum [100 mm] thick M 15-grade concrete plinth protection along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be provided. The plinth protection shall be laid over prepared sub-grade and base formed with locally available broken laterite stone to thickness of [150 mm].

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11.4.19 Painting

- Exterior Masonry Surface : Buildings shall be finished with [Acrylic Emulsion pain] as per IS specification with approved colour and scheme.
- Exterior Steel Work : Anti-corrosive synthetic enamel paint over [anti corrosive primer].
- All Woodwork: [Synthetic paint over a coat of primer].
- All Internal Steel Work : [Synthetic enamel over a coat of primer].
- Interior Office Spaces Rooms, All AC Areas : Acrylic emulsion paint over [2 mm] control thick plaster of paris punning.
- Balance areas: As indicated in finish schedule in this document.
- Fire Door: Post Office red shade shall be provided.

11.4.20 Flooring

Unless and otherwise specified, the nominal total thickness of floor finish shall be [50 mm] including under bed and topping. The flooring shall be laid on already matured concrete base. The under bed for floors shall consist of minimum grade of M 15 with stone chips [12.5 mm] downgraded as coarse aggregates. The under bed shall be provided appropriate slope towards catch pit for floor drainage.

- **False Flooring System**

Removable type false flooring system shall be provided wherever required (computer rooms etc.). RCC floor slab will be sunk to a depth [800 mm], which shall be height of the false floor system. The flooring shall consist of fire resistant phenol formaldehyde bonded particle board panels [600x600x35 mm] size, mounted on steel pedestals of adjustable height and supporting steel grid system to provide under floor space. [2 mm] thick flexible anti-static PVC topping on top and PVC strip edging on sides of each panel shall be provided.

- **PVC Floor Finish**

Two mm thick PVC as per IS: 3462 and laid as per IS: 5318 over concrete under bed of [48 mm] shall be provided in electronic cubicle rooms, conference room, etc. PVC tiles shall ensure anti static surface.

- **Vitrified ceramic Tiles**

Heavy duty vitrified ceramic tiles of appropriate thickness and of minimum size [600 mm x 600 mm] of approved shade & colour shall be provided for control room as per relevant code and manufacturer's specification over concrete bedding to result in an overall thickness of [50 mm].

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- **IPS Flooring**

IPS (cement concrete flooring) with metallic floor hardener topping [12 mm] thick with a total thickness of [50 mm] shall be provided in maintenance and unloading area, ground floors, floor of pump house, permanent stores and other plant building areas where heavy duty flooring is required.

IPS flooring with non-metallic floor hardener shall be provided in all MCC and switchgear rooms, which are not air-conditioned.

IPS flooring shall also be provided in areas, which are not provided with any special finish. Areas which are likely to be subjected to oil spillage shall be provided with two coats of oil resistant painting over IPS floor finish. If required, Bidder has to use floor hardeners at appropriate locations.

- **Heavy Duty Ceramic Tiles**

Heavy duty vitrified ceramic tiles with suitable finish shall be used in toilets, pantry, dining hall of canteen, locker rooms etc. The tiles shall be minimum of [300 x 300 x 7 mm] of approved shade, brand and colour.

- **Acid / Alkali Resisting Tiles**

Battery rooms and other areas coming into contact with acid / alkali vapours or fumes shall be given acid / alkali resistant tiles [25 mm] thick, jointed with acid / alkali resistant cement slurry. Bedding shall comprise of potassium silicate mortar conforming to IS: 4832 (Part-I) and resin based mortar like epoxy for jointing. Total thickness of flooring shall be [50 mm]. Ceramic unglazed vitreous tiles conforming to IS: 4457 with minimum thickness of 20 mm may also be used as acid / alkali resistant tile.

- **Integral Floor Finish**

For cable vaults floor finish integral to the concrete base shall be provided as per IS: 2571.

- **Cast-in-situ Terrazzo**

Risers and treads of staircases shall be provided with cast in-situ terrazzo. This shall be laid as per IS: 2114, using white cement or cement with colouring pigment. Chequered finish shall be provided for treads. Total thickness of the finish shall be 25 mm.

11.4.21 Miscellaneous

PVC nosing shall be provided for edge protection of R.C.C. stair treads.

Angles [50x50x6 mm] (minimum) with lugs shall be provided for edge protection of cutouts / openings in floor slabs, edge of drains covering gratings, edge of R.C.C cable / pipe trenches of any other place where breakage of edges / corners is expected.

Floors of switchgear rooms shall have embedded steel channel suitable for easy movement of breaker panel.

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11.4.22 Skirting/DADO

- [150] mm skirting matching with floor finish shall be provided in all areas unless specified otherwise elsewhere.
- Toilets and locker rooms shall be provided with dado of [2100] mm high with glazed tiles of minimum [5] mm thickness generally as per IS: 777.
- For Control room and control equipment room minimum 5 mm thick decorative coloured ceramic tiles shall be provided upto false ceiling level.
- For battery room and other areas coming in contact with acid / alkali spillage / fume, dado of acid / alkali resistant tiling as per IS: 4457 shall be provided to a height of [2100] mm set in potassium silicate mortar and joints pointed with resin bonded mortar
- Staircase wall shall be given dado of cast in-situ terrazzo to a height of [2100] mm or as per approved drawings.
- Before wall surfaces are covered with tiles, flags or mosaic to be set in normal mortar bedding, a sprayed coating of cement mortar shall be applied to the base unless otherwise specified. Where no adequately even surface is available for work involving thin beddings, special provisions shall be made to compensate for this, e.g., rendering coat, screed. The concrete surface to which tiles, flags, terrazzo, screed, etc are to be placed, shall be cleaned by wet sandblasting and washed with water under pressure, so as to produce the specified surface condition.
- The exterior brickwork walls shall consist of load bearing and non-load bearing type construction. Exterior surfaces shall be treated with approved chemical waterproofing over cement plaster. Bricks of minimum 75 kg/cm² crushing strength shall be provided. Brickwork shall be carried out in cement sand mortar conforming to IS: 1077. Cement sand mortar shall conform to IS: 2250.

11.4.23 Roof access

All roofs shall be provided with access thorough a staircase / cage ladder. Minimum [1000 mm] wide access path shall be provided with suitable tiles to approach equipment on roof.

11.4.24 Roof Drains

Roof drains design criteria

Minimum diameter of the pipe shall be [150 mm]. The roof drains shall be sized for the roof area runoff for a maximum rainfall per hour at site.

Detailed specification is mentioned elsewhere in this specification.

Roof Drainage and Water Proofing

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All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size [230x230x18 mm] laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

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12 GENERAL REQUIREMENTS

12.1 Roof

All the buildings having R.C.C slabs over structural steel framing are provided with troughed metal sheet decking which acts as permanent shuttering. These sheets shall meet the general requirements of IS: 14246 and shall conform to class 3 for durability. The sheeting shall be permanently colour coated galvanised M.S. troughed metal sheet decking of approved profile with minimum base metal thickness of 0.8 mm and minimum trough depth of 38 mm. Silicon modified polyester painting shall be used for permanent coating over galvanised surface with minimum rate of galvanising of 180 gm of zinc per sq. m. Dry film thickness of colour coating shall be at least 20 micron.

Roof of all buildings having R.C.C. framework shall have cast in-situ R.C.C. slab with conventional shuttering.

Structural steel roofing wherever required shall be of permanently colour coated galvanised M.S troughed metal sheet of approved profile. Minimum base metal thickness shall be 0.8 mm. The rate of zinc consumption for galvanising shall be 275 gm/sq. m. The external face shall have permanent colour coating of PVF 2 paint of minimum DFT of 20 microns and inner surface shall be coated with silicon modified polyester paint with DFT of 20 microns

12.2 Platforms and walkways

Platforms shall be provided to all major equipment, not directly accessible from the floors, for maintenance. Platforms and connecting walkways shall have a minimum width of 750 mm. Platforms in front of the entry shall be at least 900 mm wide. Platforms located close to each other shall be connected with walkways.

All steel platforms above grade level shall be constructed with kick plates at edge of the platform to prevent tools or materials from falling off. It shall consist of 8 mm thick steel plate projecting 100 mm above the platform surface. Kick plate shall be painted with the same type of coating as the material to which it is attached. Approach to EOT crane shall be ensured by Cage ladder or staircase.

12.3 Stairs and ladders

Steel Stairs

All steel staircases shall normally have minimum clear width (back to back of stringer) of 1000 mm and maximum inclination with horizontal of 35.75°. However, in case of space restriction, minimum clear width up to 750 mm and slope up to 45° may be provided. The vertical height between successive landings shall not exceed 5 m. Channels (minimum MC 200) shall be provided as stair stringers. Treads shall be minimum 250 mm wide of chequered

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plate/grating, with suitable nosing, and spaced equally so as to restrict the rise to maximum 180 mm (200 mm in exceptional cases).

Steel Ladders

Ladders shall be provided to platforms, walkways, instruments and equipments, which do not require frequent access. Ladders shall preferably be vertical and its angle with vertical shall not exceed 50. Ladders shall be of minimum 450 mm clear width with 20 mm diameter MS rungs spaced at 300 mm (maximum).

Ladders shall be provided with a safety cage of minimum 750 mm diameter clear when the top of ladder is more than 4.5 m above the landing level. However safety cages shall start at 2.5 m above the lower landing level.

RCC Stairs

All stairs shall have maximum riser of 180 mm and a minimum tread of 250 mm. However, for public buildings riser shall be limited to 150 mm and tread width of 300 mm. Minimum width of stairs shall be 1200 mm generally. All stairs normally shall not have more than 15 risers in one flight. Aluminium angle nosing with minimum 50X25X3 angle or PVC nosing shall be provided for edge protection of RCC stairs.

12.4 Handrails

Handrails shall be provided at appropriate places to ensure safety e.g. around all floors/roof openings, projections / balconies, walkways, platforms, steel stairs etc.

All handrails shall be of 32 mm nominal bore MS pipes (medium class) as per IS: 1161 galvanised using 900 gm/sq. m of zinc. Handrails for platforms, walkways and projections shall be a two-rail system with the top rail 1000 mm above the walkway surface and the intermediate rail 450 mm below the top rail. Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the protected horizontal opening. In such a case spacing shall not exceed 1850 mm centre to centre of posts. Handrails shall be shop fabricated for specific locations and field welded or bolted to the erected structural steel. For platforms at elevation more than 30 m, three rail system with top rail at 1500 mm shall be adopted.

For RCC stairs, handrails with 20 mm square MS bar balustrade with suitable MS flat & aluminium / Teakwood handrail shall be provided, unless specifically mentioned otherwise. All hand rails except stairways shall be provided with toe guard plate of 100x8mm thick.

12.5 Edge protection

Wherever possible around floor openings an RCC kerb of 100 mm wide 150 mm high shall be provided. All concrete edges, where breakage of concrete corner is expected, shall be provided with angles at least L 50x50x6 with lugs for edge protection e.g. all round the cut-outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers,

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edges of manholes supporting covers and supporting edges of precast covers etc.

12.6 Vertical Headroom

All accessible areas shall be provided with minimum clear headroom as follows, unless otherwise specified:

Table 2.9

Headroom

Description	Headroom, mm
Finished floors to ceiling (buildings)	3000
Doors, Walkways, Platforms, Stairs etc.	2100
False ceiling of office areas	3000
False ceiling walkway	1000
Safety cage for ladders	2500
Access for forklift trucks	2800
Main roads/Railway crossings & crane access	7000
Other plant roads and truck access	5000
Cable & Pipe rack (except road/rail crossings)	3000

12.7 Waterproofing of underground structures

All underground structures like basements, pump houses, water retaining structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sq.m (minimum) for water/ damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that waterproofing grouting can be injected later in case of leakage.

12.8 Anti-termite treatment/Anti-weed treatment

Pre-constructional anti termite treatment shall be given to all buildings as per IS: 6313 and other relevant Indian Standards.

Reservoirs shall be given an anti-weed treatment of approved quality and quantity as per the manufacturer's specification. Anti weed treatment shall be carried out before carrying out the lining work.

12.9 Plinth Level

The finished floor levels of CHP, transfer towers, crusher house shall be 800 mm higher than the external finished ground level. Finished ground floor level (plinth level) of all buildings and pump houses shall be minimum 500 mm above the formation level/grade level.

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All cable vaults shall be located above ground level i.e. cable vaults shall not be provided as basements in the buildings.

12.10 Statutory Requirements

All the applicable statutory rules pertaining to Indian Factories act, Factory rules of state government, Fire safety rules of Tariff Advisory Committee, Water act of Pollution Control Boards, Explosives act etc. and stipulations of other relevant statutory authorities shall be taken into consideration at the time of design.

Provisions of safety, health and welfare according to Factories act shall be complied with design stage. These shall include provision of continuous walkway (minimum 500 mm wide) along crane-girder at crane girder level on both sides of the building, comfortable approach to EOT crane cabin, railings, fire escape, locker room for workmen, pantry, toilets, rest room etc.

Adequate number of fire escapes shall be provided in a building. Fireproof doors, number of staircases, fire separation walls, lath plastering on structural steel member (in fire prone areas) shall be made according to the recommendation of TAC. For fire safety requirements of buildings IS: 1641 and IS: 1642 shall be followed in addition to TAC requirements. All masonry firewalls shall be minimum 345 mm thick and RCC firewall shall be minimum 200 mm thick.

12.11 Waterproofing of underground structures

All underground structures like basements, pump houses, water retaining structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sq.m (minimum) for water/ damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that waterproofing grouting can be injected later in case of leakage.

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13 GENERAL CIVIL WORKS AND CONSTRUCTION TOLERANCES

13.1 Basic requirements for all civil works

Design requirements

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Owner/Consultant.

- Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers (whichever is less).
- The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable nor troublesome to personnel and will not cause damage to the machine or structure.
- The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating plant.
- The differences between frequencies and the dynamic analysis of the superstructures and foundations shall be in accordance with the relevant design standard.
- The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.
- Throughout the works all floor slabs above rooms containing electrical equipment shall be watertight. No drainpipes or water pipes are permitted to pass through these rooms.
- All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Owner/Consultant and shall comply strictly with the tests prescribed hereinafter or, where tests are not laid down in this specification, with the requirements of the latest issue of the relevant Indian, American, British, German Standards or other Standards approved by the Owner/Consultant.
- Samples of all materials proposed to be used in the works may be called for at any time by the Owner/Consultant.
- The work shall be carried out by competent personnel skilled in their various trades.

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- Before commencing the works, the Bidder shall ascertain the locations and nature of all existing underground services and shall take every possible precaution against any damage occurring to them or interference therewith, during the execution of the works.
- Suitable access to the roofs of the buildings by means of steel stairs shall be provided for maintenance and repair of any installation.
- All rooms with fire hazard shall be provided with suitable emergency exits.
- Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles, which will be used (cars, forklifts, trucks/trailers etc) to reach up to the point of unloading of the equipment.
- Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms, at all levels using suitable stair wells and suitable electric hoists. The dimensions of rooms, stairwells, doors, etc shall be designed to suit the a.m. transport concept.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.

13.2 Basic requirements during construction

Basic Cleaning

Basic cleaning includes all floors, walls, ceilings, built-in fittings and equipment, including the furnishings. The basic cleaning operation must result in a degree of cleanness, which permits the fully equipped buildings and rooms and associated outdoor installations and secured surfaces to be taken over without complaint.

Advertising boards and stickers, temporary protective coatings and claddings, remains and splashes of paint, must be removed with water or suitable solvents.

Dust and other dirt must be completely removed from all wall and floor surfaces, as well as from all furniture.

Windows and mirrors must be cleaned so that they are completely clear and without streaks.

Perlator gauges, showerheads, odour traps and floor drains of the sanitary installations must be cleaned and the fittings and bright pipe work must be spotlessly polished.

Petrol and oil separators must be emptied, cleaned and refilled if necessary during basic cleaning.

Lamps, including dishes, lighting units and tubes, switches and sockets as well as bases and skirting boards, doors with frames and glazing, windows, window

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seats and other furniture and fittings must be included in the basic cleaning operation.

Initial Equipment

The specification is drawn up on the assumption that the scope of the initial equipment and consumption materials is to be provided complete in every respect; everything required for the use and care of the installations must be supplied, even if this is not expressly specified in the documentation.

Bidder shall ensure that during excavation ground water level shall be lowered by at least 0.50 m below the founding level adopting appropriate method of dewatering. Lean concrete below foundation shall be laid soon after excavation with minimum loss of time.

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14 STANDARDS, CODES AND REFERENCES

14.1 General

The Design of the Steel Structural Works shall be prepared and presented in accordance with IS codes. In absence of guidelines of specific items in the IS codes, International codes viz., American, BS, DIN or Australian code shall be used. All the Indian Standards referred to shall be the latest revision (including all amendments issued thereto) on the date of opening of the price bid. The Standards adopted shall be clearly stated in the calculations.

The Design shall comply with the current Local Authority Building Regulations (National Building Code) where appropriate. Subject to the agreement of the Owner, other International / Foreign National Standards, and, International / Foreign National Standard Codes of Practice, may be used.

To the extent that the Design shall include materials, methods or workmanship to be incorporated into the works, they shall be selected and incorporated into the design in accordance with the recommendations and requirements of the following (as appropriate in order of precedence but not mutually exclusive):

Statutory requirements

The Contract provisions

Bureau of Indian Standard Codes of Practice

International / Foreign National Standards

Agreement Certification for Materials

Manufacturer's recommendations for materials

Competent Trade Association recommendation

Engineering judgment

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

Where British / American / DIN or other codes and standards are referred to in this document, equivalent Indian Standards may be substituted if available.

Materials supplied from India shall follow the Indian Standard Specifications.

Field and laboratory testing procedures for materials follow Indian Standard Specifications.

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14.2 Codes for Loads

- IS: 875 : Code of Practice for design loads (other than earthquake) for Buildings and structures (All parts)
- IS: 1911 : Schedule of unit weights of building materials
- IS: 1893 (Part 1) : Criteria for earthquake resistant design of structure – General provisions and buildings
- IS: 1893 (Part 4) : Criteria for earthquake resistant design of structure – Industrial structures including stack-like structures

14.3 Codes for RCC

- IS: 456 : Plain and reinforced concrete - Code of Practice
- IS: 2974 : Code of Practice for design and construction of machine foundations
- IS: 2911 : Code of Practice for design and construction of pile foundation
- IS: 4326 : Code of Practice for earthquake resistant design and construction of buildings
- IS: 4995 : Criteria for design of reinforced concrete bins for storage of granular (all parts) and powdery materials
- IS: 4998 : Criteria for design of reinforced concrete chimneys: (All parts)
- IS: 5525 : Recommendation for detailing of reinforced concrete works
- IS: 1786 : Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS: 11384 : Code of Practice for composite construction in structural steel and concrete
- IS: 11504 : Criteria for structural design of Reinforced concrete Natural Draft Cooling Tower
- IS: 11682 : Criteria for design of RCC staging for overhead water tanks
- IS: 13920 : Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces

14.4 Codes for Structural Steel

- IS: 800 : Code of Practice for general construction in steel
- IS: 801 : Code of practice for use of cold-formed light gauge steel structural members in general building construction
- IS: 806 : Code of Practice for use of steel tubes in general building construction
- IS: 808 : Dimensions for hot rolled steel beam, column channel and angle section

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IS: 812	: Glossary of terms relating to welding & cutting of metals
IS: 813	: Scheme of symbols for welding
IS: 814	: Covered electrodes for manual metal arc welding of carbon and carbon manganese steel - Specification
IS: 815	: Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel
IS: 816	: Code of Practice for use of metal arc welding for general construction in mild steel
IS: 817	: Training of welders - Code of practice (Part 1 & 2)
IS: 818	: Code of practice for safety and health requirements in electric and gas welding and cutting operation.
IS: 819	: Code of practice for resistance spot welding for light assemblies in mild welding
IS: 822	: Code of practice for inspection of welds.
IS: 1182	: Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
IS: 1200	: Method of measurement of building and civil engineering works
IS: 1161	: Steel tubes for structural purpose
IS: 1363	: Indian standard- Hexagonal head bolts, screws and nuts of product grade C
IS: 1367	: Technical supply condition for threaded fasteners
IS: 1477	: Code of practice for painting of ferrous metal in building
IS: 1852	: Specification for rolling and cutting tolerance for hot-rolled steel products
IS: 2062	: Structural steel (fusion welding quality)
IS: 2074	: Ready mixed paint, air drying, red oxide zinc-chrome, priming
IS: 2645	: Specification for integral cement waterproofing compound
IS: 2932	: Specification for enamel, synthetic exterior type –I
IS: 3613	: Acceptance tests for Wire flux combination of submerged arc welding
IS: 3757	: Specification for high strength structural bolts
IS: 4000	: Code of practice for High Strength bolts in steel structures
IS: 7205	: Safety code for erection of structural steel work
IS: 7215	: Specification for Tolerances for fabrication of steel structures
IS: 7280	: Specification for Bare wire electrodes for submerged arc welding of structural steel

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- IS: 8640 : Recommendations for dimensional parameters for industrial building
- IS: 9178 : Criteria for design of steel bins for storage of bulk material (All parts)
- IS: 9595 : For Metal arc welding of carbon and carbon manganese steel - Recommendation
- IS: 11592 : Conveyor galleries
- IS: 12843 : Tolerances for erection of steel structures

14.5 Miscellaneous Codes

- IS: 919 : ISO system of limits and fits
- IS: 1038 : Specification for steel doors, windows and ventilators
- IS: 1172 : Code of basic requirements for water supply, drainage and sanitation
- IS: 1346 : Code of Practice for water proofing of roofs with bitumen felts
- IS: 1742 : Code of Practice for building drainage
- IS: 1905 : Code of Practice for structural use of unreinforced masonry
- IS: 2210 : Criteria for design of reinforced concrete shell structures and folded plates
- IS: 2633 : Method for testing uniformity of coating on Zinc Coated Articles
- IS: 3067 : Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
- IS: 4759 : Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products
- IS: 10440 : Code of Practice for construction of reinforced brick and reinforced brick concrete floors and roofs
- IS: 13592 : Un-plasticized polyvinyl chloride (UPVC) Injection molded fittings for soil & waste discharge system for inside and outside buildings including ventilation and rail water system specification
- IS: 15658 : Precast concrete blocks for paving
- SP: 6 : Handbook for structural engineers - All parts
- SP: 7 : National Building Code of India
- SP: 16 : Design Aids for reinforced concrete to IS: 456-1978
- SP: 20 : Handbook on masonry design and construction
- SP: 22 : Explanatory handbooks on codes for earthquake engineering (IS: 1893-1975 and IS: 4326-1976)

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- SP: 24 : Explanatory handbooks on Indian Standard code of Practice for plain and reinforced concrete
- SP: 25 : Handbook on causes and prevention of cracks in buildings
- SP: 32 : Handbook on functional requirements of industrial buildings
- SP: 34 : Handbook of concrete reinforcement and detailing (SCIP)
- TAC : Traffic Advisory Committee
- : Indian Explosive Act
- : Indian Factory Act and State Factory Act
- : Indian Electricity Act

Any statutory codes / standards / regulations other than listed above, as may be applicable, shall be followed.

Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in this document, the latest editions of the codes and standards given below shall also apply:

- a) Japanese Industrial Standards (JIS).
- b) American National Standards Institute (ANSI).
- c) American Society of Testing and Materials (ASTM).
- d) American Society of Mechanical Engineers (ASME).
- e) International Organization for Standardization (ISO).
- f) American Welding Society (AWS).
- g) National Electrical Manufacturers Association (NEMA).
- h) National Fire Protection Association (NFPA).
- i) International Electro-Technical Commission (IEC).
- j) German national codes (DIN)
- k) Expansion Joint Manufacturers Association (EJMA)

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-III
PART-A
TECHNICAL SCHEDULES-MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
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	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II:DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors–Coal handling Plant Volume-III, Part-A	[iv]	25.09.2014

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

**VOLUME-III, PART-A
TECHNICAL SCHEDULES-MECHANICAL
(TO BE FILLED BY BIDDER)**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[v]	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
1.0	COAL HANDLING PLANT		
1.1	Coal Bunkers		
	a) Bunker capacity at BMCR condition	h	
	b) Bunker capacity at BMCR condition	m ³	
	c) Shape		
	d) Material and thickness		
	e) Lining and thickness		
	f) Coal density considered for bunker volume calculation	kg/m ³	
	g) Coal density considered for structure design calculation	kg/m ³	
	h) Level sensing arrangement		
	i) Air blasting arrangement		
	j) Bunker drawing to be enclosed		
1.2	Belt Conveyors (Furnish information for each belt conveyor-wise)		
1.2.1	a) Guaranteed capacity b) Design Capacity	TPH TPH	
1.2.1.1	Maximum lump size of coal handled	mm	
1.2.2	Belt width x speed x Troughing angle	mm x ms ⁻¹ x deg.	
1.2.2.1	Belt Position i. Length between centers ii. Maximum angle of inclination iii. Total lift	m Degree m	
1.2.3	Type & Make of belt and standard adopted	...	
1.2.4	Belt rating	kN/m	
1.2.5	Top cover thickness x Bottom cover thickness	mm x mm	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[1]	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
1.2.6	Cover Grade		
1.2.6.1	Weight of belt/meter length	kg	
1.2.6.2	Length of belt required for replacement including jointing allowance	m	
1.2.7	Idlers:		
	i. Standard adopted: for tube x idler set		
	ii. Tube material x outside diameter (OD) x thickness	(mm x mm)	
	iii. Type & Make of bearings		
	iv. Idler spindle material (include impact)		
	v. Bearing size (exclude impact)	mm	
	vi. Bearing size (for other idlers)	mm	
	vii. Troughing idler spacing x self-aligning troughing idler spacing	m x m	
	viii. V-type (2-Roll) return idler spacing x self-aligning return idler spacing	m x m	
	ix. Impact idler spacing x Nos. per loading point	mm	
	x. Impact idler OD steel x tube thickness x OD rubber ring	mm x mm x mm	
	xi. Min. bearing life in working hours	h	
	xii. Motor name plate rating and RPM		
1.2.8	Pulleys:		
1.2.8.1	Head Pulleys (including traveling tripper's head pulley):		
	i. OD x bearing cold rolled steel (CRS) x shell thickness x end disk thickness	mm x mm x mm x mm	
	ii. Shaft diameter @ bearing x shaft material	mm	
	iii. Shaft deflection		

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
	iv. Type x thickness x lagging material x shore hardness	_ x mm x _ x Shore A	
1.2.8.2	Drive Pulleys (for dual drive and where drive unit is not at head end):		
	i. OD x bearing CRS x shell thickness x end disc thickness	mm x mm x mm x mm	
	ii. Shaft diameter @ bearing x shaft material	mm x _ mm	
	iii. Shaft deflection	min.	
	iv. Type x Thickness x Lagging material x Shore hardness	_ x mm x _ x Shore A	
1.2.8.3	Tail + Take-up + Bend Pulleys (including tripper bend pulley):		
	i. OD x bearing CRS x shell thickness x end disc thickness	mm x mm x mm x mm	
	ii. Shaft diameter @ bearing x shaft material	mm x _ mm	
	iii. Shaft deflection	min.	
	iv. Lagging thickness x material x shore hardness	mm x _ x Shore A	
1.2.8.4	Snub Pulleys		
	i. OD x Bearing CRS x Shell thickness x End disc thickness	mm x mm x mm x mm	
	ii. Shaft diameter x Shaft material	mm	
	iii. Shaft deflection	min.	
	iv. Lagging thickness x material x Shore hardness	mm x _ x Shore A	
1.2.8.5	Deflector Rollers		
	i. OD x Shell thickness x bearing CRS	mm x mm x mm	
	ii. Shaft diameter @ bearing x type of bearing	mm x _	
	iii. Lagging thickness x material	mm x _	

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[3]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	iv. Quantity provided per conveyor	Nos.	
1.2.8.6	Holding down Pulleys (on concave portion of belt):		
	i. Pulley OD x shaft diameter x bearing CRS		
	ii. Lagging thickness x material		
1.2.8.7	Pulleys (General)		
	i. Min. bearing life in working hours	h	
	ii. Type & Make bearing used		
	iii. Type & Make of Plummer block		
	iv. Material of construction of Plummer block		
1.2.8.7.1	v. Standard adopted (pulleys) Take-up i) Type ii) Estimated weight of carriage & pulley	kg	
1.2.8.8	Drive Units		
	i. Type of drive unit		
	ii. Wrap angle	Deg.	
	iii. Actual power consumption at motor shaft	kW	
	iv. Motor power installed	kW	
	v. Type; make of fluid coupling (HS side)		
	vi. kW rating of fluid coupling	kW	
	vii. Gearbox type & Make and size		
	viii. Service factor used (for gearbox selection) on motor rating		
	ix. Input kW rating x thermal rating	kW x kW	
	x. Type, size & make of low speed coupling		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[4]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	xi. Type, Size & Make of Holdback provided (where applicable)		
	xii. Service factor used to select holdback		
	xiii. Torque rating of holdback	Nm	
	xiv. Type, size & make of brake provided		
	xv. Service factor used to select brake		
	xvi. Torque rating of brake		
1.2.9	Gearbox		
	• Conveyors Nos.		
	• Manufacturer & Model no.		
	• Type		
	• Reduction Ratio (Nominal & Exact)		
	• Maximum allowable rating (Mechanical/Thermal)	KW	
	• Mechanical efficiency	%	
	• Type of Enclosure		
	• Bearing type & life		
	• Method of lubrication		
	• Type of primary coupling		
	• Type of secondary coupling		
	• Hold back provided		Yes/No
	• Details of Hold back		
	• Drive base frame provided		Yes/No
	• Materials of construction		
	• Casing		
	• Shaft		
	• Gear, pinion, worm etc.		
	• Gears & pinions hardened and ground		Yes/No
	• Duty conditions		
	• No. of working hour per day		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[5]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	<ul style="list-style-type: none"> Indoor/Outdoor 		
	<ul style="list-style-type: none"> Due consideration for Conveyor starting made 		
	<ul style="list-style-type: none"> Whether Mech. rating of Gear Box is not less than 1.25 times the rating of its drive motor or 1.5 times the demand power at motor output considering Design capacity or as per manufacturer's recommendation, whichever is higher. 		Yes/No
	<ul style="list-style-type: none"> Gear Boxes selected after thermal condition checking 		Yes/No
	<ul style="list-style-type: none"> Catalogue enclosed 		Yes/No
	<ul style="list-style-type: none"> Service factor 		
1.2.10	Fluid Couplings		
	<ul style="list-style-type: none"> Location (Mention Conv. No./Crusher No.) 		
	<ul style="list-style-type: none"> Number required (Furnish location-wise) 		
	<ul style="list-style-type: none"> Manufacturer 		
	<ul style="list-style-type: none"> Type 		
	<ul style="list-style-type: none"> Model Number 		
	<ul style="list-style-type: none"> Max. allowable KW transmitted (Mention equipment-wise) 	kW	
	<ul style="list-style-type: none"> Rated input speed 	rpm	
	<ul style="list-style-type: none"> Rated slip 	%	
	<ul style="list-style-type: none"> Whether oil quantity can be adjusted at site 		
	<ul style="list-style-type: none"> Whether fusible plug provided 		
	<ul style="list-style-type: none"> Specification of filling oil 		
	<ul style="list-style-type: none"> Temperature at which plug fuses 	deg.C	
	<ul style="list-style-type: none"> Sq.GD of Coupling 	kg.-Sq.m	
	<ul style="list-style-type: none"> Weight of coupling (Both filled & unfilled) 	kg	

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[6]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	• Type of semi-flexible/flexible coupling		
	• Material of construction		
	• Impeller		
	• Runner		
	• Casing		
	• Spare fusible plug & resilient plate provided		Yes/No
	• Service factor taken over design kW rating of conveyor	kW	
	• Can fluid coupling be removed without shifting motor & gear box		Yes/No
	• At what percent of rated speed of motor the secondary side (i.e. load side) starts rotating at		
	• Full load condition		
	• No load condition		
	• Does the equipment suitable for full load & no load start considering safe acceleration and motor safety		Yes/No
	• Location & details of brake-drum, if applicable		
	• Leaflet/ catalogue furnished		Yes/No
	• Fluid coupling shall be suitable to be used upto motor rated	kW	Yes/No
1.2.11	Flexible Couplings (Pin-Bush & Gear Type)		
	• Conv. No.		
	• Manufacturer		
	• Type of coupling		
	• Power that may be transmitted safely under actual RPM	kW	
	• Service factor over motor, rated	kW	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[7]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	• Brake-drum provided(where applicable)		
	• Size of Brake Drum Dia (mm) x Face width (mm)	mm x mm	
	• Materials of Construction		
	• Brake-drum		
	• Hub		
	• Flange		
	• Retainer disc.		
	• Pin		
	• Whether designed to cater requirement of specification		Yes/No
	• Weight	kg	
	• GD2	kg.Sq.m	
	• Permissible Misalignment		
	• Parallel		
	• Angular		
	• Leaflet/ Catalogue furnished		Yes/No
1.2.12	BRAKES FOR CONVEYORS		
	• Conveyor No.		
	• Type of Brake & Make		
	• Model No.		
	• Quantity provided		
	• Braking torque	kg-m	
	• Brake drum details		
	• Dia x Face-Width	mm	
	• Material of construction of Brake Drum		
	• Location of Brake Drum with respect of drive system		
	• Material of construction of major parts		
	• Brake Shoe		
	• Brake liner		
	• Whether the motors are as per specification for motor		

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S.No	Detail	Unit	Bidder to Indicate
	<ul style="list-style-type: none"> Maximum no. of Stopping/ Tripping permissible per hour 		
	<ul style="list-style-type: none"> Operating voltage & frequency with variations 		
	<ul style="list-style-type: none"> Electrical load demand 	kW	
	<ul style="list-style-type: none"> Equipment weight 	kg	
	<ul style="list-style-type: none"> Physical limit switch for brake release provided & interlocked with main motor where there is no fluid coupling ? 		
	<ul style="list-style-type: none"> Leaflet/Catalogue enclosed 		
1.2.13	Belt Protection Switches		
1.2.13.1	Pull Cord Switches		
	<ul style="list-style-type: none"> Name of Manufacturer 		
	<ul style="list-style-type: none"> Type No. 		
	<ul style="list-style-type: none"> Contact Rating - Amps. 240 V A.C., 1 Ph. 50 Hz. 		
	<ul style="list-style-type: none"> Whether contacts silver plated 		
	<ul style="list-style-type: none"> Maximum Spacing 		
	<ul style="list-style-type: none"> Contact pressure 		
	<ul style="list-style-type: none"> Dimension (L x B x H) 	mm	
	<ul style="list-style-type: none"> Type of Construction 		
	<ul style="list-style-type: none"> Weight of complete switch 		
	<ul style="list-style-type: none"> Details of enclosure and its degree of protection 		
	<ul style="list-style-type: none"> Catalogue furnished ? 		
1.2.13.2	For Belt Sway Switches		
	<ul style="list-style-type: none"> Name of the Manufacturer 		
	<ul style="list-style-type: none"> Type No. 		
	<ul style="list-style-type: none"> Contact Rating Amps. 240 V A.C., 1 Ph. 50 Hz. 		
	<ul style="list-style-type: none"> Whether contacts silver plated 		
	<ul style="list-style-type: none"> Maximum Spacing 	mm	
	<ul style="list-style-type: none"> Contact pressure 		

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S.No	Detail	Unit	Bidder to Indicate
	<ul style="list-style-type: none"> Deflection of the switch in operated condition from normal position 		
	<ul style="list-style-type: none"> Dimension (L x B x H) 	mm	
	<ul style="list-style-type: none"> Weight of complete switch 		
	<ul style="list-style-type: none"> Details of enclosure and degree of protection 		
	<ul style="list-style-type: none"> Whether bridging button provided at local push button stations ? 		
	<ul style="list-style-type: none"> Catalogue furnished ? 		
1.2.13.3	Zero Speed Switches		
	<ul style="list-style-type: none"> Name of the Manufacturer 		
	<ul style="list-style-type: none"> Type & Number offered 		
	<ul style="list-style-type: none"> Contact Rating Amps. 240 V A.C., 1 Ph. 50 Hz. 		
	<ul style="list-style-type: none"> No.of contacts provided & Location 		
	<ul style="list-style-type: none"> Whether contacts are Silver Plated 		
	<ul style="list-style-type: none"> No. of Operation the Contacts can withstand 		
	<ul style="list-style-type: none"> Dimension (L x B x H) 	mm	
	<ul style="list-style-type: none"> Mounting arrangement 		
	<ul style="list-style-type: none"> Maxm. recommended sensing distance 		
	<ul style="list-style-type: none"> Details of the control unit 		
	<ul style="list-style-type: none"> Power Supply Details 		
	<ul style="list-style-type: none"> Speed range 		
	<ul style="list-style-type: none"> Type of enclosure and degree of protection 		
	<ul style="list-style-type: none"> Catalogue furnished? 		
1.2.13.4	Belt Cleaners		
	i. Type and number of external cleaners for each conveyor		
	ii. Type and number of internal cleaners for each conveyor		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[10]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
1.2.13.5	Skirt Board		
	i. Skirt board length @ loading point x plate thickness	m x mm	
	ii. Liner material & thickness	__ x mm	
1.2.13.6	Deck plate length @ loading point x plate thickness	m x mm	
1.2.13.7	Deck plate length x plate thickness (at head end)	m x mm	
1.2.13.8	Safety Switches		
	i. Type x Make x Rating of zero speed switch		
	ii. Numbers with location (zero speed switch)		
	iii. Type x Make x Rating of belt sway switch		
	iv. Type x Make x Rating of Pull wire rope switch		
1.2.13.9	Chutes [Material of construction (MOC)]		
	i. Head pulley hood		
	ii. MOC x thickness of chute plate [(-) 350 mm coal]		
	iii. MOC x thickness of liner [(-)350mm coal]		
	iv. MOC x thickness of chute plate [(-)20mm coal]		
	v. MOC x thickness of liner [(-)20mm coal]		
	vi. MOC x thickness (dribble chute)		
	vii. MOC x thickness (dribble chute liner)		
	viii. Type of gate provided in 2-way chute (exclude tripper chute)		
	ix. Type & make of head pulley cleaner		
	x. Number & Location of plow cleaner		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[11]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	xi. Electric/Manual Hoist above drive unit provided as per spec.		
	xii. T.U unit features as per spec provided.		
	xiii. Minimum valley angle of chutes	Deg.	
	xiv. Type of seals at transfer points		
	xv. Dust curtains included at the entrance of chutes of all conveyors		
1.2.13.10	Frame Work		
	i. Size of stringers		
	ii. Walkway width (side/central)		
	iii. Chequered plate thickness		
	iv. Material and type of belt covering		
	v. Thickness of deck plates		
	vi. Thickness of seal plates (wherever applicable)		
1.3	GATES		
1.3.1	Rod Gates		
	i. Quantity & Location		
	ii. Make		
	iii. Rod size used (diameter).)	mm	
1.3.2	Rack & Pinion Gates		
	i. Capacity		
	ii. Quantity & Location		
	iii. Gate PL MOC x thickness	__ x mm	
	iv. Gate PL liner MOC x Thickness	__ x mm	
	v. MOC: Rack x Pinion x Roller		
	vi. Motor rating	kW	

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Tender Document for R&M of Unit No. [../] Capacity [../] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
	vii. Provision of locking & manual operation provided		
1.3.3	Flap Gates		
	i. Capacity		
	ii. Quantity & Location		
	iii. Gate PL MOC x Thickness	__ x mm	
	iv. Gate PL liner MOC x Thickness	__ x mm	
	v. Motor rating	kW	
	vi. Type x Make x Thrust rating of actuator	__ x __ x kgf	
	vii. Provision for manual operation provided		
1.4	Travelling Trippers		
1.4.1	i. Rated capacity ii. Design Capacity	TPH TPH	
1.4.2	Number of Travelling trippers provided for each conveyor		
1.4.3	Type of drive unit for tripper travel x Motor kW rating	kW	
1.4.4	Travel speed (guaranteed)	m/min.	
1.4.5	Tripper belt slope	Deg.	
1.4.6	Energy chain system provided for trailing cables. Furnish make	Yes/No	
1.4.7	Motor kW rating x Thrust rating of actuator for flap gate	kW x kgf	
1.4.8	Tripper's chute as per spec provided	2 / 3 way	
1.4.9	Rail size x Rail gauge	kg/m x mm	
1.4.10	Total number of axle & material of construction of axle		
1.4.11	Wheel diameter x MOC x BHN Type and bearings, Life of bearings & method of lubrication	mm x __x BHN	
1.4.12	Type & Make of external scraper for head pulley		

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
1.4.13	Limit switches, Rail clamp, end stops, brakes, etc for smooth & safe operation of tripper travel provided		
1.4.14	Type of last bunker feeding		
1.5	Ventilation System		
1.5.1	Type of ventilation system as per spec provided		
1.5.2	Unitary type pressure ventilation in areas as per spec provided		
1.5.3	Unitary type pressure ventilation system		
	i. Guaranteed number of air changes per hour (area wise)		
	ii. +/- ve pressure (minimum) maintained in the area (guaranteed)	mmwc	
	iii. Type & make of fan		
	iv. Louvers / filter / water spray system / ducting/grills etc as per spec provided		
	Filter type offered, size, Rating, Filter media, Efficiency, whether Cleanable?, fresh air velocity through filter.		
	Air velocity limits kept as per specification.		
	v. Ducting material of construction & PL thickness		
	vi. Air velocity through ducting & Grills.		
	vii. Fan capacity, speed, Efficiency, Impeller material, Shaft kw		
1.5.4	Ventilation System: (Furnish Air changes considered per hour for the following areas):		

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S.No	Detail	Unit	Bidder to Indicate
	i. Conveyer Tunnel		
	ii. Pump house		
	iii. Any other areas		
1.5.5	Technical features for exhaust fan		
1.5.6	Technical features for supply fan		
1.6	Dust Extraction System		
1.6.1	Number of system & location		
1.6.2	Type & Make of system		
1.6.3	Type of fan & casing thickness		
1.6.4	Motor kW x RPM (fan)	kW x rpm	
1.6.5	Static pressure	mmwc	
1.6.6	Total pressure	mmwc	
1.6.7	Power consumption	kW	
1.6.8	Bag filter:		
	i. Type & Make		
	ii. Air to cloth ratio		
	iii. Bag material and its life in working hours	h	
	iv. Type of dust removal from bag		
	v. Overall size of filter unit (W x L x M)	m x m x m	
	vi. Total cloth area.	m ²	
	vii. All auxiliaries for automatic online bag cleaning system included		
	viii. Efficiency		
1.6.9	Cyclone unit:		
	i. Material of construction and thickness		
	ii. Efficiency (with particle micron size)	(%)	
1.6.10	Stack material & thickness	mm	
1.6.11	Duct material & thickness	mm	

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S.No	Detail	Unit	Bidder to Indicate
1.6.12	Furnish details of air compressor such as capacity (free air), type & make, air receiver capacity & kW rating of motor		
1.6.13	Dust emission level in clean air discharged from the stack (guaranteed)	mg/Nm ³	
1.6.14	Dust Suppression System		
a)	Type and location		
b)	Method of Working and Detailed Description Furnished?		
c)	Spray nozzles		
d)	Area Covered by Each Spray Nozzle		
e)	Spacing		
f)	Material of Nozzle Tips and Housing		
g)	Details of Pumps		
h)	Make		
i)	Liquid handled		
j)	Capacity		
k)	Number included (operating + standby)		
l)	Location		
m)	Motor rating		
n)	Tanks		
o)	Number		
p)	Material of Construction		
q)	Capacity		
r)	Are Overflow and Drain Connections with Valves Included?		
s)	Are Level Controls Included?		
t)	Are all necessary valves, piping and fittings included?		
u)	Is schematic/water balance flow diagram for complete dust suppression system covered under the scope of supply		

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S.No	Detail	Unit	Bidder to Indicate
1.6.15	Dry Fog Dust Supression System		
	Make		
	Area where DFS is provided		
	Water requirement for each area,	m ³ / h	
	Compressed air requirement		
	Water Pressure		
	Compressed air pressure		
	Air Compressor Capacity Numbers Pressure		
	Water Nozzle Type Flow Rate Numbers provided		
	Spray bar assembly Material Pressure control system, provide write up		
	Water pump Type & Make Capacity Head		
1.6.16	Ducting		
	Minimum transport velocity (DE/Vent. System)		
	Ducting fabricated at site		Yes / No
	Ducting material (mention applicable code also)		
	Minimum thickness in straight run :		
	Additional thickness provided for		
	Duct supports provided		
	Spacing centre to centre		
	Clean out opening provided		
	Flexible connection between duct work fan provided		

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S.No	Detail	Unit	Bidder to Indicate
	Material of flexible connection		
1.7	Metal Detectors		
	Manufacturer		
	Model No.		
	Type		
	Nos. & location		
	Detection capacity/ Annunciation/ hooter provided/ Available range of hooter/ Indicator dropped on detection of metal provided		
	Overall size, mm L x mm W x mm H	mm	
	Particulars of metal detectable- Min. size Corresponding metal		
	Power Required	kW	
	Conveyor speed range in which metal detector is workable with adequate sensitivity.		
	Sensitivity level at normal operating condition		
	Sensitivity level at maximum moisture content of material		
	Total weight of the unit		
	Operating voltage & frequency with variations		
	All necessary cabling panels, electricals, hooters etc. included		
	Protective device provided to guard equipment against oversize material		
	Type of Marker arrangement provided		
	Detector is dust & moisture proof		
	Leaflet/Catalogue furnished		
1.8	Bunker Sealing Belt		
	Type and make		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[18]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Width (mm)		
	Belt Designation		
	No. of Ply		
	Thickness of Coverings		
	Top	mm	
	Bottom	mm	
	Cover Grade		
	Length of Belt	m	
	Whether requisite quantity of belt included ?		Yes/No
	Detail of tensioning arrangement		
1.9	Bunker Level Indicator		
	Type		
	Manufacturer		
	Quantity of indicator		
	Quantity of local panel		
	Local & remote hooters provided		Yes/No
	Cut-out size for hooters		
	Type of mounting for indicator		
	Type of mounting for local panel		
	Dimensional GA drawing for indicators & L.P. furnished		Yes/No
	Level meter provided at L.Ps		
	Type of level meter		
	Type of annunciation in L.P.		
	Provision for remote annunciation provided ?		Yes/No
	Resettable timer provided in L.Ps		Yes/No
	Amplifier for remote indication provided		Yes/No
	Detail description & explanatory leaflet of the equipment furnished		Yes/No

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[19]	25.09.2014

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S.No	Detail	Unit	Bidder to Indicate
	Do the equipment offered require any special cable		Yes/No
	Details of special cables		Yes/No
	Quantity & type of various cables required included		Yes/No
	Motor for E.M. type indicator		
	Rating		
	Voltage, Phase, Frequency & Variations		
	Type		
	Manufacturer		
	Protective features		
	Enclosure		
	Bill of materials furnished		
	Leaflet/Catalogue furnished		Yes/No

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[20]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
1.10	Stacker-Cum-Reclaimer		
1.10.1	Main Features		
1.10.2	Type and Make		
1.10.3	Guaranteed Capacity	TPH	
1.10.4	While stacking	TPH	
1.10.5	While Reclaiming	TPH	
1.10.6	Stock pile height and length	m	
1.10.7	Length of Runway Effective length of travel	m	
1.10.8	Track Gauge Rail size	m	
1.10.9	Tower structure detail		
1.10.10	Bucket wheel assembly details a. Type b. Width of bucket c. No. of buckets in assembling d. water fill volume of each bucket, e. MOC of bucket wheel f. MOC of bucket g. MOC of teeth h. MOC of tips		
1.10.11	Speed of long travel	:	
1.10.12	Anchoring arrangement provided	:	
1.10.13	Anemometer provided	:	
1.10.14	Height of pile envisaged	: m	
1.10.15	Type of stacker cum reclaimer envisaged		
1.10.16	Name plate rating and rpm of all motors		
1.11	Boom Conveyor		
	Length	m	
	Belt width	mm	
	Belt speed	m/s	
	Troughing angle	deg.	

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S.No	Detail	Unit	Bidder to Indicate
	Range of Luffing	deg.	
	Slewing angle of boom		
	Maximum slewing speed	m/s	
	No. of steps of slewing speeds		
	Lowering/ Hoisting speed		
	Troughing angle	deg.	
	Belt carcass Type		
	Cover grade and thickness, top & bottom		
	Drive details with power		
1.12	Boom structure or machine body		
	Type of construction		
	Material of construction		
	Codes followed for Design and Construction		
	Hopper and Chutes		
	Materials and thickness of plates		
	Gates at hopper/ chute outlets		
	Type		
	Mode of operation		
	Type of Suspension of Boom structure		
	Number of Hydraulic Cylinders supporting the Boom Structure		
	Number of trucks under each carriage support		
	Details of Wheels		
	Number/ Truck		
	Material		
	Wheel base		
	Number of driven wheels		
	Traveling speed – forward/ backward		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[22]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Maximum	m/min	
	Minimum	m/min	
	Design Live loads		
	Truss and primary member load design	kg/m ²	
	Local member design	kg/m ²	
	Travel speeds of forward & backward movement		
	Slewing range		
	Detail of overturning protection a) In operation Not in operation		
	Type, Number & Detail of Rail clamps		
	Type of Slewing Motor (Hydraulic)		
	Number of Drives		
	Diameter of slewing gear	mm	
	Finish details of Slewing Mechanism and Turn-Table		
1.13	Bucket Wheel Assembly		
	Manufacturer		
	Type		
	Diameter of Bucket wheel ring	m	
	Width of Bucket	m	
	Number of Buckets in the Assembly		
	Water Fill Volume of each Bucket	m ³	
	Ring Volume	m ³	
	Material of construction		
	Bucket wheel		
	Bucket		
	Teeth and Tips		
	Drive Motor		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[23]	25.09.2014

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S.No	Detail	Unit	Bidder to Indicate
	Number of Drive Motors and Type		
	Motor Rating	kW	
	Is speed monitor built on the bucket wheel gear included ?		Yes/No
1.13.1	Operator's Cabin		
	Type		
	Location		
1.13.2	Hoisting Machinery		
	Type of Hoisting or Luffing		
	Location of Hoisting Machinery		
	Limit of Hoisting (+ or – angle of inclination)		
	Type of Drive Motor		
	kW rating of Drive Motor		
1.13.3	Slewing Mechanism		
	Type of drive motor		
	Torque rating of drive motor		
1.13.4	Fluid Couplings		
	Manufacturer		
	Type of control		
	Number furnished and location		
1.13.5	Brakes		
	Type and make of brakes of different motions		
	Number provided for each motion		
	Starting torque as % of full load torque		
1.13.6	Gear Reducer Units		
	Type and make		
	Material of Construction		
	Gears		
	Pinion		
	Shafts		

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S.No	Detail	Unit	Bidder to Indicate
	Casing (Gear Box)		
1.13.7	Limit Switches (Boom Hoisting, Long Travel & Slewing)		
	Number provided		
	Type and Make		
	Method of Actuation		
1.13.8	Cable and Conduit Earthing		
	Type and Make of Cable		
	Power Cable		
	Control Cable		
	Length of cables		
	Current carrying capacity at 500 deg C		
	Minimum Size of Power cable 6600 V 415 V		
	Minimum Size of Control Cables		
	Minimum size of Lighting Cables		
	Conduit sizes		
1.13.9	Flood lights		
	Numbers furnished		
	Location		
	Wattage and Voltage		
	Type of Lamp		
1.13.10	Cable Reeling Drum		
	Drum		
	Type and Number furnished		
	Size and Capacity		
	Weight of machine w/o counter weight		
	Weight of counter weight		
	Details of counter weight		
1.14	Wagon Tippler		

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
	Manufacturer		
	Design (Put the name of the Company)		
	Number, Type & Model No.		
	Ring type Outboard/Inboard		
	Platform size		
	Track gauge		
	State the type of wagons that can be handled		
	Maximum and minimum dimension of wagon that can be handled		
	Maximum gross weight that can be handled		
	Maximum axle load that can be carried on rail		
	If the tippler suitable for through traffic. If so then state Load/Axle of main line loco Speed of main line loco		Yes/No
	Tippling time per cycle (sec.) with break up		
	Min. no. of tiplings per hour(considering inhaul & outhaul operations)		
	Maximum angle of rotation		
	Lubrication details		
	Type of Wagon Clamping arrangement & provision for change in type of wagons		
	Details of speed reduction with type and make of gear and reduction ratio		
	Type of high speed of low speed couplings		
	Type & no. of Brakes		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[26]	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
	Details of hydraulic motors Motor HP Type & make Drive Motor Data as asked for in motor specification furnished		
	Weighing Device Type Range of weighment Printing & indicating facilities Guaranteed accuracy		
	Dust suppression details for tipplers furnished in relevant sections ?		Yes/No
	Is control room for tippler included		Yes/No
	All control gears as per specification like limit switches, photo electric cells etc. included		Yes/No
	Is it suitable for operation by one operator from control room for entire tippler and marshalling machine		Yes/No
	Opening size of Grid over tippler		
1.15	Dribble Conveyors		
	Designation of conveyor		
	Belt Width		
	Belt Speed		
	Capacity of conveyor		
	Lift		
	Centre to Centre distance		
	Hours of Operation		
	Materials handled		
	Bulk Density of material		
	Lump size of material and moisture.		
	Angle of surcharge		

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S.No	Detail	Unit	Bidder to Indicate
	Troughing angle		
	Type of fabric		
	No. of Ply		
	Grade		
	Designation of belt		
	Cover thickness	mm	
	Top	mm	
	Bottom	mm	
	Breaker ply required		
	Type of Joint		
	Take-up allowance		
1.16	Side Arm Charger		
	Wagon hauling equipment(Side Arm Charger)		
	Type & number		
	Manufacturer		
	Capacity	T	
	Travel	m	
	Speed of hauling	m/min.	
	Return speed	m/min.	
	Consumed HP		
	Track gauge,	mm	
	Size of rails & length,	mm	
	Wheels type, size		
	Type of bearing & size		
	Arrangement of lubrication of bearings		
	Brake		
	Number & type		
	Make & location		
	Rating & size		
	Speed control		
	Type		

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
	Speed reduction Forward Return		
	Type of control equipment furnished		
	Drive arrangement		
	Motor		
	Type		
	Power supply		
	HP & RPM		
	Wagon couplings arrangements		
	Type of wagon coupling arrangement		
	Type of wagon decoupling arrangement		
	Details of protections provided?		Yes/No
1.17	Elevators		
	Location		
	Type of Service		
	Number of elevators required		
	Minimum Load		
	Rated Speed		
	Total Travel		
	Number of Floors to be served		
	Method of Control		
	Position of Machine Room		
	Size of Platform		
	Specification		
	Factor of Safety		
	Operation of Elevators		
	Hoisting beam in machine room roof slab		
	Hoist way machine room & pit lighting		
	Ventilation / Pressurization		

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S.No	Detail	Unit	Bidder to Indicate
	Individual ladder for access to inside pit		
	Automatic rescue device including siren etc.		
1.18	Manual Hoists		
	Type, make & class of hoist offered		
	Hoist capacity, quantity & location(furnished in a schedule)		
	Hoist lift (m) (furnish in a schedule)		
	Type of carriage trolley		
	Applicable standard		
	Gears		
	Type		
	Material		
	Brake		
	Number per hoist		
	Type-Make		
	Detailed description/rating		
	Holding torque(Kg-m) (furnish in the schedule)		
	Method of autoactuation		
	Hook		
	Type		
	Material		
	Does it conform to IS-3832		
	Load chain		
	Factor of safety used		
	Construction		
	Breaking strength	kg	
	Is it as per IS:6216		
	Wheels		
	Material		

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Tender Document for R&M of Unit No. [../] Capacity [../] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
	Weight of complete hoist (Furnish in schedule)	kg	
	Bearing		
	Type		
	Life		
	Lubrication		
	Whether all parts will be tested as per relevant IS& certificates given		
	Catalogue enclosed		
1.19	Electric Hoists		
	Type, make & class of hoist offered		
	Hoist capacity(furnish in a schedule)		
	Hoist lift	m	
	Location		
	Quantity		
	Travel speed	m/sec.	
	Hoisting speed	m/sec.	
	Gears		
	Type		
	Material		
	Brake		
	Type & make		
	No. of brake provided per hoist		
	Detailed description/rating		
	Holding torque	kg-m	
	Method of construction		
	Bearing		
	Type		
	Lubrication		
	Life		
	Hook		

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S.No	Detail	Unit	Bidder to Indicate
	Type		
	Material		
	Does it conform to IS-3815		Yes/No
	Wire Rope		
	Factor of safety used		
	Construction		
	Rope diameter	mm	
	Breaking strength	kg/Sq.m	
	Is it as per IS-3938 & IS-2266		
	Hoist Drum		
	Material		
	Is it as per IS-3938		
	Hoisting/Travel Motor		
	Make		
	Rating		
	Does conform to specification		Yes/No
	Operating voltage & frequency with variations		
	Limit switches for hoisting/ travel motion		
	Make		
	Type		
	Numbers provided		
	Flexible trailing cable for travel		
	Make		
	Size		
	Travel	m	
	Whether all parts will be tested as per relevant IS and certificates provided		Yes/No
	Method of hoist operation		
	Whether control station provided as per specn.		Yes/No
	Rail & end stop provided		Yes/No

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S.No	Detail	Unit	Bidder to Indicate
	Catalogue enclosed		Yes/No
1.20	Belt Vulcanizers		
	Type		
	Manufacturer		
	Quantity		
	Whether suitable for Type of belt supplied ?		Yes/No
	Maximum belt width that can be vulcanized	mm	
	Platen size and material of construction		
	How pressure is generated		
	Type of temperature controller		
	Operating pressure	kg/sq.cm	
	Operating temperature	deg.C	
	Time for vulcanising splice		
	Is the equipment suitable for all specified operations		Yes/No
	Weight of equipment		
	Method of heating		
	Total electrical load	kW	
	Power receiving plug, switch, cable provided		Yes/No
	Cable size and length		
	Leaflet/catalogue enclosed		Yes/No
	Vulcanising accessories		
	Quantity	No. of Sets	
	Details of Vulcanising accessories		Bidder to indicate

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S.No	Detail	Unit	Bidder to Indicate
1.21	Crushers		
1.21.1	Primary Crushers		
1.1.1	Type of crusher		
	Material to be crushed		
	Total Moisture		
	Hard Grove Index		
	Input Size		
	% of (-) 20 mm in feed		
	Maximum percentage of oversized lumps		
	Maximum Lump size		
	Capacity		
	Crusher & Motor	rpm	
	Design moisture content		
	Guaranteed output size		
	Hours of operation/day		
1.21.2	Second Crushers		
	Type		
	Make & Quantity		
	Model No.		
	Rotor dia x Rotor width		
	Capacity	TPH	
	Speed of Crusher	rpm	
	Input maximum lump size	mm	
	Moisture content of input lump		
	Method of feeding		
	Guaranteed output lump size at specified input size & moisture content		
	Method of adjustment of output material size		
	Material of parts		
	Material of shafts		
	Material of casing		

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S.No	Detail	Unit	Bidder to Indicate
	Material of breaker plate		
	Material of Hammer		
	Frame liner		
	Cage assembly		
	Internal parts in contact with coal including liners		
	Details of adjustment for governing product size		
	Details of casing opening		
	Screen analysis of output		
	Motor		
	Rating (KW) & operating voltage, frequency with variation	kW	
	Speed	rpm	
	Starting torque	kg m	
	Whether as per Specification		Yes/No
	How coupled with crusher		
	Method of mounting		
	Direction of rotation		
	Quantity of motor		
	Margin over actual motor power required	(%)	
	Specification of fluid coupling between motor and crusher		
	Type		
	Output torque		
	Quantity of coupling		
	Crusher bearing		
	Type		
	Life		
	Lubrication		
	Cooling arrangement		
	Whether dust tight		
	Type of bearing seal		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[35]	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate
	Make & no		
	Hours of operation/day		
	Whether crusher is suitable for given input material & rate of feed		Yes/No
	Noise level at a distance of 1M & 1.5 M above floor level in decibels		
	Power Consumption	kW/T	
	Weight of Crusher		
	Total weight with Motor, Frame & Drive		
	Rotor weight		
	Speed switch & temperature scanner for both crusher & motor, vibration monitor as specified in specification included		Yes/No
	How crusher is installed		
	Whether resistance thermo detectors provided		Yes/No
	Whether vibration monitoring system provided		Yes/No
	Life of Hammers (in tons of material crushed)		
	Catalogue of crusher enclosed		Yes/No
1.21.3	Screens		
	a. Make		
	b. No. Offered	Nos.	
	c. Maximum Lump Size	mm	
	d. Screens to Separate	mm	
	e. Capacity (rated/ design)	TPH	
	f. Size of Screen		
	g. Screen length		
	h. Screen width		
	i. Material of Construction		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[36]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	j. Frame	mm	
	k. Screen decks / discs	mm	
	l. Screen decks / discs		
	m. Shaft		
	n. Type of Drive provided		
	o. Motor Details		
	p. Rating	kW	
	q. Speed	rpm	
	r. Efficiency of screening	%	
1.22	Feeders		
1.22.1	Vibrating Grizzly Feeders		
	a. Type and Manufacture		
	b. Numbers Offered	Nos.	
	c. Capacity and Range a) Rated ii) Design	TPH	
	d. Material and Thickness of Feeder Trough	mm	
	e. Material and Thickness of Liner Plate	mm	
	f. Number of Vibrations per Minute		
	g. Range of Amplitude		
	h. Motor Rating/Power Required	kW	
	i. Type of drive		
	j. Method of Achieving Variation in Capacity		
	k. Width and length of trough	mm	
	l. Material handled, lamp size and angle of repose		
	m. Inclination of feeder		
	n. (n) Range of adjustment of inclination		
	o. Type of support		
1.22.2	Apron Feeder		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[37]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Manufacturer		
	Type and location		
	Catalogue enclosed?		Yes/No
	Quantity		
	Capacity		
	Material Input Size		
	Max. moisture content of coal		
	Screen undersize		
	Drive details and rating	kW	
	Overall dimensions		
	Inclination of screen		
	Range of variation of capacity		
	Method of variation of capacity		
	Whether size of gap between rollers adjustable		Yes/No
	Method of above adjustment & range, if applicable range, if applicable		
	Material of construction & thickness		
	Longitudinal drive shaft		
	Screen frame		
	Frame liner		
	Feed & discharge chutes		
	Chute liner		
	Details of mounting arrangement		
	Details of vibration isolator provided		
	Details of bearings		
	Type & life of bearing		
	Noise level at a distance of 1 m & 1.5 m above floor level :	DB	
	Equipment weight		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[38]	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

S.No	Detail	Unit	Bidder to Indicate
	Is the equipment suitable for operating satisfactorily during monsoon		
	Whether drawing enclosed with offer		Yes/No
	Working principle of operation		
	Whether catalogue/leaflet/ write-up enclosed with offer		Yes/No
1.22.3	Paddle Feeders		
	Type		
	Make		
	Location		
	Capacity Maximum Minimum		
	Quantity		
	Type of Material Handled		
	Lump Size (MAX)		
	Bulk Density (T/Cu.M)		
	Range of Travel (M)		
	Suitable for continuous to and fro operation		Yes/No
	Pre-limit Switches for traverse direction reversal provided		Yes/No
	Blade diameter		
	Capacity variation range		
	Method of Capacity Variation		
	Material of blade		
	Material of blade liner		
	Drive system Detail & Location of Panels		
	Maxm. & minm. speed	m/sec.	
	Paddle wheel drive type & KW Rating	kW	
	Detail of variation of paddle wheel speed		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[39]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Whether automatic reversal possible		Yes/No
	Carriage Rail		
	Size		
	Length	m	
	Centre to Centre Distance	mm	
	End stops provided		Yes/No
	Type of carriage drive		
	KW rating of carriage drive motor	kW	
	Speed of carriage		
	Range of variation of speed		
	Type/No. of over travel switches per feeder		
	Type of drive for carriage with KW rating	kW	
	Suitable Trailing Cable for Feeder Drive Motor provided		
	Length of Cable	m	
	Detail of Cable suspension arrangement		
	Liner on paddle feeder table		
	Type & Details of dust control system		
	Detail of dust sealing of track hopper slot openings		
	Type of lubrication		
	All necessary electrical control & safety facilities provided		Yes/No
	Furnish detail		
	Hours of operation per day		
	Whether equipment suitable for specified conveyor data and conditions		
	Equipment weight	kg	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[40]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Whether equipment complete with all standard parts, safety accessories etc. for smooth operation		Yes/No
	Leaflet/Catalogue furnished		Yes/No
1.22.4	Belt Feeders		
	No. of Belt Feeder provided		
	Name of Manufacturer		
	Application & Feeder Nos.		
	Capacity	TPH	
	Whether due consideration given in design for material shear effect below surge hopper		Yes/No
	Length of Belt Feeder	c/c	
	Width of Belt Feeder		
	Speed of Belt Feeder		
	Troughing Angle	deg.	
	Skirt Height	mm	
	Drive Details – <ul style="list-style-type: none"> •Type of Drive •Belt Power •Motor rating at 50 deg.C •Type of Gear Box for Drive •Type of Input Coupling •Type of Output Coupling •Type of Brake 		
	Belt Details <ul style="list-style-type: none"> •Belt Width •Belt Designation •Whether Belt Specification conform to NIT •Belt cover grade •Belt cover thickness •Cover thickness provided considering loading cycle 		Yes/No Yes/No
	Details of Idlers provided		Yes/No
	Details of pulleys provided		Yes/No

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[41]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Weather pull cord & zero speed switches provided		Yes/No
	Type & travel of take-up		
1.23	Electronic Belt Weighing System		
	a. Number	Nos.	
	b. Make		
	c. Capacity (Rated/ Design)	TPH	
	d. Range of length and weight of wagons which can be weighed on the weigh bridge		
	e. Type of weigh bridge		
	f. Type of sensing device		
	g. Type of recording devices		
	h. Length of live rail		
	i. Accuracy of weighing		
	j. Static		
	k. Dynamic		
	l. Capacity of each load cell		
	m. Indicate whether PC, printer with all accessories as per the requirement		
	n. Type of MIS reports generated		
	o. Approval by weights and measures authority		
	p. Method of calibration		
1.24	Inline Magnetic Separator		
	Type and Make		
	Number and Location		
	Size and Thickness of Tramp Iron Chute		
	Max. and Minimum Size and Weight of Tramp Iron that can be Lifted	mm	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[42]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Operating Height of Magnet	mm	
	Flux Density of Magnet at Surface of Magnet and at Operating Distance from Magnetic Separator under hot stabilized condition	Gauss	
	Speed of Inline magnetic separator		
	All Accessories as per specification included		
	Rectifier Type		
	Force Index		
	Whether Wear Plates of SS is provided for inline Magnetic below the magnet		
	Size of magnet		
	Required Power Supply	V	
	Magnetic Core and Coil Material		
	Maximum Operating Temperature of Coil	°C	
	Power Consumption under hot stabilized condition		
	Type of belt		
	Type of drive		
1.25	Metal Detectors		
	Type and Make		
	Location		
	Number		
	Detecting Capacity		
	Annunciation/Hooter provided		
	Audible Range of Hooter		
	Indicator Dropped on Detection of Metal provided	m	
	Indicator Type		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[43]	25.09.2014

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Detail	Unit	Bidder to Indicate		
1.26	Hoppers		TRACK HOPPER	SURGE HOPPER	RECLAIMHOPPER
	Capacity	T			
	MOC of Hopper				
	Thickness of main plate for ERH	mm			
	Size of Bottom Opening	mm			
	Size of Top Opening	mm			
	Height	mm			
	Minimum Side Plate Angle	deg			
	Minimum Wall Angle	deg			
	Is Shed over Hopper included?		Yes/no		
	Grating on Top of Hopper included?		Yes/no		
	Grid Opening Size	mm			
	Material & Thickness of Liner Plate	mm			
1.27	Pumps		SUMP PUMP	COAL PILE RUNOFF PUMP	
	Manufacturer				
	Model number				
	No. of pumps offered	Nos.			
	Guaranteed performance				
	Guaranteed Capacity	m ³ /h			
	Total Head	mlc			
	Speed	rpm			
	Efficiency	%			
	Pump motor rating	kW			
	Recommended Motor Rating and Speed	kW & rpm			
	Sealing Water (If required) Quantity and Pressure	m ³ /hr kg/cm ²			
	Maximum Size of Solids	mm			

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[44]	25.09.2014

S.No	Detail	Unit	Bidder to Indicate
	Construction features		
	Casing		
	Impeller Type		Open/semi-open/closed/ non-clog
	Materials of construction		
	Strainer opening size	mm	
	Type of drive transmission		
	Type of coupling		
	Type of stuffing box seal		
	Type of pump lubrication		
	Type of bearing		
	Suction velocity considered		
1.28	Dozers		
	Model		
	Type		
	Quantity	Nos.	
	Capacity	TPH	
	Lead	M	
	Engine power	kW	
1.29	Coal Sampling Unit		
	Manufacturer		
	Quantity and location		
	Rated/ Design Capacity of primary sampler		
	Rated/ Design Capacity of secondary sampler		
	Final size of Product		
	Motor rating	kW	

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-A	[45]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-III
PART-B
TECHNICAL SCHEDULES-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[i]	25.09.2014

VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

* * * * *

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[ii]	25.09.2014

VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[iii]	25.09.2014

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
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Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[iv]	25.09.2014

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)**

**VOLUME-III, PART-B
TECHNICAL SCHEDULES-ELECTRICAL
(TO BE FILLED BY BIDDER)**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[v]	25.09.2014

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{Only the Applicable portion of the Data Sheet based on the scope of work as
firmed up in Section-I, Volume-II should be retained and the remaining portion
should be deleted. The scope of work in Section-I, Volume-II is based on Residual
Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA)
Report.}

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[1]	25.09.2014

1.0 MOTOR

SL. NO.	DESCRIPTION	UNIT	DATA
1.	Manufacturer		
2.	Type and frame size		
3.	Nos. required		
4.	Application		
5.	Specification & Codes		
6.	Capacity for specified climatic conditions [50°C]		
7.	Location for installation		
8.	Type of enclosure & ventilation		
9.	Degree of protection		
10.	Type of duty		
11.	No. of phases, frequency & voltage		
12.	Permissible variations in		
a)	Voltage		
b)	Frequency		
c)	Combined		
13.	At rated voltage & frequency		
a)	Full load current		
b)	Full load speed		
c)	No load current		
14.	Minimum permissible voltage during starting :		
15.	Maximum permissible time at minimum permissible voltage during running at full load.		
16.	Maximum permissible time at 75% of rated voltage during running at full load.		
17.	Whether motor stalls at 70% of rated voltage Efficiency & power factor.		
18.	Stator winding		
	Type & nos. of terminals Brought out		
	Resistance between terminals at 20°C		
	Resistance per phase at 20°C		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[2]	25.09.2014

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

SL. NO.	DESCRIPTION	UNIT	DATA
	Inductance per phase		
	Capacitance per phase		
	Starting current as % of full load current		
19.	Torque at full load in Kgm.		
a)	Break away torque in % of full load torque		
b)	Pull up torque in % of full load torque		
c)	Pull out torque in % of full load torque		
20.	Starting time in sec.		
a)	Without mechanism coupled		
b)	Mechanism coupled through hydraulic coupling when it may be presumed that load is transferred to motor shaft only after attaining almost full speed.		
	i. with rated voltage		
	ii. with 80% of rated voltage		
	iii. with 110% of rated voltage		
21.	Starting time in sec. With mechanism coupled through flexible coupling		
a)	with rated voltage		
b)	with 80% of rated voltage		
c)	with 110% of rated voltage		
22.	Safe stall time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
23.	Safe stall time (Cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
24.	Limiting motor temperature to determine safe stall time		
25.	Permissible maximum accelerating time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[3]	25.09.2014

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

SL. NO.	DESCRIPTION	UNIT	DATA
26.	Permissible maximum accelerating time (cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
27.	Class of Insulation And Material		
28.	Whether insulation is suitable for 415 V, 6.6kV system		
29.	Temperature rise under normal conditions over 50°C ambient temperature		
30.	By resistance method --- °C over cooling water temp. for CACW motors.		
31.	Degree centigrade over cooling air temp. for CACA motor.		
32.	By Thermometer method ---- Degree centigrade over cooling water temp. for CACW motor.		
33.	Degree centigrade over cooling air temp. for CACA motor.		
34.	Method of starting :		
35.	Permissible starting duty cycles :		
36.	Stator thermal time constant :		
37.	Method of cooling (If applicable)		
	Details of water cooling system		
a)	No. of cooler		
b)	Water requirement per cooler		
c)	Losses removed by cooler		
d)	Max. permissible temperature of cooling water at inlet		
e)	Max. permissible temperature of cooling water at outlet		
f)	Maximum permissible pressure at water outlet		
g)	Water pressure drop through the cooler		
h)	Temp. of cold air coming out & entering the machine For permissible cooling water temperature of [31°C]		
i)	Temp. rise of air passing through machine at full load.		
j)	Air pressure drop through The cooler		
k)	Temp. rise of water through cooler		
l)	Protection against leakage of water :		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[4]	25.09.2014

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

SL. NO.	DESCRIPTION	UNIT	DATA
m)	Arrangement to ensure the water flow		
38.	Bearings		
a)	Number :		
b)	Type :		
c)	Lubrication system :		
d)	Quantity of lubricant reqd. For both the bearings. Life in hours at rated speed :		
e)	Recommended lubricant :		
f)	Bearing end play :		
g)	Inlet oil pressure :		
h)	Temp. rise of oil :		
i)	Max. permissible temp. of bearing :		
j)	Max. Permissible temp. of Oil		
k)	Permissible running time without forced oil at full load & full speed :		
39.	Whether bearings are provided with 4 wire, platinum RTD having 100-ohm resistance at 0°C for remote temp. Indication.		
a)	Whether bearings are provided with local temperature indicator having two adjustable contacts rated for 5A at 240V AC or 0.5A at 220V DC. : Yes/No		
b)	If forced lube oil system provided :Yes / No		
c)	Qty of lubricant required for initial filling.		
d)	Recommended period after which lubricant should be replaced		
e)	Bearing cooling water requirement		
f)	Max. Permissible bearing cooling water inlet temp. (permissible)		
g)	Max. Permissible bearing cooling water outlet temp.		
h)	Terminal designation corresponds to direction of rotation (Facing driving end).		
i)	Terminal boxes with accessories separate terminal boxes provided.		
40.	Winding temp. detectors		
41.	Bearing temp. detectors		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[5]	25.09.2014

Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
42.	Moisture detectors		
43.	Neutral terminals		
44.	Main terminal box details		
a)	Type & Nos.		
b)	Fault level permissible for 0.25 sec.		
c)	Location		
d)	Cable gland size & no.		
e)	Direction of cable entry.		
45.	Space Heater		
a)	Number		
b)	Location		
c)	Capacity of each		
d)	Total power requirement		
e)	Voltage.		
46.	Details of 4 wire platinum RTD having 100 ohm resistance at 0°C for winding temp. detector.		
a)	Nos. provided		
b)	Location		
47.	Whether CTs for differential protection are provided : Yes / No		
a)	If Yes, no. of CTs supplied along with motors C.T. details		
	i. C.T. ratio		
	ii. Knee point voltage		
b)	S.C. withstand capacity		
c)	Type of mounting		
48.	Shaft orientation		
49.	Shaft extension		
50.	Grounding pads size nos. & location		
51.	Method of coupling to driven mechanism		
52.	Motor GD ² :		
53.	Lifting device		
54.	Weight		

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[6]	25.09.2014

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
a)	Weight of stator (wound)		
b)	Weight of rotor (wound)		
c)	Weight of base plate		
d)	Weight of cooler		
e)	Net weight of motor		
f)	Shipping dimensions & weight		
55.	Thermometer provided		
a)	In cold air path		
b)	In hot air path		
c)	For measurement of oil temp.		
56.	Characteristic curves furnished		
a)	Speed vs. current at rated voltage	Yes / No	
b)	Speed vs. torque at 110%, 100%, 90% and 80% of rated voltage:	Yes / No	
c)	Thermal withstand curve for hot & cold conditions.	Yes / No	
d)	Efficiency vs. load:	Yes / No	
e)	P.F. Vs. load:	Yes / No	
f)	Current vs. time:	Yes / No	
g)	Negative phase sequence curve:	Yes / No	
57.	Drawings furnished		
a)	General arrangement of motor	Yes / No	
b)	Main terminal box showing the method of terminating the incoming cables Yes/No	Yes / No	
c)	Instruction manuals	Yes / No	
	MOTOR (DC)		
1.	GENERAL		
a)	Manufacturer :		
b)	Equipment driven by Motor :		
c)	Motor type :		
d)	Country of origin :		
2.	DESIGN & PERFORMANCE		
a)	Frame Size :		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors – Coal Handling Plant Volume-III, Part-B	[7]	25.09.2014

Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SL. NO.	DESCRIPTION	UNIT	DATA
b)	Type of duty :		
c)	Type of enclosure & type of cooling :		
d)	Applicable standard to which motor generally confirms:		
e)	Type of mounting :		
f)	Direction of rotation :		
g)	KW rating at amb. Temp. 50 °C :		
h)	Rated power supply voltage		
	i. Armature circuit (V) :	V	
	ii. Field circuit (V) :	V	
i)	Permissible voltage variation :		
j)	Minimum permissible starting voltage :		
k)	Rated speed at rated voltage (RPM) :	RPM	
l)	At rated voltage		
	i. Full load current (A) :	A	
	ii. NO load current (A) :	A	
m)	Starting current (A) :		
	i. 100% voltage :		
	ii. 85% voltage :		
n)	Starting time (with pump coupled) :		
	i. 100% voltage (Sec) :		
	ii. 85 % voltage :		
	iii. 80 % voltage :		
o)	Efficiency at rated voltage at :		
	i. 100% load :		
	ii. 75% load:		
	iii. 50% load:		
p)	Safe stall time (sec) at 110% :		
	i. Hot condition :		
	ii. Cold condition :		
q)	Torque (Kg-m) :		
	i. Starting at min. permissible voltage:		
	ii. Rated:		

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SL. NO.	DESCRIPTION	UNIT	DATA
r)	Fly wheel moment (GD2) motor (Kg-m)		
3.	CONSTRUCTIONAL FEATURES		
a)	Winding insulation :		
	i. Class & type :		
	ii. Tropicalised (Yes/No) :		
	iii. Temp. rise over specified ambient of 50 °C. :		
	iv. Method of temp. measurement :		
b)	Degree of protection of terminal box for :		
	i. Main terminal box :		
	ii. Space heaters (AUX. TB) :		
c)	For main terminal box :		
	i. No. and type of cable gland :		
	ii. Recommended cable size (Armature/field) :		
d)	Fault level (KA, sec) :		
e)	Bearings :		
	i. Type (at DE/NDE):		
	ii. Make :		
	iii. Recommended lubricant :		
	iv. Life :		
f)	Weight of motor (Kg.) :		
g)	Field current at rated speed (A)		
h)	Field resistance (Ohm) at rated speed at 30 °C		
i)	Field trimmer rating (Ohm) for getting basic speed at 30 °C.		
j)	Resistance (Ohm) between terminals at 30°C.		
	i. Armature :		
	ii. Series winding :		
	iii. Inter pole winding :		
	iv. Shunt winding resistance:		
k)	1 st and 2 nd critical speed :		
l)	Overload that can be carried by motor without changing overall performance and period for which it is applicable		

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SL. NO.	DESCRIPTION	UNIT	DATA
m)	Grounding device :		
n)	Space heater :		
	i. No. & location :		
	ii. Volt & KW rating :		
4.	RESISTORS		
a)	Starting (external) resistance :		
	i. Type of resistor :		
	ii. Ohmic, current & power rating of resistor elements		
	iii. Max. permissible temp. of resistor elements :		
	iv. Connection diag. Of resistor elements		
	v. No. of startup stages/steps :		
	vi. Resistance values of stages :		
	-at 30 deg. C (Ohm) :		
	-at running condition (Ohm) :		
	vii. Expected temp of resistor at running condition		
	viii. Expected temp of box at running condition		
	ix. Mounting/stacking of resistor elements and G.A. of resistor box		
b)	Schematic connection diag. Of motor with starting resistor and field trimmer resistor.		
5.	CHARACTERISTIC CURVES		
a)	Starting current/times :		
b)	Thermal withstand curve for hot and cold condition		
c)	Torque/speed		
d)	Load/Efficiency		
e)	Speed/Time		

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2.0 MOTOR ACTUATORS

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		
2.	Application		
3.	Motor type		
	Supply voltage	V	
4.	Phase, frequency	Hz	
5.	Motor rated voltage	V	
6.	Control Voltage	V	
7.	Voltage and its variation	V	
8.	Frequency and its variation	Hz	
9.	Combined V & f variation	%	
10.	Degree of Protection		
11.	Winding Insulation		
12.	Temperature Rise (over ambient temperature)	°C	
13.	Painting		
14.	Motor Starting		
a)	Method		
b)	Starting Current		

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3.0 LT TRANSFORMER (OIL TYPE/DRY TYPE)

6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Make		
2.	Application		
3.	Location		
4.	Type		
5.	Reference standard		
6.	Rated power (indicative)		
7.	Rated winding voltage ratio (line to line)		
8.	Number of phases		
9.	Winding		
10.	Rated frequency		
11.	Type of cooling		
12.	Insulation Class		
13.	Temperature rise Over ambient temperature of 50°C		
a	For Winding by resistance method		
b	For Oil by Thermometer method		
14.	Insulation level (LI/AC)		
a	HV- (LI/AC)		
b	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
15.	Vector group		

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16.	Short-circuit impedance on principal tap				
17.	Parallel operation of transformer				
18.	Type of taps provided				
19.	Taps provided on				
20.	Range of taps				
21.	Method of Tap charge control-				
a	Manual local				
b	Electrical local				
c	Electrical remote				
d	Automatic				
22.	System earthing				
a	H.V.				
b	L.V.				
23.	Terminal arrangement				
a	H.V.				
b	L.V.				
24.	Neutral for earthing				
25.	Transformer bushing	HV	LV	LV - N	
26.	Voltage class KV(r.m.s.)				
27.	Creepage distance mm				
28.	Min. Ph-Ph/ Ph-E clearance mm				
29.	System fault Level				
a	HV Side				
b	LV Side				

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30.	Max. Noise level		
31.	Auxiliary supply		
32.	LV neutral side current transformer for standby earth fault protection		
33.	Guaranteed no load loss (kW)		
34.	Guaranteed load loss (kW)		
35.	Efficiency		
a	At full load		
b	At 75% load		
c	At 50% load		
36.	Accessories		
	Each transformer furnished With fittings and accessories as per specification.		
37.	Approximate overall dimensions		
a	Length		
b	Breadth		
c	Height		
38.	Crane lift for un taking core and coil assembly Approximate Weights		
a	Core and coil		
b	Enclosure and fittings		
c	Oil		
d	Total weight		
39.	Shipping Details:		
a	Weight of the heaviest package		
b	Dimension of the largest package : (LxBxH)		
40.	Tests		
	Routine test as per IS and other		

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	tests as per specification		
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4.0 LT PCC/MCC/DISTRIBUTION BOARD

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material	Cu/Al	
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		

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S. No.	DESCRIPTION	UNIT	DATA
2.16	Degree of protection		
2.17	Colour finish shade	Interior exterior	
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Starters		
3.1	Type	DOL Rev / Star-Delta	
3.2	Contactor rated duty		
3.3	Single phasing preventer required.	Yes / no	
3.4	Thermal overload relay reset	Manual / Auto	
4.0	Circuit breakers		
4.1	Maker's name		
4.2	Voltage, frequency & no.of phases , poles		
4.3	Rated operating duty		
4.4	Circuit breakers type		
4.5	Short circuit withstand current for 1 sec. Duration	kA	
4.6	Rated making current	kAp	
4.7	Rated current at site reference ambient temp	A °C	
4.8	Type of operating mechanism		
4.9	Minimum no. of auxiliary Contacts for purchaser's use		
4.10	Control voltage		
a	For Spring charging motor	V AC/DC	
b	For closing/tripping	V AC/DC	
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	
b	Closing at normal voltage	%	

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S. No.	DESCRIPTION	UNIT	DATA
c	Trip coil	%	
4.12	Power required for closing at normal voltage	W	
4.13	Power required for tripping at normal voltage	W	
4.14	Spring charging motor details:		
a	Rating	kW	
b	Rated voltage	V, AC/DC	
c	Spring charging	Sec.	
	Electrical and mechanical anti-pumping features been provided	Yes/No	
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		
5.2	Rated operating duty		
5.3	Rated breaking capacity	kA (rms)	
5.4	Rated making current	kA (Peak)	
5.5	On/Off operation		
5.6	Manual	Yes/No	
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	
5.8	Auxiliary contacts required	Yes/No	
6.0	Contactors		
6.1	Make		
6.2	Rated duty	AC3/AC4	
6.3	No of poles		
6.4	Utilization category		
6.5	Rated voltage of auxiliary contacts	V	
6.6	Rated voltage of coil	V	
6.7	Rated breaking capacity	Factor of rated current	
6.8	Rated making capacity	Factor of rated	

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S. No.	DESCRIPTION	UNIT	DATA
		current	
6.9	Limits of operation		
a	Supply voltage variation		
b	Supply frequency variation for closing		
c	Drop out voltage		
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		
7.1	Voltage Ratio		
7.2	CT Ratio		
7.3	Measuring CTs		
7.4	Protection CTs		
7.5	Measuring VTs		
7.6	Protection VTs		
8.0	Control transformers		
8.1	Make		
8.2	Type		
8.3	Applicable standards		
8.4	Ratio		
8.5	Class of insulation		
8.6	Rated output	VA	
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		
10.2	Make		
10.3	Type designation		
10.4	Setting range		
11.0	Inverse time and thermal overcurrent relay		

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S. No.	DESCRIPTION	UNIT	DATA
11.1	Application		
11.2	Make		
11.3	Type		
11.4	Current setting range		
11.5	Time setting range at 10 times the current setting	Sec	
12.0	Under voltage relay		
12.1	Make		
12.2	Type		
12.3	Voltage rating	V	
12.4	Setting range	V	
13.0	Auxiliary relays and timers		
13.1	Make		
13.2	Type		
13.3	Coil voltage	V	
14.0	Control/selector switch		
14.1	Make		
14.2	Type designation		
15.0	Meters		
15.1	Applicable Standards		
15.3	Accuracy Class		
15.4	Make		
15.5	Type		
16.0	<u>Voltmeter</u>		
16.1	Make		
16.2	Type		
16.3	Applicable standards		
16.4	Accuracy class		
17.0	<u>Ammeter</u>		

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S. No.	DESCRIPTION	UNIT	DATA
17.1	Make		
17.2	Type		
17.3	Applicable standards		
17.4	Accuracy class		
18.0	<u>Indicating lamps</u>		
18.1	Make		
18.2	Type		
18.3	Voltage	V	
18.4	Wattage of lamp	W	
19.0	<u>Push buttons</u>		
19.1	Make		
19.2	Type designation		
19.3	Contact rating	A	
20.0	<u>Space heater</u>		
20.1	Make		
20.2	Type		
20.3	Rated voltage	V	
21.0	<u>Wiring and terminal blocks</u>		
21.1	Voltage grade		
21.2	Insulation		
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	
b	Control wiring	Sq.mm	
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		
	II) For Fixed Type		
21.5	Minimum current rating of terminal blocks	A	

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5.0 415V NON SEGREGATED PHASE BUS DUCT

S. No.	DESCRIPTION	UNIT	DATA
1.	Make/ Name of Manufacturer		
2.	Type of Busduct	Segregated /non segregated	
3.	Type of cooling	Natural/Forced	
4.	Reference Standard		
5.	Rated Voltage	V	
6.	No of phase and Frequency	Hz	
7.	Insulation level a) Min Power frequency Voltage b) Impulse withstand voltage	kVrms kVp	
8.	Rated Continuous current	Amp	
9.	Short time withstand capability a) Symmetrical for 1 sec b) Momentary	kA kAp	
10.	Maximum temperature rise over 50 degree design ambient temperature a) Bus bar b) Enclosure	Degree	
11.	Degree of protection of enclosure		
12.	Bus bar a) Material & Grade b) Conductivity c) Size		
13.	Enclosure a) Material & Grade b) Thickness c) Ph- ph spacing d) Over all dimension		
14.	Dc resistance in micro ohm/metre/phase a) At 20 degree		

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S. No.	DESCRIPTION	UNIT	DATA
	b) At 85 degree		
15.	Reactance in ohm/meter/phase		
16.	Capacitance to ground		
17.	Losses in watt/meter/phase		
18.	Insulators		
	a) Make		
	b) Material		
	c) No per support		
	d) Voltage Glass		
	e) Compression strength		
	f) Cantilever strength		
19.	Size and material of ground bus		
20.	Support steel structure		
21.	Whether the following has been provided		
	a) Thermostat controlled space heater		
	b) Silica gel breather		
	c) Drain plug		
	d) Neoprene rubber gaskets at joints		
	e) Disconnecting links		
22.	Painting shade		
	a) Interior		
	b) Exterior		

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6.0 220V DC SYSTEM

SL. NO.	DESCRIPTION	UNIT	DATA
A.	DC SYSTEM		
	BATTERY		
	General		
	• Make		
	• Catalogue No.		
	• Type		
	• Reference Standard		
	Rating		
	• Rated Voltage	Volt	
	• 10-hour rating at 27 Deg.C to end cell voltage	AH	
	• 2-hour discharge rate to end cell voltage	Amp	
	• 1 –hour discharge rate to end cell voltage	Amp	
	• 1 -minute discharge rate to end cell voltage	Amp	
	Performance		
	• Battery duty cycle curve furnished	Yes/No	
	• Cell voltage characteristics during duty cycle furnished	Yes/No	
	• Minimum cell voltage during duty cycle	Volt	
	• AH efficiency at 10-hour discharge rate	%	
	• Expected life of Battery	Yr	
	Battery Characteristics		
	• Recommended charging rate for		
	i) Float charging	Amp	
	ii) Equalising Charge	Amp	
	iii) Boost charging in 10 hrs.		
	• Start	Amp	
	• Finish	Amp	
	• Recommend specific gravity at 27 Deg.C		
	i) For first filling		
	ii) At full charge		

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SL. NO.	DESCRIPTION	UNIT	DATA
	iii) At end of 10-hour discharge		
	• Short-circuit current for a dead-short across battery terminals, when		
	i) Float charge at 2.15 V/Cell	kA	
	ii) Boost charge at 2.75 V/Cell	kA	
	• Battery internal resistance	Ohm	
1	Cells		
	• Number of cells per battery	Nos.	
	• Nominal Cell voltage	V	
	• Cell voltage at the end of duty cycle	V	
	• Cell voltage at the end of full discharge at 10-hour rate	V	
	• Type of the cell		
	• Cell designation as per relevant Standard		
	• Material of the container		
	• Overall dimension of each cell (LxDxH)	mm	
	• Weight of complete cell		
	i) Without electrolyte	kg	
	ii) With electrolyte	Kg	
	• Internal resistance of cell	Ohm	
2	Intercell Connector		
	• Intercell connector furnished	Yes/No	
	• Type of intercell connector	bolted/burned	
	• Material of intercell connector		
3	Plates		
	• Number of positive plates per cell	Nos.	
	• Type of positive plate		
	• Type of negative plate		
4	Separator		
	• Type		
	• Material		
	• Thickness	mm	

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SL. NO.	DESCRIPTION	UNIT	DATA
5	Electrolyte		
	• Amount of electrolyte for first filling		
	i) Per cell	litre	
	ii) Per set	litre	
	• First filling with 10% extra furnished	Yes/No	
	• Electrolyte conforms to		
6	Racks		
	• Number of racks per battery	Nos.	
	• Number of cells per rack	Nos.	
	• Type of racks	Rows/Tiers	
	• Material of rack		
	• Racks provided with		
	i) Numbering tags for cells	Yes/No	
	ii) Clamps for cables	Yes/No	
	• Insulator furnished for		
	i) Cell	Yes/No	
	ii) Stand	Yes/No	
	• Inter-row, Miter-tier connectors and end take-off furnished	Yes/No	
	• Connector hardwares furnished	Yes/No	
7	Dimension & Weight		
	• Overall dimension (LxDxH)	mm	
	• Approx. Weight	Kg	
	• Battery layout drawing furnished	Yes/No	
8	Ventilation requirement furnished	Yes/No	
9	List of accessories furnished	Yes/No	
10	Technical leaflets furnished	Yes/No	
	BATTERY CHARGER		
i)	GENERAL		
	a. Make		

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SL. NO.	DESCRIPTION	UNIT	DATA
	b. Catalogue No.		
	c. Type		
	d. Reference Standard		
ii)	A.C. Input		
	a. Voltage \pm % variation	Volt, %	
	b. Phase	No.	
	c. Frequency \pm % variation	Hz., %	
	d. Input current	Amp	
iii)	D.C. Output		
	a. Voltage	Volt/Cell	
	b. Current	Amp.	
	Type of Cooling		
iv)	Max. Temp rise within cubicle above site ambient		
	a. Rectifier transformer	°C	
	b. SCR	°C	
v)	Performance		
	a. Regulation for 0-100% rated load with $\pm 10\%$ Input voltage and $\pm 5\%$ input frequency variation	%	
	b. Ripple content in O.C. output		
	i) With battery	%	
	ii) Without battery	%	
	c. Guaranteed efficiency at rated load	%	
	d. Power factor at rated load	%	
vi)	Miscellaneous		
	a. Charger provided with following features		
	i) Automatic voltage regulation	Yes/No	
	ii) Current limiting circuitry	Yes/No	
	iii) Smoothing filter circuit	Yes/No	
	iv) Soft-start feature	Yes/No	
	v) Automatic load sharing during parallel operation	Yes/No	
	b. SCR elements provided with		

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SL. NO.	DESCRIPTION	UNIT	DATA
	i) Surge protection	Yes/No	
	ii) Fast acting HRC fuse	Yes/No	
vii)	A. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
viii)	A. C. Fuse / MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
ix)	A.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rated Current	Amp	
	e. Utilization category		
	f. Thermal overload with In-built single-phase preventer provided	Yes/No	
x)	Rectifier Transformer		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating		
	i) KVA	KVA	
	ii) Voltage	V	

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SL. NO.	DESCRIPTION	UNIT	DATA
	iii) % reactance	%	
	e. Class of insulation		
	f. Method of cooling		
xi)	Controlled Rectifier (SCR)		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. RMS Current rating	Amp	
	e. Surge Current		
	i) One-cycle	Amp	
	ii) Repetitive Cycle	Amp	
	f. Peak inverse voltage		
	i) Continuous	Volt	
	ii) Surge	Volt	
xii)	D.C. Fuse/MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating		
	i) Continuous	Amp	
	ii) Interrupting	KA	
xiii)	D.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating	Amp	
	e. Utilization category		
xiv)	Blocking Diodes		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		

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SL. NO.	DESCRIPTION	UNIT	DATA
	d. Current Rating		
	i) One – minute	Amp	
	ii) One-hour	Amp	
	e. Peak inverse voltage	Volt	
xv)	Indication Lamps		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Wattage	Watt	
	e. Series resistor	Ohm	
xvi)	Meters		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Size	mm	
	e. Accuracy		
xvii)	Alarm Facia		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. No. of window per facia	Nos.	
xviii)	D. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating	Amp	
	e. No. of poles	Nos.	
xix)	Charger Panel		
	a. Make		
	b. Type		
	c. Reference Standard		

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SL. NO.	DESCRIPTION	UNIT	DATA
	d. Enclosure		
	i) Degree of protection		
	ii) Sheet steel thickness	mm	
	e. Panel provided with		
	i) Internal lamp with door-switch	Yes/No	
	ii) Space heater with thermostat	Yes/No	
	iii) 5A, 3-pin receptacle with plug	Yes/No	
	f. Internal Wiring		
	i) Insulation		
	ii) Voltage grade	V	
	iii) Minimum conductor size	mm ²	
	g. Power Terminals		
	i) Make		
	ii) Size/Cat. No.		
	h. Control Terminals		
	i) Make		
	ii) Size/Cat. No.		
	iii) 20% spare terminal furnished	Yes/No	
	i. Ground Terminal furnished	Yes/No	
	j. Overall dimension (LxDxH)	mm	
	k. Weight	Kg	
	l. General Arrangement drawings furnished	Yes/No	

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7.0 HV CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.1.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
a)	In air	A	
b)	In ground	A	
c)	In duct	A	
d)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
a)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
b)	Grad and Shape of conductor		
c)	Nominal cross section area	mm ²	
d)	Number of wires		
e)	Diameter of wire	mm	
f)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
i.	Between cores	mm	
ii.	Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.20	Inner sheath		
a)	Material, confirming standard / type		
b)	Extruded	Yes/No	
c)	Calculated diameter over laid up cores		
d)	Thickness (min)	mm	
e)	Diameter of cable over inner sheath	mm	
f)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
g)	Filler Material details		
1.21	Armouring		
a)	Material		
b)	Type of armouring		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S. No.	DESCRIPTION	UNIT	DATA
c)	No. and size of strip/wire		
d)	Whether galvanized	Yes/No	
e)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
a)	Material confirming standard/ type		
b)	Extruded	Yes/No	
c)	Minimum Thickness of sheath	mm	
d)	Tolerance on thickness of sheath	mm	
e)	Min. tensile strength	N/sq mm	
f)	Min. elongation percentage at rupture		
g)	Colour of Outer sheath		
h)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification and standards	Yes/No	
1.23	Overall diameter of cable and and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous current		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/k m	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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8.0 LT POWER & CONTROL CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.2.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
e)	In air	A	
f)	In ground	A	
g)	In duct	A	
h)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
g)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
h)	Grad and Shape of conductor		
i)	Nominal cross section area	mm ²	
j)	Number of wires		
k)	Diameter of wire	mm	
l)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	iii. Between cores	mm	
	iv. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.20	Inner sheath		
h)	Material, confirming standard / type		
i)	Extruded	Yes/No	
j)	Calculated diameter over laid up cores		
k)	Thickness (min)	mm	
l)	Diameter of cable over inner sheath	mm	
m)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
n)	Filler Material details		
1.21	Armouring		
f)	Material		
g)	Type of armouring		

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S. No.	DESCRIPTION	UNIT	DATA
h)	No. and size of strip/wire		
i)	Whether galvanized	Yes/No	
j)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
i)	Material confirming standard/ type		
j)	Extruded	Yes/No	
k)	Minimum Thickness of sheath	mm	
l)	Tolerance on thickness of sheath	mm	
m)	Min. tensile strength	N/sq mm	
n)	Min. elongation percentage at rupture		
o)	Colour of Outer sheath		
p)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification	Yes/No	
1.23	Overall diameter of cable and and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous currents		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/k m	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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9.0 ILLUMINATION SYSTEM

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC	
1.2	Variation in Supply		
	a) Voltage	%	
	b) Frequency	%	
	c) Combined voltage & frequency	%	
1.3	Design Ambient Air Temperature	°C	
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	
	b) At 220V DC (For DC LP)	kA(DC)	
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		
b	Conductor size	SWG	
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		
2.2	Rated Voltage, phase and Frequency	AC	
2.3	One Minute Withstand Voltage	V	
2.4	Mounting Type		
	a) LDBs		
	b) Single Phase LP		
2.5	Type and no of circuits & feeder rating		
2.6	Colour shade		
2.7	Lighting Transformer		
	a) Type		
	b) Voltage Ratio	V	
	c) Taps	%	
	d) Vector Group		
	e) Impedance	%	
	f) Rating	KVA	
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		
3.2	Luminaries		
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		

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	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		
	a) Luminaires		
	b) Accessories		
4.0	Schedule of fitting and Accessories		
5.0	Technical details of luminaries		
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumens	
	ii) After 1000 burning hours	Lumens	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		
a	Power factor		
5.4	Luminaires		
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		
	ii) Suitable upto conductor size	SWG	
c	Internal wiring size	Sq.mm	
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		

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6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		
8.1	Make		
8.2	Type		
8.3	Output	VA	
8.4	Accuracy Class		
8.5	Literature enclosed	Yes/No	
9.0	Meters		
9.1	Make		
9.2	Type		
9.3	Accuracy Class		
9.4	Literature enclosed	Yes/No	
10.0	Relays (if any provided)		
10.1	Make		
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a) Normally open		
	b) Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		
11.2	Suitable for use in hazardous area		
	a) Area classification		
	b) Gases/Vapor group		
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	
12.0	Lighting Control Switches		
12.1	Make		
12.2	Decorative		

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12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	
14.0	Lighting wires		
14.1	Make		
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	CONDUITS		
15.1	Make		
15.2	Rigid Steel		
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		
17.1	Make		
17.2	Type of Poles/Towers		
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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10.0 CABLE CARRIER SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		
2.	Size of Tray	mm	
3.	Material		
4.	Application		
5.	Type of Tray		
6.	Thickness of Tray	mm	
7.	Thickness of Galvanization	mm	
8.	Tray Cover Size	mm	
9.	Cable Tray Accessories		
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	

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11.0 EARTHING & LIGHTNING PROTECTION SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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12.0 6.6KV SWITCHGEAR

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material		
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Color finish shade	Interior Exterior	

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		
3.3	Rated operating duty		
3.4	Circuit breakers type		
3.5	Short circuit withstand current for 1 sec. Duration	kA	
3.6	Rated making current	kAp	
3.7	Rated current at site reference ambient temp	A	
3.8	Type of operating mechanism		
3.9	Minimum no. of auxiliary Contacts for purchaser's use		
3.10	Control voltage		
	Spring charging motor	V AC/DC	
3.11	Closing Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.12	Opening Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.13	Operating time		
	Opening time	ms	
	Breaking time	ms	
	Total tripping time	ms	
	Total Closing time	ms	
3.14	Number of breaks per pole		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

S. No.	DESCRIPTION	UNIT	DATA
4.0	Contactor		
	Voltage class	kV	
	Short time Rating		
	Duty		
5.0	Fuse		
	Voltage class	kV	
	Rupturing capacity	kAp	
6.0	Current Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Basic Insulation level	kV	
6.1	CT for differential protection		
	Class		
	Secondary resistance at 75 ° C		
	Knee Point Voltage		
	Excitation Current		
6.2	CT for Metering		
	Class		
	Secondary resistance at 75 ° C		
6.3	CT for Protection		
	Class		
7.0	Voltage Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Voltage ration		
8.0	Meters		
a	Make		
b	Type		

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S. No.	DESCRIPTION	UNIT	DATA
8.1	Voltmeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
8.2	Ammeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
9.0	Indicating lamps		
a	Make		
b	Type		
c	Voltage	V	
d	Wattage of lamp	W	
10.0	Push buttons		
a	Make		
b	Type		
c	Contact rating	A	
11.0	Space heater		
a	Make		
b	Type		
c	Rated voltage	V	
d	Power rating	W	
12.0	Wiring and terminal blocks		
a	Voltage grade		
b	Insulation		
c	Minimum size of conductor for:		
d	Power wiring	Sq.mm	
e	Control wiring	Sq.mm	
f	Type of terminal blocks:		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

S. No.	DESCRIPTION	UNIT	DATA
g	I) For Withdraw able Type		
h	II) For Fixed Type		
i	Minimum current rating of terminal blocks	A	
13.0	ABT Panel		
a	Make		
b	Type		
c	Panel thickness	mm	
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		

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13.0 VARIABLE FREQUENCY DRIVE

S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
1	Manufacturer Name		
2	Model No.		
3	Application		
4	Quantity		
5	Enclosure Protection Rating		
6	Output Current Rating at ambient temperature		
7	% derating considered for specific ambient		
8	Rated Voltage (volts) Input		
9	Output Frequency Range (Hz)		
10	Number of Phases and Frequency (Hz)		
a.	Short time current rating		
b.	Dynamic rating		
11	Rectifier type & Design		
12	Inverter type & Design		
13	Min/Recommended / Max switching frequencies (kHz)		
14	Filters		
a.	Line Side		
b.	Load Side		
15	Drive Input		
16	Output Modulation Method		
17	Speed Accuracy (+ /- %)		
18	Response time (speed)		
19	Response time (Torque)		
20	Type of cooling		
21	Whether VVFD is suitable for outdoor installation		
22	Drive Control Capabilities		
a.	Start/Stop Push button		
b.	Modbus control		
23	Permissible % variation		
a.	Voltage		
b.	Frequency		
24	Load parameters at rated voltage & frequency		
a.	Output Frequency (Hz)		
b.	Full Load current (Amp)		
c.	VVF Heat dissipation (w)		
25	VVF Efficiency		
a.	At Full rated Torque		
b.	At 75% of full load torque		
c.	At 50% of full load torque		
26	Drive Power factor range		
	At rated speed, Torque		
27	DC Voltage		
28	Fundamental power factor		
29	Switching Frequency		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
a.	Drive Dimensions		
b.	Length		
c.	Height		
d.	Depth		
e.	Weight		
30	Metering		
a.	Applicable Standards		
b.	Accuracy Class		
c.	Make		
d.	Type		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**COAL HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-III
PART-C
TECHNICAL SCHEDULES-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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* * * * *

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

COAL HANDLING PLANT (PACKAGE NUMBER: R&M-SP-04)

VOLUME-III, PART-C TECHNICAL SCHEDULES-I&C (TO BE FILLED BY BIDDER)

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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1 PROGRAMMABLE LOGIC CONTROLLER (PLC)

Table 1.1
Data Sheet for PLC

S.N	Feature	To be Filled by Bidder
1	Type of the system offered and Model No.	
2	Make	
3	Year of launching of the system	
4	Is the system offered, the latest system available/ being marketed in the international market by the vendor	
5	Place of Manufacturing	
6	Is the offered system confirms to the Specification provided in the tender document with regard to Spare Capacity, Expandability, Redundancy,	
7	Is the System offered is with open system architecture to enable integration of third party hardware/ software applications	
8	Support direct connectivity to Ethernet based LAN	
9	Deterministic and secure architecture	
10	On-line removal/replacement of I/O modules/ drive control modules possible without switching off power supply to the corresponding rack & without affecting controller operation	
11	Total I/O handling capacity of Controller	
12	No. of Tags handling capacity of Controller	
13	Total Power requirement for the offered system	
14	Total Heat Load of all cabinets	
15	Scanning rate for	
a	Analog Signal	
b	T/C Signal	
c	RTD Signal	
d	Binary Signal	
16	Loop Execution Time for	

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S.N	Feature	To be Filled by Bidder
a	Interlocks	
b	Close loops	
17	Auto switchover to backup redundancy Level	
a	Controller Level	
b	Power supply Level	
c	Communication Level	
18	Output Status on Controller Failure	
19	Battery back-up duration for control processor	
20	Non-volatile memory capacity to store programs, standard software to perform control, DAS & Diagnostic functions	
21	Maximum no. of Channels for	
a	Analog Input module	
b	T/C Input module	
c	RTD Input module	
d	Analog Output module	
e	Binary Input Module	
f	Binary Output module	
22	Optical Isolation for Binary Input/Output provided.	
23	Galvanic isolation for Analog Input/Output provided	
24	Can the analog and binary controls be implemented at different execution speeds, in the multi-function controllers.	
25	Simulation of Analog/Digital Input/Output possible.	
26	Data Transmission speed for	
a	Ethernet LAN	
b	Data Highway	
c	I/O Bus	

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Table 1.2
Data Sheet for High Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	No. of Inputs/Module	
2	Types of Input (Linear)	
3	Accuracy	
4	A/D Converter	
5	Temperature Effect	
6	CMRR	
7	NMRR	
8	MTBF	
9	Stability	
10	Diagnostic	
11	Isolation	

Table 1.3
Data Sheet for Low Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input (Grounded/ Ungrounded)	
4	Cold junction compensation	
5	Accuracy	
6	A/D Converter	
7	Temperature Effect	
8	CMRR	
9	NMRR	
10	MTBF	
11	Stability	
13	Diagnostic	
14	Isolation	

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Table 1.4
Data Sheet for Binary Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Contact Bounce Filtering Provided	

Table 1.5
Data Sheet for SOE Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Time stamping provided	
14	Time Resolution	

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S.N	Feature	To be Filled by Bidder
15	Filter Delay Time	

Table 1.6

Data Sheet for Smart Transmitter Interface Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Protocol	
6	Accuracy	
7	Function	
8	Diagnostic	
9	Isolation	

Table 1.7

Data Sheet for Pulse Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Minimum Pulse Width	

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Table 1.8
Data Sheet for Analog Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Isolation	
6	Accuracy	
7	Load	
8	Diagnostic	
9	Isolation	
10	Power supply	
11	Short circuit Protection	

Table 1.9
Data Sheet for Binary Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Contact rating	
6	Contact Voltage	
7	Switching Frequency	
8	Contact Life	
9	Power supply	
10	Isolation	

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Table 1.10
Data Sheet for Controller

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	Processor make	
3	Type of Processor/minimum word length	
4	Memory Size	
5	No. of Loops	
6	No. of I/O	
7	Configuration	
8	Battery Backup Available	
9	Duration of Battery backup	
10	Redundancy	
11	Change Over Time	
12	Failure of any one of the processor not to affect system operation	
13	What could be the maximum loading of the Controller CPU with the configuration offered	
14	Cycle Time	
15	Expansion facility available	
16	Data Transfer mode	
17	MTBF & MTTR	

Table 1.11
Data Sheet for Engineering Station

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Processor	
3	Cache Memory	
4	RAM	
5	Hard disk Drive	

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S.N	Feature	To be Filled by Bidder
6	CD Drive	
7	Video card	
8	Operating System	
9	Interfacing Ports	
10	Monitor	
a	Type	
b	Size	
c	Resolution	
d	Colors	
e	Sync	
f	Dot per inch	
g	Glare Filter	
h	Make & Model no.	
11	keyboard	
a	Type	
b	Make & Model No.	
c	Key lock control	
12	Mouse	
a	Type	
b	Make & Model no.	
13	Is on line program modification (Control algorithms, logic, sequence programs etc.) and loading possible from Engineering console through data highway without taking the controller in 'standby' mode? Specify limitation, if any	
14	Is it possible to access the control configurations (both regulatory and discrete) along with dynamic updating of process variables (analog values and binary status) from the Engineering station.	
15	Can the system configuration modified and loaded into controller from engineering station	
16	Programming language used for implementing	

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S.N	Feature	To be Filled by Bidder
	logics / control schemes	

Table 1.12
Data Sheet for Laser Printer

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Printer memory	
4	Speed	
5	Resolution	
6	Colors	
7	Duty Cycle	
8	Power Supply	
9	Paper Size	
10	Cartridge Life	
11	Diagnostic	
12	Interfaces	

Table 1.13
Data Sheet for Interposing Relays

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Coil Voltage	
4	Contact	
5	Contact Rating	
6	Coil Insulation Class	
7	Mechanical Life	
8	Coil Protection	
9	Connection	

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S.N	Feature	To be Filled by Bidder
10	Mounting	

Table 1.14
Data Sheet for Operator Work Stations

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	Monitor Support	
5	CD Drive	
6	Power Supply	
7	Keyboard	
8	Pointing Device	
9	Monitor	

Table 1.15
Data Sheet for Servers

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	RAID	
5	Monitor Support	
6	CD Drive	
7	Power Supply	
8	Keyboard	
9	Pointing Device	
10	Monitor	

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Table 1.16
Data Sheet for LCD

S.N	Features	Minimum Requirements
1	Viewable Picture Area	
2	Resolution	
3	Aspect Ratio	
4	Display Colors	
5	LCD Panel	
6	Contrast Ratio	
7	Brightness	
8	Viewing Angle	
9	Computer Interface	
10	Cabinet Material	
11	Finish	
12	Mounting	
13	Power supply	
14	Accessories	

Table 1.17
Data Sheet for Engineering Laptop

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	CD Drive	
5	Power Supply	
6	Communication Ports	
7	Screen size	
8	Battery	

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Table 1.18
Data Sheet for RTD Module

S.N	Feature	To be Filled by Bidder
1	Input Range	
2	Output Voltage range	
3	Output Current Range	
4	Accuracy	
5	Zero & Span Adjustment Range	
6	Input Bias Current	
7	Input Resistance	
8	Noise	
9	Output Rise Time from 10% to 90% Span	
10	Common Mode Voltage (CMV)	
11	Common Mode Rejection (CMR)	
12	Normal Mode Rejection (NMR)	
13	Sensor Excitation Current	
14	Lead Resistance Effect	
15	Input Protection	
16	Voltage Output Protection	
17	Current Output Protection	
18	Power Supply Voltage	
19	Mechanical Dimension	
20	Environmental Performance Details	

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2 UN-INTERRUPTED POWER SUPPLY (UPS)

Table 2.1
Data Sheet for UPS

Sr. no	Description	To be Filled by Bidder
1	Make	
2	Type	
3	Nominal output power for PF = 0.8 Lag	
4	Audible noise level	
5	Protection degree	
6	Standards	
7	Internal protection	
8	Installation	
9	Service access	
10	External cable connections	
11	Earthing	
12	Cooling	
13	Bypass & Interfacing	
14	Input connection	
15	Primary components	
16	Overload on bypass	
17	Voltage limits for inverter/bypass Load Transfers	
18	Programmable signaling	
19	Metering	
20	Dimension & Weights	
a)	Number of cabinets	
b)	Dimension of Inverter cabinet (W x H x D) mm	
c)	Dimension of static switch cabinet (W x H x D) mm	
d)	Dimension of A.C. distribution board (W x H X D) mm	
e)	Dimension of transformer and stabilizer panel (WxHxD) mm	

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f)	Dimension of any other UPS cabinet, if furnished (WxHxD)mm	
g)	Overall dimension (LxHxD) mm	
16	Heat load for Ventilation/Air Conditioning requirement	
a)	Inverter and static switch at 100% load	
b)	Inverter and static switch at 50% load	
c)	Inverter and static switch at 33% load	

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3 FIELD INSTRUMENTS

Table 3.1
Specifications for Belt Weigher System

S.NO	Features	To Be Filled By Bidder
1	Type	
2	Accuracy	
3	Weigh Span	
4	Belt width	
5	Belt speed	
6	Capacity	
7	Load cell	
a)	Construction	
b)	Protection	
c)	Sensitivity	
d)	Overload	
e)	Type	
f)	Rating	
g)	Capacity	
8	Belt speed sensor	
a)	Type	
b)	Mounting	
c)	Pulse frequency	
d)	Housing	
e)	Protection Class	
9	Power supply	
10	Communication port	
11	Output	
12	Calibration	
13	Display	

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Table 3.2
Specifications for Pull Chord Switch

S.No	Features	To Be Filled By Bidder
1	Type	
2	Design	
3	Sensor module	
4	Protection	
5	No. of Contacts	
6	Contact rating	
7	Terminals	
8	Enclosure material	
9	Operation	
10	Reset	

Table 3.3
Specifications for Belts Way Switch

S.N	Features	To Be Filled By Bidder
1	Type	
2	Design	
3	Sensor module	
4	Protection	
5	No. of Contacts	
6	Contact rating	
7	Terminals	
8	Enclosure material	
9	Cable Entry	
10	Reset	

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Table 3.4
Specifications for Zero Speed Switch

S.N	Features	To Be Filled By Bidder
Sensor Probe		
1	Type	
2	Supply	
3	Effective sensing distance	
4	Protection	
5	Material of enclosure	
6	Sensor cable	
Monitoring Electronic Unit		
1	Type	
2	Supply	
3	Output contacts	
4	Contact rating	
5	Speed range	
6	Switching Hysteresis	
7	Speed setting	
8	Time delay	
9	Protection	

Table 3.5
Specifications for Chute Blockage Switch

S.N	Features	To Be Filled By Bidder
1	Type	
	Sensing Probe	
1	Material	
2	Mounting	
3	Enclosure Housing	
4	Enclosure Protection	
5	Temperature	

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S.N	Features	To Be Filled By Bidder
	Electronic Controller	
1	Relay output	
2	Supply	
3	Contact Rating	
4	Local Indication	
5	Enclosure Housing	
6	Enclosure Protection	
7	Accessories	

Table 3.6

Specifications for Electromechanical Type Limit Switch

S.N	Features	To Be Filled By Bidder
1	Sensor / Lever	
2	Protection	
3	Contacts	
4	No. of contacts	
5	Housing	
6	Enclosure	
7	Roller / Lever	

Table 3.7

Specifications for Proximity Type Limit Switch

S.N	Features	To Be Filled By Bidder
1	Type	
2	Shape	
3	Sensing range	
4	Control supply	
5	Output Logic	
6	Switching frequency	
7	Mounting position	
8	Design	

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S.N	Features	To Be Filled By Bidder
9	Ambient Temperature	
10	Indication	
11	Terminal box / Enclosure	
12	Cable Entry	
13	Terminals	

Table 3.8
Data Sheet for Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	Turn Down ratio	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Operating Voltage	
13	Output Signal	

Table 3.9
Data Sheet for RTD

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	No. of Elements	

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S.N	Features	To be Filled by Bidder
4	Wire Gauge	
5	Protection tube OD/ Material/ Filling	
6	Response time	
7	Accuracy	
8	Characteristics	
9	MOC Head/ protection class	
10	Cable connection	

Table 3.10

Data Sheet for Pressure Gauge/DP Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Sensing Element Material	
4	Movement Material	
3	Case Material / Protection Class	
5	Dial Size	
6	Scale	
7	Over range Protection	
8	Adjustment	
9	Element Connection	
10	Process Connection	
11	Accuracy	
12	Repeatability	
13	Response time	
14	Chemical Seal Unit	

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Table 3.11

Data Sheet for Temperature Gauge

S.N	Feature	To be Filled by Bidder
1	Make/Model No.	
2	Type	
3	Stem	
4	Movement Materials	
5	Case Material/Protection class	
6	Dial Size	
7	Scale	
8	Adjustment	
9	Range Selection	
10	Over range Protection	
11	Instrument Connection	
12	Process Connection	
13	Accuracy	
14	Repeatability	
15	Response Time	

Table 3.12

Data Sheet for Pressure/DP Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing material Element	
4	Wetted Parts material	
5	Case Material	
6	Over range for Pressure / Vacuum Switch	
7	Process Connection	

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S.N	Feature	To be Filled by Bidder
8	Switch Configuration	
9	Switch Rating	
10	Cable Connection	
11	Enclosure Class	
12	Accuracy	
13	Repeatability	

Table 3.14
Data Sheet for Radar Type Level Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	
10	Mounting	
11	Transmitter housing	

Table 3.15
Data Sheet for RF Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Particle size	
3	Insertion length	
4	Mounting	

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S.N	Feature	To be Filled by Bidder
5	Process connection	
6	Protection Class	
7	Cable connection	

Table 3.16

Specification for Speed Probe

S.N	Feature	To Be Filled By Bidder
1	Type	
2	Frequency Response	
3	Housing	
4	Sensing distance	
5	Enclosure class	
6	Power supply	
7	Cable	
8	Mounting	
9	Accessories	

Table 3.17

Specification for Speed Transmitter

S.N	Feature	To Be Filled By Bidder
1	Type	
2	Enclosure Protection	
3	Accuracy	
4	Power Supply	
5	Range	
6	Resolution	
7	Output	
8	Input signal	
9	Display	

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Table 3.18

Specification for Vibration Monitor

S.N	Features	To Be Filled By Bidder
1	Sensitivity	
2	Frequency Response	
3	Accuracy	
4	Transducer Supply	
5	Alarm Adjustment	
6	Power Supply	

Table 3.19

Specification for Vibration Sensors

S.N	Features	To Be Filled By Bidder
1	Type	
2	Mounting	
3	Frequency Response	
4	Linear Range	
5	Linearity	
6	Sensitivity	
7	Temperature Sensitivity	
8	Ambient Temperature	
9	Relative Humidity	
10	Case Material	
11	Enclosure Class	
12	Power Supply	
13	Accessories	

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Table 3.20
Data Sheet for Limit Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Sensing Element	
3	Material	
4	Repeatability	
5	No. of Contacts	
6	Contact Ratings	
7	Enclosure type/material	
8	Electrical Connection	
9	Set point	
10	Mounting	

Table 3.21
Data Sheet for Solenoid Valve

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Operating Principle	
3	Coil Voltage Rating	
4	Body	
5	Trim	
6	Manual Operation	
7	Duty	
8	Sealing	
9	Coil enclosure	
10	Coil Insulation Class	
11	Cable Connection	

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4 INSTRUMENTATION CABLES & ACCESSORIES

Table 4.1
Data Sheet for RTD Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Triads	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Triad Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 4.2
Data Sheet for Instrumentation Signal Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Pairs	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	

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S.N	Feature	To be Filled by Bidder
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Pair Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 4.3
Data Sheet for Fibre Optic Cable (Single Mode)

S.N	Feature	To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@1310 nm
		@1550 nm
2	Mode field Diameter	@1310 nm
		@1550 nm
3	Maximum Cable Cut-off Wavelength	
4	Maximum Zero Dispersion Wavelength	
5	Minimum Zero Dispersion Wavelength	
6	Maximum Zero Dispersion Slope	
7	Maximum Polarization Mode Dispersion	
8	Gigabit Ethernet Length 1000BASE-LX	
9	Ten Gigabit Ethernet Length	10GBASE-LX
		10GBASE-LX4

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S.N	Feature	To be Filled by Bidder
10	Maximum Core/cladding Concentricity Error	
11	Cladding Diameter	
12	Cladding Non-circularity	
13	Coating Diameter	
14	Maximum Coating Concentricity Error	
15	Temperature Dependence (-60 to +85C)	
16	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)	
17	Minimum Proof Test	
18	Bending Induced Attenuation (100 turns, 75mm diameter)	

Table 4.4
Data Sheet for Fibre Optic Cable (Multi Mode)

S.N	Feature	To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@850 nm
		@1300 nm
2	Overfilled Launch Bandwidth	@850 nm
		@1300 nm
3	Gigabit Ethernet Length	1000BASE-SX
		1000BASE-LX
4	Ten Gigabit Ethernet Length	10GBASE-SR
		10GBASE-LX4
5	Numerical Aperture	
6	Core Diameter	
7	Maximum Core Non-circularity	
8	Maximum Core/cladding Concentricity Error	
9	Cladding Diameter	
10	Cladding Non-circularity	

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S.N	Feature	To be Filled by Bidder
11	Coating Diameter	
12	Maximum Coating Concentricity Error	
13	Temperature Dependence (-60 to +85C)	
14	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)	
15	Minimum Proof Test	
16	Bending Induced Attenuation (100 turns, 75mm diameter)	

Table 4.5
Data Sheet for Cable Tray

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size (Width/Height)	
4	Perforation	
5	Length	
6	Thickness	
7	Coating of Hot dip Galvanizing	
8	Accessories	
9	Code/Standard	

Table 4.6
Data Sheet for Cable Glands

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Protection	
3	Compression	
4	Threading Type	
5	Material	
6	Check Nut	

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5 SYSTEM CABINETS & JUNCTION BOX

Table 5.1
Data Sheet for Cabinets

S.N	Feature	To be Filled by Bidder
1	Make	
2	Cabinet Dimension	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Anti vibration pad	
8	Painting	
9	Gland Plate thickness	
10	Grounding	
11	Ventilation	
12	Lighting	
13	Lifting arrangement	
14	Tag Plates	

Table 5.2
Data Sheet for Junction Box

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Dimension	
3	Mounting	
4	Protection class	
5	Material & Thickness	
6	Doors	
7	Cable entry	
8	Gasket	
9	Painting	
10	Gland Plate thickness	

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S.N	Feature	To be Filled by Bidder
11	Grounding	
12	Tag Plates	
16		

Signature : _____

Name : _____

Designation : _____

Seal of Company

Date : _____

Document Number	Rev No.	Description	Page No.	Date of Issue
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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-I
COMMERCIAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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[Logo of Utility]

MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

ASH HANDLING SYSTEM (PACKAGE NUMBER: R&M-SP-05)

VOLUME-I COMMERCIAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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List of Acronym

CIF	:	Cost Insurance Freight
CIP	:	Carriage insurance paid
CPBG	:	Contract Performance Bank Guarantee
DCB	:	Domestic Competitive Bidding
FOB	:	Freight on Board
GCC	:	General Condition of Contract
GOI	:	Government of India
GST	:	Goods & Service tax
INR	:	Indian Rupee
I&C	:	Instrumentation & Control
ITB	:	Instruction to Bidder
LOA	:	Letter of Award
LOI	:	Letter of Intent
MoEF	:	Ministry of Environment and Forests
PERT	:	Program evaluation and review technique
R & M	:	Renovation and Modernization
SCC	:	Special Condition of Contract
VAT	:	Value added Tax

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1.0 INVITATION FOR BID

Tender No : [-----]

1.1 Introduction

[Give brief introduction about the name, ownership, business & Power Projects of the utility inviting tender for R & M work]

[XXX is undertaking renovation & modernization of Ash Handling System of Unit no.-XX -----of the Power Plant]

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, invites sealed Tenders in English language from Prequalified Bidders for the Renovation & Modernization of Ash Handling System of Unit No.*[XXX]* of the *[XXX]* Power Plant on Domestic Competitive Bidding (DCB) basis as per the scope of work given in Technical Specification Volume-II.

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly of existing equipment / systems, replacement of specified Equipment / systems by supplying new Equipment/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing and forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, all associated civil works including supply of cement, steel etc., testing & commissioning, successful completion of trial operation and guarantee tests for *[Ash Handling System]* of Unit no. *[XXX]* of *[XXX]* Power Plant. The detailed scope of work is given in Technical Specification Vol. II.

The brief scope of work is given below: -

[-----]
[-----]
[-----]
[-----]

For detailed Scope of Work & Services, refer Section-I of Volume-II of this Specification.

1.4 Tender Details

(a)	Cost of Tender Documents	:	INR <i>[---]</i>
(b)	Bid Guarantee Amount	:	INR <i>[-----]</i>
(c)	Date of issuance of Tender Document	:	<i>[-----]</i>
(d)	Date & Time of pre-Bid Conference	:	<i>[-----]</i>
(e)	Last Date & Time of	:	<i>[-----]</i>

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	Receipt of Bid (Both Part I & Part II)		
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of facilities and performance guarantee test shall be as per SCC.

1.6 Bid Submission

- (a) The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.
- (b) The Bid proposals are to be submitted in two parts in separate sealed covers as follows:
 - Part I** : Bid Guarantee and Technical & Commercial Proposal without prices
 - Part II** : Price Schedule and Schedule of Functional Guarantee parameters with values.
- (c) All other terms and conditions along with the Technical Specifications, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- (d) Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:
 [Designation, Address and Contact details.....]
]
- (e) Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- (f) The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the respective quoted Foreign Currencies.
- (g) Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- (h) The Tender Documents are meant for the exclusive purpose of bidding against the subject package and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Owner, intends to carry out the Renovation & Modernization of [Unit no.-XX ----- of the XXXX Power Plant].

Under the subject Tender, [Utility] invites bid for Renovation & Modernization of Ash Handling System of the said Renovation & Modernization work to be carried out as per the accompanying Technical Specifications. The Bidder shall submit the offer for complete scope of work indicated in the Technical Specification.

2.2 Address and Contact Details of Owner

[Designation, Address and Contact details

-----]

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Owner's Consultant

[-----], hereinafter referred to as "Consultant" is the Consulting Engineer for the project, appointed by the Owner, [-----], to provide project consultancy services.

2.5 Sources of Fund

[Utility] intends to finance the subject Package of the said renovation & modernization work, through Internal and other sources & External/ Domestic Commercial/ Borrowing from international development funding agencies. [Utility] has tied up the required fund for this package.

2.6 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Owner will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.7 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.8 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents. It shall include the following:

- (a) Disassembly of existing equipment/ systems as required.
- (b) Detailed design of the systems/equipment covering all Mechanical, Electrical, Control & Instrumentation, Civil and Structural works.
- (c) Complete manufacture, including shop inspection and testing.
- (d) Providing engineering drawings, data, operational & maintenance manuals, etc., for the Owner's review/ approval.

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- (e) Packing, forwarding and transportation including insurance from the manufacturer's works to plant site and transportation from storage yard to erection site.
- (f) Receipt, storage, preservation and conservation of system/equipment at site including construction of storage facility viz. covered, semi-covered, air-conditioned, open yard at the space allocated at site by Owner including storage-cum-erection and all other specified & statutorily required insurance.
- (g) Pre-assembly, if any, erection, testing, commissioning, completion of plant and equipment/ system, conducting trial operation, performance guarantee test and handing over of all the plant and equipment/ system covered under this specification.
- (h) Carrying out all related civil and structural works at site including construction of foundations, buildings, structures etc. Including supply of cement and steel and all other required materials.
- (i) Supply of mandatory spares and tools & tackles.
- (j) Training of Owner's personnel.

Detailed scope is provided in Volume-II of the Technical Specifications.

Bids not covering the entire scope mentioned hereinabove may be treated as incomplete and hence are liable for rejection.

2.9 Time Schedule

The completion Time Schedule for Completion of R&M work and Performance Guarantee Tests shall be as given in the SCC.

2.10 Tender Documents

The scope of contract, technical specification, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following volumes:

Volume – I	:	Commercial
Volume – I Chapter-1	:	Invitation for Bid
Volume – I Chapter-2	:	Instructions To Bidders
Volume – I Chapter-3	:	General Project Information
Volume – I Chapter-4	:	General Condition of Contract (GCC)
Volume – I Chapter-5	:	Special Condition of Contract (SCC)
Volume – I Chapter-6	:	Forms & Schedules
Volume – II	:	Technical Specifications
Volume – II Section-I	:	Project Technical Specification
Volume – II	:	Detailed Technical Specification-Mechanical

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Section-II, Part-A		
Volume – II Section-II, Part-B	:	Detailed Technical Specification-Electrical
Volume – II Section-II, Part-C	:	Detailed Technical Specification-I&C
Volume – II Section-II, Part-D	:	Detailed Technical Specification-Civil
Volume – III	:	Technical Schedules
Volume – III, Part-A	:	Technical Schedule-Mechanical
Volume – III, Part-B	:	Technical Schedule-Electrical
Volume – III, Part-C	:	Technical Schedule-I&C

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Owner.

The Bidder is expected to examine all instructions, forms, terms, conditions, specifications and other information in the bidding documents. Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Owner in writing by post or by e-mail followed by postal confirmation at the Owner's address indicated in ITB. The Owner will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than twenty-one (21) days prior to the deadline for submission of bids prescribed by the Owner. Owner's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Owner will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operation and does not in any way adversely impact the interest of the Owner. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Owner may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the bidding documents.

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The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.11 Preparation of Bids

2.11.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.11.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

The bidders are required to submit, the bids for the Renovation and Modernization work in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical Data Sheets, List of Tools & Tackles, Deviations to Technical and Commercial Specifications/Conditions, Overall Completion Time Period & L-1 Network Schedule, Resource Deployment Schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part-II Bid will comprise Quoted Price and Quoted Performance Guarantee Parameters. Initially, only the Part-I Bid will be opened and Part-II Bid is kept in safe custody.

After evaluation of the Techno-Commercial (Part-I) Bids, each Bidder who has submitted a broadly responsive Part-I Bid, will be invited for Techno-Commercial Discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a memorandum. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions. The date & time for opening of Price Bid will be intimated separately.

Techno-Commercial Bid should not contain any price data.

Price Bid should not contain any matter in respect of Technical and / or Commercial aspects other than the details specifically sought by the Owner.

2.11.3 Bid Submission

- (1) Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2) All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered. All bids shall be prepared in the English language only, by typing or printing.

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- (3) *[One original and 9 (nine) identical copies of the original]* with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., “Original”, “Copy No. 1”, “Copy No. 2” etc.).
- (4) All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (5) The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (6) The Bidder’s Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (7) In the event of discrepancy between “Original” and any copy of the bids, the hard copy of Original shall prevail.
- (8) The Bid shall be submitted to [-----]. Bid submitted to any other office of Owner is liable for rejection. Bids submitted by Telefax or e-mail will be rejected
- (9) Owner will receive Bids in respect of all the equipment/systems and scope of work as set forth in the accompanying Technical Specifications. All bids shall be prepared and submitted in accordance with the Tender Documents.
- (10) Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Technical Specifications in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11) A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Owner’s rights or the successful Bidder’s obligations under the contract.
- (12) Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13) Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Contractor under the Contract.
- (14) Either the agent or the Principal manufacturer directly could bid in a tender, but not both. In case both submit the tenders, the tender of the manufacture will alone be considered.
- (15) An agent representing one manufacturer in a tender will not be allowed to quote on behalf of another manufacturer along with previous manufacturer in a subsequent / parallel tender for the same item.

2.11.4 Bid Guarantee

- (1) The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of “[-----]” payable at “[-----]”.

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- (2) The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank.
- (3) Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Owner at ([-----]). In the event of any deviation in this regard, the decision of Owner as to whether the same could be accepted or not, will be final and binding on the Bidder.
- (4) The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Owner.
- (5) No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified herein above or from banks not specified hereinabove will be liable for rejection.
- (6) Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7) The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Owner or fails to submit Contract Performance Guarantee.
- (8) The Bid Guarantee of all unsuccessful Bidders shall be returned after price cover opening and price evaluation. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Owner and acceptance thereof.

2.11.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part– I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part–I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Owner, at its discretion, may consider appropriate, shall be read out. The Part – II (Price Bid) will be lodged and opening date of the same will be intimated separately to those Bidders whose Part-I Bid will be determined to be substantially responsive to Tender Conditions and Technical specifications in all respects.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.
3. Owner takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

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2.12 Composition of Techno Commercial Bid (Part-1 Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 9 (nine) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B of this Volume).
- (ii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iii). Deleted
- (iv). Bid Guarantee- as per Annexure A.
- (v). Schedule of Prices as per Schedule – F1 (Table 1 to Table-7) with the word "Quoted" in lieu of Price data and all other details except price data.
- (vi). Mandatory spares as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (vii). Recommended spares (with the word "Quoted" in lieu of Price data)
- (viii). Tools & Tackles as per Technical Specifications (with the word "Quoted" in lieu of Price data)
- (ix). Schedule of Performance Guarantees- as per Schedule – F1 (Table-8) with the word "Quoted" in lieu of Performance Guarantee parameters
- (x). Signed copy of all the corrigendum's/amendments/clarifications, if any issued for the tender
- (xi). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (xii). Deviations to the Commercial specification, if any, as per Schedule – F3.
- (xiii). Deviations to Technical Specifications, if any, as per Schedule – F4.
- (xiv). Requirements of the Contractor at site, as per Schedule – F5.
- (xv). Resource deployment schedule as per Schedule – F6
- (xvi). Details of the present commitments of the Bidder, details of contracts in hand
- (xvii). Details of Sub-Contractors/Sub-Suppliers/Sub-Vendors, if any
- (xviii). Quality Assurance Programme
- (xix). Technical Details to be furnished with the Bid as called for in the Technical Specification Vol-II and Technical Bid Data Sheet Vol-III.
- (xx). Schedule of weights and dimensions
- (xxi). Coefficients and indices for price variation formula

The Part-I Bid shall not contain any Price data.

2.13 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices and the Performance Guarantee parameters only in the specified format. Price given in Part-II should cover the entire scope of work as given in Part-I of the offer including list of mandatory spares and Tools & tackles with itemized price and should be as per Schedule of Price enclosed. **[One original and 9 (Nine) identical]** copies shall be submitted.

1. The Price Bid shall contain the following :

- (i). Duly filled in Form of bid as per Annexure-C
- (ii). Completely filled in Schedule of Prices Schedule – F1 (Table 1 to Table-7)

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- (iii). Completely filled in Schedule of Performance Guarantees Schedule – F1 (Table-8).
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed formats. The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
 3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Owner shall be final. All entries shall be in English language only.
 4. The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the quoted Foreign Currencies.
 5. Prices in Indian supply shall be quoted on Ex-works supply of plant & equipment basis including Packing & forwarding. Inland transportation, Insurance charges, etc. shall be indicated separately.
 6. Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation.

2.14 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the Contractor's obligations mentioned in tender document specification or to be reasonably inferred from the tender documents/ specification in respect of the disassembly/ dismantling of existing equipment facility as specified, design, manufacture, including procurement and subcontracting (if any), delivery, construction, installation, commissioning, completion of the facilities and conductance of Performance Guarantee tests for the facilities including supply of mandatory spares, recommended spare & tools/ tackles (if any). This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the facilities, conducting Guarantee tests and, where so required by the tender documents, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the tender documents, all in accordance with the requirements of the Conditions of Contract and Technical Specifications.

Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the tender documents.

Prices quoted by the Bidder shall be subject to adjustment during performance of the Contract to reflect changes in the cost of labour, material, etc. A bid submitted with a fixed price quotation will not be rejected, but the price adjustment will be treated as zero. The price adjustment provision will not be taken into consideration in bid evaluation.

2.15 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if

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any shall be signed by the person signing the Bid. Printed literature, it enclosed need not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.16 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Owner may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Specifications by amendment.
2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Specifications, which will be notified. Amendments will be hosted in Owner's website. Bidders are requested to visit Owner's website and note amendments, if any, before submission of bid. Owner shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.17 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

2.18 Information to be Furnished with the Bid

1. The Bid (Part-I) must clearly indicate the name of the manufacturer, the type or model of each principal item of equipment proposed to be supplied and erected. The Bid should also contain drawings and descriptive materials indicating general dimensions, material from which the parts are manufactured, principles of operation and the extent of pre-assembly involved, major erection equipment required to be deployed, method of erection and the proposed erection Organization structure.
2. The above information shall be provided by the Bidder in the form of separate sheets, drawings, catalogues, etc.
3. Any Bid not containing sufficient descriptive material to describe accurately the system / equipment proposed may be treated as incomplete and hence rejected. Such descriptive materials and drawings submitted by the Bidder will be retained by the Owner. Any major departure from these 'drawings and descriptive material submitted will not be permitted during the execution of the Contract' without specific written permission of the Owner.
4. Oral statements made by the Bidder at any time regarding quality, quantity or arrangement of the equipment or any other matter will not be considered.
5. Standard catalogue pages and other documents of the Bidder may be used in the Bid to provide additional information and data as deemed necessary by the Bidder.
6. In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy of all data sheets, Schedule, List of Mandatory spares, tools & tackles and Bar Chart/PERT as well as deviation tables in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation. Bidder shall submit all the filled in datasheet also in soft copy. Bidder shall also furnish soft copies and hard copies of Data Sheet with filled in details wherever details are required to be indicated by the Bidder.

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2.19 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other interested parties are advised to refrain from contacting by any means, the Owner and/or his employees/ representatives on matters related to the Bids under consideration. The Owner, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

2.20 Validity of Bid

1. The Bid shall be kept valid for acceptance for **[180 days]** from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Owner from participating in any of the Owner's tenders.

2.21 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully informs himself as to all the conditions and matters which may in any way affect the 'Renovation and Modernization work to be carried out or the cost thereof. Bidders are required to visit the plant to get familiarized with local conditions. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Owner.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Owner at least **[7 (seven) days]** before the date stipulated for pre-bid meeting. The Owner then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till **[21 days]** prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Owner. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.
3. Pre-Bid Conference will be organized and outcomes of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Owner to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.
5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

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2.22 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Owner not later than [-----] Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

2.23 Single Bidder Responsibility

1. The scope of supply and services shall be under single Bidder responsibility.
2. The successful Bidder should not sub contract the entire work on back to back basis or otherwise.

2.24 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Owner for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Owner, even though the Owner may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

2.25 Deputation of Representatives for Discussion

After opening of the Bid, if the Owner desires to have techno-commercial discussion on the Bid, the Bidder shall be in a position to depute his competent representatives of various disciplines at short notice with full authority for finalising technical parameters as well as Commercial Terms and Conditions of the Tender.

2.26 Evaluation of Bid

1. For evaluation and comparison of price bid, the prices indicated at [-----] summary of Prices as per Schedule [-----] will be considered. The Bids received will be evaluated by the Owner to ascertain the lowest evaluated substantially responsive Bid vis-à-vis the Tender Specifications. The Bidder has to satisfy himself that full information is furnished as required in the specifications. Lack of particulars or incomplete information furnished will run the risk of rejection of the bid. The following major procedures would be followed for evaluation of bids.
2. All the Bidders would be brought on par with reference to Technical Specification, Commercial Condition, Instructions to Bidders and subsequent techno-commercial discussions/ clarifications.
3. Commercial loading would be done for non-compliance of commercial terms and conditions of the Tender Specifications other than the vital clauses, as the case may be.
4. After the evaluation of Part-I bids (techno-commercial bids) and before opening of Part-II bids (Price Bids), in case the bidders are asked to make changes to their techno commercial offer that may have price implications, Owner may give the bidders opportunity to submit addendum to price bid covering the price implication only against such changes before the opening of Part-II bids (Price Bids). All the bidders will be notified, at least 15 days before the Price Bid opening date, about such changes against which they can submit addendum to Price Bid.

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5. To facilitate evaluation and comparison, the Owner will convert all bid prices expressed in foreign currencies into Indian Rupee at State Bank of India Bills Selling exchange rates prevailing on the date of opening of the price bid.
6. The Bidder is eligible for a price variation as per Tender Condition. However Price variation shall not be considered for Bid evaluation.
7. Technical loading will be done for omission of price data in respect of equipment/facilities, spares, tools & tackles, etc. The highest quoted corresponding price will be loaded against such omission. If no quoted price is available, the loading will be done as per the corresponding price as estimated by the Owner.
8. The quoted values for Performance Guaranteed Parameters given in Table below would be evaluated using evaluation factors specified. The evaluation factors shall be applicable to the differential values calculated from among the Bidders of corresponding item with appropriate highest or lowest value (i.e., the best quoted value) as the base. The evaluation will be based on the guarantee parameters inclusive of all tolerance furnished at the Guaranteed Condition. Bidders to note that the values indicated in the Schedule of Performance Guarantees shall be inclusive of all tolerances including measurement uncertainty.

Table-Bid Evaluation Factors

Sl. No.	Functional Performance Parameter	Evaluation Factor Rate
1.	Auxiliary Power	[-----] INR per kW

The evaluation factors rate shall be prorated for any fractions of the specified value.

- (1). Arithmetical errors will be rectified on the following basis:
 - If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.
 - If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
 - If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.
- (2). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder shall not charge any amount separately for that item from the Owner. If the terms, such as 'not applicable' "-----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.27 Local Conditions

1. The Bidder shall inspect the site and shall satisfy himself of the site conditions and shall apprise himself of the procedure for engagement of agencies/labour and shall collect any other information, which may be required before submitting the Bid.

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2. Wages not less than Minimum wages for Contract labour shall be paid as applicable in this region from time to time. Claims and objections due to ignorance of site conditions will not be considered after submission of Bid.
 - (i). The Bidder is required to carefully examine the Technical & General Specification, commercial Terms and Conditions, drawings and other details relating to work given in the Tender Specification and get fully acquainted as to all conditions and matters which may in any way affect the work or the cost thereof.
 - (ii). The Bidder shall be deemed to have exhaustively examined the Tender Specifications including the Form of Contract, to have obtained all information and clarifications on all matters whatsoever that might affect the carrying out of the work and to have satisfied himself as to the adequacy of his Bid. He is deemed to have known the scope, nature and magnitude of the work and the requirements of materials and labour involved etc. and as to all work he has to complete in accordance with the Contract for the adequacy of his Bid.
 - (iii). The Bidder shall be deemed to have visited and carefully examined the plant/ site and surroundings, to have satisfied himself about the nature and details of all existing structures, if any, and also as to the nature and conditions of the railways, roads, bridges and culverts, means of transport and communications, whether by land, water or air and as to possible interruptions thereto and the access to and from the site, to have made independent enquiries, examined and satisfied himself as to the sources for obtaining earth, gravel, sand, stones, bricks and all other construction materials, the site for disposal of surplus earth and debris, the available accommodation, underground existing services, sub-soil water conditions, storms, prevailing winds, climatic conditions and all other similar matters which may affect the work.
 - (iv). The Bidder shall be deemed to have acquainted himself with the Indian Income tax Act, 1961, Indian Companies Act, 1956, Indian Customs Act, 1962, Indian Central Excise Act, Value Added Tax, Indian Sales Tax Act, Indian Electricity Act, Central Electricity Authority Regulations Indian Boiler Regulations, Factories Act, Pollution Control Regulations and other related Acts & Laws prevalent in the State of [-----] and in India and as amended from time to time. The Owner shall not entertain any request for clarifications from the Bidders regarding such local conditions.
 - (v). Any neglect or omission or failure on the part of the bidder in obtaining necessary and reliable information as stated above or on any other matter affecting the Bidder shall not relieve him from any risk or liabilities or the entire responsibility for completion of the work in accordance with the Tender Specifications.

2.28 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and technical specification. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with “Original” of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily rejected and ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.

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2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Owner at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Owner towards Owner's cost, loss and damage to Owner.

2.29 Blacklisting/Debarring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Owner.

2.30 Award of Contract

1. Award Criteria
 - The Owner will award the contract to the successful Bidder whose Techno-commercial bid has been determined to be substantially responsive and Price Bid to be the lowest evaluated bid, provided that the Bidder is determined to be qualified to perform the contract satisfactorily.
 - The Owner reserves the right to vary the quantity of any of the Items / Spares and / or delete any Item / Spares altogether at the time of Award of Contract.
2. Owner's Right to Accept Any Bid and to Reject Any or All Bids

The Owner reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Owner's action.
3. Notification of Award

Prior to the expiration of the period of bid validity, the Owner will notify the successful Bidder in writing by registered letter (Letter of Award or LOA) or by email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Owner will promptly notify each unsuccessful Bidder and will discharge its bid security.
4. Signing the Contract Agreement

At the same time as the Owner notifies the successful Bidder that its bid has been accepted, the Owner will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

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Within *[twenty-eight (28)]* days of receipt of the Contract Agreement, the successful Bidder shall sign and date the Contract Agreement and return it to the Owner.

5. Corrupt or Fraudulent Practices

The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, *[Name of Utility]* requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. The Employer may reject a Bid Proposal of a successful Bidder if it emerges that the Bidder recommended for award has engaged in Corrupt or Fraudulent practices in competing for the subject contract. The Employer may declare a Bidding firm ineligible for participation in future tenders of the Employer, either indefinitely or for a stated period of time, if it at any time it emerges that the firm has engaged in Corrupt or Fraudulent practices in competing for or in executing a contract of the Owner. Corrupt Practice means the offering, giving, receiving or soliciting of anything of value to influence the procurement process or contract execution. Fraudulent practice means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition.

2.31 Agency Commission

No Agency commission shall be payable under the Contract.

2.32 Contract Performance Bank Guarantee (CPBG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period. If the contract price is in more than one currency, CPBG shall be 10% of respective currency.

2.33 Contract Quality Assurance

1. The Bidder shall include in his Bid a detailed Quality Assurance Programme containing the overall quality, management and procedures which he proposes to follow in the performance of the 'Works' during various phases.
2. After Letter of Award (LOA) the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall form a part of the 'Contract'.

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2.34 Codes & Standards

Specifications give reference to Indian or internationally accepted Standards. However, equipment or materials meeting other recognized National or International Standards, which ensure an equal or superior quality than Standards specified, will also be accepted. For details of codes and standards refer Technical specification, Volume-II.

2.35 Vital Clauses

The following clauses in the Tender Specification & Draft Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Warranty
- Liquidated Damages
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Owner / Purchaser : [-----]
- Consultant : [-----]
- Project Title : [-----]
- Location : [-----]
- Latitude : [-----]
- Longitude : [-----]
- Elevation above MSL : [-----]
- Nearest Railway Station : [-----]
- Nearest Sea Port : [-----]
- Nearest Airport : [-----]
- Road Access/Approach to Site : [-----]

For Project & Site related detailed information, refer Clause No. 2 of Section-I of Volume-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Works, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract.
- iv. **"Contract"** means the Agreement entered into between Owner and Contractor as per the 'Contract Agreement' signed by the parties, including contract documents, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Contractor's Equipment"** means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities.
- vii. **"Contractor"** means the person(s), Firm or a Company whose bid to perform the Contract has been accepted by the Owner and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Contractor.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Owner for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.
- ix. **"Contractor's Representative"** means any person nominated by the Contractor & approved by the Owner hereof to perform the duties delegated by the Contractor.
- x. **"Consulting Engineer"** means Owner's Engineer appointed by the Owner. Also refers to any other firm(s) or person(s) as may be appointed by the Owner from time to time.

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- xi. **“Commissioning”** means the construction of plant and equipment for operation of the Facility at rated capacity are complete and the plant and equipment achieves the designated full load/full capacity, at designated fuel/input.
- xii. **“Completion”** means that the Facilities (or a specific part thereof where specific parts are agreed) have been completed operationally and structurally and put in a tight and clean condition, and that all work in respect of pre-commissioning of the Facilities or such specific part thereof has been completed and commissioning has been attained as per Technical Specifications.
- xiii. **“Competent Authority”** means any agency, authority, department, inspectorate, ministry or statutory person (whether autonomous or not) of GOI, [Name of the State], Ministry of Environment and Forests (MoEF) any other State of the Republic of India or any local authority.
- xiv. **“Day”** means calendar day of the Gregorian calendar.
- xv. **“Defect Liability Period”** means the period of validity of the warranties given by the Contractor, commencing at completion of the Facilities or a part thereof, during which the Contractor is responsible for defects with respect to the Facilities.
- xvi. **“Effective Date”** means the date from which the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor shall be determined.
- xvii. **“Erection Services”** means those entire services ancillary to the supply of the plant and equipment for the Facilities, to be provided by the Contractor under the Contract. e.g. transportation and provision of marine or other similar insurance, inspection, expediting, site preparation works (including the provision and use of Contractor's Equipment and the supply of all construction materials required), installation, testing, Pre-commissioning, commissioning, operations, maintenance, the provision of operations and maintenance manuals, training of Employer's Personnel etc.
- xviii. **“Facilities”** means the plant and equipment to be supplied and installed, as well as all the Erection Services to be carried out by the Contractor under the Contract.
- xix. **“Force Majeure”** means mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- xx. **“GCC”** means the General Conditions of Contract hereof.
- xxi. **“Good Industry Practice”** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Contractor, equipment manufacturer or operator applying the standards generally adopted by global Contractors, global equipment manufacturers and operators in the construction or operation of power generation facilities or the manufacture of equipment therefore, except in so far as inconsistent with any applicable Indian law or directive.
- xxii. **“Guarantee Test(s)”** means the test(s) specified in the Technical Specifications to be carried out to ascertain whether the Facilities or a

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- specified part thereof is able to attain the Functional/Performance Guarantees specified in the Technical.
- xxiii. **"Incoterms"** means International rules for interpreting trade terms published by the International Chamber of Commerce (latest edition), Paris (France). Unless inconsistent with any provisions of the contract, the meaning of any trade term and the rights and obligations of the parties there under shall be as prescribed by Incoterms.
 - xxiv. **"Inspector/Inspecting Engineer"** means the Owner or any person nominated by the Owner from time to time, to inspect the equipment of works under the contract and/or the duly authorized representative of the Owner.
 - xxv. **"Latent Defect"** means the defects inherent in the material or arising out of design deficiency which does not manifest itself during the Warranty Period/Defect Liability Period, as described in this GCC.
 - xxvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Owner notifying the Contractor that its Bid Proposal has been accepted.
 - xxvii. **"Month"** means calendar month of the Gregorian calendar.
 - xxviii. **"Manufacturer's Works" or "Contractor's Works"** means the place used by the Contractor, its manufacturer, supplier, collaborators or sub-contractors/vendors/sub-vendors for the performance of the works.
 - xxix. **"Operational Acceptance"** means the acceptance by the Owner of the Facilities (or any part of the Facilities where the Contract provides for acceptance of the Facilities in parts), which certifies the Contractor's fulfillment of the Contract in respect of performance guarantees of the Facilities.
 - xxx. **"Owner" or "Purchaser"** shall mean the [Name of the Utility], , and includes its legal successors or permitted assignees.
 - xxxi. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
 - xxxii. **"Pre-commissioning"** means the testing, checking and other requirements specified in the Technical specifications that are to be carried out by the Contractor in preparation for commissioning.
 - xxxiii. **"Project"** means the Owner's [-----] in respect of which the Contract has been signed.
 - xxxiv. **"Project Consultant" or "Owner's Consultant"** means the engineering firm or person(s) appointed by the Owner to render engineering project consultancy services for the project.
 - xxxv. **"Project Manager"** means the person appointed by the Owner thereof and named as such, to perform the duties delegated by the Owner.
 - xxxvi. **"Plant and Equipment"** means permanent plant, equipment, systems, machinery, apparatus, articles and things of all kinds to be provided and incorporated in the Facilities by the Contractor under the Contract (including the spare parts to be supplied by the Contractor under the Contract Agreement), but does not include Contractor's Equipment.
 - xxxvii. **"SCC"** means the Special Conditions of Contract hereof.

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- xxxviii. **“Site”** means the land and other places upon which the Facilities are to be installed, and such other lands or places as may be specified in the Contract as forming part of the Site.
- xxxix. **“Sub Contractor”, including “Vendors/Sub-Vendors”**, means any firm or person to whom execution of any part of the Facilities, including preparation of any design or supply of any plant and equipment is subcontracted directly or indirectly by the Contractor, and includes its legal successors or permitted assignees.
- xl. **“Technical Specification / “Tender Documents”** means the document, setting out a description and specification of the Works and statement of the technical and other standards to which the Works are to be performed including any modifications thereto made in accordance with the Conditions. This includes the technical & commercial specifications and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xli. **“Tenderer”/“Bidder”** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Owner, for the Project.
- xl. **“Time for Completion”** means the time within which completion of the Facilities as a whole (or of a part of the Facilities where a separate time for completion of such part has been specified) is to be attained in accordance with the stipulations and provisions of the Contract.
- xl. **“Warranty Period” or “Defect Liability Period”** means the period during which the Contractor shall remain liable for repair or replacement of any defective part of the works performed under the contract, free of cost.
- xl. **“Work(s)”** means and includes the tasks of furnishing of equipment, labour & services, transport, handling, unloading and storage at site, civil construction and complete erection, testing, commissioning putting into satisfactory operation and completion of successful performance tests, reliability tests and any other guaranteed parameters as defined in the Contract, replacement, modification, repair of defective parts or equipment during warranty period and rectification of latent defects during latent defect period.
- xl. **“Writing” or “Written”** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Owner. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

Terms and expressions not herein defined shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

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4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Owner.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing.
- vi. The bid & schedules/ attachment submitted by the contractor

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Construction of the Contract

The Contracts to be entered between the Owner and the Contractor shall be as under:

First Contract: For Ex-Works Supply of all Plant & Equipment including Mandatory Spares and technological and miscellaneous structures with all accessories.

Second Contract : For providing all services i.e. Inland Transportation for Delivery at Site, Inland Transit Insurance, Unloading, Storage, Handling at Site, Erection, Insurance Covers other than inland transit insurance, Testing, Commissioning and Conducting Guarantee Tests in respect of all the Equipment supplied under the First Contract, Civil works including supplies such as cement & reinforcement steel and all other services as specified in the Contract Documents.

The above two Contracts will contain a cross-fall breach clause specifying that breach of one Contract will constitute breach of the other Contracts which will confer a right on the Owner to terminate the other Contract also at the risk and the cost of the Contractor.

The award of the separate Contracts shall not in any way dilute the responsibility of the Contractor for the successful completion of the Facilities as per Contract Documents and a breach in one Contract shall automatically be construed as a breach of the other Contract which will confer a right on the Owner to terminate the other Contract also at the risk and the cost of the Contractor.

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4.6 Independent Contractor

The Contractor shall be an independent contractor performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Contractor shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or Subcontractors engaged by the Contractor in connection with the performance of the Contract shall be under the complete control of the Contractor and shall not be deemed to be employees of the Owner, and nothing contained in the Contract or in any subcontract awarded by the Contractor shall be construed to create any contractual relationship between any such employees, representatives or Subcontractors and the Owner.

4.7 Joint Venture or Consortium

Not Used.

4.8 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.9 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.10 Origin

"Origin" means the place where the materials, Equipment and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.11 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or E-mail to the address of the relevant party indicated in the Contract.

Either party may change its postal address, telefax number, or E-mail ID or addressee for receipt of such notices by ten (10) days' notice to the other party in writing.

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

4.12 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [.....] shall have exclusive jurisdiction in all matters arising under the Contract.

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4.13 Settlement of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Owner and the Contractor in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Owner & Contractor shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

Either Owner or the Contractor may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities.

Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Owner and the Contractor shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within *[twenty eight (28)]* days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by the Appointing Authority for arbitrator is given below.

Appointing Authority for Arbitrator:

- President, Institution of Engineers in case of an Indian Contractor.

If one party fails to appoint its arbitrator within *[forty-two (42)]* days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Arbitration proceedings as follows:-

- In case of an Indian Contractor Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996.

The Place for Arbitration shall be: *[New Delhi]*, India.

The language of arbitration shall be English.

The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- The parties shall continue to perform their respective obligations under the Contract unless they otherwise agree.

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- The Owner shall pay the Contractor consideration due to the Contractor.

4.14 Scope of Facilities

- Unless otherwise expressly limited in the Technical Specifications, Facilities the Contractor's obligations cover the provision of all Plant and Equipment including spares and the performance of all Services required for design, manufacture (including procurement, quality assurance, construction, installation, associated civil works, Structural and others construction works, precommissioning and delivery) of the Plant and Equipment and the installation, commissioning, completion of facilities and performance testing of the Facilities in accordance with the plans, procedures, specifications, drawings, codes and any other documents as specified in the Technical Specifications. Such specifications include, but are not limited to, the provision of supervision and engineering services; the supply of labour, materials, equipment, spare parts and accessories; Contractor's Equipment; construction utilities and supplies; temporary materials, structures and facilities; transportation loading & unloading.
- The Contractor shall, unless specifically excluded in the Contract, perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for attaining Completion of the Facilities.

4.15 Time for Commencement and Completion

- The Contractor shall commence work on the scope of work under this Tender from the date of Letter of Award. Contractor shall thereafter proceed with the Facilities in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- The Contractor shall attain Completion of the Facilities (or of a part where a separate time for Completion of such part is specified in the Contract) within the time stated in the SCC subject to time extensions, the contractor is entitled under the contract conditions or time extension expressly grouted by the Owner.

4.16 Spare Parts

In addition to the supply of Mandatory Spare Parts included in the Contract, the Contractor agrees to supply other spare parts (recommended spares) required for the operation and maintenance of the Facilities for 3 years. However, the identity, specifications and quantities of such spare parts and the terms and conditions relating to the supply thereof are to be agreed between the Owner and the Contractor, and the price of such spare parts shall be that given in Price Schedule for recommended spares. The price of such spare parts shall include the purchase price thereof and other costs and expenses (including the Contractor's fees) relating to the supply of spare parts. The prices of recommended spares covered in price schedule shall be valid for a period of six months after the date of Notification of Award of Main Equipment and Mandatory Spares.

- The Contractor shall supply the recommended spares at the same terms and conditions as are otherwise applicable to this Contract.
- All the spares for the equipment under the Contract will strictly conform to the Specification and other relevant documents and will be identical to the corresponding main equipment/components supplied under the Contract and shall be fully interchangeable.
- All the Mandatory Spares covered under the Contract shall be manufactured along with the main Equipment as a continuous operation and the delivery of

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the spares will be affected along with the main Equipment in a phased manner and the delivery would be completed by the respective dates for the various categories of equipment as per the agreed schedule. If order for the Recommended Spares has been placed with the Contractor prior to commencement of manufacture of the main equipment this shall be applicable for manufacturer of recommended spares as well.

- The Contractor will provide the Owner with the manufacturing drawings, catalogues, assembly drawings and any other document required by the Owner for the recommended spares. Such details will be furnished to the Owner as soon as they are prepared but in any case not later than six months prior to commencement of manufacture of the corresponding main equipment.
- In addition to the spares recommended by the Contractor, if the Owner further identifies certain particular items of spares, the Contractor will submit the prices and delivery quotation for such spares within [30] days of receipt of such request with a validity period of 6 months for consideration by the Owner and placement of order for additional spares, if the Owner so desires.
- The quality plan and the inspection requirement finalised for the main equipment will also be applicable to the corresponding spares.
- The Contractor will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/components/equipment covered under the Contract and will further ensure with his vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.
- The Contractor shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered under the Contract. The same provision will also be applicable to spares supplied by Sub-contractors.
- For the first 6 years from the schedule date of completion of facilities the prices will be derived from the corresponding Ex-Works Price at which the order for such spares have been placed by Owner as a part of Mandatory Spares or Recommended Spares, or from the rates of Mandatory Spares or Recommended Spares as quoted by/negotiated with the Contractor. Ex-Works order price of future spares shall be computed in accordance with the price adjustment provisions covered under the main Contract excepting that the base indices will be counted from the scheduled date of Commissioning of the last equipment under the main project. The Contractor will indicate in advance the delivery period of the items of spares, which the Owner may procure in accordance with this clause. In case of emergent requirements of spares, the Contractor would make every effort to expedite the manufacture and delivery of such spares on the basis of mutually agreed time schedule.
- In case the Contractor fails to supply the mandatory or recommended spares in the terms stipulated above, the Owner shall be entitled to purchase the same from the alternate sources at the risk and the cost of the Contractor and recover from the Contractor, the excess amount paid by the Owner over the rates worked on the above basis. In the event of such risk purchase by the Owner, the purchases will be as per the Works and Procurement Policy of the Owner prevalent at the time of such purchases and the Owner at his option may include a representative from the Contractor in finalising the purchases.

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- It is expressly understood that the final settlement between the parties in terms of relevant clauses of the Contract Documents shall not relieve the Contractor of any of his obligations under the provision of long term availability of spares and such provisions shall continue to be enforced till the expiry of 6 years period reckoned from the scheduled date of Commissioning of the Plant and Equipment unless otherwise discharged expressly in writing by the Owner.
- The Contractor shall warrant that all spares supplied will be new and in accordance with the Contract Documents and will be free from defects in design, material and workmanship. The defects liability period for spares shall be 12 months from the date it is put to use. In case of failure of any spare part due to fault in design material or workmanship the same part will be replaced by the contractor without any extra cost of the Owner.

In case of any failure in the original component/equipment due to faulty designs, materials and workmanship, the corresponding spare parts, if any, supplied will be replaced without any extra cost to the Owner unless a joint examination and analysis by the Owner and the Contractor of such spare parts prove that the defect found in the original part that failed, can safely be assumed not to be present in spare parts. Any replaced spare parts will have the Defects Liability period of 12 months from the date it is put in use. The discarded spare parts will become the property of the Contractor as soon as they have been replaced by the Contractor. In any case the defect liability of spares will expire at the end of 48 months from the date of their receipt at site

The Defects Liability of spares that are not used within 18 months from the respective date of the delivery at Site will, be subject to condition that all such spares are stored in accordance with Contractor's standard recommended practice, if any, and the same has been furnished to the Owner.

4.17 Contractor's Responsibilities

- a) The Contractor shall design, manufacture (including associated purchases and/or subcontracting), disassemble/dismantle wherever required, install, commission and complete the Facilities and carryout the Guarantee tests with due care and diligence in accordance with the Contract.
- b) Before entering into this contract the Contractor is responsible to have examined the data relating to the Facilities provided by the Owner, and on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve contractor of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.
- c) The Contractor shall acquire in its name all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Contractor's and Subcontractor's personnel and entry permits for all imported Contractor's Equipment.
- d) The Contractor shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any and all liabilities, damages, claims, fines, penalties and expenses of

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whatever nature arising or resulting from the violation of such laws by the Contractor.

4.18 Owner's Responsibilities

- a) The Owner shall be responsible for acquiring and providing legal and physical possession of the Site and access thereto, and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract, including all requisite rights of way.
- b) The Owner shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Owner to obtain them in the Owner's name, are necessary for the execution of the Contract.
- c) If requested by the Contractor, the Owner shall use its best endeavours to assist the Contractor in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Contractor or Subcontractors or the personnel of the Contractor or Subcontractors, as the case may be, to obtain.
- d) The Owner shall be responsible for the continued operation of the Facilities after Completion.

4.19 Taxes & Duties

- a) Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation. The reimbursement of these taxes shall be on actual subject to the quoted value of these taxes as ceiling corresponding to the base price. Additional liability of taxes and duties arising out of price variation shall be reimbursed against documentary evidence over and above the ceiling (quoted value). Statutory variation in Indian taxes and duties will be dealt with as per the relevant stipulations of the specification.
- b) Except as otherwise specifically provided in the Contract, the Contractor shall bear and pay all Taxes, Duties, Levies and Charges including Entry Tax, Service Tax, if applicable in connection with the Facilities in India and outside India. All taxes, duties & levies on works contract, if any, shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- c) All taxes, duties and levies including entry tax/octroi (if any) in respect of all components, Equipment and material to be dispatched directly from the sub-vendor's works to site shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- d) In case there is introduction of GST or any other tax in lieu of existing Excise Duty/Service Tax and VAT/ Sales Tax, the contract price will be adjusted for the impact of any differential tax liability subject to documentary evidence. This will be restricted to direct transaction between the owner and contractor, and bought out items directly dispatched from sub-vendor's works to project site.
- e) Further all taxes, duties and levies including sales tax on works contract, Entry Tax, if any, in respect of civil construction works, erection & commissioning if any and custom duty/sales tax as applicable on the materials used for such construction works shall be to the contractor's account and no separate claim in this regard will be entertained by the Owner. Incidence of Service Tax & cess on any component

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of the Bid Price shall be to the Contractor's account and bidders shall include Service Tax as applicable at the date seven (7) days prior to the date of bid submission in the bid price. The Contract Price will be adjusted for impact of any change in the rate of service tax or cess on service tax subsequent to this date for direct transactions between the Owner and the Contractor.

- f) If any tax exemptions, reductions, allowances or privileges may be available to the Contractor, the Owner shall use its best endeavours to enable the Contractor to benefit from any such tax savings to the maximum allowable extent.

4.20 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Owner by the Contractor herein shall remain vested in the Contractor or, if they are furnished to the Owner directly or through the Contractor by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Owner shall however be free to reproduce all drawings, documents and other material furnished to the Owner for the purpose of the contract including, if required, for operation and maintenance.

4.21 Confidential Information

- a) The Owner and the Contractor shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Contractor may furnish to its Subcontractor(s) such documents, data and other information it receives from the Owner to the extent required for the Subcontractor(s) to perform its work under the Contract, in which event the Contractor shall obtain from such Subcontractor(s) an undertaking of confidentiality similar to that imposed on the Contractor.
- b) The Owner shall not use such documents, data and other information received from the Contractor for any purpose other than the operation and maintenance of the Facilities. Similarly, the Contractor shall not use such documents, data and other information received from the Owner for any purpose other than the design, procurement of Plant and Equipment, construction or such other work and services as are required for the performance of the Contract.
- c) The obligation of a party, shall not apply to that information which
- now or hereafter enters the public domain through no fault of that party
 - can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto
 - Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

4.22 Representatives

- a) Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Owner shall appoint and notify the Contractor in writing of the name of the Project Manager. The Owner may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Contractor without delay.

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The Owner shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Owner at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

All notices, instructions, information and other communications given by the Contractor to the Owner under the Contract shall be given to the Project Manager, except as herein otherwise provided.

b) Contractor's Representative & Construction Manager

- If the Contractor's Representative is not named in the Contract, then within *[fourteen (14) days]* of the Effective Date, the Contractor shall appoint the Contractor's Representative and shall request the Owner in writing to approve the person so appointed. If the Owner makes no objection to the appointment within *[fourteen (14)]* days, the Contractor's Representative shall be deemed to have been approved. If the Owner objects to the appointment within *[fourteen (14)]* days giving the reason there for, then the Contractor shall appoint a replacement within *[fourteen (14) days]* of such objection.
- The Contractor's Representative shall represent and act for the Contractor at all times during the currency of the Contract and shall give to the Project Manager all the Contractor's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Owner or the Project Manager to the Contractor under the Contract shall be given to the Contractor's Representative or, in its absence, its deputy, except as herein otherwise provided. The Contractor shall not revoke the appointment of the Contractor's Representative without the Owner's prior written consent, which shall not be unreasonably withheld. If the Owner consents thereto, the Contractor shall appoint some other person as the Contractor's Representative.
- The Contractor's Representative may, subject to the approval of the Owner (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Contractor's Representative, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Owner and the Project Manager.
- From the commencement of installation of the Facilities at the Site until Operational Acceptance, the Contractor's Representative shall appoint a suitable person as the construction manager (hereinafter referred to as "the Construction Manager"). The Construction Manager shall supervise all work done at the Site by the Contractor and shall be present at the Site throughout normal working hours except when on leave, sick or absent for reasons connected with the proper performance of the Contract. Whenever the Construction Manager is absent from the Site, a suitable person shall be appointed to act as his or her deputy.
- The Owner may by notice to the Contractor object to any representative or person employed by the Contractor in the execution of the Contract who, in the reasonable opinion of the Owner, may behave inappropriately, may be

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incompetent or negligent, or may commit a serious breach of the Site regulations.

- If any representative or person employed by the Contractor is removed.

4.23 Work Program

a) Contractor's Organization

The Contractor shall supply to the Owner and the Project Manager a chart showing the proposed organization to be established by the Contractor for carrying out work on the Facilities. The chart shall include the identities of the key personnel together with the curricula vitae of such key personnel to be employed within *[twenty one (21)]* days of the Effective Date. The Contractor shall promptly inform the Owner and the Project Manager in writing of any revision or alteration of such an organization chart.

b) Program of Performance

Within *[twenty-eight (28)]* days after the date of Notification of Award of Contract, the Contractor shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply, transport, assemble, install and precommissioning the Facilities, as well as the date by which the Contractor reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Contractor to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Contractor shall accord with the Time Schedule included in Contract Schedule 3 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Contractor shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Contractor's actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Contractor shall, at the request of the Owner or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

e) Work Procedures

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Owner and the Contractor, the Contractor may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

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4.24 Subcontractors and Subvendors

- a) The Contract Agreement specifies major items of supply or services and a list of approved Subcontractors against each item, including vendors. Insofar as no Subcontractors are listed against any such item, the Contractor shall prepare a list of Subcontractors for such item for inclusion in such list. The Contractor may from time to time propose any addition to or deletion from any such list. The Contractor shall submit any such list or any modification thereto to the Owner for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Owner for any of the Subcontractors shall not relieve the Contractor from any of its obligations, duties or responsibilities under the Contract.
- b) The Contractor shall select and employ its Subcontractors/Subvendors for such major items from those listed.

4.25 Design and Engineering

- a) Specifications and Drawings

The Contractor shall execute the basic and detailed design and the engineering work in compliance with the provisions of the Contract, or where not so specified, in accordance with good engineering practice. The Contractor shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents that it has prepared, whether such specifications, drawings and other documents have been approved by the Project Manager or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Contractor by or on behalf of the Owner.

- b) Codes and Standards

Wherever references are made in the Contract to codes and standards in accordance with which the Contract shall be executed, the edition or the revised version of such codes and standards current at the date *[twenty eight (28)]* days prior to date of bid submission shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

- c) Approval/Review of Technical Documents by Project Manager

The Contractor shall prepare (or cause its Subcontractors to prepare) and furnish to the Project Manager the documents for its approval Any part of the Facilities covered by or related to the documents to be approved by the Project Manager shall be executed only after the Project Manager's approval thereof.

Project Manager shall either return one copy thereof to the Contractor with its approval endorsed thereon or shall notify the Contractor in writing of its disapproval thereof and the reasons there for and the modifications that the Project Manager proposes. The Project Manager shall not disapprove any document, except on the grounds that the document does not comply with some specified provision of the Contract or that it is contrary to good engineering practice. The procedure for submission of the documents by the Contractor and their approval by the Project Manager shall be discussed and finalised with the Contractor.

If any dispute or difference occurs between the Owner and the Contractor in connection with or arising out of the disapproval by the Project Manager of any document and/or any modification(s) thereto that cannot be settled between the parties within a reasonable period, then such dispute or difference may be referred to an Adjudicator. If such dispute or difference is referred to an Adjudicator, the Project Manager shall give instructions as to whether and if so, how, performance of the

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Contract is to proceed. The Contractor shall proceed with the Contract in accordance with the Project Manager's instructions, provided that if the Adjudicator upholds the Contractor's view on the dispute, then the Contractor shall be reimbursed by the Owner for any additional costs incurred by reason of such instructions and shall be relieved of such responsibility or liability in connection with the dispute and the execution of the instructions as the Adjudicator shall decide, and the Time for Completion shall be extended accordingly.

The Project Manager's approval, with or without modification of the document furnished by the Contractor, shall not relieve the Contractor of any responsibility or liability imposed upon it by any provisions of the Contract except to the extent that any subsequent failure results from modifications required by the Project Manager.

4.26 Procurement

a) Plant and Equipment

The Contractor shall manufacture or procure and transport all the Plant and Equipment in an expeditious and orderly manner to the Site.

b) Transportation

The Contractor shall at its own risk and expense transport all the Plant and Equipment and the Contractor's Equipment to the Site by the mode of transport that the Contractor judges most suitable under all the circumstances. Unless otherwise provided in the Contract, the Contractor shall be entitled to select any safe mode of transport operated by any person to carry the Plant and Equipment and the Contractor's Equipment. Upon dispatch of each shipment of the Plant and Equipment and the Contractor's Equipment, the Contractor shall notify the Owner by telex, cable, telefax, facsimile or Electronic Data Interchange (EDI) of the description of the Plant and Equipment and of the Contractor's Equipment, the point and means of dispatch, and the estimated time and point of arrival in the country where the Site is located, if applicable, and at the Site. The Contractor shall furnish the Owner with relevant shipping documents to be agreed upon between the parties.

The Contractor shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Plant and Equipment and the Contractor's Equipment to the Site. The Owner shall use its best endeavours in a timely and expeditious manner to assist the Contractor in obtaining such approvals, if requested by the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any claim for damage to roads, bridges or any other traffic facilities that may be caused by the transport of the Plant and Equipment and the Contractor's Equipment to the Site.

4.27 Installation

a) Setting Out/Supervision/Labour

Bench Mark: The Contractor shall be responsible for the true and proper setting-out of the Facilities in relation to bench marks, reference marks and lines provided to it in writing by or on behalf of the Owner.

If, at any time during the progress of installation of the Facilities, any error shall appear in the position, level or alignment of the Facilities, the Contractor shall forthwith notify the Project Manager of such error and, at its own expense, immediately rectify such error to the reasonable satisfaction of the Project Manager. If such error is based on incorrect data provided in writing by or on behalf of the Owner, the expense of rectifying the same shall be borne by the Owner.

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Contractor's Supervision: The Contractor shall give or provide all necessary superintendence during the installation of the Facilities, and the Construction Manager or its deputy shall be constantly on the Site to provide full time superintendence of the installation. The Contractor shall provide and employ only technical personnel who are skilled and experienced in their respective callings and supervisory staff who are competent to adequately supervise the work at hand.

The Contractor shall provide and employ on the Site in the installation of the Facilities such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the Contract. The Contractor is encouraged to use local labour that has the necessary skills. Unless otherwise provided in the Contract, the Contractor shall be responsible for the recruitment, transportation, accommodation and catering of all labour, local or expatriate, required for the execution of the Contract and for all payments in connection therewith.

The Contractor shall at its own expense provide the means of repatriation to all of its and its Subcontractor's personnel employed on the Contract at the Site to their various home countries. It shall also provide suitable temporary maintenance of all such persons from the cessation of their employment on the Contract to the date programmed for their departure. In the event that the Contractor defaults in providing such means of transportation and temporary maintenance, the Owner may provide the same to such personnel and recover the cost of doing so from the Contractor.

The Contractor shall, in all dealings with its labour and the labour of its Subcontractors currently employed on or connected with the Contract, pay due regard to all recognized festivals, official holidays, religious or other customs and all local laws and regulations pertaining to the employment of labour.

b) Contractor's Equipment

All Contractors' Equipment brought by the Contractor onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Contractor shall not remove the same from the Site without the Project Manager's consent that such Contractor's Equipment are no longer required for the execution of the Contract. Unless otherwise specified in the Contract, upon completion of the Facilities, the Contractor shall remove from the Site all Equipment brought by the Contractor onto the Site and any surplus materials remaining thereon.

The Owner will, if requested, use its best endeavours to assist the Contractor in obtaining any local, state or national government permission required by the Contractor for the export of the Contractor's Equipment imported by the Contractor for use in the execution of the Contract that is no longer required for the execution of the Contract.

c) Site Regulations and Safety

The Owner and the Contractor shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. The Contractor shall prepare and submit to the Owner, with a copy to the Project Manager, proposed Site regulations for the Owner's approval, which approval shall not be unreasonably withheld.

Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Facilities, gate control, sanitation, medical care, and fire prevention.

d) Opportunities for Other Contractors

The Contractor shall, upon written request from the Owner or the Project Manager, give all reasonable opportunities for carrying out the work to any other contractors

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employed by the Owner on or near the Site. If the Contractor, upon written request from the Owner or the Project Manager, makes available to other contractors any roads or ways the maintenance for which the Contractor is responsible, permits the use by such other contractors of the Contractor's Equipment, or provides any other service of whatsoever nature for such other contractors, the Owner shall fully compensate the Contractor for any loss or damage caused or occasioned by such other contractors in respect of any such use or service, and shall pay to the Contractor reasonable remuneration for the use of such Equipment or the provision of such services.

The Contractor shall also so arrange to perform its work as to minimize, to the extent possible, interference with the work of other contractors. The Project Manager shall determine the resolution of any difference or conflict that may arise between the Contractor and other contractors and the workers of the Owner in regard to their work.

The Contractor shall notify the Project Manager promptly of any defects in the other Contractors' work that come to its notice, and that could affect the Contractor's work. The Project Manager shall determine the corrective measures, if any, required to rectify the situation after inspection of the Facilities. Decisions made by the Project Manager shall be binding on the Contractor.

e) Emergency Work

If, by reason of an emergency arising in connection with and during the execution of the Contract, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Facilities, the Contractor shall immediately carry out such work.

If the Contractor is unable or unwilling to do such work immediately, the Owner may do or cause such work to be done as the Owner may determine is necessary in order to prevent damage to the Facilities. In such event the Owner shall, as soon as practicable after the occurrence of any such emergency, notify the Contractor in writing of such emergency, the work done and the reasons there for. If the work done or caused to be done by the Owner is work that the Contractor was liable to do at its own expense under the Contract, the reasonable costs incurred by the Owner in connection therewith shall be paid by the Contractor to the Owner. Otherwise, the cost of such remedial work shall be borne by the Owner.

f) Site Clearance

Site Clearance in Course of Performance: In the course of carrying out the Contract, the Contractor shall keep the Site reasonably free from all unnecessary obstruction, store or remove any surplus materials, clear away any wreckage, rubbish or temporary works from the Site, and remove any Contractor's Equipment no longer required for execution of the Contract. **Clearance of Site after Completion:** After Completion of all parts of the Facilities, the Contractor shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site and Facilities clean and safe.

g) Watching and Lighting

The Contractor shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper execution and the protection of the Facilities, or for the safety of the owners and occupiers of adjacent property and for the safety of the public as per specification.

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4.28 Testing & Inspections

- a) The Contractor shall at its own expense carry out at the place of manufacture and/or on the Site all such tests and/or inspections of the Plant and Equipment and any part of the Facilities as are specified in the Contract.
- b) The Owner and the Project Manager or their designated representatives shall be entitled to attend the aforesaid test and/ or inspection, provided that the Owner shall bear all costs and expenses incurred in connection with such attendance including, but not limited to, all travelling and board and lodging expenses.
- c) Whenever the Contractor is ready to carry out any such test and/or inspection, the Contractor shall give a reasonable advance notice of such test and/or inspection and of the place and time thereof to the Project Manager. The Contractor shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Owner and the Project Manager (or their designated representatives) to attend the test and/or inspection.
- d) The Contractor shall provide the Project Manager with a certified report of the results of any such test and/or inspection. If the Owner or Project Manager (or their designated representatives) fails to attend the test and/or inspection, or if it is agreed between the parties that such persons shall not do so, then the Contractor may proceed with the test and/or inspection in the absence of such persons, and may provide the Project Manager with a certified report of the results thereof.
- e) The Project Manager may require the Contractor to carry out any test and/or inspection not required by the Contract, provided that the Contractor's reasonable costs and expenses incurred in the carrying out of such test and/or inspection shall be added to the Contract Price. Further, if such test and/or inspection impede the progress of work on the Facilities and/or the Contractor's performance of its other obligations under the Contract, due allowance will be made in respect of the Time for Completion and the other obligations so affected.
- f) If any Plant and Equipment or any part of the Facilities fails to pass any test and/or inspection, the Contractor shall either rectify or replace such Plant and Equipment or part of the Facilities and shall repeat the test and/or inspection upon giving a notice.
- g) If any dispute or difference of opinion shall arise between the parties in connection with or arising out of the test and/or inspection of the Plant and Equipment or part of the Facilities that cannot be settled between the parties within a reasonable period of time, it may be referred to the Adjudicator.
- h) The Contractor shall afford the Owner and the Project Manager, at the Owner's expense, access at any reasonable time to any place where the Plant and Equipment are being manufactured or the Facilities are being installed, in order to inspect the progress and the manner of manufacture or installation, provided that the Project Manager shall give the Contractor a reasonable prior notice.
- i) The Contractor agrees that neither the execution of a test and/ or inspection of Plant and Equipment or any part of the Facilities, nor the witnessing of any test by the Owner, nor the issuance of any test certificate shall relieve the Contractor of any obligation under this Contract.
- j) No part of the Facilities or foundations shall be covered up on the Site without the Contractor carrying out any test and/or inspection required under the Contract. The Contractor shall give a reasonable notice to the Project Manager whenever any such part of the Facilities or foundations is ready or about to be ready for test and/or inspection; such test and/or inspection and notice thereof shall be subject to the requirements of the Contract.

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- k) The Contractor shall uncover any part of the Facilities or foundations, or shall make openings in or through the same as the Project Manager may from time to time require at the Site, and shall reinstate and make good such part or parts.

4.29 Completion of the Facilities

- a) As soon as the Facilities or any part thereof has, in the opinion of the Contractor, been completed operationally and structurally and put in a tight and clean condition as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Contractor shall so notify the Owner in writing.
- b) The Owner shall supply the operating and maintenance personnel as specified in the Form of Contract Agreement for Pre-commissioning of the Facilities or any part thereof.
- c) As soon as all works in respect of Pre-commissioning are completed and, in the opinion of the Contractor, the Facilities or any part thereof is ready for Commissioning, the Contractor shall commence Commissioning as per procedures stipulated in Technical Specifications, and as soon as Commissioning is satisfactorily completed, the Contractor shall so notify the Project Manager in writing.
- d) If the Project Manager notifies the Contractor of any defects and/ or deficiencies, the Contractor shall then correct such defects and/or deficiencies.
If the Project Manager is satisfied that the Facilities or that part thereof have reached Completion, the Project Manager shall, within **[seven (7)]** days after receipt of the Contractor's notice, issue a Completion Certificate stating that the Facilities or that part thereof have reached Completion as at the date of the Contractor's notice.
If the Project Manager is not so satisfied, then it shall notify the Contractor in writing of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's repeated notice, and the above procedure shall be repeated.
- e) If the Project Manager fails to issue the Completion Certificate and fails to inform the Contractor of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's notice, or if the Owner makes use of the Facilities or part thereof, then the Facilities or that part thereof shall be deemed to have reached Completion as of the date of the Contractor's notice, or as of the Owner's use of the Facilities, as the case may be.
- f) As soon as possible after Completion, the Contractor shall complete all outstanding minor items so that the Facilities are fully in accordance with the requirements of the Contract, failing which the Owner will undertake such completion and deduct the costs thereof from any monies owing to the Contractor.
- g) Upon Completion, the Owner shall be responsible for the care and custody of the Facilities or the relevant part thereof, together with the risk of loss or damage thereto, and shall thereafter take over the Facilities or the relevant part thereof.

4.30 Commissioning & Operation Acceptance

- a) Commissioning
Commissioning of the Facilities or any part thereof Acceptance shall be completed by the Contractor as per procedures detailed in the Technical Specifications. The Contractor shall, unless otherwise specified in Contract/ Tender Specifications, supply the utilities, lubricants, chemicals, catalysts, facilities, services and other matters required for Commissioning.
- b) Guarantee Test

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The Guarantee Tests (and repeats thereof) shall be conducted by the Contractor after Commissioning of the Facilities or the relevant part thereof to ascertain whether the Facilities or the relevant part can attain the Functional Guarantees specified in the Contract Documents. The Contractor's and Project Manager's advisory personnel shall attend the Guarantee Test. The Owner shall promptly provide the Contractor with such information as the Contractor may reasonably require in relation to the conduct and results of the Guarantee Tests (and any repeats thereof). If for reasons not attributable to the Contractor, the Guarantee Tests of the Facilities or the relevant part thereof cannot be successfully completed within the period from the date of Completion, specified in the SCC or any other period agreed upon by the Owner and the Contractor, the Contractor shall be deemed to have fulfilled its obligations with respect to the Functional Guarantees.

c) **Operational Acceptance**

Operational Acceptance shall occur in respect of the Facilities or any part thereof when

- the Guarantee Tests have been successfully completed and the Functional Guarantees are met; or
- The Guarantee Tests have not been successfully completed or has not been carried out for reasons not attributable to the Contractor within the period from the date of Completion specified in the SCC or any other agreed upon period as specified in GCC.
- The Contractor may give a notice to the Project Manager requesting the issue of an Operational Acceptance in respect of the Facilities or the part thereof specified in such notice as at the date of such notice.
- The Project Manager shall, after consultation with the Owner, and within forty five (45) days after receipt of the Contractor's notice, issue an Operational Acceptance Certificate. If within *[forty five (45)]* days after receipt of the Contractor's notice, the Project Manager fails to issue the Operational Acceptance Certificate or fails to inform the Contractor in writing of the justifiable reasons why the Project Manager has not issued the Operational Acceptance Certificate, the Facilities or the relevant part thereof shall be deemed to have been accepted as at the date of the Contractor's said notice.

d) **Partial Acceptance**

If the Contract specifies that Completion, Commissioning and Guarantee Tests shall be carried out in respect of parts of the Facilities, the provisions relating to Completion and Commissioning including the Guarantee Tests shall apply to each such part of the Facilities individually, and the Operational Acceptance Certificate shall be issued accordingly for each such part of the Facilities. If a part of the Facilities comprises facilities such as buildings, for which no Commissioning or Guarantee Tests are required, then the Project Manager shall issue the Operational Acceptance Certificate for such facility when it attains Completion, provided that the Contractor shall thereafter complete any outstanding minor items that are listed in the Operational Acceptance Certificate.

4.31 Completion Time and Liquidated Damage

a) **Completion Time Period**

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The Contractor guarantees that it shall attain Completion of the Facilities (or a part for which a separate time for completion is specified in the SCC) within the Time for Completion specified in the SCC.

- b) If the Contractor fails to attain Completion of the Facilities or any part thereof within the Time for Completion, the Contractor shall pay to the Owner liquidated damages in the amount computed at the rates specified in the SCC. The aggregate amount of such liquidated damages shall in no event exceed the amount specified as "Maximum" in the SCC.

However, the payment of liquidated damages shall not in any way relieve the Contractor from any of its obligations to complete the Facilities or from any other obligations and liabilities of the Contractor under the Contract.

- c) No bonus will be given for earlier completion of the facilities or part thereof.

4.32 Defects Liability

- a) The Contractor warrants that the Facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the Plant and Equipment supplied and of the work executed.
- b) The Defects Liability Period shall be *[eighteen (18)]* months from the date of Completion of the Facilities (or any part thereof) or *[twelve (12)]* months from the date of Operational Acceptance of the Facilities (or any part thereof).

If during the Defects Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipment supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect. The Contractor shall not be responsible for the repair, replacement or making good of any defect or of any damage to the Facilities arising out of or resulting from any of the following causes:

- improper operation or maintenance of the Facilities by the Owner
 - operation of the Facilities outside specifications provided in the Contract
 - Normal wear and tear.
- c) The Owner shall give the Contractor a notice stating the nature of any such defect together with all available evidence thereof, promptly following the discovery thereof. The Owner shall afford all reasonable opportunity for the Contractor to inspect any such defect.
- d) The Owner shall afford the Contractor all necessary access to the Facilities and the Site to enable the Contractor to perform its obligations.
- e) If the repair, replacement or making good is of such a character that it may affect the efficiency of the Facilities or any part thereof, the Owner may give to the Contractor a notice requiring that tests of the defective part of the Facilities shall be made by the Contractor immediately upon completion of such remedial work, whereupon the Contractor shall carry out such tests.
- f) If the Contractor fails to commence the work necessary to remedy such defect or any damage to the Facilities caused by such defect within a reasonable time (which shall in no event be considered to be less than fifteen (15) days), the Owner may, following notice to the Contractor, proceed to do such work, and the reasonable costs incurred by the Owner in connection therewith shall be paid to the Owner by

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the Contractor or may be deducted by the Owner from any monies due to the Contractor or claimed under the Performance Security.

If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defects Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the Defects Liability Period extended by a period of *[twelve (12) month]* from the time such replacement/repair of the Facilities or any part thereof.

4.33 Functional Guarantees

The Contractor guarantees that during the Guarantee Tests, the Facilities and all parts thereof shall attain the Functional Guarantees as per the Contract. If, for reasons attributable to the Contractor, Functional Guarantees are not met either in whole or in part, the Contractor shall, within a mutually agreed time, at its cost and expense make such changes, modifications and/or additions to the Plant or any part thereof as may be necessary to meet such Guarantees. The Contractor shall notify the Owner upon completion of the necessary changes, modifications and/or additions, and shall seek the Owner's consent to repeat the Guarantee Test. If the specified Functional Guarantees are not established even during the repeat of the Guarantee Tests, the Owner may at its option, either reject the plant and equipment and recover from the Contractor payments already made or Accept the equipment/system/plant after levying Liquidated Damages as specified.

4.34 Patents Indemnity

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Owner may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Contractor or the use of the such Facilities.

4.35 Limitation of liability

Except in cases of criminal negligence or wilful misconduct by the Contractor, the aggregate liability of the Contractor to the Owner, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Contractor to indemnify the Owner with respect to patent infringement.

Except in cases of criminal negligence or wilful misconduct by the Contractor, the Contractor shall not be liable to the Owner, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or loss of profits or interest costs, provided that this exclusion shall not apply to any obligation of the Contractor to pay liquidated damages to the Owner.

4.36 Transfer of Ownership

Ownership of the Plant and Equipment (including spare parts) to be imported into India shall be transferred to the Owner upon loading on to the mode of transport to be used to convey the Plant and Equipment from the country of origin to that country.

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Ownership of the Plant and Equipment (including spare parts) procured from within India shall be transferred to the Owner when the Plant and Equipment including spares are loaded on to the mode of transport to be used to convey the Plant and Equipment including spares from the works to the site and upon endorsement of the despatch documents in favour of the Owner. Ownership of the Contractor's Equipment used by the Contractor and its Subcontractors in connection with the Contract shall remain with the Contractor or its Subcontractors. Ownership of any Plant and Equipment in excess of the requirements for the Facilities shall revert to the Contractor upon Completion of the Facilities or at such earlier time when the Owner and the Contractor agree that the Plant and Equipment in question are no longer required for the Facilities, provided quantity of any Plant and Equipment specifically stipulated in the Contract shall be the property of the Owner whether or not incorporated in the Facilities. Notwithstanding the transfer of ownership of the Plant and Equipment, the responsibility for care and custody thereof together with the risk of loss or damage shall remain with the Contractor until Completion of the Facilities.

4.37 Care of Facilities

The Contractor shall be responsible for the care and custody of the Facilities or any part thereof until the date of Completion of the Facilities, where the Contract provides for Completion of the Facilities in parts, until the date of Completion of the relevant part, and shall make good at its own cost any loss or damage that may occur to the Facilities or the relevant part thereof from any cause whatsoever during such period. The Contractor shall also be responsible for any loss or damage to the Facilities caused by the Contractor or its Subcontractors in the course of any work carried out.

4.38 Loss of or Damage to Property; Accident or Injury; Indemnification

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with the supply and installation of the Facilities and by reason of the negligence of the Contractor or its Subcontractors, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Owner, its contractors, employees, officers or agents.

4.39 Insurance

- a) The Contractor shall at its expense take out and maintain in effect, or cause to be taken out and maintained in effect, during the performance of the Contract, the insurances set forth below in the sums and with the deductibles and other conditions as specified. The identity of the insurers and the form of the policies shall be subject to the approval of the Owner, who should not unreasonably withhold such approval.
 - Cargo Insurance during Transport:-Covering loss or damage occurring while in transit from the Contractor's or Subcontractor's works or stores until arrival at the Site, to the Plant and Equipment (including spare parts thereof) and to the Contractor's Equipment.
 - Installation All Risks Insurance:-Covering physical loss or damage to the Facilities at the Site, occurring prior to Completion of the Facilities, with an extended maintenance coverage for the Contractor's liability in respect of any loss or damage occurring during the Defects Liability Period while the

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Contractor is on the Site for the purpose of performing its obligations during the Defects Liability Period.

- Third Party Liability Insurance: - Covering bodily injury or death suffered by third parties (including the Owner's personnel) and loss of or damage to property occurring in connection with the supply and installation of the Facilities.
 - Automobile Liability Insurance:-Covering use of all vehicles used by the Contractor or its Subcontractors (whether or not owned by them) in connection with the execution of the Contract.
 - Workers' Compensation:-In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Other Insurances Such other insurances as may be specifically agreed upon by the parties.
- b) The Owner shall be named as co-insured under all insurance policies taken out by the Contractor pursuant except for the Third Party Liability, Workers' Compensation and Owner's Liability Insurances, and the Contractor's Subcontractors shall be named as co-insured's under all insurance policies taken out by the Contractor except for the Cargo Insurance During Transport, Workers' Compensation and Owner's Liability Insurances. All insurers' rights of subrogation against such co-insured's for losses or claims arising out of the performance of the Contract shall be waived under such policies.
 - c) The Form of Contract Agreement, deliver to the Owner certificates of insurance (or copies of the insurance policies) as evidence that the required policies are in full force and effect. The certificates shall provide that no less than twenty one (21) days' notice shall be given to the Owner by insurers prior to cancellation or material modification of a policy.
 - d) The Contractor shall ensure that, where applicable, its Subcontractor(s) shall take out and maintain in effect adequate insurance policies for their personnel and vehicles and for work executed by them under the Contract, unless such Subcontractors are covered by the policies taken out by the Contractor.
 - e) The Owner shall at its expense take out and maintain in effect during the performance of the Contract those insurances specified.
 - f) the Owner may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Contractor under the Contract any premium that the Owner shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Contractor. If the Owner fails to take out and/or maintain in effect the insurances the Contractor may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Owner under the Contract any premium that the Contractor shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Owner. If the Contractor fails to or is unable to take out and maintain in effect any such insurances, the Contractor shall nevertheless have no liability or responsibility towards the Owner, and the Contractor shall have full recourse against the Owner for any and all liabilities of the Owner herein.
 - g) The Owner shall give to the Contractor all such reasonable assistance as may be required by the Contractor. With respect to insurance claims in which the Owner's interest is involved, the Contractor shall not give any release or make any compromise with the insurer without the prior written consent of the Owner. With respect to insurance claims in which the Contractor's interest is involved, the Owner shall not give any release or make any compromise with the insurer without the prior written consent of the Contractor.

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- h) Wherever total damages/loss of Equipment/materials, would occur, the Contractor will be entitled to payment of all payments received from the underwriters except the following amounts:
- The amount paid to the Contractor under the Contract in respect of Equipment/materials damaged/lost (excluding the pro-rata initial advance) but including the entire amount of escalation, if any, already paid to the Contractor.
 - Custom Duties and taxes which have already been paid by the Owner.
 - In case of damage to any Equipment/materials during any stage, the Contractor upon rectification of the damaged equipment to the satisfaction of the Owner shall be paid to the extent of full claims settled by the underwriters.
- i) All the Plants & Equipment being supplied by the Owner free of cost for installation of the equipment, cabling, earthing and lightning protection etc. by the Contractor, covered by this specification shall be kept insured by the Contractor against loss, damage, theft, pilferage, fire etc. from the point of unloading at Site up to the time of taking over by the Owner including handling, in plant transportation, storage, installation, testing and commissioning, etc. and the Contractor shall be fully responsible for making good of any loss or damage at his own cost within a reasonable time as mutually agreed upon by the Owner and the Contractor. Any loss/damage shall be brought to the Owner's notice immediately. The premium paid by the Contractor to the Insurance Company for such insurance shall be reimbursed by the Owner to the Contractor at actual against documentary proof to be furnished by the Contractor. The Contractor shall obtain competitive quotation for such insurance and shall take prior approval from the Owner before taking the insurance. The insurable value of the equipment being procured by the Owner will be intimated to the Contractor for the purpose of insurance.
- It will be the responsibility of the Contractor to lodge, pursue and settle all claims with the Insurance Company in case of any damage, loss, theft, pilferage, fire, etc. and the Owner shall be kept informed about it. The losses, if any, will have to be borne by the Contractor, if the claims are not lodged and pursued properly or in the time or if the same are not settled by the Insurance Company.
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4.40 Change in Laws & Regulation

- a) If, after the date [seven (7)] days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Contractor and/or the Time for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Contractor has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Owner and the Contractor and not on procurement of raw materials, intermediary components etc. by the Contractor. Notwithstanding the foregoing, such additional or reduced costs shall not be separately paid or credited if the same has already been accounted for in the price adjustment provisions wherever applicable.

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4.41 Force Majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected. Force Majeure events include Acts of God, Acts of Government, war, sabotage, riots, civil commotion, revolution, flood, earthquake, cyclone, fire, epidemic etc.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within **[fourteen (14)]** days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfil its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
 - constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby
 if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.
- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than **[sixty (60)]** days or an aggregate period of more than one hundred and **[twenty (120)]** days on account of one or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.
- (g) Force Majeure shall not apply to any obligation of the Owner to make payments to the Contractor herein.
- (a)

4.42 Change in the Facilities

(a) Introducing a Change

- The Owner shall have the right to propose, and subsequently require, the Contractor during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Facilities (hereinafter called "Change"), provided that such Change falls within the general scope of the Facilities and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the Facilities and the technical compatibility of the Change envisaged with the nature of the Facilities as specified in the Contract.
- The Contractor may from time to time during its performance of the Contract propose to the Owner (with a copy to the Project Manager) any Change that the Contractor considers necessary or desirable to improve the quality, efficiency or safety of the Facilities. This includes any additional scope of work that the contractor thinks is essential for achieving the minimum

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performance level specified in the SCC or the Contract. The Owner may at its discretion approve or reject any Change proposed by the Contractor.

- No change made necessary because of any default of the Contractor in the performance of its obligations under the Contract shall be deemed to be a Change, and such change shall not result in any adjustment of the Contract Price or the Time for Completion.

(b) Changes Originating from Owner

- If the Owner proposes a Change, it shall send to the Contractor a "Request for Change Proposal," requiring the Contractor to prepare and furnish to the Project Manager as soon as reasonably practicable a "Change Proposal," which shall include the following:
 - ✓ brief description of the Change
 - ✓ effect on the Time for Completion
 - ✓ estimated Cost of the Change
 - ✓ effect on Functional Guarantees (if any)
 - ✓ effect on any other provisions of the Contract.
- The pricing of any Change shall, as far as practicable, be calculated in accordance with the rates and prices included in the Contract. If the rates and prices of any change are not available in the Contract, the parties thereto shall agree on specific rates for the valuation of the Change.
- If before or during the preparation of the Change Proposal it becomes apparent that the aggregate effect of compliance therewith and with all other Change Orders that have already become binding upon the Contractor to increase or decrease the Contract Price as originally set forth in the Contract Agreement by more than fifteen (15) percent, the Contractor may give a written notice of objection thereto prior to furnishing the Change Proposal as aforesaid. If the Owner accepts the Contractor's objection, the Owner and the Contractor shall agree on specific rates for valuation of the change.
- Upon receipt of the Change Proposal, the Owner and the Contractor shall mutually agree upon all matters therein contained including agreement on rates if such rates are not available in the Contract or if the limit of 15% set forth has been exceeded. Within *fourteen (14)* days after such agreement, the Owner shall, if it intends to proceed with the Change, issue the Contractor with a Change Order.
- If the Owner is unable to reach a decision within *fourteen (14)* days, it shall notify the Contractor with details of when the Contractor can expect a decision.
- If the Owner decides not to proceed with the Change for whatever reason, it shall, within the said period of *fourteen (14)* days, notify the Contractor accordingly.
- If the Owner and the Contractor cannot reach agreement on the price for the Change, an equitable adjustment to the Time for Completion, or any other matters identified in the Change Proposal, the Owner may nevertheless instruct the Contractor to proceed with the Change by issue of a "Pending Agreement Change Order."

Upon receipt of a Pending Agreement Change Order, the Contractor shall immediately proceed with effecting the Changes covered by such Order. The

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parties shall thereafter attempt to reach agreement on the outstanding issues under the Change Proposal.

(c) Changes Originating from Contractor

- The Contractor shall submit to the Project Manager a written “Application for Change Proposal,” giving reasons for the proposed Change and including the information. Upon receipt of the Application for Change Proposal, the parties shall follow the procedures indicated above for “Request for Change Proposal.”

4.43 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Contractor is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:
- Any Change in the Facilities or
 - any occurrence of Force Majeure or
 - any suspension order given by the Owner or reduction in the rate of progress or
 - any changes in laws and regulations or
 - any default or breach of the Contract by the Owner, or any activity, act or omission of any other contractors employed by the Owner or
 - any other matter specifically mentioned in the Contract;
- By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Contractor.
- (b) Except where otherwise specifically provided in the Contract, the Contractor shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Owner and the Contractor shall agree upon the period of such extension.
- (c) The Contractor shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.44 Suspension

- (a) The Owner/ Project Manager may, by notice to the Contractor, order the Contractor to suspend performance of any or all of its obligations under the Contract. Such notice shall specify the obligation of which performance is to be suspended, the effective date of the suspension and the reasons thereof. The Contractor shall thereupon suspend performance of such obligation (except those obligations necessary for the care or preservation of the Facilities) until ordered in writing to resume such performance by the Project Manager/ Owner.
- If, by virtue of a suspension order given by the Project Manager/ Owner, other than by reason of the Contractor’s default or breach of the Contract, the Contractor’s performance of any of its obligations is suspended for an aggregate period of more than *[ninety (90)]* days, then at any time thereafter and provided that at that time such performance is still suspended, the Contractor may give a notice to the Project Manager requiring that the Owner shall, within *[twenty eight (28)]* days of receipt of the notice, order the resumption of such performance or

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request and subsequently order a change, excluding the performance of the suspended obligations from the Contract.

- (b) If the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas;

Then the Contractor may by *[fourteen (14)]* days' notice to the Owner suspend performance of all or any of its obligations under the Contract, or reduce the rate of progress. If the Contractor's performance of its obligations is suspended or the rate of progress is reduced, then the Time for Completion shall be extended, and any and all additional costs or expenses incurred by the Contractor as a result of such suspension or reduction shall be paid by the Owner to the Contractor in addition to the Contract Price, except in the case of suspension order or reduction in the rate of progress by reason of the Contractor's default or breach of the Contract.

- (c) During the period of suspension, the Contractor shall not remove from the Site any Plant and Equipment, any part of the Facilities or any Contractor's Equipment, without the prior written consent of the Owner.

4.45 Termination

(a) Termination for Owner's Convenience

The Owner may at any time terminate the Contract for any reason by giving the Contractor a notice of termination. Upon receipt of the notice of termination, the Contractor shall either immediately or upon the date specified in the notice of termination

- (i) cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition.
- (ii) terminate all subcontracts, except those to be assigned
- (iii) remove all Contractor's Equipment from the Site, repatriate the Contractor's and its Subcontractors' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Contractor, subject to the payment, shall

- ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- ✓ Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Contractor the following amounts

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- ✓ the Contract Price, attributable to the parts of the Facilities executed by the Contractor as on the date of termination
- ✓ the costs reasonably incurred by the Contractor in the removal of the Contractor's Equipment from the Site and in the repatriation of the Contractor's and its Subcontractors' personnel
- ✓ any amounts to be paid by the Contractor to its Subcontractors in connection with the termination of any subcontracts, including any cancellation charges
- ✓ costs incurred by the Contractor in protecting the Facilities and leaving the Site in a clean and safe condition
- ✓ the additional cost of satisfying other obligations, commitments and claims that the Contractor may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Contractor's Default

- (i) The Owner, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons thereof to the Contractor:

If the Contractor becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Contractor is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Contractor takes or suffers any other analogous action in consequence of debt

If the Contractor assigns or transfers the Contract or any right or interest therein in violation of the provision.

If the Contractor, in the judgement of the Owner has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

- (ii) If the Contractor
- has abandoned or repudiated the Contract
 - has without valid reason failed to commence work on the Facilities promptly the progress of Contract performance for more than *[twenty eight (28)]* days after receiving a written instruction from the Owner to proceed

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- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient materials, services or labor to execute and complete the Facilities in the manner specified in the program at rates of progress that give reasonable assurance to the Owner that the Contractor can attain Completion of the Facilities by the Time for Completion as extended

then the Owner may, without prejudice to any other rights it may possess under the Contract, give a notice to the Contractor stating the nature of the default and requiring the Contractor to remedy the same. If the Contractor fails to remedy or to take steps to remedy the same within *[fourteen (14)]* days of its receipt of such notice, then the Owner may terminate the Contract forthwith by giving a notice of termination to the Contractor.

(iii) The Contractor shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d) below
- deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Works and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

(iv) The Owner may enter upon the Site, expel the Contractor, and complete the Facilities itself or by employing any third party. The Owner may, to the exclusion of any right of the Contractor over the same, take over and use with the payment of a fair rental rate to the Contractor, with all the maintenance costs to the account of the Owner and with an indemnification by the Owner for all liability including damage or injury to persons arising out of the Owner's use of such equipment, any Contractor's Equipment owned by the Contractor and on the Site in connection with the Facilities for such reasonable period as the Owner considers expedient for the supply and installation of the Facilities.

Upon completion of the Facilities or at such earlier date as the Owner thinks appropriate, the Owner shall give notice to the Contractor that such Contractor's Equipment will be returned to the Contractor at or near the Site and shall return such Contractor's Equipment to the Contractor in accordance with such notice. The Contractor shall thereafter without delay and at its cost remove or arrange removal of the same from the Site.

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- (v) The Contractor shall be entitled to be paid the Contract Price attributable to the Facilities executed as at the date of termination, the value of any unused or partially used Plant and Equipment on the Site, and the costs, if any, incurred in protecting the Facilities and in leaving the Site in a clean and safe condition. Any sums due to the Owner from the Contractor accruing prior to the date of termination shall be deducted from the amount to be paid to the Contractor under this Contract.
- (vi) If the Owner completes the Facilities, the cost of completing the Facilities by the Owner shall be determined.

If the sum that the Contractor is entitled to be paid, plus the reasonable costs incurred by the Owner in completing the Facilities, exceeds the Contract Price, the Contractor shall be liable for such excess.

The Owner and the Contractor shall agree, in writing, on the computation described above and the manner in which any sums shall be paid.

(c) Termination by Contractor

- i. If
 - the Owner has failed to pay the Contractor any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Contractor may give a notice to the Owner that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Owner to remedy the same, as the case may be. If the Owner fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within [fourteen (14) days] after receipt of the Contractor's notice, or
 - the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas or failure to obtain any governmental permit necessary for the execution and/or completion of the Facilities which the Owner is required to obtain as per provision of the Contract or as per relevant applicable laws of the country,

then the Contractor may give a notice to the Owner thereof, and if the Owner has failed to pay the outstanding sum, to approve the invoice or supporting documents, to give its reasons for withholding such approval, or to remedy the breach within [twenty eight (28) days] of such notice, or if the Contractor is still unable to carry out any of its obligations under the Contract for any reason attributable to the Owner within [twenty eight (28) days] of the said notice, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.
- ii. If the Owner becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a

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receiver is appointed over any part of its undertaking or assets, or if the Owner takes or suffers any other analogous action in consequence of debt, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.

- iii. If the Contract is terminated, then the Contractor shall immediately
 - cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
 - terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d)(ii)
 - remove all Contractor's Equipment from the Site and repatriate the Contractor's and its Subcontractor's personnel from the Site.
 - In addition, the Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipment as of the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
 - ✓ Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as of the date of termination in connection with the Facilities.
- iv. If the Contract is terminated, the Owner shall pay to the Contractor all payments, and reasonable compensation for all loss or damage sustained by the Contractor arising out of, in connection with or in consequence of such termination.
- (d) The expression "Facilities executed" shall include all work executed, Erection Services provided, any all Plant and Equipment acquired (or subject to a legally binding obligation to purchase) by the Contractor and used or intended to be used for the purpose of the Facilities, up to and including the date of termination.
- (e) In calculating any payment due from the Owner to the Contractor, account shall be taken of any sum previously paid by the Owner to the Contractor under the Contract, including any advance payment paid.

4.46 Assignment

The Contractor shall not, without the express prior written consent of the Owner, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Contractor shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Renovation & Modernization of Ash Handling System-AHS) Package for [-----]
- **Bid Document No. :** [-----]
- **The Owner is:**
 - Name of Owner: [-----]
 - Address of Owner: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]
- **The Project Manager is:**
 - Name of Project Manager: [-----]
 - Address of Project Manager: [-----]
 - Telephone No. : [-----]
 - Fax No: [-----]
 - E-Mail: [-----]

5.2 Effective Date

The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor.

The following three activities will be completed within [two (2)] months from the date of Letter of Acceptance:

- (a) The contract agreement will be executed by the Owner and the Contractor.
- (b) The Contractor will submit to the Owner the Contract Performance Bank Guarantee, and the Advance Payment Bank Guarantee.
- (c) The Owner will pay the Contractor the Advance Payment as per the Terms of Payment.

The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Owner shall be as follows:

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Owner) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Owner may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

5.4 Liquidated Damage for Delay

5.5 Rate of Liquidated Damage for Delay

If the Contractor fails to successfully achieve completion of R&M activities and commissioning of the retrofitted facilities as per the scope of work within the time period specified in SCC, the Contractor shall pay to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

1.	Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	Liquidated Damage payable at the rate Rs.[.....] for each week of delay
2.	Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	Liquidated Damage payable at the rate Rs [.....] for each day of delay

The Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender are independent and shall be applied separately.

5.6 Liquidated Damage for Non-fulfillment of Functional Guarantees

If the Contractor fails to successfully achieve the Functional Guarantees during Performance Guarantee Test as per the Tender Specification, the Contractor shall pay

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to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

Sl. No.	Functional Guarantee Parameter	Rate of Liquidated Damage
1	Auxiliary Power	[.....] INR per kW increase

The reference condition for Performance Guarantee Parameters shall be as per Volume-II Technical Specification.

The Liquidated Damage for non-fulfillment of the different Functional Guarantee Parameters are independent of one another and shall be applied separately.

{Note: The rate of LD for any functional guarantee parameter shall be at least 1.5 times the corresponding Bid Evaluation Factor}

5.7 Maximum Leivable Liquidated Damages

The amount of Liquidated Damage for delay shall be limited to a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares. This limit is applicable for the Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender taken together.

The aggregate amount **of Liquidated Damage for non-fulfilment of functional guarantee shall be limited to** a maximum of 10 % of the total contracts price (i.e. sum of Ist and IInd contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The limit on maximum leivable Liquidated Damage for Delay and maximum leivable Liquidated Damage for non-fulfillment of functional guarantee are independent of each other and shall apply separately.

5.8 Payment of Liquidated Damages

Contractor shall pay to the owner any Liquidated Damages that are payable as per the provisions of the Contract within thirty (30) days of receipt of Owner's invoice setting forth amount of Liquidated Damages that are then due and payable. If Contractor delays payment of Liquidated Damages that are payable under the provisions of the Contract beyond thirty (30) days, Owner, at its discretion, shall be entitled to recover such amounts by either setting off the relevant unpaid amount against any payment(s) due to the Contractor or by making a demand under Contract Performance Bank Guarantee.

5.9 Contract Price

- The Contract Price shall be as (Contract Price and Terms of Payment) of the Form of Contract Agreement.

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- b) The Contractor shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

5.10 Terms of Payment

- a) The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement. The procedures to be followed in making application.
- b) No payment made by the Owner herein shall be deemed to constitute acceptance by the Owner of the Facilities or any part(s) thereof.
- c) The currency or currencies in which payments are made to the Contractor under this Contract to the Form of Contract Agreement, subject to the general principle that payments will be made in the currency or currencies in which the Contract Price has been stated in the Contractor's bid.

5.11 Contract Securities (Bank Guarantees)

- a) The Contractor shall provide the Bank Guarantee specified below in favour of the Owner at the times, and in the amount, manner and form specified below.
- b) Advance Payment Bank Guarantee
- The Contractor shall, within *[thirty (30)]* days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to *[ninety (90)]* days beyond the date of Completion of Facilities.
 - The security shall be in the form of an Unconditional Bank Guarantee. The Advance payment Bank Guarantee shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of equipment/facilities received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Facilities supplied and received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of those Facilities. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Contractor's responsibility and liabilities under the Contract including in respect of the Facilities for which the reduction in the value of security is allowed.
- c) Performance Bank Guarantee
- The Contractor shall, within *[thirty (30)]* days of the notification of award, provide a Bank Guarantee for the due performance of the Contract for ten percent (10%) of the Contract Price with an initial validity up to *[ninety (90)]* days beyond the Defects Liability Period
- d) The performance Bank Guarantee shall be denominated in the currency or currencies of the Contract, or in a freely convertible currency acceptable to the Owner.

5.12 Sequential Supply

The Contractor is required to supply the material and equipment under the Contract in a sequential manner as per the requirement at site for erection. If Contractor supplies any material/equipment ahead of the requirement as per the agreed Detailed Time Schedule, the Owner, at its discretion, may withhold progressive payment for such material/equipment till the time it is due for supply as per the agreed Detailed Time Schedule.

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	NOT USED
Annexure-E	NOT USED
Schedule F1 Table-1	Summary of Price Schedule
Schedule F1 Table-2	Price Schedule for Supply of Plant and Equipment Including Packing and Forwarding Charges
Schedule F1 Table-3A	Price Schedule for Mandatory Spares
Schedule F1 Table-3B	Price Schedule for Recommended Spares
Schedule F1 Table-4	Price Schedule for Tools & Tackles
Schedule F1 Table-5	Price Schedule for Erection Services Including Dismantling / Disassembly, Unloading, Handling, Storage, Preservation at Site, Erection, Testing, Commissioning and Performance Guarantee Tests of Plant and Equipment
Schedule F1 Table-6	Price Schedule for Civil works
Schedule F1 Table-7	Price Schedule for Training Charges
Schedule F1 Table-8	Schedule of Performance Guarantee Parameters
Schedule F2	Overall Time Schedule
Schedule F3	Deviation Schedule to Tender Document Vol-I Commercial
Schedule F4	Deviation Schedule to Technical Specification
Schedule F5	Requirements of the Contractor at Site
Schedule F6	Contractor's Resource Deployment Schedule

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Schedule F7	Coefficients and Indices for Price Variation Formula
II	Forms and Appendices to form part of Contract
Annexure-F	Form of Contract Agreement
Contract Schedule-1	Terms of Payment
Contract Schedule-2	Price Adjustment
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Approved Subcontractors
Contract Schedule-5	Scope of Works and Supply by the Owner
Contract Schedule-6	Functional Guarantees
Contract Schedule-7	Quality Assurance
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Bank Guarantee

ANNEXURES & SCHEDULES

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.: _____ Bank Guarantee No: _____
Date _____ :

To:
[Details of Designated Official]
[-Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [.....] dated [.....] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [.....] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [Name of package and R&M project], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [.....] (in words and figures) valid for 300 days from [.....] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [.....] Bank at (local address) [.....] having our Head Office at [.....] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of [.....] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

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This Guarantee shall be irrevocable and shall remain valid up to [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorized officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
 Name :
 Designation :
 Staff Code No. :

Banker's Seal :
 Date :

Witness:

1. Signature :
 Full name in block letters :
 Designation :
 Address :

2. Signature :
 Full name in block letters :
 Designation :
 Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[-Name of Utility] [.....]

Sub : ____ (Name of Package) [.....]

Tender

No.

[.....]

Having carefully examined the Tender Specifications issued to us for your Tender No. [.....] dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the 'works' in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification. The plant, equipment and systems offered are of the best and latest technology and of international standards.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR (Indian Rupees [.....] only)/ _____ in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of [180 (One Hundred and Eighty)] days from the date of opening of bids by Owner and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to [Name of Utility], assignees or authorized nominees such sums of money as are stipulated in conditions contained in Tender Specification and agree to furnish Bank Guarantee for Contract Performance as per the proforma prescribed by Owner and for

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the sum equal to 10% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Owner is not bound to accept the lowest or any Bids received and Owner has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Owner and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From:

Dated:

[-----]
[-----]
[-----]

To :

[-----]
[-----]
[-----]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire works as described in the specifications in conformity with the specifications and Tender Specifications, as per prices quoted by us in the Schedule of Prices and Schedule of Performance Guarantees *[Schedule]* enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Employer *[Name of Utility]* and for the sum equal to 10% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Employer is received and accepted by the Employer

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

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1. Signature
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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ANNEXURE – D

Not Used

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**ANNEXURE – E
NOT USED**

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SCHEDULE – F1: TABLE - 1

SUMMARY OF PRICE SCHEDULE

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.1	NOT USED		
1.2	NOT USED		
1.3	NOT USED		
1.4	NOT USED		
2.	NOT USED		
3.	Supply of Plant & Equipment including Technological and misc. structures with all accessories (Ex-Works) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum price basis.		
4.	Sales Tax Payable on Indigenous equipment - on Ceiling basis. (a) VAT (b) Central Sales Tax (CST)		
5.	(a) Inland transport of imported plant & equipment on lumpsum and firm price basis.		
	(b) Inland transport of Indigenous plant & equipment on lumpsum and firm price basis		
6.	Lumpsum price for Civil Works including, supplies such as cement, reinforcement steel etc.at site cost, including Design & Engineering and Construction of entire Civil works.		
7.	Erection services including dismantling/disassembly, unloading, handling, storage and preservation at site, Erection, testing, commissioning and PG tests of plant & equipment on lumpsum price basis		
8.	Marine cum erection insurance on lumpsum and firm price basis		
9.	NOT USED		
10.	Training charges on firm price basis with ceiling.		
11.	VAT on Works Contract on ceiling basis		
12.	Service Tax including Education Cess on Ceiling basis		

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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(In Figures and Words)

S.No.	Description	Foreign Currency	INR
13.	Others, if any (Please specify),		
14.	Total price of package (excluding mandatory spares and Tools & Tackles. (Total of SI.Nos.1.4 + 2 to 13).		
15.	Mandatory Spares on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-3)		
16.	Tools & Tackles on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-4)		
17.	Grand total price of package including Mandatory Spares and Tools & Tackles. (Total of SI Nos 14+15+16).		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SCHEDULE – F1: TABLE - 2

**PRICE SCHEDULE FOR SUPPLY OF PLANT AND EQUIPMENT INCLUDING
PACKING AND FORWARDING CHARGES**

S.No.	Description	
		Supply Ex-works price including packing and forwarding
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		

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S.No.	Description	Supply Ex-works price including packing and forwarding

	Sub Total (3)	
4	Total (1 + 2 + 3)	

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3A
PRICE SCHEDULE FOR MANDATORY SPARES

S. No.	Description	Price
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2	NOT USED	
3	Supply (Ex-works) of Mandatory Spares including Packing and Forwarding on lumpsum and Firm Price	
4.	a) NOT USED.	
	b) Inland transport on lumpsum and firm price basis.	
5	Insurance (Lumpsum and firm price basis)	
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7	Total price of Mandatory Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3B
PRICE SCHEDULE FOR RECOMMENDED SPARES

S. No.	Description	Price
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2	NOT USED	
3	Supply (Ex-works) of Recommended Spares including Packing and Forwarding on lumpsum and Firm Price	
4.	a) NOT USED.	
	b) Inland transport on lumpsum and firm price basis.	
5	Insurance (Lumpsum and firm price basis)	
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7	Total price of Recommended Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-4
PRICE SCHEDULE FOR TOOLS & TACKLES

S. No	Description	Indigenous Price in INR
1.1	NOT USED	
1.2	NOT USED	
1.3	NOT USED	
1.4	NOT USED	
2.	NOT USED	
3.	Supply (Ex-works) of Tools and Tackles including Packing and Forwarding on Lumpsum and firm Price	
4.	a) NOT USED.	
	b) Inland transport for indigenous items on lumpsum and firm price basis.	
5.	Insurance (lumpsum and firm price basis)	
6.	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST	
7.	Total price of Tools and Tackles (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-5

**PRICE SCHEDULE FOR ERECTION SERVICES INCLUDING
DISMANTLING/DISASSEMBLY, UNLOADING, HANDLING, STORAGE,
PRESERVATION AT SITE, ERECTION, TESTING, COMMISSIONING AND
PERFORMANCE GUARANTEE TESTS OF PLANT AND EQUIPMENT**

(In Figures and Words)

S.No.	Description	Total Price for complete work at Site
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		
	Sub Total (3)	
4	Total (1 + 2 + 3)	

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Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 6

PRICE SCHEDULE FOR CIVIL WORKS

S.No.	Description	PRICE
1.		
2		
3		
4		
5		
.....		
.....		
	Total	

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

Document Number	Rev No	Description	Page No.	Date of Issue
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SCHEDULE – F1: TABLE - 7

PRICE SCHEDULE FOR TRAINING CHARGES

S.No.	Description	PRICE
1.		
2		
3		
4		
5		
.....		
.....		
	Total	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 8

SCHEDULE OF PERFORMANCE GUARANTEE PARAMETERS

The Bidder shall furnish performance guarantee of the Package in respect of all items listed below.

Category – I: Performance Guarantees under Liquidated Damages [L.D]

S. No	Particulars	Unit	Value inclusive of design, manufacture and all other Tolerances including measurement uncertainty
1			
2			
3			
.....			
.....			

Category – II: Mandatory Performance Guarantees

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			

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S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
3			
.....			
.....			

Category -III: Requirement under Demonstration Category

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			
3			
....			
.....			
.....			

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F2
OVER ALL TIME SCHEDULE
(Bidder to fill-in and submit with its Bid)

S.No	Work Description	Days from Effective Date	
		Start	Finish
1	Design & Engineering		
2	Manufacture of Plant/Equipment		
	(a)		
	(b)		
	(c)		
		
		
3	Delivery of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
4	Dismantling/Disassembly of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
5	Civil work at Site		
6	Erection of of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
7	Trial Operation & Provisional Take Over		
8	Performance Guarantee tests Completion and Final Take Over		

Signature :

Name :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Designation :

Company :

Company Seal

Date :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I). The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I), then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F4

DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Owner's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Owner's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F5
REQUIREMENTS OF THE CONTRACTOR AT SITE
(Bidder to fill-in and return with its Bid)

The Bidder shall state his requirements against each of the following including the basis of requirements:

A.	Requirements Description	Quantity

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE - F6
CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE

A) Construction Equipment

The Bidder shall indicate the schedule of construction equipment, proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
1									
2									
3									
...									
...									

B) Resource Deployment Schedule

The Bidder shall indicate the schedule of manpower resources proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
2.	Human Resources								
2.1	Engineering Category								
2.1.1	Project Engineers								
2.1.2	Mechanical Engineers								
2.1.3	Electrical Engineers								
2.1.4	Civil Engineers								
2.1.5	C&I Engineers								
2.1.6	Commissioning Engineers								
2.1.7	Structural Engineers								
2.1.8	Others (bidder shall indicate) as applicable for the work								
2.2	Supervisory Category								
2.2.1	Const. Manager								
2.2.2	Electrical Supervisors								
2.2.3	Mechanical Supervisors								
2.2.4	C&I Supervisors								
2.2.5	Civil Supervisors								
2.2.6	Purchase Officer (s)								
2.2.7	Finance/Site Office								
2.2.8	Inspection/Quality Control								
2.2.9	Others (Bidder shall indicate) as applicable for the work								

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S. No.	Type of Resource	Months						
2.3	Labour Category							
2.3.1	Welder							
2.3.2	Fitter							
2.3.3	Rigger							
2.3.4	Un-skilled labour							
2.3.5	Others (Bidder shall indicate) as applicable for the work							

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F7
COEFFICIENTS AND INDICES FOR PRICE ADJUSTMENT FORMULA

Ex-Works price component of Plant and Equipment excluding mandatory spares				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Erection Services Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Civil Works Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

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Note: Bidder to fill up value of all Coefficients, names of indices and value of indices on the base date for Price Adjustment as per Contract Schedule-2. This schedule must be submitted along with Part-I Bid (Techno Commercial Bid) Bidders to use continuation sheets if required.

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Form of Contract Agreement

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Form of Contract Agreement

THIS CONTRACT AGREEMENT is made the _____day of _____, 20_____.
 BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of [country of Employer] and having its principal place of business at [address of Employer] (hereinafter called “the Employer”), and (2) [name of Contractor], a corporation incorporated under the laws of [country of Contractor] and having its principal place of business at [address of Contractor] (hereinafter called “the Contractor”)

WHEREAS the Employer desires to engage the Contractor to dismantle/disassemble, design, manufacture, test, deliver, install, complete and commission certain Facilities, viz.

[.....]
 [.....]
 [.....]

(“the Facilities”) and the Contractor have agreed to such engagement upon and subject to the terms and conditions hereinafter appearing.

NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

- a) Contract Documents means this signed Contract agreement and its annexure/appendices, and the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. The following will constitute the Contract Documents:
 - i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
 - ii. Letter of award.
 - iii. Special Condition of Contract
 - iv. General Condition of Contract
 - v. Technical specification & Tender Drawing.
 - vi. The bid & its schedules/ attachment submitted by the contractor.

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.

- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender.
- vi. The bid & schedules/ attachment Drawing submitted by the contractor.

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1.3 Definitions

The Definitions of terms and expressions shall be as per GCC clause 4.1. Terms and expressions not defined in GCC shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder:
The Contract Price shall be the aggregate of: [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Employer shall be as follows:

1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Employer) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Employer may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

The detailed Time Schedule shall be as per Contract Schedule 2.

Contract Schedules

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The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]

-----[Title]

In the presence of -----

Signed by for and on behalf of the Contractor

-----[Signature]

-----[Title]

In the presence of -----

CONTRACT AGREEMENT

dated the -----day of-----, 20_-----

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

Contract Schedule 1 :	Terms of Payment
Contract Schedule 2 :	Price Adjustment
Contract Schedule 3 :	Time Schedule
Contract Schedule 4 :	List of Approved Subcontractors
Contract Schedule 5 :	Scope of Works and Supply by the Employer
Contract Schedule 6 :	Functional Guarantees
Contract Schedule 7:	Quality Assurance

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Contract Schedule-1

Terms of Payment

The Employer shall pay the Contractor in the following manner and at the following times, on the basis of the Price Break down given in the Section on Price Schedules. Payments will be made in the currencies quoted by the Bidder unless otherwise agreed between the parties. Application for payment in respect of part deliveries may be made by the Contractor as work proceeds.

I. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares):

1	10% of the total Ex-Works price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, and Advance Payment Bank Guarantee by Contractor
2	50% of Ex-Works price for each identified equipment as progressive payment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of Ex-Works price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer
4	20% of the total Ex-Works price	On Completion of Facilities
5	5% of the total Ex-Works price	Successful completion of Performance Guarantee Test

II. Terms of Payment for Supply of Mandatory Spares and Recommended Spares

1	70% of the Ex-Works Price of each Spare	Upon dispatch of the identified Spare after dispatch clearance by employer on raising of invoice by the Contractor and submission of evidence of shipment
2	30% of the Ex-Works Price of each Spare from within India	On receipt of Spare at site and physical verification and certification by the Employer

III. Terms of Payment for Local Transportation, Inland Transit Insurance

For Plant & Equipment except Spares		
1	100% of Local Transportation, Inland Transit Insurance pro-rata to value of the equipment	On receipt of Equipment at site and upon raising of Invoice by the Contractor
For Spares		

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2	100% of Local Transportation, Inland Transit Insurance pro-rata to value of Spare	On receipt of Spare at site and upon raising of Invoice by the Contractor
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IV. Terms of Payment for Erection of Plant & Equipment

1	10% of Total Price for Erection of Plant & Equipment	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Erection of Plant & Equipment as progressive payment pro-rata to value of plant & equipment erected	On certification by Employer of successful erection of plant & equipment and successfully passing of quality checks
3	10% of Total Price for Erection of Plant & Equipment	On Completion of Facilities
4	5% of Total Price for Erection of Plant & Equipment	Successful completion of Performance Guarantee Test

V. Terms of Payment for Civil Works

1	10% of Total Price for Civil Works	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Civil Works as progressive payment	On certification by Employer regarding value of work completed & successfully passing of quality checks
3	10% of Total Price for Civil Works	On Completion of Facilities
4	5% of Total Price for Civil Works	Successful completion of Performance Guarantee Test

VI. Terms of Payment for Price Adjustment Amount

Any increase in the Price of any component Contract shall be paid as per the Terms of Payment for base price. The initial 10% advance payment pertaining to increase in price shall be paid along with progressive payment of that equipment. Reduction to the Contract Price, if any, due to price adjustment provisions, shall be effected by recovering 100% of the reduction amount (including advance) from any of the Contractor's bills falling immediately due for payment.

VII. Terms of Payment for Taxes & Duties

Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other

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Tax or Duty payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon receipt of corresponding Plant & Equipment or Spare at site and submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such Taxes & Duties.

VIII.

Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such variation.

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Contract Schedule-2

PRICE ADJUSTMENT

- (i) The Contract Price shall be subject to price adjustment during performance of the Contract to reflect changes in the cost of labour and material in accordance with the provisions described below.
- (ii) Only following components of the Contract Price will be subject to Price adjustment :
 - (a) Ex-Works (India) price of plant and equipment excluding Mandatory Spares. The price adjustment amounts towards these price components shall be without any ceiling.
 - (b) Erection Services component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
 - (c) Civil Works component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
- (iii) Price adjustment amounts towards aforesaid components of Contract Price shall be paid in the respective currencies of Contract.
- (iv) The indices for price adjustment shall necessarily be of India and shall be well established and nationally recognized in India. Preferably Government indices shall be used.
- (v) The price adjustment formula for the components of the Contract Price above shall be as stipulated hereinafter.
- (vi) **Ex-Works price component of Plant and Equipment excluding mandatory spares**

The price component of the equipment for any shipment/ dispatch comprises of a fixed portion (designated as 'F' and the value of which is specified hereunder) and a variable portion linked with the indices for various materials and labour.

The amount of price adjustment towards variable portion payable/recoverable on each shipment/dispatch shall be computed as under :

$$ES = ES_1 - ES_0$$

ES₁ will be computed as follows:

$$ES_1 = ES_0 \left\{ F + a \times \frac{A_1}{A_0} + b \times \frac{B_1}{B_0} + c \times \frac{C_1}{C_0} + Lb \times \frac{L_1}{L_0} \right\}$$

Where

ES = Adjustment to Ex-Works component expressed in the currency of the Contract payable to the contractor for each shipment/dispatch

ES₁ = Adjusted amount of Ex-works price component expressed in the currency of the Contract payable to the Contractor for each shipment/dispatch

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- ES_0 = Ex-works for the plant and equipment in the currency of the Contract, shipment/dispatch wise.
- The fixed portion of the ex-works component of the Contract Price (F) shall be 0.15.
 - a, b, c etc. shall be co-efficient of major materials/items involved in the ex-works component of the Contract Price. The sum of these co-efficient shall be between 0.50 to 0.60.
 - A, B, C etc. shall be published price indices of corresponding major materials/items. Such indices shall necessarily be of India.
 - 'Lb' shall be co-efficient for labour component in the ex-works of the Contract Price which shall be between 0.25 to 0.35.
 - 'L' shall be labour index.
 - Sum of all the material co-efficient and the labour co-efficient shall be 0.85.

For the indices(A, B, C etc.), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid.

Subscript '1' refers to indices/exchange rates as of:

(a) three months prior to the date of shipment/dispatch for labour, and

(b) six months prior to the date of shipment/dispatch for material.

In case of shipments/dispatches which are delayed beyond the schedule date of shipment/dispatch for reasons attributable to the Contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of shipment/dispatch and the actual date of shipment/dispatch.

(vii) Erection Services Component

The price component for erection services comprises of a fixed portion and a variable portion linked with the index of labour.

$$ER = ER_1 - ER_0$$

ER_1 will be computed as follows:

$$ER_1 = ER_0 \left(0.15 + 0.85 \frac{FL_1}{FL_0} \right)$$

Where:

ER	=	Adjustment to erection services component of contract price payable to the contractor for each billing.
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ER ₁	=	Adjusted amount of erection services component of Contract Price payable to the Contractor.
ER ₀	=	Value of the Erection work done in the billing period (month)
FL	=	Indian field labour index namely, All India Consumer Price Index for Industrial Workers (All India Monthly Average) as published by Labour Bureau, Simla, Government of India.

For the indices, subscript 'o' refers to indices as on 30 days prior to date set for opening of Part-I bids. .

For the indices, subscript '1' refers to the indices as applicable for the month of execution of the erection work. For the exchange rates, subscript '1' refers to the exchange rates as applicable on the last day of the month of execution of the erection work.

In case of erection activities which are delayed beyond the schedule date for reasons attributable to the contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of completion and actual date of completion of the respective erection activity.

(viii) The following components of the contract price shall not be subject to price adjustment and shall remain firm during the execution of the contract :

- (1) Ocean Freight and Marine Insurance for Plant and Equipment, mandatory spares and recommended spares.
- (2) Price for Mandatory spares & Recommended Spares.
- (3) Inland Transportation charges (including Inland Transit Insurance, port clearance, port handling & port charges) for plant & equipment and Spare Parts.

(ix) Civil Works Component

The Price of Civil Works for any month comprises a fixed part designated as 'F' and variable parts linked to indices for labour, steel, cement, other commodities and Fuel & Power. The monthly price adjustment amount for the civil works component of the Contract Price will be computed as per the formula given below:

$$EC = EC_1 - EC_0$$

EC₁ will be computed as follows:

$$EC_1 = EC_0 \left\{ F + a \times \frac{MI_1}{MI_0} + b \times \frac{LI_1}{LI_0} + c \times \frac{FI_1}{FI_0} + d \times \frac{SI_1}{SI_0} + e \times \frac{CI_1}{CI_0} \right\}$$

Where

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- EC = Adjustment to Civil Works price component expressed in the currency of the Contract payable to the contractor for each month
- EC₁ = Adjusted amount of Civil Works price component expressed in the currency of the Contract payable to the Contractor for each month
- EC₀ = Value of Civil Works done expressed in the currency of the Contract for the billing period (month).
- The fixed portion (F) of the Civil Works component of the Contract Price shall be 0.15.
 - 'a' is the coefficient for material cost other than cement and steel involved in the Civil Works component of the Contract Price and it shall be 0.15.
'b' is the coefficient for labour cost involved in the Civil Works component of the Contract Price and it shall be 0.3.
'c' is the coefficient for Fuel & Power cost involved in the Civil Works component of the Contract Price and it shall be 0.05.
'd' is the coefficient for steel cost involved in the Civil Works component of the Contract Price and it shall be 0.25.
'e' is the coefficient for cement cost involved in the Civil Works component of the Contract Price and it shall be 0.10.
 - MI shall be All India Whole Sale Price Index for all commodities as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry.
LI shall be All India Consumer Price Index for industrial labour as published by Labour Bureau, Government of India
FI shall Index Number of Wholesale Price for group Fuel & Power as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry
SI shall Index Number of Wholesale Price for Steel as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry
CI shall Index Number of Wholesale Price for Cement as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

For the indices(MI, LI,FI, SI and CI), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid. Subscript '1' refers to indices as of one prior to the month for which Civil Works is being billed.

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Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

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Contract Schedule-4
LIST OF SUB-CONTRACTORS
[List of approved subcontractors shall be placed]

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Contract Schedule-5

SCOPE OF WORKS AND SUPPLY BY THE OWNER

[Scope of Works and Supply by the Employer shall be placed]

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Contract Schedule-6
FUNCTIONAL GUARANTEES
[Functional Guarantees shall be placed]

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Contract Schedule-7
QUALITY ASSURANCE

[After Letter of Award (LOA), the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall]

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Contractor]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:	Bank Guarantee No:	Date:
--------	--------------------	-------

To:

[Name & Address of Owner (Utility)]

.....
.....]

Dear Sirs,

1 In consideration of the [...] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Contractor's Name] having its registered office at.....hereinafter referred to as the 'CONTRACTOR', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures] and the same having been unequivocally accepted by the CONTRACTOR and the CONTRACTOR having agreed to provide a **Contract Performance Bank Guarantee** for the faithful performance of the entire CONTRACT including the Warranty Obligations /Liabilities under the CONTRACT equivalent to 10% (ten percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONTRACTOR by reason of any breach of the said CONTRACTOR of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to Rs.....(Rupees.....only). Any

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such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONTRACTOR or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The Bank further irrevocably guarantees and undertakes to pay any amount due and payable by the CONTRACTOR by reasons of non-fulfilment of any of the following obligations of the Contractor:
 - (a) Successful and satisfactory operation of the plant & equipment supplied and erected under the said Contract as per the Technical Specifications and other Tender/Contract documents.
 - (b) That the equipment installed under the said Contract shall be new and in accordance with Contract Documents and be free from all defects in design, engineering, material workmanship and performance for a period of 12 calendar months after final takeover of the equipment by the OWNER and that upon written notice from the OWNER, the CONTRACTOR shall remedy free of any expense to the OWNER, such defects as noticed and developed under the normal use of the said plant & equipment, within the said guarantee period.
- 4 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONTRACTOR. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 5 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONTRACTOR and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONTRACTOR or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 6 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONTRACTOR to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 7 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Contractor or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 8 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONTRACTOR's liabilities.

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- 9 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONTRACTOR(S).
- 10 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended from time to time for such period as may be desired by [Name of Contractor.....] on whose behalf this guarantee has been given.
- 11 Signed at.....this.....day of.....20.....

Signature :
Name :
Designation :
Staff Code No :

Bank Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
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6. Forms and Schedules

* * * * *

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* * * * *

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(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
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* * * * *

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)**

**VOLUME-II,
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**RENOVATION & MODERNISATION
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ABBREVIATIONS TO BE USED

{The utilities are advised to use the following standard abbreviations while preparing Model Tender Document for their power plant.}

AAQ	Ambient Air Quality
AC	Air Condition
ACG	Automatic Control Gear
ASME	American Society of Mechanical Engineers
ASH	Ash Handling System
BA	Bottom Ash
CCTV	Closed Circuit Television
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CV	Control Valve
EOT	Electrically Operated Travelling Crane
ESP	Electrostatic Precipitator
ESV	Emergency Stop Valve
EWS	Engineer's Work Station
FO	Fiber Optics
FS	Fly Ash
HMI	Human Machine Interface
I/O	Input / Output
IP	Internet Protocol

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IPR	Inter Posing Relay
ISH	Intermediate Surge Hopper
ISMB	Indian Standard Medium Beam
LE	Life Extension
LPA	Loss Prevention Association of India
LVS	Large Video Screen
MCCB	Module Case Circuit Breaker
MoEF	Ministry of Environment & Forest
OPC	Object linked embedded Process Control
OWS	Operator Working Station
PLC	Programmable Logic Controller
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RSO	Recurrent Surge Oscillograph
RTD	Resistance Temperature Detector
SADC	Secondary Air Damper Control
SM	Suspended Magnet
SSCC	Submerged Scraper Chain Conveyor
TMCR	Turbine Maximum Continuous Rating
TC	Thermocouple
TCP	Transfer Control Protocol

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

TPS	Thermal Power Station
TR	Tons of Refrigeration
TT	Traveling Tripper
VS	Ventilation System
WIBS	Water Impounded Bottom Ash

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1 INTENT OF SPECIFICATION

- 1.1 The intent of this specification is to Renovate and Modernize various equipment & systems of Ash Handling Plant (AHP) including but not limited to [Bottom Ash Handling System, Wet Fly Ash Handling System, Dry Fly Ash Handling System (Vacuum conveying or Pressurized transport system) including all associated Electrical system, Control & Instrumentation systems and Civil & Structural work]. The renovated Ash Handling Plant shall be designed considering the following parameters to evacuate ash from different zones of Boiler and ESP of each of the [210/215/220/250] MW unit:

Description	Units	Design Parameters
Coal Consumption/Unit	TPH	[...]
No. of Units to be catered by the designated AHP	....	[...]
Ash Content in Coal	%	[...]
Bottom Ash and Economizer ash	%	[...]
Fly Ash and Air Pre-Heater ash	%	[...]
Duration of Bottom Ash and Economizer ash evacuation in a shift of 8 hours	Hours	[...]
Duration of Fly Ash and Air Pre-Heater ash evacuation in a shift of 8 hours	Hours	[...]

- 1.2 The Bidder shall carry out the required replacement / refurbishment / retrofitting of the various equipment/systems of Ash Handling Plant package as per the requirements of his design so as to make the same capable of operating for an extended life of [20/25] years and giving the output specified in the subsequent clauses in this specification in order to be compatible with the requirement of Main Plant package. The scope of replacement / refurbishment / retrofitting shall include but shall not be limited to the scope of work mentioned in clause 4.6 which is based on the recommendation of RLA/CA and EA studies conducted during [.....]. However, any other items/systems which have not been specifically mentioned but are considered necessary by the Bidder for giving the intended performance of various equipment/systems of ASH package, shall also be included in the scope of Bidder and shall be separately highlighted by the Bidder in his proposal.

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- 1.3 Bidders are required to quote the performance guarantee value for Auxiliary power consumption as per Table 1.2 below:

Table: 1.2

S.No.	Parameter	Performance Guarantee Values
1	Maximum Auxiliary Power Consumption (kW)	[....]

For Auxiliary power consumption, the best quoted value shall be considered as base parameter and other bids shall be cost loaded as per difference between base parameter and respective quoted guaranteed parameter multiplied by evaluation factors specified in the Commercial Volume (Volume-I).

- 1.4 The modified/replaced/retrofitted equipment will conform to the requirement of the specification prescribed in Section-II of Volume-II. The relevant technical details like OEM's Specifications and Drawings for the existing equipment required to be modified / replaced / retrofitted have also been provided in Volume-II, Section-II for the reference of the Bidders.
- 1.5 Bidders are required to carry out necessary modifications / replacement in the existing mechanical / electrical equipment or systems including related civil/structural works as per specification requirement and also based on their own assessment.
- 1.6 The scope of work for R&M shall include designing / re-designing, basic and detailed engineering, re-engineering, refurbishing / retrofitting, supply, inspection and testing at supplier's works, packing, forwarding to site, forwarding from site to Bidder's facilities, unloading and storage at site, pre-assembly, machining if required, site fabrication, erection, replacing of various equipment and systems, application of paints and thermal insulation, carrying out all pre-commissioning checks/ tests and any other work required to complete the system, commissioning and trial operation, performance tests of various equipment and systems covered under this Specification. Bidder's scope shall also include dismantling of the existing equipment/ facilities, including unloading & transportation to designated storage / disposal yard, wherever required as a result of augmentation of existing mechanical, electrical, I&C and civil/structural/ architectural works. The Bidder shall restore the equipment/ facilities, whenever applicable, after carrying out necessary renovations/modifications under the scope of R&M works.

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All the tools & tackles, labour and other facilities required for dismantling and restoration shall also be in the scope of the Bidder.

Bidder shall also put back into service all the systems/equipment of the units after completion of R&M works, whether any modification is carried out on the same or not. All necessary tools, tackles, labour, instruments, spares, consumables etc. required for putting back into operation shall also be provided by the Bidder.

- 1.7 It is not the intent to specify completely herein all aspects of services and equipment to be provided by the Bidder who in any case shall be responsible for fulfillment of the intent of Specification. Irrespective of whether specifically mentioned or not, the services, equipment and systems to be provided in accordance with this Specification shall also form a part of the scope of work and shall conform in all respects to the highest standard of engineering, design, quality and workmanship so that after completion of R&M work by the Bidder, the plant shall be capable of performing completely in a safe, reliable and sustained manner as acceptable to the Owner.
- 1.8 Unless otherwise specifically clarified by the Owner, interpretation by the Owner in respect of scope of supplies & services and the meaning of the Specifications, drawings, requirements of operation, maintenance, redundancy etc., shall be final and binding on the Bidder. Owner shall have the right to reject or accept any work or material which in his assessment is not technically complete and proven to meet the requirements of this Specifications and/or applicable National and International Codes & Standards mentioned elsewhere in this Specification.
- 1.9 The requirements, conditions, appendices etc, given in various parts/ sections of technical Specifications shall form integral part of this Specification. Bidder is required to carefully examine and understand the Specifications and seek clarifications, if required, to ensure that he has understood the Specifications as intended by the Owner. In the absence of any specific clarifications made to the Owner during Bidding stage, the interpretation of Owner shall be final. The Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. All such points are required to be clarified & resolved during Bidding stage.
- 1.10 Any deviation or variation from the scope of supply and services or the intent of the Specification shall be clearly brought out under the schedule of Technical / Commercial deviations, irrespective of the fact that such

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deviation / variation may be standard practice or possible interpretation of the Specifications by the Bidder. In case, no clear and specific deviation is taken by the Bidder in the relevant schedule of Bid Proposal Sheet while making his Bid proposal, it will be construed that the Bidder shall comply with the stipulations of the Specification fully with regard to scope of services and supplies to be provided by him to achieve the objective of R&M. Further, unless otherwise specifically clarified by the Owner, the interpretation by the Owner in respect of scope of supplies and services to be performed by the Bidder shall be final and binding.

- 1.11 If the Bidder feels that, in his opinion certain features brought out in his offer are superior to what has been specified, these may be highlighted separately in the Bid. The Bidder at his own discretion may also make Alternate offers, which in his opinion are of superior technology, material etc. to the specified requirements leading to better performance like efficiency / output etc. of the units after renovation. In such case, the Bidder shall carry out a comprehensive study and clearly identify the scope of offer in his alternate proposal. The Bidder shall furnish that detailed study to Owner along with the Bid where the Bidder shall bring out in detail the scope of modifications required to be carried out by him in the various systems and equipment including but not limited to *[Bottom Ash Handling System, Wet Fly Ash Handling System, Dry Fly Ash Handling System (Vacuum conveying or Pressurized transport system) including all associated Electrical system, Control & Instrumentation systems and Civil & Structural work]*.

Such Alternate proposals shall be supplemented with sufficient amount of information like specified design standards and performance requirements, Bidder's experience, operating feedback, provenness, etc. for justifying such proposals. Implications of such Alternate offers on the performance, output, efficiency, auxiliary power consumption, etc. shall be clearly brought out in the Bid to enable the Owner to determine the advantages, superiority and acceptability of the proposals.

However the Bidder's Base offer shall necessarily be in line with the Specification requirements.

The Base offers will be evaluated as per procedure outlined in the Bid documents and the Alternate Offers of the lowest evaluated Bidder will only be considered for acceptance or otherwise. Owner may reject alternative proposals submitted by the Bidder at his sole discretion, without assigning any reason what so ever.

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- 1.12 In the event of conflict between requirements of any two clauses of the Specification documents or requirements of different Codes/ Standards specified, the more stringent requirement as per the interpretation of the Owner shall apply, unless confirmed otherwise by the Owner in writing.
- 1.13 The General technical conditions pursuant to the Contract, placed separately in this Specification, shall form an integral part of the Specification. These conditions shall supplement all the detailed technical Specification and requirement identified in this Specification.
- 1.14 Out of complete unit comprising of mechanical, electrical, C&I systems and equipment, some components/systems are envisaged to be replaced with new ones having better design features while some of the other components are to be refurbished / upgraded by the Bidder under present R&M Work. It shall be the responsibility of the Bidder to ensure that components/ equipment/ systems being supplied new OR components/ equipment/ systems being refurbished / upgraded by him are fully compatible and integrated with the existing equipment / systems so as to give safe, reliable and sustained operation of the complete unit. Modifications needed on the assembled equipment to ensure complete integration are to be brought out by the Bidder in the Bid and such modifications, if any, after Owner's approval shall be carried out by the Bidder to the satisfaction of the Owner.
- 1.15 The systems shall operate without any restriction over the entire range of operating conditions as envisaged in the subsequent section of the Specification. The Bidder shall ensure that after R&M there are no restrictions/ alterations in modes of operations of the system, as per the original/existing operation philosophy.
- 1.16 As the various equipment/ systems/ components are to be fitted in the existing plant, Bidder is advised to visit the plant site to get fully conversant with the job, site conditions, and constraints, and collect all the information as required and as available before quoting against this Specification.
- 1.17 A brief extract of the existing plant, the original design details/ performance parameters along with plant details, operating history and known problem areas; wherever possible are brought out in the successive section of this Specification. Relevant plant layout drawings and certain key schematic drawings, as available, have also been provided in Annexure-I of this section

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of the specification for the purpose of familiarization & guidance only. The successful Bidder shall prepare and provide the additional drawings and documents describing the design and engineering details and the manuals for carrying out erection, commissioning and operation of the renovated unit.

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2 SITE & PROJECT SPECIFIC INFORMATION

2.1 Project Name

Project Title: [...]

Existing Capacity: [X xMW]

2.2 Project Location

The proposed project site is located at [...], in District [...] in the state of [...]. The location details of the project site are as indicated below:

Table: 2.1

Particulars	
Latitude	[... ° ...' ..."] N
Longitude	[... ° ...' ..."] E
Height above mean sea level	[...] m
Seismic Zone	Zone - [...]
Distance from [...] town	[...] km
Distance from national highway No. [...]	[...] km
Distance from state highway No. [...]	[...] km
Distance of nearest airport [...]	[...] km
Distance of nearest seaport [...]	[...] km

2.3 Climatological Data

Table: 2.2

Particulars	
Highest monthly mean of daily maximum temperature	[...] °C
Lowest monthly mean of daily maximum temperature	[...] °C

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Particulars	
Highest monthly mean of daily minimum temperature	[...] °C
Lowest monthly mean of daily minimum temperature	[...] °C
Annual mean of daily maximum temperature	[...] °C
Annual mean of daily minimum temperature	[...] °C
Extreme highest temperature	[...] °C
Extreme lowest temperature	[...] °C
Design ambient temperature (unless specified otherwise)	{50} °C
Relative Humidity: Maximum Minimum	[...] % [...] %
Average annual rainfall	[...] cm
Heaviest rainfall in 24 hours so far	[...] cm
Number of rainy days in a year	[...]
Highest monthly mean of wind speed	[...] km/h
Lowest monthly mean of wind speed	[...] km/h
Maximum wind speed	[...] km/h

Table: 2.3

Season	Dry bulb temperature	Wet bulb temperature
Summer	[...] °C	[...] °C
Monsoon	[...] °C	[...] °C
Winter	[...] °C	[...] °C

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2.4 Fuel

At present the power station is sourcing coal from [...] coal mines. The coal is being transported to the project site by [Indian Railways/ MGR system/ cross country conveyor]. Proximity of Railway line to site from [...] Railway Station is about [...] km. The railway link shall also be used for transportation of heavy equipment to site during construction phase and to bring main and secondary fuel to the power plant during operation of plant.

2.4.1 Coal Analysis

Proximate and ultimate analysis of coal (on as received basis)

Table: 2.4

Sl. No.	Particulars	Unit	Performance Coal	Worst Coal	Best Coal
(i)	Proximate Analysis				
1	Moisture	%	[...]	[...]	[...]
2	Ash	%	[...]	[...]	[...]
3	Volatile Matter	%	[...]	[...]	[...]
4	Fixed Carbon	%	[...]	[...]	[...]
	Total	%	100	100	100
(ii)	Gross calorific value	kCal/kg	[...]	[...]	[...]
(iii)	Grindability index	HGI	[...]	[...]	[...]
(iv)	Ultimate analysis				
1	Carbon	%	[...]	[...]	[...]
2	Hydrogen	%	[...]	[...]	[...]
3	Sulphur	%	[...]	[...]	[...]
4	Nitrogen	%	[...]	[...]	[...]

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Sl. No.	Particulars	Unit	Performance Coal	Worst Coal	Best Coal
5	Oxygen difference (by difference)	%	[...]	[...]	[...]
6	Moisture	%	[...]	[...]	[...]
7	Ash	%	[...]	[...]	[...]
	Total	%	100	100	100

2.4.2 Ash analysis

Table: 2.5

Characteristics	Unit	Range/ value
SiO ₂	%	[... / ...]
Al ₂ O ₃	%	[... / ...]
Fe ₂ O ₃	%	[... / ...]
TiO ₂	%	[... / ...]
CaO	%	[... / ...]
MgO	%	[... / ...]
Chloride as Cl	%	[... / ...]
Sulphate as SO ₄	%	[... / ...]
Alkalies as NaOH	mg/kg	[... / ...]
Chromium as Cr	mg/kg	[... / ...]
Mercury as Hg	mg/kg	[... / ...]
Lead as Pb	mg/kg	[... / ...]
Cadmium as Cd	mg/kg	[... / ...]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

Characteristics	Unit	Range/ value
Nickel as Ni	mg/kg	[... / ...]
Zink as Zn	mg/kg	[... / ...]
Copper as Cu	mg/kg	[... / ...]

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3 EXISTING PLANT DETAILS

The Power Plant, is of the configuration of [...x...MW]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The boiler for the unit is of [PF/CFBC] design. The boiler is provided with [front & rear/ corner/down shot] firing system. LP stage of Turbine is designed with [Bauman] exhaust. Condenser cooling system of the unit is designed on [once through / re-circulation system]. The Ash Handling Plant was supplied by M/s [...] and designed for rated capacity of [...] TPH. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [... substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...] coal mines. The consumptive water for the power plant is being sourced from [...river /...sea].

3.1 Operational Background

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Though the boiler was originally designed for coal with Gross Calorific Value (GCV) of [...kCal/kg], it presently operates on coal supplied with GCV of about [...kCal/kg]. The deterioration experienced over the years in Plant's Average Performance Parameters is shown in Table 3.1.

3.1.1 Average Performance Parameters of AHP over the Life

Table: 3.1
Average Performance Parameters over the Life of Ash Handling Plant

Years after Installation	Name of the Equipment	Availability (%)	Output (Capacity)	Aux. Power Consumption (%)	Total Consumptive water requirement
5	[...]	[...]	[...]	[...]	[...]
10	[...]	[...]	[...]	[...]	[...]
15	[...]	[...]	[...]	[...]	[...]
20	[...]	[...]	[...]	[...]	[...]
25	[...]	[...]	[...]	[...]	[...]

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3.1.2 AHS Equipment's Average Performance Parameters during the last five years

Table 3.2 indicated below, illustrates variations over the last five years in the performance parameters.

{Furnish in the Table 3.2 below, the Average Values for the last five years. However, for the Parameters in respect of 'One Year back' and 'Current Year', furnish the Maximum, the Minimum and the Average Values.}

Table: 3.2
AHS Equipment's Average Performance Parameters during the Last Five Years

Period	Name of the Equipment	Availability (%)	Output (Capacity)	Aux. Power Consumption (%)	Total Consumptive water requirement
Four Years Back
Three Years Back
Two Years Back
One Year Back
Current Year

3.1.3 Auxiliary Power Consumption of Ash Handling Systems (for running stream)

Table-3.3

Sl. No.	Equipment/System	Units	Power Consumption
i.	Bottom Ash crushers	kW	
ii.	Bottom Ash H.P. water pumps	kW	
iii.	Bottom Ash L.P. water pumps	kW	
iv.	Fly Ash water pumps	kW	
v.	Bottom ash slurry transportation pumps	kW	
vi.	Bottom ash slurry disposal pumps	kW	

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Sl. No.	Equipment/System	Units	Power Consumption
vii.	Fly ash conveying vacuum pumps	kW	
viii.	Transport air compressor with air drying plant (ADP)	kW	
ix.	Lean slurry Pumps	kW	
x.	Instrument air compressor with air drying plant (ADP)	kW	
xi.	Ash water recirculation pumps	kW	
xii.	Bottom Ash crushers	kW	

3.1.4 Feedback from the Plant Operators

Detailed discussions were held with the Plant operators who provided the feedback about the design and operation related problems of various systems. These are listed in the Table 3.4 below.

Table 3.4
Feedback from the Plant Operators

S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
1	[.....]	[.....]	[.....]
2	[.....]	[.....]	[.....]
3	[.....]	[.....]	[.....]
4	[.....]	[.....]	[.....]
5	[.....]	[.....]	[.....]
6	[.....]	[.....]	[.....]
7	[.....]	[.....]	[.....]
8	[.....]	[.....]	[.....]

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S. No.	Name of the System/Equipment	Type of Problem	Probable Solution as per the Operators
9	[.....]	[.....]	[.....]
...	[.....]	[.....]	[.....]

3.1.5 Tripping and Maintenance Record

{Indicate in the table below the tripping and maintenance record for the past three years.}

Table: 3.5

Year	Name of Equipment	Total Trippings	Major Causes of Trippings	Maintenance carried out
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current Year	[.....]	[.....]	[.....]	[.....]

3.1.6 Maximum Achievable Load due to performance constraint

[Due to performance constraint of various equipment of Ash handling Plant, the maximum generation from the unit is restricted to [...] MW. The operational data at the above maximum load is indicated in the table below.]

Table: 3.6

Nature of constraint	Output (MW)	Aux. Power Consumption (%)	Unit's Gross Efficiency (%)
[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]

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Nature of constraint	Output (MW)	Aux. Power Consumption (%)	Unit's Gross Efficiency (%)
[...]	[...]	[...]	[...]

3.1.7 Record of Reportable Accidents

[The record of reportable accidents for the past three years, is mentioned in the Table below]

Table: 3.7

Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
Two Years Back	[.....]	[.....]	[.....]	[.....]
One Year Back	[.....]	[.....]	[.....]	[.....]
Current Year	[.....]	[.....]	[.....]	[.....]

3.1.8 Operation & Maintenance Difficulties due to Plant Limitations

[Difficulties are being experienced in day to day maintenance of the plant due to design deficiency, layout of the plant, obsolescence of equipment and non availability of spare parts etc. These are mentioned in the Table below]

Table: 3.8

S.No.	Nature of Difficulty	Specific Reason (Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)
1	[.....]	[.....]

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2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

3.2 Salient Technical Feature of Existing Ash Handling System

{Describe in this sub-section, the Design Parameters and Salient Features of all the important Equipment and Systems of existing Ash Handling Plant as mentioned below}.

3.2.1 Mechanical System

The Ash handling system shall be design for [...] units of [...] MW.

The Ash is generated after burning of coal in boiler. Ash is generated in two forms, one is the bottom ash/ coarse ash and another is fly ash. The ash is being disposed in to the ash pond which is outside the plant boundary.

[The details of the system are mentioned in the table below:]

Table: 3.9

Description	Units	Design Parameters
A. Bottom Ash Handling System		
Water Impounded Bottom Ash Hopper		
Type of Hopper	[.....]
Location	[.....]
Minimum effective ash storage capacity	h	[.....]
Maximum allowable ash level in bottom ash hopper	[.....]
Capacity of makeup system		
• Hopper	[.....]

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Description	Units	Design Parameters
• Seal trough	[...]
Minimum angle between hopper wall & horizontal	[...]
Seal trough	[...]
Material of Construction		
• Hopper Body	[...]
• Refractory anchors	[...]
• Sluicing/ Arch Breaking /wash nozzles	[...]
• Cooling water header	[...]
• Seal trough	[...]
• Refractory	[...]
Bottom Ash Water Impound Hopper Discharge Gates		
Quantity / Nos.	[...]
Size	[...]
Capacity of Each Gate	[...]
Drive of Feed Gate	[...]
Adjustment of ash gate seal	[...]
Inclination of feed gate	[...]
Wear protection liners	[...]
Accessories of Ash gate housing	[...]
Access door	[...]

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Description	Units	Design Parameters
Flushing nozzles on either side of feed gate	[...]
Material of Construction		
• Gates		[...]
• Gate wear liners	mm	[...]
• Housing wear plates/impingement plates	mm	[...]
• Housing	mm	[...]
Jet Pumps		
Quantity	.....	[...]
Rated Capacity	m ³ /h	[...]
Material of Construction		
• Inlet section, throat & discharge/tail piece	.....	[...]
• Nozzle Inlet	.....	[...]
• Nozzle Tip	.....	[...]
Slurry line Valve		
Type of Valves	.....	[...]
Numbers required	[...]
Size of valves	[...]
Method of operation	[...]
Material of Construction		

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Description	Units	Design Parameters
• Body/Cover:	[....]
• Gate/Plug	[....]
• Stem	[....]
• Sleeve/Yoke	[....]
• Gland Packing	[....]
Submerged scraper chain conveyor system		
Capacity of SCC	TPH.....	[....]
No. of submerged scraper chain conveyor	[....]
Location	[....]
Continuous normal operating capacity of each SCC	[....]
Continuous maximum operating capacity of each SCC	[....]
Minimum operating depth of water in upper trough	[....]
Operating water temp. to be maintained in upper trough	[....]
Available cooling water temperature	[....]
Drive of each SCC	[....]
Chain tensioning arrangement	[....]
Material of construction		
• Trough (upper & lower)	[....]
• Liners (Upper Trough & Lower Trough)	[....]
• Scraper bar (Flights)	[....]

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Description	Units	Design Parameters
<ul style="list-style-type: none"> Chain Associated components e.g. sprocket, pulleys flight connectors etc. 	[...]
<ul style="list-style-type: none"> Chain 	[...]
Clinker Grinder		
Number of clinker grinder/clinker crusher required for each unit		
Capacity (dry ash basis)		
Grinder input feed material size	[...]
Max particle size after crushing	mm	
Type	[...]
Duty	[...]
Bearings	[...]
Source of seal water supply	[...]
Speciality of Seal water line	[...]
Seal water pressure	[...]
Drive Data		
<ul style="list-style-type: none"> Type of coupling 	[...]
<ul style="list-style-type: none"> Protective guard for coupling 	[...]
<ul style="list-style-type: none"> Protective guard for belt/chain 	[...]
<ul style="list-style-type: none"> Reversing mechanism 	[...]
<ul style="list-style-type: none"> Type 	[...]

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Description	Units	Design Parameters
<ul style="list-style-type: none"> Drive Arrangement 	[...]
<ul style="list-style-type: none"> Common base plate of drive motor and gear box 	[...]
Flushing Boxes		
Numbers required	[...]
Capacity	[...]
Material of Construction		
Body	[...]
Liners	[...]
Nozzles	[...]
No. of nozzles per flushing apparatus	[...]
Gear Box		
Type	[...]
Location	[...]
Gear Types	[...]
Rating of gear box	[...]
Material of Construction	[...]
Expansion joint for Economizer hopper		
Number	[...]
Location	[...]
Type	[...]

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Description	Units	Design Parameters
Material of construction of component parts	[...]
BA Hopper CW Overflow Tank		
Effective storage capacity	[...]
Density of Stored contents	[...]
Accessories	[...]
Material of Construction	[...]
Fly ash collection chute isolation valves		
Body	[...]
Gate	[...]
Seat	[...]
B. Fly Ash Handling System		
Fluidizing Blowers		
Blower designation	[...]
Type	[...]
Quantity Required	[...]
Rated Capacity	Nm ³ /h	[...]
Discharge pressure at rated capacity	mmw (g)	[...]
Rated speed	rpm	[...]
Medium handled	[...]
Type of coupling	[...]

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Description	Units	Design Parameters
Air Compressor and Auxiliaries		
Air Compressor		
Discharge Pressure	[...]
Duty	[...]
Noise level	dBA	[...]
Compressed air outlet temp	[...]
Oil carryover in discharge air	[...]
Location	[...]
Vibration Limit (measured at top & bottom of main bearing)	[...]
Construction Features		
• Type of Compressor	[...]
• No. of Air compressors required	[...]
• Nos. of starts per Hr.	[...]
• Type of Transmission	[...]
• Anti vibration Arrangement required	[...]
• Maximum temperature for any stage	[...]
• during the cycle		
• Type of Control	[...]
• Type of Annunciation	[...]

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Description	Units	Design Parameters
<ul style="list-style-type: none"> Flange Standard 	[...]
Details of Accessories and Services		
<ul style="list-style-type: none"> Intake Air Filter with Silencer 	[...]
<ul style="list-style-type: none"> Inter Coolers 	[...]
<ul style="list-style-type: none"> After Cooler and Moisture Separator 	[...]
<ul style="list-style-type: none"> Automatic drain traps 	[...]
<ul style="list-style-type: none"> Anti-vibration pads 	[...]
<ul style="list-style-type: none"> Local Instruments 	[...]
<ul style="list-style-type: none"> Coupling guard 	[...]
<ul style="list-style-type: none"> Air Receiver 	[...]
<ul style="list-style-type: none"> Base Plate 	[...]
<ul style="list-style-type: none"> Foundation bolts, nuts, sleeves etc. 	[...]
<ul style="list-style-type: none"> Eye bolts, lifting lugs, tools and tackles 	[...]
Intake Air Filter		
<ul style="list-style-type: none"> Intake Air Filter 	[...]
<ul style="list-style-type: none"> Quantity 	[...]
<ul style="list-style-type: none"> Location 	[...]
<ul style="list-style-type: none"> Type 	[...]
<ul style="list-style-type: none"> Silencer 	[...]
<ul style="list-style-type: none"> Air Flow rate, 	Cu.m/mi	[...]

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Description	Units	Design Parameters
	n	
<ul style="list-style-type: none"> Particle size in micron 		[...]
Air Receiver		
Quantity	.....	[...]
Installation	.....	[...]
Type	.....	[...]
Design Pressure	kg/Sq. cm	[...]
Hydraulic Test Pressure	kg/Sq. cm	
Capacity (nominal)	.....	[...]
Material of Construction		
<ul style="list-style-type: none"> Shell	.....	[...]
<ul style="list-style-type: none"> End Plates	.....	[...]
<ul style="list-style-type: none"> Flanges	.....	[...]
Supply of Accessories and Services		
<ul style="list-style-type: none"> Companion flanges with nuts, bolts & gaskets etc.	.....	[...]
<ul style="list-style-type: none"> Pressure Indicator with snubber 	[...]
<ul style="list-style-type: none"> Pressure Switches 	[...]
<ul style="list-style-type: none"> Temperature Indicators 	[...]
<ul style="list-style-type: none"> Relief Valves 	[...]

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Description	Units	Design Parameters
• Trap Stations	[...]
• Level Gauges	[...]
• Supporting stand with necessary • foundation bolts, nuts, sleeves etc.	[...]
Fluidizing Air Heater		
Application	[...]
Working Atmosphere	[...]
Design ambient dry bulb Temperature	deg	
Type	[...]
Quantity Required	[...]
Rate of Air Flow	[...]
Air Pressure	[...]
Inlet Air Temperature for design purpose	[...]
Design Outlet Air Temp	[...]
Installation	[...]
Type of Duty	[...]
Supply Details	[...]
Air Heater Load Condition	[...]
Vacuum pump		

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Description	Units	Design Parameters
Type	[...]
Nos. working	[...]
Nos. standby	[...]
Capacity	m ³ /hr	[...]
Material of construction		
• Casing	[...]
• Shaft	[...]
• Impeller	[...]
• Shaft sleeves	[...]
Type of coupling between pump & motor	[...]
Motor rating	[...]
Fly Ash Feed valves/Fly Ash Branch Separation Valves		
➤ Vacuum system		
Type	[...]
Material of Construction		
• Body	[...]
• Plate/Disc	[...]
• Seat	[...]
• Method of operation	[...]
➤ Pressure system		

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Description	Units	Design Parameters
Type	[...]
Material of construction		
• Body	[...]
• Plate/Disc/Dome/Cone	[...]
• Seat	[...]
Vacuum breakers		
Type of Vacuum Breaker	[...]
Numbers and size	[...]
Method of operation	[...]
Material of Construction		
• Body	[...]
• Plate	[...]
Air Intake Valve		
Type of Valves	[...]
Numbers required	[...]
Size of valves	[...]
Material of construction		
• Body	[...]
• Disc	[...]
C. Pneumatic Ash Extraction and Transportation Pipelines		
Material of construction	[...]

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Description	Units	Design Parameters
Pipelines	[...]
Fittings	[...]
No. of Dry Ash transportation lines to Silos	[...]
Type of joint	[...]
Pipe to pipe	[...]
Pipe to fittings	[...]
D. Fly ash Buffer/Intermediate Hopper		
Number	[...]
Material of construction	[...]
Discharge	[...]
E. Air locks/pump tanks		
Design pressure	[...]
Material of construction	[...]
Liners	[...]
F. Bag Filters		
Design	[...]
Special features :	[...]
G. Horizontal Centrifugal Pumps		
Capacity	m ³ /hr	[...]
Type	[...]

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Description	Units	Design Parameters
Location	[...]
Pump Speed	[...]
Type of coupling	[...]
Material of construction		
Casing	[...]
Impeller	[...]
Wear plate/liners wear rings	[...]
Shaft	[...]
Shaft sleeve	[...]
Base plate	[...]
H. High Concentration Slurry System (HCSD)		
Description	[...]
Quantity Required	[...]
Discharge pressure rating at rated capacity	[...]
Rated Speed	[...]
Speed variation	[...]
Operating Fluid	[...]
Operating temperature of the handled medium	[...]
Maximum temperature handled	[...]
Ambient Condition	[...]

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Description	Units	Design Parameters
Type of coupling	[...]
Ambient Condition	[...]
Type of coupling	[...]
Installation	[...]
Material of construction		
• Cylinder	[...]
• Piston	[...]
• Shaft	[...]
• Diaphragm	[...]
Pump BHP at rated point	[...]
Motor Rating	KW	
Capacity of Pump pressure relief valve	[...]
Set point of the pressure relief valve	[...]
Drive motor	[...]
I. Ash water Recirculation pump		
Type	[...]
Nos. Required	[...]
Capacity	m ³ /hr	[...]
Head	[...]
Operating speed	[...]
Liquid to be handled	[...]

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Description	Units	Design Parameters
Operating range	[...]
Duty	[...]
J. Portable Submersible Pumps		
Type	[...]
Nos. Required	[...]
Capacity	m3/hr	[...]
Head	[...]
Operating Speed	[...]
Location	[...]
Material of Construction		
• Casing	[...]
• Submergence available	[...]
• Impeller	[...]
• Shaft	[...]
• Fasteners	[...]
K. Hoist and Monorails		
Lifting and Hoisting Capacity for Electric Hoist	[...]
Lifting and Hoisting Capacity for Manual Hoist		
Maximum trolley travel speed for electric hoists		
Maximum Hoisting speed for electric hoists	[...]
Drive Motors	[...]

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Description	Units	Design Parameters
No. of starts for drive motor	[...]
Wire Rope		
• Type/Construction	[...]
• Breaking Strength	[...]
Bearing		
• Type	[...]
• Life	[...]
Brake	[...]
Load Hook Swiveling type	[...]
Monorail location/layout	[...]
Cross section	[...]
Distance between C/L of monorail & C.G. of equipment to be lifted	[...]
Power Cables Support	[...]
L. Piping , Fittings and accessories		
Type of Pipes	[...]
Pipe Sizes	[...]
Thickness of Pipes	[...]
Type of Line joints.	[...]
Fittings (Bends	[...]

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Description	Units	Design Parameters
Flanges	[....]
Bolts , nuts and Gaskets	[....]

3.2.2 Electrical System

[Two numbers of 100% rated 6.6 kV feeders are provided by Owner/Utility/Purchaser at 6.6kV Station switchgear for feeding power to the complete Ash handling plant. Required number of adequately rated service Transformers of 6.6/0.433kV near load centres and associated 415V switchgear for feeding the auxiliaries of the complete Ash handling plant and all other associated equipments and system of like Cable Carrier System, Lighting System and Earthing & Lightning system are covered in AHP package.]

{Note: DC battery and Charger is provided by others. However supply and termination of cables from Station DCDB (supplied by others) to DCDB of AHP is in scope of AHP Contractor}

A brief extract of the existing Electrical Equipments and Systems of Ash Handling System package describing the original design details are given below. Relevant plant layout drawings and certain key schematic drawings have also been furnished in Annexure-I of this section of the specification for the purpose of familiarization and modification if required.

A. Service Transformer

[The Service transformer of Oil/Dry type is designed to cater 100% of Ash Handling System LT load with 2 x100% configuration. The design parameters of the Service Transformer are furnished below:]

Table: 3.10

Description	Units	Design Parameters
Make/Manufacturer		[....]
Type		[Oil/Dry.....]
Transformer application		[..Service]{Application Wise to

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Description	Units	Design Parameters
		<i>be indicated}</i>
Installation		<i>[...Indoor/Outdoor.]</i>
Rating of transformer	MVA	<i>[....]</i>
No load voltage ratio at principal tap HV/LV	kV	<i>[....]</i>
Rated frequency	Hz	<i>[....]</i>
Impedance value at principal tap on rated MVA base.	%	<i>[....]</i>
Tolerance on impedance at nominal tap		<i>[....]</i>
Winding connection and vector group		<i>[....]</i>
System fault level	kA	<i>[HV.....]; [LV.....]</i>
Insulation Level: a) One minute Power frequency withstand voltage b) Impulse withstand voltage	kV kV(peak)	<i>[....]</i>
System earthing (a) HV (b) LV		<i>[....] [.....Solidly earthed.....]</i>
Type of tap changer		

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Description	Units	Design Parameters
a) Range of Taps		[.....Off Circuit.....]
b) No of Steps		[....]
Guaranteed no load loss	kW	[....]
Guaranteed load loss	kW	[....]
Guaranteed efficiency at	%	[....]
a) Full load		
b) 75% load		

B. LV Switchgear (PMCC/MCC)

[The LV Switchgear is provided with two incomers and bus coupler or single bus with one incomer with outgoing feeders intend for AHP loads. The design parameters of the LV Switchgear /MCC are furnished below:]

Table: 3.11

Description	Units	Design Parameters
Make/Manufacturer		[....]
Rated voltage, phases & frequency	V, Hz	[....]
System neutral earthing		[....]
Maximum system voltage	V	[....]
One minute power frequency Voltage		[....]
Continuous current rating of bus bars		[....]
Short Circuit rating of Bus bar with duration	kA & sec	[....]

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Description	Units	Design Parameters
Bus bar Material	Al/Cu	[...]
Type- Fully Draw out/Fixed		[...]
Type of Panel	Single/double Front	[...]

C. Non Segregated Phase Bus Duct (NSPBD)

[The Non Segregated Phase Bus Duct (NSPBD) connects Service Transformer to Low Voltage Switchgear. The design parameters of the NSPBD are furnished below]:

Table: 3.12

Description	Units	Design Parameters
Make/Manufacturer		[...]
Type of bus duct		[...]
Rated voltage and No. of phase	V	[...]
Material of Bus bar and Enclosure		[...]
Rated Current	A	[...]
Designation (From and To)		[...]
Type of cooling (NSPBD)		[...]
Maximum temperature rise of conductor over 50oC ambient	oC	[...]
Maximum temperature rise of enclosure over 50°C	°C	[...]

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Description	Units	Design Parameters
ambient		
One minute power frequency voltage withstand	KV (RMS)	[...]
Continuous current rating at 50°C design ambient air temperature	A	[...]
One second short circuit withstand rating	KA (RMS)	[...]
Momentary short circuit withstand current	KA (Peak)	[...]

D. MV Cables

[The MV cables of 6.6kV UE Voltage grade is used for Tie connection between Station MV board and Service Transformer of AHP. The design parameters of the MV Cables are furnished below:]

Table: 3.13

Description	Units	Design Parameters
Make/Manufacturer		[...]
Voltage Grade		[...]
Nominal Power System Voltage	kV	[...]
Maximum System Voltage	kV	[...]
System Neutral Earthing		[...]
No. of Cores		[...]

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Description	Units	Design Parameters
Conductor Material		[...]
Conductor (stranded/solid)		[...]
Conductor Screen		[...]
Insulation		[...]
Insulation Screen		[...]
Inner Sheath		[...]
Outer Sheath		[...]
Armoured/Unarmoured		[...]
Material of cable drum		[...]
Type of End Sealing		[...]

E. LV Cables

[The LV cables of 1.1kV Voltage grade are used for feeding LV motors of AHS package as well as for sub distribution system boards. The design parameters of the LV Cables are furnished below:]

Table: 3.14

Description	Units	Design Parameters
Make/Manufacturer		[...]
Voltage Grade		[...]
Nominal Power System Voltage	kV	[...]
Maximum System Voltage	kV	[...]

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Description	Units	Design Parameters
System Neutral Earthing		[...]
No. of Cores		[...]
Conductor Material		[...]
Conductor (stranded/solid)		[...]
Conductor Screen		[...]
Insulation		[...]
Insulation Screen		[...]
Inner Sheath		[...]
Outer Sheath		[...]
Armoured/Unarmoured		[...]
Material of cable drum		[...]
Type of End Sealing		[...]

F. Control (Core) Cables

[The Control cables of 1.1kV Voltage grade are used for Protection, CT, VT connection and feedback/interlock signals. The design parameters of the Control (Core) Cables are furnished below:]

Table: 3.15

Description	Units	Design Parameters
Make/Manufacturer		[...]
Voltage Grade		[...]
Nominal Power System	kV	[...]

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Description	Units	Design Parameters
Voltage		
Maximum System Voltage	kV	[...]
System Neutral Earthing		[...]
No. of Cores		[...]
Conductor Material		[...]
Conductor (stranded/solid)		[...]
Conductor Screen		[...]
Insulation		[...]
Insulation Screen		[...]
Inner Sheath		[...]
Outer Sheath		[...]
Armoured/Unarmoured		[...]
Material of cable drum		[...]
Type of End Sealing		[...]

G. MV/LV Motor

[The design parameters of MV Motors (if required)/LV motors used for AHP package are furnished below]

{If MV motors are applicable for AHP package, same will be fed from MV board which is covered under Package of TG & Auxiliaries.}

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Table: 3.16

Description	Units	Design Parameters
Make/Manufacturer		[...]
Application		[...](For each application)
Rating	kW	[...]
Rated Voltage, Phase, Frequency	kV, Hz	[...]
Frame Size		[...]
Type of Cooling		[...]
Installation		[...]
Duty Type		[...]
Load Factor		[...]
Full load current		[...]
Starting current & Starting PF	Times Normal current	[...]
Winding connection	Star/Delta	[...]
Full load speed		[...]
Power factor and Efficiency		[...]
Class of insulation		[...]
Method of starting: :		[...]
Main terminal box details		[...]
Space Heater Details		[...]

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Description	Units	Design Parameters
CT details if provided with differential protection		[...]
RTD/BTD Details		[...]

H. Actuator

[The design parameters of Electrical Actuators used for Ash Handling System package are furnished below]:

Table: 3.17

Description	Units	Design Parameters
Make/Manufacturer		[...]
Application		[.....](For each application)
Rating	kW	[...]
Rated Voltage, Phase, Frequency	kV, Hz	[...]
Installation		[...]
Duty Type		[...]
Load Factor		[...]
Type		[... Integral/Non Integral.....]
Class of Insulation		[...]

I. Cable Carrier System

[The Cable Carrier system for Ash handling package is described as below: Indoor Buildings are provided with Cable cellar/Trench and outdoor areas are

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provided with Pipe cum cable rack/Duct bank/Trench. Separate Tray is envisaged for MV cables. LV cables, Control cables and Instrumentation cables in the order that MV cables Tray at the top followed by LV, Control and Instrumentation Tray. Ladder type tray is used for MV, LV and Control cables, however Perforated Tray is used for Instrumentation cables The Design parameters of Cable Carrier System are furnished below:
 {The Cable carrier system of Boiler, TG, CHP, eBOP and Mechanical BOP are covered in respective package itself}

Table: 3.18

Description	Units	Design Parameters
Make/Manufacturer		[....]
Size of Tray	mm	[....]
Material		[....]
Application		[.....] (I.e. MV/LV/Control/Inst.)
Type of Tray		[.....] (i.e.Ladder/Perforated)
Thickness of Tray	mm	[....]
Thickness of Galvanization	mm	[....]
Tray Cover Size	mm	[....]
Cable Tray Accessories		
Tee	mm	[.....] {List out all size}
Cross	mm	[.....]{List out all size}
Bends	Deg	[.....]{List out all size}
Reducer	mm	[.....] to [.....]{List out all size}
Steel Supports		
a) ISMC b) ISA	mm	[.....]{List out all size} [.....]{List out all size}

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J. Illumination System

[The illumination system is categorized mainly as Normal & DC lighting. Lighting System of AHP covers AHP Switchgear room, Peripheral Lighting and roads etc which are in the boundary of AHP package. DC lighting is provided at strategic location which gets supply from DCDB. Lighting Distribution Board (LDB) is normally getting supply from 415V PMCC. Each LDB is provided with lighting transformer for isolation of lighting circuit from power circuit and also for limiting short time current rating. Outgoing circuits of LDB feeds Lighting panels which is placed local to fixtures. Separate LDB provided for indoor as well as for outdoor area. The Design parameters of Illumination System and its major components comprising of LDB with transformer, Lighting Panel, Lighting Fixtures, Lighting wires and Lighting Poles are furnished below]:

{Note: Lighting system for Boiler, TG, CHP, Mechanical BOP and eBOP are covered in respective package itself.}

Table: 3.19

Description	Units	Design Parameters
Lighting System:		
Voltage		
a)AC system		
Rated Voltage	V	[....]
Maximum Voltage	V	[....]
b)DC system		[....]
Rated Voltage	V	[....]
Maximum Voltage	V	[....]

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Description	Units	Design Parameters
One Minute Withstand Voltage	V	[....]
System Short-Circuit Level		
a) 415V AC	kA(rms)	[....]
b) 220V DC	kA(DC)	[....]
LDB/LP:		
Manufacturer Name		[....]
Mounting		
a)LDB		[...Floor.....]
b) LP		[...Wall.....]
Installation		[.....](For each application ie for Indoor/Outdoor and area)
Type, No of Circuits/Feeder rating		[....]
Lighting Transformer:		
Make of Transformer		[....]
Type of Transformer		[...Dry.....]
Rating	KVA	[.....]

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Description	Units	Design Parameters
Voltage Ratio		[.....]
Impedance	%	[....]
Lighting Wires:		
Make		[....]
Voltage Grade	V	[....]
Conductor Material	Cu/Al	[....]
Size	Sq.mm	[....]
Lighting Fixtures:		
Make		[....]
Type of Luminaries		[....]
Ballast Type		[....]
Lighting Poles:		
Make		
Type of Poles		

K. Earthing and Lightning System

[The Earthing & Lightning System for Ash Handling package is described as below: Complete Equipment earthing with riser from main grid, peripheral building earthing and connecting to main grid with treated electrode with test link within the battery limit of AHP is covered in AHP package. All above ground earthing for AHP is covered in this package. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are

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interconnected to form an integrated single earthing system. Lightning system for AHP battery limit of outdoor and building are covered in AHP package and same is in line with earthing system. The Design parameters of Earthing and Lightning System are furnished below]:

{Peripheral underground earthing as well as main earth grid below ground will be provided by others}.

Table: 3.20

Description	Units	Design Parameters
Earthing System:		
Make/Manufacturer		[....]
Main Earthing Conductor a) Material b) Dia		[....]
Treated Earth Pit/Earth Rod(Dia and Length)	mm & m	[....]
Size of Earth Conductor a) MV Switchgear b) LV Switchgear c) MV Motors d) LV Motors {List out KW rating wise} e) Control panel, LPBS Etc. f) Transformer Body g) Transformer Neutral List out	mm x mm	[.....] <i>{List out size of Flat Earth conductor used for different equipments of Power plant and no of points }</i>

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Description	Units	Design Parameters
Transformer wise} h) Any other panel/Equipments		
Lightning System:		
Air Termination Rod a) Dia & Length b) Material		[...]
Down comer a) Material b) Size		[...]
Lightning Electrode with test link a) Material b) Dimension(Length and Dia)		[...]

3.2.3 Control & Instrumentation

[The existing control and instrumentation system generally is an old control system and requires large scale replacement owing to obsolescence of the existing equipment. Existing Ash handling plant control system is envisaged with the relay based hardwired logic which requires replacement with new Control System for ash handling plant which shall be Programmable Logic Controller (PLC) based or shall be implemented through micro-processor based distributed control system (DCS) covering total functional requirements of sequence control, interlock & protection, monitoring, alarm and data logging. Remote I/O cabinets shall be provided wherever required depending upon distance/location Integrated microprocessor based open loop control, sequential control and data acquisition system for Ash Handling System in hierarchical levels with integrated unit monitoring systems in the upper level are therefore to be envisaged for the plant.]

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3.2.4 Civil Works

Bidder shall go through the details of the existing Buildings / Structures / Foundations / Facilities mentioned hereunder (but not limited to) for thorough understanding of conditions of the same. In order to assess the quantum of Civil / Structural / Architectural R&M work within the package, Bidder shall also carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions at site and identification of modification requirements in any other structure or foundation not included here. Conditional details of important buildings / structures / foundations / facilities which require major modifications have been described below:

{Details of the existing buildings / structures and their foundations in the Vacuum Pump House including Switchgear Room, Ash water pump house including ash water tank, switchgear and control room, Ash slurry pump house including make-up water sump, ash slurry sump, switch gear and control room, Bottom Ash Disposal System Structures including Storage hopper, Fly Ash Disposal System Structures including intermediate surge hoppers, Fly ash equipment building, Fly ash silos, Silo utility building, Pipe racks & Cable racks, Ash Pond, AHP Clarifier, Clear Water Tank and Recirculation Pump House and Chemical House for Ash WTP etc. shall be indicated in this section. Also the available GA/Construction Drawing including Load Data shall also be provided.}

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4 SCOPE OF SUPPLY & SERVICES

4.1 The scope of supply and services to be provided by the Bidder shall include all such activities as required to meet the target and intent of this specification. The scope for each unit shall generally cover, but will not be limited to the following:

- (i) Replacement of some of the existing components with new components of improved and better design.
- (ii) Incorporation of new systems / components wherever required in line with the Specification.
- (iii) Refurbishing / Retrofitting of some of the components in the existing equipment/system.
- (iv) All types of civil/structural works like modification and strengthening of foundation of existing and upgraded equipment, making new structures or foundations (if applicable), dismantling, restoration, supply and erection of any temporary supports or any other construction work required for implementation of renovation work.

All structural modifications/strengthening of existing structure of building, equipment foundation, etc. including supply, fabrication and erection of any new structure and provision of any additional platform if required for access to new equipment or existing equipment as specified.

Supply of all materials, equipments, machinery and manpower required for civil/structural R&M works.

Site enabling works as per the requirements to support civil/structural R&M works.

- (v) Design, engineering, submission of design calculations for review and approval, manufacturing, inspection and testing at suppliers' works, packing, forwarding to site, unloading, erection, supervision, pre-commissioning, testing and commissioning and performance testing of the equipment / systems and works indicated in clause No. 4.6 of this technical Specification.
- (vi) Mandatory spares, start-up and commissioning spares. The general requirements in respect of various types of spares are given in Clause 9 of this section of Technical Specification.
- (vii) Packing, transportation and transit insurance of all materials required for renovation / replacement work as per this Specification from the supplier's/sub supplier's works to [Name of the Plant], unloading, preservation and storage at site. Packing, transportation, transit insurance, clearance from all concerned agencies etc. of all components/materials

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required to be forwarded from [Name of the Plant] to Bidder's facilities and back to [Name of the Plant].

- (viii) Dismantling of the systems, reassembly and re-erection / reinstallation along with associated inspection, testing, commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.
- (ix) Dismantling of the systems, handling and storage of dismantled equipment, reassembly and re-erection / reinstallation along with associated inspection, testing, commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.
- (x) Materials which are removed from the existing machines but are not re-used during the re-assembly of the machines as well as those components which are found to be beyond refurbishment shall be the property of Owner and shall be deposited at Owner's designated stores. Bidder shall prepare a record of all such dismantled material and hand it over to the Owner.
- (xi) Loading, transportation, unloading and disposal of scrap to the designated storage/disposal yard.
- (xii) It shall be the responsibility of the Bidder to obtain on behalf of the Owner the necessary approvals of Inspection Authority as may be required for design and design calculations, manufacturing, erection procedure renovation. Bidder shall also be responsible for obtaining approval from the other statutory authorities in India, as may be required, for other plants and systems supplied by him. All such documentation submitted to statutory authorities shall also be submitted to the Owner for his review.

Handling of materials at site including handling / transportation as required to take equipment components to the workshop for carrying out the modification work and to bring it back for installation. All arrangements for such activities are to be done by the Bidder.
- (xiii) Erection of all material supplied new for renovation (including erection of components, replacing old components). Re-erection of any component / equipment removed for modification so as to make complete unit consisting of ash Handling systems including electrical & control and instrumentation equipment /system ready for commissioning.
- (xiv) All gas cutting / dismantling, edge preparation, welding, bolting etc. and conductance of all NDTs like radiography, ultrasonic testing, MPI, die penetration testing etc. Any new matching pieces, piping, hangers & supports etc. required for assembly of equipment/ systems, as per system requirements shall also be included in the scope of the Bidder.

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- (xv) All Pre-commissioning activities as may be required such as hydraulic testing, air & gas tightness test, steam blowing for steam piping under fuel oil system, floating of safety valves, oil flushing etc. including erection and dismantling of all temporary systems like piping / tanks etc. and Conductance of all demonstration tests including performance test.
- (xvi) Assisting and coordinating with Owner in tuning various control loops finalizing protection and control requirements of all Systems under Ash Handling package.
- (xvii) Insurance for all items / activities in line with the provisions of General Condition of Contract of Volume-I.
- (xviii) Making arrangement for proper electrical grounding of all systems, supplied by him as required by the system design. All required accessories including grounding cables are also included in Bidder's scope.
- (xix) Installation, Interconnection laying and termination of all Bidder supplied cables, testing and commissioning of all equipment/systems furnished by the Bidder.
- (xx) Civil / Mechanical work (such as grouting, cutting, welding etc.) related to mounting of New Cabinets, CRT / Keyboards, laying & termination of associated Cables.
- (xxi) Supply of all necessary tools, tackles, commissioning spares, test instruments and deputing of experienced personnel for completion of the above erection, testing and commissioning work.
- (xxii) Dismantling of existing C&I cabinets along with associated cabling, for various systems under Ash handling package for retrofitting the new C&I systems, based on requirement as described in clause No. 4.6.
- (xxiii) Providing all site execution and supervision by qualified and experienced engineering personnel during execution of all works under the scope of Bidder. Also providing all facilities and qualified personnel for implementing the approved quality assurance program me.
- (xxiv) Dismantling of the existing Instrumentation Cables and relaying of new cables as may be required.
- (xxv) The Bidder shall conduct all shop and site tests as per the requirements of this Specification and Owner approved "Quality Assurance Program" to be finalized before the award of this Contract. Facilitating inspection, witness of shop and site tests by the representatives of Owner shall be in the scope of the Bidder.
- (xxvi) Performance Guarantee tests after successful completion of initial operation.

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(xxvii) Construction Water

[Construction water shall be made available to Bidder at a single point in a suitable location. The Bidder shall arrange at his own cost the required pumps, distribution pipe line network for further distribution as required to carry out construction work.]

(xxviii) Construction Power

[Construction power shall be made available to bidder at single point at [...] kV level. Further distribution as required to carry out the construction work shall be carried out by Bidder at his own cost.]

(xxix) Providing all other services necessary for meeting the intent and requirement of this Specification. This shall include but not limited to system engineering, furnishing drawings, data, and information for Owner's review, participation in meeting & reviews, System warranty, revision of O&M Manuals etc.

4.2 Tools & Tackles

One (1) set of special tools and tackles required for the maintenance of equipment/systems have to be supplied by the Bidder. These tools and tackles shall be separately packed and brought to site. These shall not be used for erection/commissioning purposes and shall be in an unused and new condition, when they are handed over to the Owner. A list of all such special tools and tackles shall be submitted along with the offer.

For C&I system, Bidder shall supply one set for each unit of special non standard tools, module testing kit, cables, and any other equipment required for erection commissioning, testing, trouble shooting, calibration, maintenance and inspection of all systems / equipment provided. Any tools required to make changes (DIP shunt cutter, soldering irons, tips, wire wrap guns and bit unwrapping tools, strippers, terminal guard, connector repair tool, dies etc.) shall also be supplied.

Bidder's scope shall also include supply of all Cranes, welding sets and NDT testing equipment, scaffolding, special tools and tackles, jigs and fixtures as may be required during modification / erection and commissioning. Those items specifically brought to site solely for erection / modification purpose and if no more needed for regular maintenance of the equipment, can however, be taken back by the Bidder after completion of the work at site, subject to the approval of Owner.

4.3 Safety

The design of the equipment shall incorporate every reasonable precaution and provision for the safety of all personnel and for the safety and security

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of all persons and property. The design shall comply with all appropriate statutory regulations relating to safety.

Newly constructed structures and equipment shall be designed and constructed to withstand every foreseeable static and dynamic loading condition, including loading under earthquake conditions, with an adequate margin of safety.

Ready and safe access with clear head room shall be provided to all the newly supplied parts of the plant for operation, inspection, cleaning and maintenance.

- 4.3.1 While carrying out the R&M work as per this Specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items/ equipment supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipment / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipment / foundations / structure and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

4.4 Training Requirements

Bidder shall include in his offer the training programme for Owner's Operation & Maintenance staff in view of introduction of new systems/ equipment. This training shall be organized before handing over the unit.

- 4.5 In case there is any difference in scope of work and services as described in this section of the Specifications and individual Specification volumes, then more stringent of the Scope of work and services shall prevail.

4.6 Detail Scope of Work:

4.6.1 Ash Handling Plant

{Describe in this chapter, all the equipment/components which need to be replaced/refurbished/retrofitted as finalized in the DPR on the basis of RLA/CA and EA report. Scope with regard to Civil, structural and architectural work as required for the Ash Handling System due to incorporation of new equipment/components shall also be incorporated in this chapter.}

The Bidder shall include in his scope the following works for the R&M of the Unit, which are based on RLA/CA and EA studies. The overall scope of work

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shall include but shall not be limited to the scope of work mentioned below. Any other items not specifically mentioned but considered necessary by the Bidder for carrying out the R&M work, shall also be included in his scope so as to meet the intended performance of various equipment & systems.

Table: 4.1

Equipment	Scope of Work	Quantity
[Water Impounded Bottom Ash Hopper]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bottom Ash Water Impound Hopper Discharge Gates]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Jet Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Slurry line Valve]	[.....]	[.....]
	[.....]	[.....]
[Submerged scraper chain conveyor system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Clinker Grinder]	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Flushing Boxes]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Gear Box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Expansion joint for Economizer hopper]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[BA Hopper CW Overflow Tank]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fly ash collection chute isolation valves]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fluidising Blowers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Compressor and Auxiliaries]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[58]	25.09.2014

Equipment	Scope of Work	Quantity
[Air Receiver]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fluidizing Air Heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Vacuum pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fly Ash Feed valves/Fly Ash Branch Separation Valves]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Vacuum breakers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air Intake Valve]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pneumatic Ash Extraction and Transportation Pipelines]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[59]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Fly ash Buffer/Intermediate Hopper]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air locks/pump tanks]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bag Filters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Horizontal Centrifugal Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[High Concentration Slurry System (HCSD)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ash water Recirculation pump]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Portable Submersible Pumps]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[60]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Hoist and Monorails]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Piping , Fittings and accessories]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

[Low Pressure Piping and Fittings]

Tag No.	Description	Fluid	Size	Schedule / Thickness	Class	Material	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]

[Motorized Valves]

Tag No.	Service Description	Size/ Type	Class	End Conn.	Travel time	Drg. No.	Qty
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]	[...]

[Manually Operated Valves]

Tag	Service Description	Size/	Class	End	Material	Qty
-----	---------------------	-------	-------	-----	----------	-----

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[61]	25.09.2014

Equipment		Scope of Work			Quantity	
No.		Type		Conn.		
[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]
[...]	[...]	[...]	[...]	[...]	[...]	[...]
[Control Valve]						
Replacement/ Retrofitting of Control Valves		[.....]			[.....]	
		[.....]			[.....]	
		[.....]			[.....]	
Electrical Works						
[LV Transformers]						
[Transformer HV/LV coil]		[.....]			[.....]	
		[.....]			[.....]	
		[.....]			[.....]	
[Tap changer]		[.....]			[.....]	
		[.....]			[.....]	
		[.....]			[.....]	
[Bushing]		[.....]			[.....]	
		[.....]			[.....]	
		[.....]			[.....]	

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[62]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of Service transformer(oil type/dry type)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[LV Switchgear (PMCC MCC)]		
[Air circuit breaker/MCCB/SFU/MCB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT/PT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Numerical relay]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[63]	25.09.2014

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[AC/DC Starters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Electronic over load relay]	[.....]	[.....]
	[.....]	[.....]
[Transducers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ground bus]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Switch socket]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Push button station]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[64]	25.09.2014

Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Terminal block]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Any other part/system of LV Switchgear (PMCC/MCC)	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[DC System]		
[DCDB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air break switch]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Annunciation system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system DC system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[NSPBD]		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[65]	25.09.2014

Equipment	Scope of Work	Quantity
[Bus duct enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bus duct conductor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Support insulators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Disconnecting link/flexible]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[support structure]	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of NSPBD]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[MV Cables]		
[Joint and termination kit]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[66]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Any other part/system of HV cables]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
LV Power & Control cables		
[Lugs and Glands]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of LV power and control cable]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[MV Motors & LV Motors]		
[Motor terminals box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor stator winding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Motor Rotor winding]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[67]	25.09.2014

Equipment	Scope of Work	Quantity
[Motor enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor cooling system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of MV/LV motors]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Motor Actuators]		
[Motor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Position indicator/Transmitter]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bearing]	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[68]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Limit switches]	[.....]	[.....]
[space heater]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of motor actuators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Cable Carrier System]		
[Cable Tray]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Conduit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Trench/Duct bank]	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[69]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
Coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Termination/joints]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of Cable carrier system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Illumination System]		
[Distribution boards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting transformer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[DC light with self contained batteries]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[70]	25.09.2014

Equipment	Scope of Work	Quantity
[Lamps and fixtures]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Industrial socket outlet]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fan and regulators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Switches and switchboards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Street or road light poles]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[High mast tower]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting junction box and conduits]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[71]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Any other part/system of lighting system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Earthing & Lightning Protection system]		
[Electrode]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[GI flat/wire]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air terminals]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Clamp/test links]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Shielding mast]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Any other part/system of	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[72]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
earthing and lightning protection]		
Control & Instrumentation Works		
[Bottom Ash Handling Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ash Slurry Sump Pump Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ash Water Pump Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fly Ash Handling Control]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fly Ash Unloading]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Conveying Air Pressure Control]	[.....]	[.....]
	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[73]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[UPS System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pressure / DP Gauges]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Level Gauges]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Temperature Gauges]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pressure / DP Switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Capacitance Type Level Switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Temperature]	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[74]	25.09.2014

Equipment	Scope of Work	Quantity
[Switches]	[.....]	[.....]
	[.....]	[.....]
[Flow Switches]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[RTD]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Level Transmitters (Ultrasonic Type, Displacer, Radar Type)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pressure/Differential Pressure Transmitters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Temperature Transmitters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Flow Elements /Orifice]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Control Valves]	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[75]	25.09.2014

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Solenoid Valves]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Impulse Pipeline & Instrument fittings]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Instrumentation & Control Cabling]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Junction boxes/LIRs]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Time Synchronization System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other systems]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[76]	25.09.2014

Equipment	Scope of Work	Quantity
Civil Works		
[Vacuum Pump House including Switchgear Room]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ash water pump house including ash water tank, switchgear and control room]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ash slurry pump house including make-up water sump, ash slurry sump, switch gear and control room]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bottom Ash Disposal System Structures including Storage hopper]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fly Ash Disposal System Structures including intermediate surge hoppers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Fly ash equipment building]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[77]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
[Fly ash silos]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Silo utility building]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Pipe and cable racks]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Ash pond]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[AHP clarifier]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Clear Water Tank and Recirculation Pump House and Chemical House for Ash WTP]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

4.6.2 Miscellaneous

- a. In addition to the above listed works, scope of civil / structural / architectural works and supplies shall be as detailed below.

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors - Ash Handling System Volume-II, Section-I	[78]	25.09.2014

Bidder shall carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions of the buildings, structures, foundations & facilities mentioned in this specification and identification of modification requirements in any other structure or foundation not included here.

Bidder shall be provided with the existing drawings and documents as listed in Annexure-I by the Owner to facilitate the civil / structural / architectural, refurbishment and replacement works.

Subsequently Bidder shall prepare and submit for approval by Owner, a detailed scheme including methods techniques, requirements etc. for carrying out civil/structural/architectural R&M works to executed in the plant.

b. The scope of Civil / Structural / Architectural works to be carried out by the Bidder under this package shall generally cover the following:

- Inspection and checking the design adequacy of the foundations of existing structures like [Vacuum Pump House including Switchgear Room, Ash water pump house, switchgear and control room, Ash slurry pump house, switch gear and control room, Bottom Ash Disposal System Structures, Fly Ash Disposal System Structures, Fly ash equipment building, Fly ash silos, Silo utility building, Pipe racks & Cable racks, Recirculation Pump House and Chemical House for Ash WTP etc.] for all the applicable loads and construction of new foundations / modification of existing, wherever required.
- Inspection and checking for any corrosion / damage of existing structures of [Vacuum Pump House including Switchgear Room, Ash water pump house including ash water tank, switchgear and control room, Ash slurry pump house including make-up water sump, ash slurry sump, switch gear and control room, Bottom Ash Disposal System Structures including Storage hopper, Fly Ash Disposal System Structures including intermediate surge hoppers, Fly ash equipment building, Fly ash silos, Silo utility building, Pipe racks & Cable racks, Ash Pond, AHP Clarifier, Clear Water Tank and Recirculation Pump House and Chemical House for Ash WTP etc.].
- Carrying out all interior / exterior architectural repair and replacement works [such as flooring, painting, plastering, door/windows, roof finishing, water proofing, sheet cladding, roof sheeting, new false ceiling, glass partitions, lighting works replacement or modification of AC duct where ever applicable].
- Any other civil related work required in buildings / structures of the package from aesthetics ambience & ease of operation point of view.

In addition to this any other modification/alteration to existing nearby foundation/structural steel/concrete/underground pipes work if required for

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satisfactory execution of intended work covered under this specification shall be carried out by the Bidder. Supply of all material required for the above work is included in Bidder's scope

c. Supplies for Civil/Structural Work

The Bidder shall supply all material needed for completion of all civil, structural and architectural works as per this specification. The Bidder's scope of supply generally includes but is not limited to the following:

- Supply of cement, steel (for reinforcement as well as for any other use), grout, admixture for RCC work, sand and all other construction/ architectural / building materials as may be required for any repair/modification of existing civil works / foundation or for construction of new foundation / civil works.
- Supply of structural steel for all structural erection / modification / strengthening.
- Supply of all foundation bolts, and nuts base plates, embedments with lugs, miscellaneous steel where ever needed
- Supply of steel helical springs and viscous dampers for new equipment (if any).

d. Construction Enabling Works

[The owner shall provide the following facilities to the by Bidder to carry out the construction work.

- *Temporary Stores to store construction material.*
- *Fabrication Yard]*

e. Quality Control Laboratory

- *[To conduct acceptance test on all construction material, weldments, concrete cubes etc laboratory facilities if available in the existing unit shall be used. In case the laboratory facility is not available within the unit, Bidder shall get the testing done at his own cost from a reputed test laboratory approved by the Owner.]*

f. Construction Tools & Materials Supplied By the Bidder. The Bidder shall arrange adequate number and type of machinery and equipment for proper setting out and timely completion of the various works covered under the scope of the work. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expense.

The Bidder shall provide all fuels and lubricants required for the operation and maintenance of construction machinery and equipment as well as his transport vehicles at his own cost. Work Execution and Supervision:

g. Work Execution and Supervision:

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The Bidder shall have at the site accredited and qualified engineers and foremen / supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the works.

- h. The Bidder shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner with full understanding of the importance of work for a R&M project of this magnitude.
- i. In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accident. He shall also report such accidents to all the competent authorities wherever such reports are required by those authorities.
- j. Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner is not in accordance with the specification / bid document.
- k. During inclement weather, rains etc., the Bidder shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at the Bidder's cost and any damage to works shall be made good by the Bidder at his own expense.
- l. Safety of Adjacent Plant/Equipment and Civil Structure

While carrying out the R&M work as per this specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items / equipments supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipments / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipments / foundations / structures and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

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4.6.3 Spares

All spares as specified in Annexure-II of this Specification in accordance with Clause No. 9.

4.6.4 Consumable, Oil & Lubricants

All the first fill and consumables such as greases, oil, lubricants, servo fluids/control fluids, gases and essential chemicals etc. as required up to the complete commissioning of the Ash handling systems, are covered in the scope of Bidder. Suitable standard lubricants as available in India are preferable. Efforts should be made to limit the variety of lubricants to minimum.

4.6.5 Embedded Parts & Fixture

All fixtures, embedded parts, steel embedment including fixing lugs and welding between them, foundation plates, grouting, nuts, bolts etc. for fixing all the equipment, piping on civil works shall be included in scope work of this package. All structures which would be required by the Bidder for supporting the piping shall also be included in scope of work of this package.

4.6.6 Other Services

The scope of Erection, Commissioning and Testing shall include the following:

- a) Complete pre-commissioning work including tests of facilities such as line flushing, hydraulic testing, chemical cleaning of pressure parts etc and all other tests as mutually agreed in the Bidder's quality assurance program me as well as those identified in the Specification.
- b) Supply of all consumables (except coal and fuel oil for firing) like chemicals for chemical cleaning, passivation, inhibition etc., oil for line flushing, any other consumable as required for above pre-commissioning/ commissioning activities.
- c) Necessary arrangement as required for the start up of various equipment & systems of Ash handling package.
- d) Supply of all temporary equipment such as tanks, piping, including supports, valves, pumps and all necessary instrumentation for successful conductance of pre-commissioning and commissioning activities. All temporary equipment and instruments shall be clearly listed out in the Bid.
- e) Providing safety barricades and signage during dismantling, erection and testing etc.

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- f) Supply of all labour, skilled/semi skilled supervisors, engineers and any other manpower.
- g) All the erection materials and consumables like shims, welding rods, soldering and brazing alloys, industrial gases, insulating tapes, compounds, chemicals etc. required for the erection and commissioning works.

Note: The temporary equipment specifically brought by the Bidder solely for the pre-commissioning and commissioning work shall, on completion of these activities, remain the property of the Bidder.

The selection of material of all the temporary equipment/instruments shall be compatible with the service conditions expected during pre-commissioning/ commissioning activities.

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5 TERMINAL POINTS & EXCLUSIONS

5.1 Terminal Points

For all terminal points, scope of this contract shall include supply of matching flanges, gaskets, bolts, nuts etc including any isolation valve. Terminal Points mean Engineering, Procurement and Erection in entirety. The terminal points of the complete package to be supplied shall be as follows.

(a) **Furnace Bottom Ash Hopper**

Furnace Bottom Ash Hopper outlet flange

(b) **Economiser Hopper**

Economiser Hopper outlet flange

(c) **Air Pre Heater Hopper**

Air preheater and ESP Hopper outlet flange

(d) **ESP Hopper**

ESP Hopper outlet flanges

(e) **Ash Slurry Disposal**

Ash Slurry Disposal System – Discharge point of ash slurry disposal pipeline

(f) **Service Water**

One no. Stub connection with isolation valve shall be provided on service water supply header Near [AHP control room at °N, °E].

Bidder has to provide service water lines and valves for all the areas covered under this package.

(g) **Drinking Water**

One no. Stub connection with isolation valve shall be provided on drinking water supply header Near [AHP control room at . °N, °E].

Bidder has to provide drinking water lines and valves for all the areas covered under this package.

(h) **Electrical**

Between equipments which are covered under AHP package, supply and termination at both ends are in the scope of AHP contractor. Between equipment supplied by AHP contractor and others, scope of work is defined is as below.

- **MV cable:** At the terminal of 6.6 kV Station switchgear of Owner. All Power and control cables and termination from the terminals of 6.6kV Station Switchgears are included in the scope of AHP package.
- **DC System:** At the terminal of 220V Station DCDB supplied by others. All Power and Control cables and termination from the terminals of 220V DCDB of others to AHP DCDBs are included in the scope of AHP package.

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- **Cable Carrier System:** At the point outside of Ash handling Main Switchgear room. Complete Cable carrier system in side AHP battery limit is in the scope of AHP bidder. However Connection to interplant cable carrier system at Main switchgear room will be carried out by Owner.
- **Earthing and Lightning System:** At the terminal of Riser provided by Owner at below ground peripheral earthing of Main AHP switchgear room.

Note:

- Only relay contacts (1 NO/1 NC) shall be provided by the other package contractor. The required auxiliary relays, control cables including their laying & termination shall be in the scope of AHP Bidder. Similarly, necessary contact (1 NO/1 NC) required by other package Contractors shall be provided by AHP Bidder.
- Wherever Power is tapped from Purchaser's board, Bidder's scope starts from the outgoing terminals of the respective board. Bidder has to include all necessary termination materials, cables, trays, conduits, supporting structure, terminations, and necessary earthing accessories in his scope.

(i) Control & Instrumentation

Instrumentation Cabling & interface between CHS PLC and DCS:

Redundant Modbus TCP/IP through FO cable (by BIDDER) shall be provided between AHP PLC and Common Station DCS. All hardware and software requirements at the AHP PLC end to establish Modbus TCP/IP interface with Common Station DCS shall be in BIDDER scope.

5.2 Exclusions

- Ash Dyke
- Open trucks, closed tankers for dry/semi dry fly ash disposal
- 6.6kV Station switchgears.
- DC Battery and Charger.
- Below ground earth mat

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6 GENERAL TECHNICAL REQUIREMENTS

6.1 Codes & Standards

- 6.1.1 Apart from some specific application, the proposed R&M equipment shall comply with the appropriate Indian Standard / DIN or equivalent international Standard. Specification as listed below in this section and mentioned in detailed Specifications, each incorporating the latest revisions at the time of tendering.
- 6.1.2 Wherever specified or required the Plant & Equipment shall conform to various statutory regulations such as Indian Electricity Rules/Act, Indian Boiler Regulations, Factories Act, etc.
- 6.1.3 In the event of any conflict between the codes and standards referred above, and the requirements of this Specification, the requirements, which are more stringent, shall govern.
- 6.1.4 In case of any change of code, standards and regulations between the date of purchase order and the date, the Bidder proceeds with manufacturing, the Owner shall have the option to incorporate the changed requirements.
- 6.1.5 List of Reference Codes/Standard
Relevant Standards as specified in Detailed Technical Specification, Section-II of Volume-II shall be followed.

6.2 Name Plates

- 6.2.1 Instruction plates, nameplates or labels shall be permanently attached to each main and auxiliary item of plant in a conspicuous position. These plates shall be engraved with the identifying name, type and manufacturers serial number, together with the loading conditions under which the item of plant has been designed to operate.
- 6.2.2 Items such as valves, which are subject to hand operation, shall be provided with nameplates so constructed as to remain clearly legible throughout the life of the plant giving due consideration to the difficult climatic conditions to be encountered. Nameplates shall be securely mounted where they will not be obscured in service by insulation, cladding, actuators or other equipment. Direction of flow is also to be engraved.
- 6.2.3 All trade nameplates and labels shall be in Bilingual language. All measurements shall be in M.K.S. Units.
- 6.2.4 The size and location of nameplates shall be subject to Approval of the Owner.

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6.3 Guards and Fences

- 6.3.1 Effective guards and fences must be provided to prevent injury to operators.
- 6.3.2 Mesh guards which allow visual inspection of equipment with the guard in place are generally preferable. The guards shall be constructed of mesh attached to a rigid framework of mild steel rod, tube, or angle and the whole galvanized to prevent loss of strength by rusting or corrosion. The guards shall be designed to facilitate removal and replacement during maintenance.
- 6.3.3 Guards for couplings and rotating shafts shall be in accordance with BS 5304-1975 or similar approved standard. All rotating shafts and parts of shafts must be covered.

6.4 Operation, Maintenance & Availability

- 6.4.1 Equipment/works offered shall be designed for high availability, high reliability, low maintenance and ease of operation & maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability, availability, operability and ease of maintenance. He shall also furnish details of availability records in plants stated in his experience list.
- 6.4.2 Wherever required platforms and walkways with access ladders having hand rails shall be provided to facilitate operation and maintenance.

6.5 Materials

- 6.5.1 In selecting materials of construction of equipment, the Bidder shall pay particular attention to the atmospheric conditions existing at the Site and the nature of material/fluid handled. Wherever deviations are taken in respect of materials specified, the reasons shall be spelt out clearly in the proposal.
- All materials shall be new, and shall be of the quality most suited to the proposed application.
- 6.5.2 As far as possible; materials shall be in accordance with Indian or international standard Specifications. Where such standards are not available, sufficient information shall be provided to allow the Owner to assess the suitability of the material for the particular application.
- All materials used shall have performed lengthy satisfactory service in similar or more arduous conditions to those proposed by the Bidder.
- 6.5.3 All parts which could deteriorate or corrode under the influence of the atmospheric, meteorological or soil conditions at the Site, or under the influence of the working conditions shall be suitably and effectively protected so that such deterioration or corrosion is a minimum over the life of the plant.

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6.6 Lubricants, Chemical and Control Fluids

- 6.6.1 Provision shall be made for suitable efficient lubrication where necessary to ensure smooth operation free from undue wear.
- 6.6.2 Non ferrous capillary tubing shall be used throughout.
- 6.6.3 Oil baths shall be provided with filling and drain plugs, both of adequate size. An approved means of oil indication including level switches and temperature indication shall be provided.
- 6.6.4 Lubrication points shall be conveniently situated for maintenance purposes. It must be possible to carry out lubrication from a gangway or landing and without the removal of guarding or having to insert the hand into it. Where accessibility to a bearing for oiling purposes would be difficult a method of remote lubrication shall be fitted.
- 6.6.5 The Bidder shall provide a detailed and comprehensive Specification for all lubricating oils, greases and control fluids required for the entire plant. A sufficient supply of these shall be provided by the Bidder for initial commissioning, first fill and till handing over of the unit.
- 6.6.6 The Bidder shall supply a detailed schedule giving the lubricant testing, cleaning and replacement procedures. All equipment and facilities necessary for the testing, cleaning and changing of lubricants and control fluids shall be provided. The Bidder shall endeavour to reduce the varieties and grades of required lubricants, chemicals and control fluids to a minimum, matching them where possible to those already in use in the generating station in order to simplify procurement and minimize storage requirements. All lubricants, chemicals and control fluids shall be of internationally recognized standards and shall be easily obtainable from a large number of Indian suppliers. Bidder shall also indicate the equivalent Indian Standard for the above for easy procurement in future.
- 6.6.7 No lubricant or control fluid shall have toxic or other harmful effects on personnel or on the environment.

6.7 Plant Life and Mode of Operation

- 6.7.1 On completion of the R&M project, the plant/equipment and systems individually and collectively shall be possible to operate continuously with routine maintenance and overhauls for an economic service life of not less than [20/25 years] under the prevailing site conditions and for the type of duty intended.
- 6.7.2 After R&M of Ash Handling system and associated auxiliaries, the unit shall be able to operate to its rated capacity continuously and there shall be no restriction of the operation of the supplied system.

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6.8 Packaging & Marking

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing all the materials, the limitations from the point of view of availability of railway wagon sizes in India should be taken account of. The details of various wagons normally available with Indian Railways for transportation of heavy equipment shall be considered by the Bidder. The Bidder shall be responsible for all loss or damage during transportation, handling and storage due to improper packing.

The identification marking indicating the name and address of the consignee shall be clearly marked in indelible ink on two opposite sides and top of each of the packages. In addition the Bidder shall include in the marking gross and net weight, outer dimension and cubic measurement. Each package shall be accompanied by a packing note (in weather proof paper) quoting specifically the name of the Bidder, the number and date of Contract and names of the office placing the Contract, nomenclature of contents and Bill of Material.

6.9 Protection

Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures. Coated surfaces shall be protected against impact, abrasion, discoloration and other damages. Surfaces that are damaged shall be repainted.

Electrical and C&I equipment shall be protected against moisture and water damages. All external gasket surfaces and flange faces, couplings, rotating equipment shafts, bearings and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection. All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors.

All piping, tubing and conduit connections on equipment and other equipment openings shall be closed with rough usage covers or plugs. Male threaded openings shall be closed with rough usage covers or plugs. Female threaded openings shall be closed with forged steel plugs. The closures shall be taped to seal the interior of the equipment. Open ends of piping, tubing and conduit shall be sealed and taped.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Bidder's expense.

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6.10 Painting

6.10.1 General

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. Surfaces not easily accessible after shop assembly shall be treated before-hand and protected for life of the equipment. Surfaces to be finish painted after installation shall be shop painted with at least two (2) coats of primer. Steel surfaces, which are not to be painted, shall be coated with suitable rust preventive compound subject to the approval of the Owner.

All paints shall be used in accordance with the manufacturer's instructions. No thinners or other substance shall be added to the coating material without the approval of the Owner. The quality and vendor of the paints shall require approval of the Owner.

All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

All primers shall be well marked into the surface, particularly in areas where pitting is evident, and the first priming coat shall be applied as soon as possible after cleaning, within four hours maximum. If the drying interval between successive coats, which should not exceed one week, has been so long as to endanger the adhesion of the following coat, the paint already applied shall be lightly rubbed down with fine abrasive paper before putting on the next coat.

Paint spraying on large surfaces shall not normally be done indoors, except with the approval of the Owner. Spray guns shall not be used outdoors in windy weather or near unprotected surfaces of a contrasting colour and under no circumstances shall spray guns be used where spray may be carried into or onto exposed electrical equipment.

Paint containers shall not be opened until required and the paint shall be mechanically mixed thoroughly before use, and agitated occasionally during use.

Electrical equipment shall be shop finished with one or more coats of primer and two coats of high-grade oil resistant enamel. The interior of all panels' cabinets and enclosures shall be finished with gloss white enamel.

The Bidder shall furnish sufficient touch up paint for one complete finish coat on all exterior factory surfaces of each item of equipment. The touch up paint shall be of the same type and colour as the factory applied paint and shall be carefully packed to avoid damage during shipment. Complete painting instructions shall be furnished.

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Shop primer for steel and iron surfaces which will have a continuous operating temperature below 35 °C shall be selected by the Bidder, in accordance to the relevant standard. Special high temperature primer shall be used on surface exposed to operating temperature above 35 °C.

The colour scheme shall be submitted during execution of Contract for approval by the Owner.

6.10.2 Preparation

Oil and grease shall be removed from the surface by washing with a suitable detergent, rinsing with clean water, and drying.

Surfaces to be shot blasted shall be cleaned to Swedish Standard SA 2.5 or equivalent, and all dust remaining after cleaning shall be removed.

The priming coat shall be applied without delay.

6.10.3 Damaged Paintwork

Any damaged paintwork shall be corrected / modified as follows:

- a) The damaged area, together with an area extending 25 mm around its boundary, shall be cleaned down to bare metal.
- b) A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm around the perimeter of the original damage.
- c) The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

6.10.4 Painting Systems

The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as stated below, unless otherwise specified elsewhere in this Specification.

a) Surfaces Subject to Weathering

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	35 micron DFT per coat

The total minimum DFT shall be 140 micron.

b) Surfaces Inside Buildings

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All surfaces shall have a minimum of three coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	25 micron DFT per coat

The total minimum DFT shall be 120 micron.

The type and colour of primer & finish coat shall be selected by the Bidder after approval by the Owner.

6.11 Environment Protection

6.11.1 Environment Protection

The plant & equipment under this R&M project shall be designed for installation and operation in harmony with the surrounding environment and all measures of pollution control shall be ensured by the Bidder to restrict pollution from the liquid effluent and RPM emission within the limits as given below with due consideration of Environment (Protection) Rules.

6.11.2 For Liquid Effluent

During construction activities, Bidder shall maintain the statutory compliance of State Pollution Control Board and MoEF in respect of pollution control and environmental protection within and around plant boundary. Any specific requirement of State Pollution Authorities over and above shall be maintained.

6.11.3 Noise Level Requirement

The plant & equipment under this R&M project will be designed, constructed and provided with suitable acoustic measures to ensure the noise level criteria as per the following stipulations of MoEF & State Pollution Control Board.

- a) Maximum noise level shall not exceed 85 dB (A) when measured at 1.0 m away from the noise emission source.
- b) Maximum noise level from its source within the premises shall not exceed 70 dB (A) as per Environment (Protection) Rules 1986, Schedule-III, 'Ambient Air Quality Standards' in respect of noise.
- c) Any statutory changes in stipulations regarding noise limitation that may occur in future according to State Pollution Control Board or Central pollution Control Board or Ministry of Environment & Forest regulation during tenure of the Contract, the Bidder shall comply with the updated/amended requirement.

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An exception will be made for the plant at startup operations of other big pressure reducing devices operating during emergency periods and for the safety valves.

6.12 Inspection and Testing

6.12.1 Inspection and Tests during Manufacture

- 6.12.1.1 The method and techniques to be used by the Bidder for the control of quality during manufacture of all plant and equipment shall be agreed with the Owner prior to the Award of Contract.
- 6.12.1.2 The Owner's general requirements on quality control and shop tests as mentioned in Section II of Volume-II.
- 6.12.1.3 Owner shall be informed for witnessing the shop tests of any item of the plant or equipment for checking the compliance with the Specification requirement and or related standards prior to leave place of manufacturing.
- 6.12.1.4 Advance notice shall be given to the Owner as agreed in the Contract, prior to the stage of manufacture being reached, and the piece of plant must be held at this stage until the Owner has inspected the piece, or has advised in writing that inspection is waived. If having consulted the Owner and given reasonable notice in writing of the date on which the piece of plant will be available for inspection, the Owner does not attend, the Bidder may proceed with manufacture having forwarded to the Owner duly certified copies of his own inspection and test results.
- 6.12.1.5 The Bidder shall forthwith forward to the Owner the Test Certificates in [...] copies for approval.
- 6.12.1.6 Under no circumstances any repair or welding of castings be carried out without the consent of the Owner. Proof of the effectiveness of each repair by radiographic and/or other non destructive testing technique, shall be provided to the Owner.
- 6.12.1.7 All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.
- 6.12.1.8 Where accurate alignment is necessary for component parts of machinery normally assembled on site, the Bidder shall allow for trial assembly prior to dispatch from place of manufacture.
- 6.12.1.9 All materials used for the manufacture of equipment covered under this Specification shall be of tested quality. Relevant test certificates shall be made available to the Owner. The certificates shall include tests for mechanical properties and chemical analysis of representative material.

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- 6.12.1.10 All pressure parts connected to pumping main shall be subjected to hydraulic testing at a pressure of 150% of design pressure. The duration of the pressure tests shall be sufficient, as approved by the Owner, to show any leakage paths and to permit a thorough examination of the component whilst under pressure.
- 6.12.1.11 All necessary non destructive examinations shall be performed to meet the applicable code requirements.
- 6.12.1.12 All welding procedures adopted for performing welding work shall be qualified in accordance with the requirements of applicable code. Radiography, magnetic particle examination magnuflux and ultrasonic testing shall be employed wherever necessary/ recommended by the applicable code.
- 6.12.1.13 The Bidder shall furnish the quality procedures to be adopted for assuring quality from the receipt of material at site, during storage, erection, pre-commissioning to tests on completion and commissioning of the complete system/equipment.
- 6.12.2 Performance Tests at Site**
- 6.12.2.1 The full requirements for testing the system shall be agreed between the Owner and the Bidder prior to Award of Contract. The completely erected System shall be tested by the Bidder on site under normal operating conditions. The Bidder shall also ensure the correct performance of the System under abnormal conditions, i.e. the correct working of the various emergency and safety devices, interlocks, etc.
- 6.12.2.2 The Bidder shall provide complete details of his normal procedures for testing, for the quality of erection and for the performance of the erected plant. These tests shall include site pressure test on all erected pipe work to demonstrate the quality of the piping and the adequacy of joints made at site.

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7

LAYOUT CONSIDERATION

{Effort should be made to keep the Layout of the newly equipped system / packages under the R&M project unchanged to the extent possible with respect to existing layout to avoid disturbance to the existing equipment & facilities for which any modification/changes are not envisaged based on RLA/LA and EA assessment. However a general guidelines, which needs to be followed, as required, are given below :}

[The Ash handling equipment has been distributed in following major facilities/buildings.

- a) Ash slurry pump house containing slurry pumps of multiple series. Space shall be provided to install one more stage slurry pump at later stage / date to enable dispose slurry to new ash dump area or rising existing ash pond dyke height and maintenance area.
- b) Ash Water Pump House Containing [...] Nos. HP Water Pumps, [...] Nos. LP Water Pumps, [...] Nos Economizer Pumps and [...] Nos. Seal Water Pumps.
- c) Buffer Hoppers and Collector Tank Tower.
- d) Dry Fly Ash Silos.
- e) Fly ash equipment building containing fluidizing blowers and heaters, instrument air compressor and drier etc.
- f) Compressor House with Vacuum Pumps and Transport Air Compressors with maintenance area.
- g) Ash handling system central control room.
- h) Silo utility building.
- i) Chemical house for recirculation ash water treatment plant.
- j) Ash Water recovery clarifier.
- k) Recovered water pump house.]

[Aeration blower is installed away from the silo in order to ease the maintenance.

Slurry pipe streams for BA slurry or Mixture of BA and FA Slurry should remain 1 meter above the ground level and approach road in order to ease the maintenance.

The associated electrical facilities shall be placed in annexed buildings or as found suitable. The buildings shall be provided with necessary office space, toilet etc as applicable. Adequate maintenance space and lay-down area shall be provided in buildings.

Approach to all equipment, piping, valves shall be provided. Where such facilities are not possible, separate platform, approach ladder etc shall be

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provided. A clear space of 1200 mm minimum shall be provided between two equipment / pipe / valve. Headroom of minimum 2500 mm shall be provided wherever human approach is applicable. Head room of 2100 mm over EOT crane rail level walkways shall be maintained. All pipe racks shall have walkways.

In case of two (2) rows of pumps/equipment located in parallel, minimum distance between the equipment shall meet the following criteria.

Clear distance between edges of pedestals/motors of pump located parallel shall be 2000 mm.

In case the space provided is acting as the handling space for the equipment by overhead crane, the space shall be maximum size of equipment being handled plus the clearance of 500 mm minimum on either side with the stationary equipment.

Withdrawal spaces of equipment.

Adequate space provisions shall be kept within the Ash transportation pipe trestle, compressor house & the associated MCC room for further extension, if required.]

- 7.1 The safety requirements as per the Factories Act, Indian Electricity Rules and other applicable codes/standards etc. shall be observed while developing the layout.
- 7.2 The available existing layout details of the plant are indicated in the enclosed drawings as Annexure-I. However, Bidder to suggest his own modified layout arrangement which shall be subject to approval of the Owner.

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8 PERFORMANCE GUARANTEES

The term "Performance Guarantees" wherever appears in this Section shall have the same meaning and shall be synonymous to "Functional Guarantees".

Similarly the term "Performance Tests" wherever appears in this Section shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

8.1 General Requirements

- 8.1.1 The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in this technical Specifications.
- 8.1.2 The guaranteed performance parameters furnished by the Bidder in the Bid proposal, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.
- 8.1.3 The Bidder shall demonstrate all the guarantees covered herein under Category I, II & III during functional guarantee / acceptance test. The various tests which are to be carried out during performance guarantee/acceptance test are listed elsewhere in this Section. The guarantee tests shall be conducted by the Bidder at site in presence of Owner.
- 8.1.4 All costs associated with the tests including the cost associated with the supply, calibration, installation and removal of test instrumentation shall be included in the price offered by Bidder.
- 8.1.5 At all times during the Performance Tests the emissions as applicable and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.
- 8.1.6 It shall be the responsibility of the Bidder to make the plant ready for the performance guarantee tests.
- 8.1.7 All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Bidder shall get these instruments calibrated in an independent test institute approved by the Owner. All test instrumentation required for performance tests shall be supplied by the Bidder and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subjected to the approval of the Owner. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.

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- 8.1.8 Tools and tackles, thermowells (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the Bidder free of cost.
- 8.1.9 The Performance/ Acceptance test shall be carried out as per the agreed procedure. The PG test procedure including demonstration tests shall be submitted within [90 days] of the date of Notification of Award and finalization of the PG test procedure shall be done within [180 days] from the date of Notification of Award. After the conductance of Performance test, the Bidder shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. However, preliminary test reports shall be submitted to the Owner after completing each test run.
- 8.1.10 The PG test procedures shall be submitted for equipment/ system & subsystem under Bidder's scope for all Guarantees under category I, II & III as mentioned below, as per latest International codes & standard including correction curves, meeting the Specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.
- 8.1.11 The Bidder shall submit for Owner's approval the detailed Performance Test procedure containing the following:
- Objective of the test.
 - Various guaranteed parameters & tests as per Contract.
 - Method of conductance of test and test code.
 - Duration of test, frequency of readings & number of test runs.
 - Method of calculation.
 - Correction curves, as applicable to various system/equipment.
 - Instrument list consisting of range, accuracy, least count, and location of instruments.
 - Scheme showing measurement points.
 - Sample calculation.
 - Acceptance criteria.
 - Any other information required for conducting the test.
- 8.1.12 In case, during performance guarantee tests, it is found that the equipment/systems has failed to meet the guarantees, the Bidder shall carry out all necessary modifications and/or replacements to make the

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equipment/system comply with the guaranteed requirements at no extra cost to the Owner. However, if the Bidder is not able to demonstrate the guarantees, even after the above modifications/replacements within [ninety (90) days] or a reasonable period allowed by the Owner after the initial performance guarantee tests have been completed, the Owner will have the right to impose the stipulated clauses under Guarantee Category I, II & III as specified in this Specification:

8.1.13 For Category-I Guarantees

Reject the equipment/system/plant and recover from the Contractor payments already made

(OR)

Accept the equipment/system/plant after levying Liquidated Damages (LD) as specified in Clause No. 5.6 of Volume I. The LDs shall be prorated for the fractional parts of the deficiencies.

8.1.14 For Category-II Guarantees

Reject the equipment/plant/system and recover, from the Contractor, the payments already made. Conformance to the performance requirements under Category-II is mandatory.

8.1.15 For Category-III Guarantees

Reject the equipment/system/plant & recover, from the Contractor, the payments already made.

(OR)

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the Contract price an amount equivalent to the damages as determined by the Owner. Such damages shall however be limited to the cost of replacement of the equipment/systems replacement of which shall remove the deficiency so as to achieve the guaranteed performance.

8.2 Performance Guarantees under Category-I

The performance guarantees which will attract liquidated damages shall be as follows:

- (i) **Total Auxiliary Power Consumption** – The auxiliary power consumption shall be calculated using the following relationship.

$$P_{au} = \sum P_u$$

P_{au} = Guaranteed Unit Auxiliary Power Consumption.

P_u = Power consumed by each of the continuously running equipment of

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Ash Handling Plant System under the scope of Bidder.

While guaranteeing the auxiliary power consumption the Bidder shall necessarily include all continuously operating equipment of Ash handling package. Auxiliary power shall be guaranteed stream wise as defined .The auxiliaries to be considered shall include but not be limited to the following:

S.No	Drive	Weightage Factor
1.	Bottom Ash crushers	[0.625]
2.	Bottom Ash H.P. water pumps	[0.625 for jet pump system and 1.0 for submerged scrapper conveyor system]
3.	Bottom Ash L.P. water pumps	[1.0]
4.	Fly Ash water pumps	[0.5]
5.	Bottom ash slurry transportation pumps	[1.0]
6.	Bottom ash slurry disposal pumps	[0.625 for jet pump system and 1.0 for submerged scrapper conveyor system]
7.	Fly ash conveying air compressors with air drying plant (ADP)	[1.0]
	Fly ash conveying vacuum pumps	[1.0]
8.	Transport air compressor with air drying plant (ADP)	[1.0]
9.	Lean slurry Pumps	[1.0]
10.	Instrument air compressor with air drying plant (ADP)	[1.0]
11.	Ash water recirculation pumps	[1.0]

Note:

The Bidder shall furnish a list of equipment for Ash Handling System to be covered under auxiliary power consumption for the approval of Owner.

8.3

Guarantees under Category-II

The Performance Guarantees, conformance to which is mandatory are as follows:

Liquid Effluent: *Liquid Effluent discharge to an outside body, from the plant*

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battery limit, shall meet statutory requirements State Pollution Control Board.

8.4 Guarantees under Category-III

The performance guarantee tests shall be conducted for *[Seven (7) days]* continuous operation of the boiler at 80% to 100% load. In case of any major breakdown in any of the equipment disrupting the operation of Ash Handling Plant, the breakdown period shall be added to the testing period of *[7 days]*. The performance guarantee test shall be conducted to prove uninterrupted operation of ash handling plant of each unit separately as they are completed and all units simultaneously when they are completed. The ash handling plant shall be operated with its normal auxiliaries, (as applicable commensurate with the number of boiler units in operation) without using standby pumps or any other standby equipment.

The parameters guaranteed shall have no tolerance value whatsoever. The equipment and systems offered shall be guaranteed to meet the following performance.

a) Bottom Ash Handling System

In case of intermittent type bottom ash removal system employing water impounded hopper and jet pumps, the system shall be guaranteed to meet the following performance:

- i) Continuous effective extraction, crushing and conveying of bottom ash generated during various modes of boiler operation to the ash slurry sump and the continuous effective pumping of combined slurry from this sump to the ash slurry dump area.

The extraction of bottom ash shall be done once in every shift of eight (8) hours. The total time for evacuating the eight (8) hour collection of bottom ash corresponding to maximum collection rates specified shall not exceed [...] hours.

b) Economiser and Air Pre-heater Ash Handling System

Economizer ash shall be drained to BA hopper through HP water, from where the same shall be transferred through jet pumps to Ash Slurry Sump.

Air Pre heater Ash shall be extracted through vacuum conveying system to Intermediate surge Hopper along with ESP Fly Ash.

The continuous effective conveying of ash as stated above shall be established by no stagnation of ash or slurry at any point in the complete system and with all interlocks, protections working satisfactorily.

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c) Fly Ash Handling System

- i) Continuous effective conveying of fly ash from all fly ash collection hoppers i.e. ESP hoppers, generated during various modes of boiler operation up to collecting channel/ buffer hoppers, from buffer hoppers to ash storage silo and from collecting channel to the ash slurry sump and the continuous effective pumping of ash slurry from this sump to dyke area. Total time for evacuating the fly ash collected in each unit in every shift of eight (8) hours corresponding to maximum ash collection rates shall not exceed [...] hours.
- ii) The continuous effective conveying and pumping as stated above shall be established by no stagnation of ash or slurry at any point in the complete system and with all interlocks, protections and sequential operation working satisfactorily.
- iii) Rated capacity at rated discharge pressure of each air compressor/blower/vacuum pump as applicable.

d) Ash water and Seal Water Pumps

- i) Rated capacity at rated head of each ash, seal and flushing water and other water pumps.

e) Ash slurry Disposal Pumps

- i) Rated capacity at rated head of each ash slurry disposal pump.

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9 SPARE PARTS

The Bidder shall include in his scope of supply all the necessary mandatory spares, start up and commissioning spares and recommended spares and indicate these in the relevant schedules. The general requirements pertaining to the supply of these spares is given below:

9.1 Mandatory Spares

The list of mandatory spares considered essential by the Owner is enclosed in Annexure-II of this Specification. The Bidder shall indicate the prices for each and every item (except for items not applicable to the Bidders design) in the 'Schedule of mandatory spares' whether or not he considers it necessary for the Owner to have such spares. If the Bidder fails to comply with the above, the cost of such spares shall be deemed to be included in the Contract price. The Bidder shall furnish the population per unit of each item in the relevant Schedules. Whenever the quantity is mentioned in "sets" the Bidder has to give the item details and prices of each item.

Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the R&M Contract unless specified otherwise, and the fraction will be rounded off to the next higher whole number. Wherever the requirement has been specified a 'set' it will include the total requirement of the item for a unit, module or the R&M Contract scope or as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.

All mandatory spares shall be delivered at site at least two months before scheduled date of initial operation of the first unit. However, spares shall not be dispatched before dispatch of corresponding main equipment.

Wherever quantity is specified both as a percentage and a value, the Bidder has to supply the higher quantity until and unless specified otherwise. Price of mandatory spare parts will also be evaluated.

9.2 Recommended Spares

In addition to the mandatory spare parts mentioned above, the Bidder shall also provide a list of recommended spares for [five (5)] years of normal operation of the plant and indicate the list and total prices in relevant schedule. The list shall take into consideration the mandatory spares specified and should be independent of the list of the mandatory spares. The

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Owner reserves the right to buy any or all of the recommended spares. The recommended spares shall be delivered at project site at least two months before the scheduled date of initial operation of first unit. However, the spares shall not be dispatched before the dispatch of the main equipment.

Prices of recommended spares will not be used for evaluation of the Bids. The price of these spares will remain valid up to execution of the Contract. However, the Bidder shall be liable to provide necessary justification for the quoted prices for these spares as desired by the Owner.

9.3 Start-up & Commissioning Spares

Start up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system till the handing over of the Plant. The Bidder shall provide all such start up and commissioning spares and keep an adequate stock of the same to be brought by him to the site for the plant erection and commissioning. These must be available at site before the equipment are energized. The unused spares, if any, should be removed from there, only after handing over of the plant. All start up spares which remain unused at the time shall remain the property of the Bidder.

9.4 General Requirements

The Bidder shall indicate the service expectancy period for the spares parts (both mandatory and recommended) under normal operating conditions before replacement is necessary.

All spares supplied under this Contract shall be strictly inter-changeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desiccators packs as necessary.

All the spares (both mandatory and recommended) shall be manufactured along with the main equipment components as a continuous operation as per same Specification and quality plan.

The Bidder will provide Owner with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the Owner to identify and finalize order for recommended spares.

Each spare part shall be clearly marked or labeled on the outside of the packing with its description. When more than one spare part is packed in a single case, a general description of the content shall be shown on the

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outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.

All cases, containers or other packages are to be opened for such examination as may be considered necessary by the Owner.

The Bidder will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on Vendors for items/ components/ equipment covered under Contract and will further ensure with his Vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such Vendors.

The Bidder shall warrant that all spares supplied will be new and in accordance with the Contract documents and will be free from defects in design, material and workmanship.

In addition to the recommended spares listed by the Bidder, if the Owner further identifies certain particular items of spares, the Bidder shall submit the prices and delivery quotation for such spares within [30 days] of receipt of such request for consideration by the Owner and placement of order for additional spares if the Owner so desires.

The Bidder shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered in the Contract. The Bidder shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the Owner [at least 2 years] advance notice so that the latter may order his bulk requirement of spares, if he so desires. The same provision will also be applicable to Sub-Bidders. Further, in case of discontinuance of manufacture of any spares by the Bidder and/or his sub-Bidders, Bidder will provide the Owner, two years in advance, with full manufacturing drawings, material Specifications and technical information including information on alternative equipment makes required by the Owner for the purpose of manufacture/procurement of such items.

The prices of all future requirements of spares beyond [five (5)] years shall be derived from the corresponding Ex-works price at which the order for such spares have been placed by the Owner as a part of the mandatory spares or recommended spares. Ex-works order price of future spares shall be computed in accordance with the price escalation formula to be furnished by Bidder indicating base price reference variation indices for material, labour

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etc. Based on the formula and considering escalation indices prevailing at the time of order of spares, order price shall be worked out. The base indices will be counted from the scheduled date of successful completion of trial operation of the last plant/equipment under the project. The above option for procuring future recommended spares by the Owner shall remain valid for the period of fifteen [fifteen (15)] years from the date of successful completion of trial operation of the last plant/equipment. In case the spare parts from the same sub-Vendor are not available due to obsolescence or any other reason, the Bidder shall supply the spares for a period of [fifteen (15)] years from an alternative source.

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10 ANNEXURE

10.1 Annexure-I (List of Existing Drawings)

{Available as Built/RFC drawings of the Existing Unit shall be provided to the Bidder as per the list mentioned in Annexure-I for their information & familiarization of the existing Unit}

10.2 Annexure-II (Mandatory Spares)

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II}

10.3 Annexure-III (List of Sub-Vendors)

{List of Sub-vendors for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the format in Annexure-III}

10.4 RLA/CA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.5 EA Study Report

{Not attached with this document. This is to be provided by Utilities}

10.6 **Geotechnical Investigation Report]**

{Not attached with this document. This is to be provided by Utilities}

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-I, ANNEXURE-I
LIST OF EXISTING DRAWINGS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-I

List of Existing Drawing

{Available as Build/RFC drawing of the Existing Unit shall be provided to the Bidder as per the list mentioned below for their information & familiarization of the existing Unit}

i) MECHANICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[General Layout (Plot Plan)]
2	[.....]	[General layout battery limit]
3	[.....]	[Symbol /Legends]
4	[.....]	[Flow Scheme For Ash Handling System]
5	[.....]	[GA of Water Impounded System]
6	[.....]	[GA for Scraper Chain Conveyor System]
7	[.....]	[GA for Air Compressor for Ash Handling System]
8	[.....]	[GA of Slurry Pump House]
9	[.....]	[GA for HCSD System]
10	[.....]	[Any other Drawing]

ii) ELECTRICAL

S.No.	Drawing/Document No.	Title
1	[.....]	[Key Single Line Diagram of Power Plant]
2	[.....]	[Metering & Protection Single Line Diagram of Power Plant]
3	[.....]	[Key Single Line Diagram/Power Distribution Diagram of Ash Handling System]

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4	[.....]	[General Arrangement & Schematic Diagram of AHP Service Transformer]{Application Wise to be provided}
5	[.....]	[General Arrangement and Schematic drawing of LV switchgear]{Application Wise to be provided}
6	[.....]	[General Arrangement and Schematic drawing of DCDB system of AHP package]
7	[.....]	[Cross Section drawings and Data sheets of Cables]. {Voltage grade as well application wise i.e power , control wise to be provided}
8	[.....]	[General Arrangement and Data sheet/Document of of NSPBD]
9	[.....]	[Cable Tray Layout and BOQ of Cable Carrier System]. {Building wise to be provided}
10	[.....]	[Lighting Layout and BOQ & Calculation of Lighting System]. {Building wise to be provided}
11	[.....]	[Earthing & Lightning BOQ and Layout]. {Building wise to be provided}
12	[.....]	[Any other drawings /documents for AHP package(if applicable)]
13	[.....]	[General Arrangement & Schematic Diagram of AHP Service Transformer]{Application Wise to be provided}
14	[.....]	[General Arrangement and Schematic drawing of DCDB system of AHP package]
15	[.....]	[Cross Section drawings and Data sheets of Cables]. {Voltage grade as well application wise i.e power , control wise to be provided}
16	[.....]	[General Arrangement and Data sheet/Document of of NSPBD]
17	[.....]	[Cable Tray Layout and BOQ of Cable Carrier System]. {Building wise to be provided}

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18	[.....]	[Lighting Layout and BOQ & Calculation of Lighting System]. {Building wise to be provided}
19	[.....]	[Earthing & Lightning BOQ and Layout]. {Building wise to be provided}
20	[.....]	Any other drawings /documents for AHP package(if applicable)]

iii) **CONTROL & INSTRUMENTATION**

S.No.	Drawing/Document No.	Title
1	[.....]	[PLC Configuration Drawing For Ash Handling Plant]
2	[.....]	[PLC Control Room Layout Drawing]
3	[.....]	[Instrument Installation Diagram (Pressure Gauge)]
4	[.....]	[Instrument Installation Diagram (Pressure Switch)]
5	[.....]	[Instrument Installation Diagram (Temperature Gauge)]
6	[.....]	[Instrument Installation Diagram (Temperature Elements)]
7	[.....]	[Instrument Installation Diagram (Radar Type Level Transmitter)]
8	[.....]	[Instrument Installation Diagram (Level Measurement using gauge & switch)]
9	[.....]	[Instrument Installation Diagram (Level Measurement using DP Transmitter & Ultrasonic/Radar type Transmitter)]
10	[.....]	[Instrument Installation Diagram (Level Measurement for Open/Close Vessels)]
11	[.....]	[Instrument Source Connection Details – Pressure Measurement on Pipe]

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S.No.	Drawing/Document No.	Title
12	[.....]	[Instrument Source Connection Details – Temperature Measurement on Pipe]
13	[.....]	[Instrument Source Connection Details – Level Measurement]
14	[.....]	[Grounding Scheme for Cabinets/Panels]
15	[.....]	[C&I Power Supply distribution cabling Philosophy]
16	[.....]	[C&I Instrumentation cabling Philosophy]
17	[.....]	[Logic Diagrams of Coal Handling System]
18	[.....]	[Cable Interconnection Drawing]
19	[.....]	[Drive Control Philosophy-Bidirectional drive (ON-OFF Type MOV)]
20	[.....]	[Drive Control Philosophy-Bidirectional drive (Inching Type MOV)]
21	[.....]	[Drive Control Philosophy- LT drive]
22	[.....]	[Drive Control Philosophy- HT drive]
23	[.....]	[Drive Control Philosophy-Solenoid Valve]
24	[.....]	[Drive Control Philosophy-VFD]
25	[.....]	[Instrument Installation Diagram (Level Measurement using DP Transmitter & Ultrasonic/Radar type Transmitter)]
26	[.....]	[Instrument Installation Diagram (Level Measurement for Open/Close Vessels)]
27	[.....]	[Instrument Source Connection Details – Pressure Measurement on Pipe]
28	[.....]	[Instrument Source Connection Details – Temperature Measurement on Pipe]
29	[.....]	[Instrument Source Connection Details – Level

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S.No.	Drawing/Document No.	Title
		<i>Measurement]</i>
30	<i>[.....]</i>	<i>[Grounding Scheme for Cabinets/Panels]</i>
31	<i>[.....]</i>	<i>[C&I Power Supply distribution cabling Philosophy]</i>
32	<i>[.....]</i>	<i>[C&I Instrumentation cabling Philosophy]</i>
33	<i>[.....]</i>	<i>[Logic Diagrams of Coal Handling System]</i>
34	<i>[.....]</i>	<i>[Cable Interconnection Drawing]</i>
35	<i>[.....]</i>	<i>[Drive Control Philosophy-Bidirectional drive (ON-OFF Type MOV)]</i>
36	<i>[.....]</i>	<i>[Drive Control Philosophy-Bidirectional drive (Inching Type MOV)]</i>
37	<i>[.....]</i>	<i>[Drive Control Philosophy- LT drive]</i>
38	<i>[.....]</i>	<i>[Drive Control Philosophy- HT drive]</i>
39	<i>[.....]</i>	<i>[Drive Control Philosophy-VFD]</i>
40	<i>[.....]</i>	<i>[Any Other Drawing]</i>

iv) CIVIL

S.No.	Drawing No.	Description
1	<i>[.....]</i>	<i>[Geotechnical Investigation Report]</i>
2	<i>[.....]</i>	<i>[Road, drains, trench layouts etc., as available]</i>
3	<i>[.....]</i>	<i>[Design documents of the existing structures]</i>
	<i>[.....]</i>	<i>[Drawings of existing structures & foundations]</i>
4	<i>[.....]</i>	<i>[Drawings for loading data of the existing structures & foundations]</i>

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-I, ANNEXURE-II
MANDATORY SPARES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-II

Mandatory Spares

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II. Available Mandatory spares of the existing Unit, which can be used after completion of R&M work, shall also be verified before finalization of the below mentioned Spare List. The list given below is indicative.}

A. MECHANICAL

S.No	Description	Quantity	Remarks
1.0	BOTTOM ASH SYSTEM		
	(Jet Pumps System)		
1.1	Bottom Ash Hopper		
	<ul style="list-style-type: none"> Bottom Ash Hopper Refractory Wall Cooling Assembly including cooling pipes, pipe fittings, nozzle 	4 sets	
	<ul style="list-style-type: none"> Bottom Ash Hopper Liners 	4 sets	
1.2	Hopper Discharge Gate		
	<ul style="list-style-type: none"> Gate Wear Liners 	6 sets	
	<ul style="list-style-type: none"> Gate and Shaft Assembly including pneumatic cylinder 	6 sets	
	<ul style="list-style-type: none"> Gate Housing Liners 	6 Sets	
	<ul style="list-style-type: none"> Roller & Roller shaft assembly 	6 Sets	
	<ul style="list-style-type: none"> Hydraulic pump & motor for discharge gates 	2 Sets	
1.3	Ash Crusher/Clinker Grinder		
	<ul style="list-style-type: none"> Complete Ash Crusher Assembly 	6 Nos.	
	<ul style="list-style-type: none"> Ash Crusher Liners 	6 Sets	

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S.No	Description	Quantity	Remarks
	• Ash Crusher Gear Box	6 Sets	
	• Ash Crusher Rolls (Drive roll & driven rolls)	6 Sets	
	• Bearing for Crusher Motor along with the housing	6 Sets	
	• Lantern Rings	4 Sets	
	• Wearing Rings	4 Sets	
	• Motor for ash crusher	2 No.	
	• Drive fluid coupling	4 Sets	
1.4	Jet Pumps		
1.4.1	Nozzle Assembly (nozzle along with nozzle tip)	12 Nos.	
1.4.2	Complete jet pump assembly	6 No. s	
1.4.3	Jet pump discharge section	6 No. s	
2.0	BOTTOM ASH SYSTEM (SCRAPPER CONVEYOR SYSTEM)		
2.1	Bottom Ash hopper		
	• Bottom Ash hopper Gate liners	6 Sets	
	• Quenching Nozzle Assembly including Nozzle tip.	6 Sets	
	• Inspection Window assembly including glass panel gaskets	6 Sets	
2.2	Submerged Scrapper Conveyors		
2.2.1	Scrapper Conveyor Chains		
2.2.2	Scrapper bars complete with fixing lugs etc.	2 Sets	
2.2.3	Guide Pulley Assembly Complete with	2 Sets	

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S.No	Description	Quantity	Remarks
	<i>shaft, bearing, mounting plate etc</i>		
<i>2.2.4</i>	<i>Trive End Sprocket</i>	<i>2 Sets</i>	
<i>2.2.5</i>	<i>Tail End Take-up Sheaves</i>	<i>2 Sets</i>	
<i>2.2.6</i>	<i>Sprocket segments</i>	<i>2 Sets</i>	
<i>2.2.7</i>	<i>Fluid Coupling</i>		
	<ul style="list-style-type: none"> <i>Fusible plugs</i> 	<i>5 Nos. for 100% cap conveyor or 10 Nos. for 50% cap. Conveyors</i>	
	<ul style="list-style-type: none"> <i>Reselience plate</i> 	<i>1 No. for 100% cap Conveyor or 2 Nos. for 50% cap conveyors</i>	
	<ul style="list-style-type: none"> <i>Flexible coupling</i> 	<i>2 Nos. for 100% cap conveyor or 4 Nos. for 50% capacity conveyors</i>	
	<i>Hydraulic Drive for Scrapper Chain</i>		
<i>2.2.8</i>	<i>Hydraulic Pump & Electric motor set with coupling, valves mounted on pump etc</i>	<i>1 sets of each type</i>	
<i>2.2.9</i>	<i>Hydraulic Motor and gear box set with coupling etc</i>	<i>1 nos. of each type</i>	
<i>2.2.10</i>	<i>Filter elements</i>	<i>3 nos. of each type and size</i>	
<i>2.2.11</i>	<i>Coupling</i>	<i>2 nos. of each type and size.</i>	
<i>2.2.12</i>	<i>Return Line Filter elements</i>	<i>3 nos. of each type</i>	
<i>2.2.13</i>	<i>Check Valves</i>	<i>2 nos. of each type and size</i>	
<i>2.2.14</i>	<i>Directional Valves /DC Valve</i>	<i>2 nos. of each type and size</i>	

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S.No	Description	Quantity	Remarks
2.2.15	Solenoid for Directional Valve	2 nos. of each type and size	
2.2.16	Pressure Reducing Valve	2 nos. of each type and size	
2.2.17	Flow Control Valve	2 nos. of each type and size	
2.2.18	Pressure Relief Valve	2 nos. of each type and size	
2.2.19	Proportional valve	1 no. of each type and size	
2.2.20	Pressure Gauges	1 no. of each type and range	
2.2.21	Gauge Adapter	2 no. of each type and size	
2.2.22	Bladder and Seal Kit for Tank	2 nos.	
2.2.23	Flange Ball Valve	1 no. of each type and size	
2.2.24	Pressure Switch	1 no. of each type and range	
2.2.25	Level Regulator	1 no.	
2.2.26	Resistance Thermometer	1 no. of each type and range	
2.2.27	Hydraulic Cylinder	2 nos. of each type and size	
2.2.28	Ball Valve	1 no. of each type and size	
2.2.29	Hose	6 nos. of each type	
2.2.30	Seal kit for hydraulic cylinder	6 sets	
2.2.31	Seal kit for pump	4 sets of each type	
2.2.32	Seal kit for hydraulic motor	4 sets of each type	

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S.No	Description	Quantity	Remarks
2.2.33	Thermostat	1 no. of each type and range	
	Chain Tensioning Hydraulic System		
2.2.35	Hydraulic Pump and Electric Motor set with coupling, valves mounted on pump etc	2 sets of each type	
2.2.36	Filter elements	3 nos. of each type and size	
2.2.37	Coupling	2 nos. of each type and size	
2.2.38	Return Line Filter elements	3 nos. of each type	
2.2.39	Check Valves	2 nos. of each type and size	
2.2.40	Directional Valves /DC Valve	2 nos. of each type and size	
2.2.41	Solenoid for Directional Valve	2 nos. of each type and size	
2.2.42	Pressure Reducing Valve	2 nos. of each type and size	
2.2.43	Flow Control Valve	2 nos. of each type and size	
2.2.44	Pressure Relief Valve	2 no. of each type and size	
2.2.45	Proportional valve	1 no. of each type and size	
2.2.46	Pressure Gauges	1 no. of each type and range	
2.2.47	Gauge Adapter	2 no. of each type and size	
2.2.48	Bladder and Seal Kit for Tank	2 nos.	
2.2.49	Flange Ball Valve	1 no. of each type and size	
2.2.50	Pressure Switch	1 no. of each type and range	
2.2.51	Level Regulator	1 no.	
2.2.52	Resistance Thermometer	1 no. of each type and range	

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S.No	Description	Quantity	Remarks
2.2.53	Hydraulic Cylinder	2 nos. of each type and size	
2.2.54	Ball Valve	1 no. of each type and size	
2.2.55	Hose	4 nos of each type	
2.2.56	Seal kit for hydraulic cylinder	4 sets of each type	
2.2.57	Seal kit for pump	4 set of each type	
2.2.58	Seal kit for hydraulic motor	4 set of each type	
2.2.59	Thermostat	1 no. of each type and range	
2.3.00	Clinker Grinder/ Ash Crusher		
2.3.01	Clinker Grinder Assembly	4 No. s	
2.3.02	Clinker Grinder Liners	4 Sets	
2.3.03	Clinker Grinder Shaft Sleeves	8 Sets	
2.3.04	Clinker Grinder Gear Box	2 No	
2.3.05	Clinker Grinder Drive Fluid Couplings	4 Nos.	
2.3.06	Bearing for Grinder motor along with the housing	3 Sets	
2.3.07	Lantern rings	3 Sets	
2.3.08	Wearing rings	3 Sets	
2.3.09	Motor for ash crusher	2 No. s	
3.0.00	ASH WATER PUMPS		
3.1.00	Bottom Ash High Pressure Water Pumps		

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S.No	Description	Quantity	Remarks
3.1.01	Pump Bearings	6 Sets	
3.1.02	Pump/Motor Couplings with pin & bush assembly	2 Set	
3.1.03	Impeller along with wear parts	6 Sets	
3.1.04	Casing wearing rings	3 Sets	
3.1.05	Pump Shaft	6 No.	
3.1.06	Gland	2 Sets	
3.1.07	Shaft Sleeve	3 Sets	
3.1.08	Motor Bearings	2 Sets	
3.2.00	Low Pressure Water Pumps		
3.2.01	Pump bearings	6 Sets	
3.2.02	Impeller along with wearing Parts	6 Sets	
3.2.03	Casing wearing rings	3 Sets	
3.2.04	Pumps Shafts	6 Nos.	
3.2.05	Gland	4 Sets	
3.2.06	Shaft Sleeve	3 Sets	
3.2.07	Motor bearings	2 Sets	
3.3.00	Fly Ash Water Pumps		
3.3.01	Pump bearings	3 Sets	
3.3.02	Pump/Motor coupling with pin& bush assembly	2 Sets	

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S.No	Description	Quantity	Remarks
3.3.03	Impeller along with wear Parts	3 Sets	
3.3.04	Casing wearing rings	3 Sets	
3.3.05	Pump shaft	2 No.	
3.3.06	Glands	4 Sets	
3.3.07	Shaft Sleeve	3 Sets	
3.3.08	Motor Bearings	3 Sets	
3.4.00	Flushing Water Pumps/BA Hopper Over Flow Water Pumps/Surge Tank Overflow Pumps	[Quantities as specified is be applicable for each type of pumps separately]	
3.4.1	Pump bearings	2 Sets	
3.4.2	Pump/Motor coupling with pin& bush assembly	2 Sets	
3.4.3	Impeller along with wear parts	2 Sets	
3.4.4	Casing wearing Rings	2 Sets	
3.4.5	Pump Shaft	2 No.	
3.4.6	Glands	2 Sets	
3.4.8	Shaft Sleeve	2 Nos.	
3.4.9	Motor Bearings	2 Sets	
3.5.00	Seal water pumps	[Quantities as specified is be applicable for each type of seal water pumps separately]	
3.5.1	Pump bearing	2 Sets	
3.5.2	Pump/Motor coupling with pin& bush	1 Set	

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S.No	Description	Quantity	Remarks
	assembly		
3.5.3	Pump impeller along with wearing rings	1 Set	
3.5.4	Pump shaft	1 No	
3.5.5	Shaft sleeves	2 Sets	
3.5.6	Glands	2 Sets	
3.5.7	Motor bearings	2 Sets	
3.6.00	Economiser Water Pumps		
3.6.1	Pump bearings	1 Set	
3.6.2	Pump/Motor coupling with pin& bush assembly	1 Set	
3.6.3	Impeller along with wear Parts	1 Set	
3.6.4	Casing wearing rings	2 Sets	
3.6.5	Pump shaft	1 No.	
3.6.6	Glands	2 Sets	
3.6.7	Shaft Sleeve	2 Sets	
3.6.8	Motor Bearings	1 Set	
4.0.0	FLY ASH PNEUMATIC CONVEYING SYSTEM		
4.1.1	i. Air Eductor System		
	<ul style="list-style-type: none"> Collection chute isolation plate valve assembly 	8 Nos.	
	<ul style="list-style-type: none"> Fly Ash feeder valve assemblies 	8 Nos.	

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S.No	Description	Quantity	Remarks
	• Fly ash feeder valve seats	8 Nos.	
	• Air Eductors	4 Nos.	
	• Eductor air supply valves	4 Nos.	
4.1.2	ii. Airlock/Blow Tank System	For first stage pressure Conveying (if applicable)	
	• Airlock/pump tank inlet valve	16 Nos.	
	• Air lock/pump tank outlet valve	16 Nos.	
	• Air lock/pump tank inlet/outlet valve seats (each)	16 Nos.	
	• Airlock/pump tank air injector nozzles	16 Nos.	
	• Air line valve solenoid	16 Nos.	
4.3.0	VACUUM CONVEYING SYSTEM		
4.3.1	Vacuum Breaker valves	6 Nos.	
4.3.2	Buffer hopper bag filter spares(each set shall consist of total no. of bags in one filter assembly)	15 Sets	
4.3.3	Buffer hopper bag filter pulsation solenoid valve complete assembly	10 Nos.	
4.3.4	Air Intake Valve	10 Nos.	
4.4.0	Instrument Air Compressor		
4.4.1	HP Stage	2 Set of each type /rating	
4.4.2	LP Stage	2 Set of each type /rating	
4.4.3	Motor Bearing	1 sets of each type.	

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S.No	Description	Quantity	Remarks
4.4.4	HP stage Gear and Pinion	1 set of each type	
4.4.5	LP stage Gear and Pinion	1 set of each type.	
4.4.6	Air Intake Filter Element with Gaskets	4 sets of each type.	
4.4.7	Oil Filter Element with Gaskets & Seals	4 sets of each type.	
4.4.8	Safety Valve Springs and Gaskets for HP stage	1 set of each type	
4.4.9	Safety Valve Springs and Gaskets for LP stage	1 set of each type	
4.4.10	Valves with actuator (Within compressors house and Air drying Plant)	1 no of each type/rating/size	
4.4.11	Oil Pump/Motor		
4.4.12	Oil Pump and Motor Assembly	1 set	
4.4.13	Impeller/Rotor with shaft	1 set	
4.4.14	Bearings for pumps and drives	2 sets	
4.4.15	Set of Seals	2 sets	
4.4.16	Drain/Moisture Trap	1 sets of each type/size	
4.4.17	Gaskets and seals for Oil cooler	4 sets	
4.4.18	Moisture trap element/ assembly	2 sets of each type/size	
4.5.0	SCREW COMPRESSOR [Transport Air compressors (TAC) & Conveying Air Compressor (CAC)]		
4.5.1	Air Filter element	6 Nos.	
4.5.2	Oil Filter	4 Nos.	
4.5.3	Main Shaft Oil Seal	4 Nos.	

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S.No	Description	Quantity	Remarks
4.5.4	Discharge check valve	2 Nos.	
4.5.5	Intercooler/After cooler parts (including O-rings, gaskets, washer)	2 Sets	
4.5.6	Solenoid valve	2 Nos	
4.5.7	Coupling element	1 Set	
4.5.8	LP/HP Safety Valve	2 Nos. each	
4.5.9	Motor DE bearing	2 Nos.	
4.5.10	Motor NDE bearing	2 Nos.	
4.5.11	Oil stop valve	2 Nos.	
4.5.12	Minimum pressure valve	2 Nos.	
4.5.13	Oil separator	2 Nos.	
4.5.14	Compressor Motor	2 No.	
4.5.15	Drive shaft assembly parts (including bearings, O-rings, circlips, oil seal)	2 Sets	
4.5.16	Electronic regulator	2 Nos.	
4.5.17	Expansion module	2 Nos.	
4.5.18	Oil pump parts (including distance ring, eccentric ring, pump element, pin, key, O-ring)	2 Set	
4.5.19	LP/HP pinion	2 Nos. each	
4.5.20	Bypass valve	2 Nos.	
4.5.21	Inlet valve assembly	1 No.	

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S.No	Description	Quantity	Remarks
4.6.00	Air Drying Plant for IA System		
4.6.1	Pre filter element (ceramic candle)	2 Sets	
4.6.2	After filter element (ceramic candle)	2 Sets	
4.6.3	Heater element	2 Sets	
4.6.4	Blower bearing	2 Sets	
4.6.5	Blower motor bearing	2 Sets	
4.6.6	Valve actuators	2 Nos.	
4.7.00	Air Blowers (Buffer Hopper Aeration Blower, HCSD Silo aeration blower & Storage Silo aeration blower)		
4.7.1	• Intake filters	4 Sets	
	• Silencer	2 Nos.	
4.7.2	Seals	4 Sets	
4.7.3	Bearing Housing	2 Sets	
4.7.4	Couplings	2 Sets	
4.7.5	Air blower motor bearings	2 Sets	
4.7.6	Air blower motor	1 No.	
4.7.7	Impeller/rotor complete with bearings, shaft, seals, thrust blocks etc.	3 Nos.	
4.7.8	Lubricating Oil Filter	3 Sets	
4.7.9	Outlet Air Filter/oil separator	3 Sets	
4.8.0	Vacuum pump		
4.8.01	Vacuum pump internals (each set shall consist of all components inside the	8 Sets	

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S.No	Description	Quantity	Remarks
	casing of vacuum pump including rotor, shaft necessary packing, glands etc for replacement of complete rotating assembly)		
	• Vacuum pump bearings	8 Sets	
	• Silencer	4 Sets	
	• Bearing housing	4 Sets	
	• Couplings	4 Sets	
	• Vacuum pump motor bearings	4 Sets	
	• Vacuum pump motor	2 Nos.	
4.9.0	Refrigerant Air Dryer (Conveying Air Compressor dryer & Transport air compressor Dryer)		
4.9.1	Inner ring plate for discharge valve	4 Nos.	
4.9.2	Ring plate for suction valve	4 Nos	
4.9.3	Compressor shaft seal assembly	2 Nos.	
4.9.4	Piston ring/Guide ring	6 Sets	
4.9.5	V-belts for compressor	2 Sets	
4.9.6	Oil pressure failure safety switch	2 Nos.	
4.9.7	Crank case heater	2 Nos	
4.9.8	Gaskets		
4.9.9	Set of "O" rings and oil seals each type	2 Sets	
4.9.10	Suction filter elements	4 Sets	
4.9.11	Bearings	2 Sets	
4.9.12	Complete set of suction valves	2 Sets	

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S.No	Description	Quantity	Remarks
4.9.13	Complete set of Discharge valves	2 Sets	
4.9.14	Thermostatic Expansion Valve	2 Sets	
5.0.0	FLY ASH CONVEYING LINE ISOLATION VALVES/ FITTINGS COUPLINGS		
5.0.1	Material handling valve/Ash intake valve below ESP	160 Nos.	
5.0.2	Fly ash extraction line segregating valve seats	160 Nos.	
5.0.3	Fly ash extraction line isolation valve Gates/Flaps	80 Nos.	
5.0.4	Fly ash extraction line couplings	80 Nos	
5.0.5	Fly ash extraction line fittings (Bends/laterals)	8 Nos. for each degree & type bend & fittings	
6.0.0	FLY ASH STORAGE SILO AND HCSD SILO		
6.0.1	Storage Silo filter spares (each set shall consist of total no. of bags in one filter assembly)	10 Sets	
6.0.2	Storage Silo filter pulsation solenoid valves – complete assembly	18 Nos.	
6.0.3	Storage Silo aeration pads	25% of total population	
6.0.4	Storage hopper aeration sectionalizing valves	25% of total population	
6.0.5	Storage Silo isolation valves	1 No.	
6.0.6	Dry fly ash retractable chute assembly	1 No.	
6.0.7	Interconnection Valves at Silo top /FA transport pressure lines.	2 Nos.	

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S.No	Description	Quantity	Remarks
7.0.0	BOTTOM ASH SLURRY DISPOSAL SYSTEM		
7.1.1	Ash slurry disposal pumps & Drives		
7.1.2	Impeller	6 Nos	
7.1.3	Casing Liners (One set consists of all the liners section used in one pump)	6 Sets	
7.1.4	Liners (Suction side and gland side)	6 Sets	
7.1.5	Pump bearings	3 Sets	
7.1.6	Shaft sleeves	6 Sets	
7.1.7	Motors bearings	3 Sets	
7.1.8	Pump shaft	3 Sets	
7.1.9	Complete fluid coupling for	4 Nos.	
7.1.10	Ash Slurry Pump		
7.1.11	Fusible plug	6 Nos.	
7.1.12	Resilience plate	6 Nos.	
7.1.13	Flexible coupling	4 Nos.	
7.1.14	Ash slurry pump speed reduction gear box	2 No	
7.2.0	Slurry Line Valves		
7.2.1	Complete assembly of valves at bottom ash slurry disposal pumps discharge	6 Nos.	
7.2.2	Knife edge gate valve in bottom ash slurry disposal pumps suction(complete assembly)	6 Nos.	
8.0.0	SUMP DRAINAGE PUMPS		

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[16]	25.09.2014

S.No	Description	Quantity	Remarks
8.0.1	Impeller	1 No. of each type	
8.0.2	Pump and motor bearings	2 Sets of each type	
8.0.3	Casing Liners	2 Sets of each type	
9.0.0	WATER AND AIR LINE VALVES AND JETTING NOZZLES		
9.0.1	Valves for each size used in system		
9.0	Nozzle tips for nozzles in ash slurry jetting, agitation, quenching, and flushing service.	20 Nos. of each type & size	
10.0.0	HCSD SYSTEM		
10.1.0	Ash Mixer		
10.1.1	Impeller Blades (one set consist of all blades for mixer	6 Sets	
10.2.0	Ash Mixer Gear Box		
10.2.1	Oil Seals of each type and size	6 Nos	
10.2.2	Gaskets of each type and size	8 Nos	
10.2.3	Bearing of each type and size	4 Nos	
10.2.4	Retaining Rings of each type and size	4 Nos	
10.3.0	HCSD Pumps		
10.3.1	Valve Unit (D)	2 Set	
10.3.2	Conical valve	72 No. s	
10.3.3	Valve Disc	144 No. s	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[17]	25.09.2014

S.No	Description	Quantity	Remarks
10.3.4	Valve Seat	72 No. s	
10.3.5	Lock Nut	8 No. s	
10.3.6	Compression spring	4 No. s	
10.3.7	Clamping piece	2 No. s	
10.3.8	Guide Bush	40 No. s	
10.3.9	Stud bolts of each type and size	3 No. s	
10.3.10	Piston	3 No. s	
10.3.11	Nuts of each type and size	3 No. s	
10.3.12	Sealing Rings of each type and size	4 No. s	
10.3.13	Connecting nipple	3 No. s	
10.3.14	Treating reducing piece	3 No. s	
10.3.15	Sealing Ring	3 No. s	
10.3.16	Plug	3 No. s	
10.3.17	Retaining Rings of each type and size	60 No. s	
10.3.18	O' Ring of each type and size	60 No. s	
10.3.19	Seal	3 No. s	
10.3.20	Hex. Socket Head Screw	15 No. s	
10.3.21	Valve Unit (S)	1 Set	
10.3.22	Valve Support	3 No. s	
10.3.23	Clamping piece	3 No. s	
10.3.24	Pin		
10.3.25	Diaphragm Housing unit		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[18]	25.09.2014

S.No	Description	Quantity	Remarks
	• Clamping bush	2 No. s	
	• Diaphragm	12 No. s	
	• Sealing Ring	4 No. s	
	• Discharge dampener diaphragm	10 No. s	
10.4.0	Ash Conditioners		
10.4.1	Nozzle	2 Sets	
10.4.2	Blades	2 Sets	
10.4.3	Blade liner	2 Sets	
10.4.4	Shaft	2 Sets	
10.4.5	Plumer block	2 Sets	
10.4.6	Flexible coupling	2 Sets	
10.4.7	Gear box with drive motor	1 No	
10.4.8	Oil seals & bearing sets for Gear Box	2 Sets	
10.5.0	Rotary Feeders		
10.5.1	Body	4 No. s	
10.5.2	Rotor	4 No. s	
10.5.3	Shaft	4 No. s	
11.0.0	ASH WATER RECIRCULATION SYSTEM		
11.0.1	Horizontal Centrifugal Pumps (Each Type & Model)		

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[19]	25.09.2014

S.No	Description	Quantity	Remarks
11.0.2	<ul style="list-style-type: none"> Impeller 	2 Set	
	<ul style="list-style-type: none"> Shaft 	2 No.	
	<ul style="list-style-type: none"> Shaft Sleeves 	1 Set	
	<ul style="list-style-type: none"> Lantern Rings 	2 Sets	
	<ul style="list-style-type: none"> Bearings 	4 Sets	
	<ul style="list-style-type: none"> Searing rings (wherever applicable) 	1 Set	
11.2.0	Butterfly Valves spare (for each type & size)		
	<ul style="list-style-type: none"> Spindle 	1 No.	
	<ul style="list-style-type: none"> Seats 	1 Set	
	<ul style="list-style-type: none"> Gland 	1 Set	
	<ul style="list-style-type: none"> Gate Valves 	1 No. of each type and size	
	<ul style="list-style-type: none"> Non-Return Valve 	1 No. of each type and size	
	<ul style="list-style-type: none"> Air Release Valve 	2 Nos. of each type and size	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[20]	25.09.2014

B. ELECTRICAL

S.No / Cl. No.	Item	Quantity	Remarks
1.	SERVICE TRANSFORMER		
	SERVICE TRANSFORMERS - 6.6/0.433KV (To be repeated for each service area)		
	(For the following items each type & rating to be repeated)		
	HV Bushing	1 Set	
	LV Bushing	1 Set	
	Neutral Bushing	1 Set	
	RTD	3 No	
	Complete Winding Temperature scanner	1 No	
	Current Transformer	2 No.	
	Support Insulator	5 Set	
2.	LV SWITCHGEAR/PMCC/MCC		
	(For the following items each type & rating to be repeated)		
	Breaker complete with operating mechanism	1 No.	
	Closing coil	2 No.	
	Tripping coil	2 No.	
	Operating mechanism rod	3 No.	
	Fixed and moving contact assembly	2 Set.	
	Spring charging motor	2 No.	
	Breaker Protection Module	1 No	
	Gasket	5 Set	
	Aux. switch assembly	3 Set	
	Limit Position Switch	3 No	
	Busbar support insulators of different	3 Set	

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[21]	25.09.2014

S.No / Cl. No.	Item	Quantity	Remarks
	sizes		
	Switches	3 No.	
	Numerical Relay	3 No.	
	Auxiliary relay	2 No.	
	Interposing relay of each type for DDCMIS	2 No.	
	Clustered type LED	5 No.	
	Current Transformer	6 No.	
	Voltage Transformer	6 No.	
	Meters	2 No.	
	Power Fuse	5 No.	
	Control Fuse	5 No.	
	Timer	2 No.	
	Check synchronizing relay	1 No.	
	Disconnecting type Terminal block for CT wiring	5 No.	
	Non-disconnecting type Terminal Block	5 No.	
	Electronic overload relays	2 No.	
	Single phase control transformer 415V/110V	5 No.	
	Intelligent Controller Module	5 No.	
	Power contactor	1 No	
	MPCB	1 No	
	MCB	1 No	
	MCCB/SFU	1 No	
	Push button with contact assembly	3 No.	
	ACDB/PDB PANEL (To be repeated for each board)		
	(For the following items each type &		

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[22]	25.09.2014

S.No / Cl. No.	Item	Quantity	Remarks
	<i>rating to be repeated)</i>		
	Power Fuse	2 No.	
	Control Fuse	5 No.	
	Push button with contact element	2 No.	
	Ammeter	2 No.	
	Voltmeter	2 No	
	Terminal Blocks	2 No	
	MCB	2 No.	
	SFU/MCCB	2 No.	
3.	DC System		
	DCDB		
	Switch Fuse Unit / MCCB	2 No.	
	Power Fuse	3 No.	
	Control Fuse	3 No.	
	Semi conducting Fuse	6 No.	
	MCB	2 No.	
4.	NON-SEGREGATED PHASE BUS DUCTS (LT) (To be repeated for each Bus duct Unit)		
	<i>(For the following items each type & rating to be repeated)</i>		
	Busbar support insulators of different sizes	2 Set	
	Flexible Connectors (for equipment connection) (Complete set for all the phases)	2 Set	
	Expansion joints (for conductor for all the phases)	2 Set	
	Silica gel breather	2 No	
5.	MOTORS AND ACTUATORS (TO BE REPEATED FOR EACH SERVICE AREA)		
	<i>(For the following items each type & rating to be repeated)</i>		

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[23]	25.09.2014

S.No / Cl. No.	Item	Quantity	Remarks
	<i>Motor bearings</i>	<i>1 Set</i>	
	<i>Torque/Limit switch</i>	<i>5 Set</i>	
	<i>End Limit switch</i>	<i>5 Set</i>	
	<i>Position transmitter for inching type</i>	<i>2 No</i>	
6.	ILLUMINATION SYSTEM		
	<i>MLDB/LDB Panel (To be repeated for each board)</i>		
	<i>(For the following items each type & rating to be repeated)</i>		
	<i>Temperature surveillance unit for Lighting Transformer</i>	<i>1 No.</i>	
	<i>RTD element for Lighting Transformer</i>	<i>1 Set</i>	
	<i>Busbar support insulators of different sizes</i>	<i>2 Set</i>	
	<i>Power Fuse</i>	<i>2 No.</i>	
	<i>Control Fuse</i>	<i>2 No.</i>	
	<i>Push Buttons with contact element</i>	<i>5 No.</i>	
	<i>Ammeter</i>	<i>1 No.</i>	
	<i>Voltmeter</i>	<i>1 No</i>	
	<i>Power Terminal Block</i>	<i>2 No</i>	
	<i>MCB</i>	<i>2 No.</i>	
	<i>MCCB/SFU</i>	<i>2 No.</i>	
	ALDB/LDB PANEL		
	<i>(For the following items each type & rating to be repeated)</i>		
	<i>Busbar support insulators of different sizes</i>	<i>2 Set</i>	
	<i>Power Fuse</i>	<i>20 No.</i>	
	<i>Control Fuse</i>	<i>20 No.</i>	
	<i>Push button with contact element</i>	<i>5 No.</i>	

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[24]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

S.No / Cl. No.	Item	Quantity	Remarks
	<i>Ammeter</i>	<i>2 No.</i>	
	<i>Voltmeter</i>	<i>2 No</i>	
	<i>Electronic energy meter</i>	<i>2 No.</i>	
	<i>Terminal Blocks</i>	<i>5 No</i>	
	<i>MCB</i>	<i>5 No.</i>	
	<i>SFU/MCCB</i>	<i>5 No.</i>	

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[25]	25.09.2014

C. I&C

S.No	Item	Quantity/Unit	Remarks
1	Programmable Logic controller (PLC) for Ash Handling Plant		
1.1	Power Supply Unit/Module for PLC and I/O	10% of each type & Model, minimum 1 no whichever is higher	
1.2	Input/ Output modules	10% of each type & Model, minimum 1 no whichever is higher	
1.3	Central Processor Unit Module	1 no. of each type & Model	
1.4	Communication Module	1 no. of each type & Model	
1.5	Interface Module	1 no. of each type & Model	
1.6	PLC Backplane I/O Bus without modules	1 no. of each type & Model	
1.7	Network adapters/converter, LIU,OLM, Network/ Ethernet Switch and other network hardware used	1 no. of each type & Model	
1.8	Display Units (LCD/LED/TFT)	1 no. of each type & Model	
1.9	Keyboard	2 nos.	
1.10	Mouse	2 nos.	
1.11	Hard Disk Dive Unit (capacity as per requirement)	1 no.	
1.12	CD/DVD Read/Write Drive	1 no.	
1.13	CDs/DVDs	25 Nos.	
1.14	Installation Software (for OWS, EWS, Controllers, Firewall Security and any supporting softwares)	1 no. copy of CD/DVD of each requirement	
1.15	Interconnecting Cables with connectors (within panels)	1 no. of each type	
1.16	Prefab Interconnecting Cables with connector	1 no. of each type & length	
1.17	System Bus Cable With Connector	1 no. of each type & length	
1.18	IO bus cable with connector for remote IO units	1 no. of each type & length	
1.19	Loose Connectors	3 nos. of each type	
1.20	Batteries for RAM battery back-up	1 set for each type and model no. of CPU	
1.21	Printer Paper	3000 sheets of each type	
1.22	Printer Cartridge / Toner/ Ribbon	5 Nos. of each type	
2	UPS for CHP Package)		

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[26]	25.09.2014

S.No	Item	Quantity/Unit	Remarks
2.1	Intelligent UPS		
2.2	Silicon Controlled Thyristors, Diodes & Power Transistors	100%	
2.3	Capacitors	1 set	
2.4	CT's, CVT's, VT's, Chokes, AC/DC isolators, Contactors, Timers, Relays	10% of each type and rating	
2.5	Fuses of Each Type & Ratings	100%	
2.6	Fuse Free Circuit Breakers	5%	
2.7	Electronic Modules	10%	
2.8	Lamp Holders With Series Resistors	10%	
2.9	Cooling Fans	1 nos of each type	
2.10	Digital/Analog panel meters/indicators	1 nos of each type	
2.11	Relays of all types including overload relays	10%	
3	Field Instruments for Ash Handling Plant		
3.1	RTD (single/Duplex type), Thermocouple	10% of each type & Range	
3.2	Pressure Gauge, DP Gauge	10% of each type & Range	
3.3	Temperature Gauge	10% of each type & Range	
3.4	Level Gauge	10% of each type & Range	
3.5	Pressure Switch	10% of each type & Range	
3.6	Differential Pressure Switch	10% of each type & Range	
3.7	Level Switch (Capacitance/RF Type/Float/Displacer etc)	10% of each type & Range	
3.8	Level transmitter (Ultrasonic, Radar type)	1 no. in each type and range	
3.9	Pneumatic power Cylinder	1 No. of each type & Range	
3.10	Solenoid Valve with coil	1 No. of each type & Range	
3.11	Accessories for Transmitters & Gauges(valve manifold, snubber, isolation valve, drain valve etc.,)	2 nos. in each type and range	
3.12	Pneumatic Valve Actuator spare kit(including diaphragm, piston, gaskets, O-rings etc.,)	2 sets for each type and size of actuator	
3.13	Position Limit Switch	10% of each type & Range	
3.14	Solenoid Valve with coil	10% of each type & Range	

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[27]	25.09.2014

S.No	Item	Quantity/Unit	Remarks
3.15	Pneumatic Valve Actuator spare kit (including diaphragm, piston, gaskets, O-rings etc.,)	2 sets for each type and size of actuator	
3.16	Smart Valve Positioner	10% of each type & model	
3.17	Air Filter Regulator	10% of each type & range	
4	Process connection Piping for Ash Handling Plant		
4.1	2 way, 3 way valves for instruments	10% of each type, size, rating, class, material & model	
4.2	Fittings	10 Nos. of each type, rating, material & size	
4.3	Valve manifolds (2way, 3 way & 5way)	10 % of each type, rating & model	
4.4	Air Filter Regulator	10 % of each type, model & range	
4.5	Impulse piping & tubing	5 nos. of standard Length of each size, rating & material	
5	Instrumentation cables & Accessories For Ash Handling Plant		
5.1	All Instrumentation Field Cables from Instrument to JB and JB to DCS/PLC (including compensating cable)	5% of total installed Length (In running meter) if total installed length < 1000 metres or 1 no. of 1000 metre. Drum if total installed length > 1000 metres, of each type, pair & size	
5.2	Fiber optic cable	1000 metres of each type and size	
5.3	Communication cable from PLC to RIO	1000 meters in each type and size	
5.4	Communication cable from PLC to OWS/EWS	500 meters in each type and size	
6	Cabinets, Panels & Junction Box For Ash Handling Plant		
6.1	Terminal Blocks	5% of each type & rating (for types of total quantity > 100 nos.)	
6.2	MCB	10% of each type & rating	
6.3	Fuse	50% of each type & rating	
6.4	Junction box	1 no. of each size & material	
6.5	LED Indicator	10% of each type, Colour & voltage rating	
6.6	Panel/Cabinet cooling fan	5% of each type & model	
6.7	Panel/Cabinet door switch	5% of each type & model	
6.8	Panel/Cabinet CFL	5% of each type & model	

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash handling System Volume-II, Section-I, Annexure-II	[28]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-04)
VOLUME-II
SECTION-I, ANNEXURE-III
LIST OF SUB-VENDORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-III

List of Sub-vendors

{List of approved vendors for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the given format.}

A. MECHANICAL EQUIPMENT

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

B. ELECTRICAL EQUIPMENT

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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C. CONTROL & INSTRUMENTATION

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

D. CIVIL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash Handling System Volume-II, Section-I, Annexure-III	[2]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-A
DETAILED TECHNICAL SPECIFICATION- MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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LII-GETS12021-G-00129-005	00	Tender Document for Selection of R&M Contractors –Ash Handling System Volume-II, Section-II, Part-A	[i]	25.09.2014

VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	00	Tender Document for Selection of R&M Contractors –Ash Handling System Volume-II, Section-II, Part-A	[ii]	25.09.2014

VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II:DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
4. Detailed Technical Specification-Civil

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	00	Tender Document for Selection of R&M Contractors –Ash Handling System Volume-II, Section-II, Part-A	[iii]	25.09.2014

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

* * * * *

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	00	Tender Document for Selection of R&M Contractors –Ash Handling System Volume-II, Section-II, Part-A	[iv]	25.09.2014

MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

BALANCE OF PLANT (PACKAGE NUMBER: R&M-SP-05)

VOLUME-II, SECTION-II, PART-A DETAILED TECHNICAL SPECIFICATION- MECHANICAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash Handling Plant Volume-II, Section-II, Part-A	[v]	25.09.2014

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GENERAL

The ash handling system shall be complete in all respects with mechanical, civil & structural, architectural, electrical, control & instrumentation systems. The scope shall include bottom ash handling system, coarse ash handling system, fly ash handling system, ash disposal system up to the ash disposal area and water recovery system from ash pond for [210/215/220/250] MW Power Project. The plant shall be designed to cater for [...] % PLF and ash content of worst coal as [...] %.

Design, manufacture, inspection and testing of all the equipment shall comply with all the currently applicable statutory regulations and safety code in the locality where the equipment are to be installed. Other internationally acceptable standards, which ensure equal or higher performance than those specified, shall also be accepted. Nothing in this specification shall be construed to relieve the bidder of the related statutory responsibility. In case of any conflict between standards and this specification, decision of the Owner/Owner's Engineer shall be final and binding.

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CODES & STANDARD

List of standards is given below for reference:

Standard No	Description
IS: 1239	Mild Steel ERW tubes, tubular and other wrought steel fittings (Part I & II)
IS: 3589	Electrically Resistance welded steel pipes for water gas and sewage (150 to 2000 mm nominal diameter)
IS: 4736	Hot dip Zinc coating on steel tubes
IS: 5822	Code of practice for laying steel pipes
IS: 9404	Colour code for identification of pipelines in thermal power plants.
BS: 534	Black bolts screws and nuts.
BS: 2633	Specification for Class- I Arc welding of ferritic steel for pipe work carrying fluids.
BS: 4504	Flanges and bolting for pipes, valves, and fitting metric series
ANSI B 16.5	Steel pipe flanges, flanged valves and fittings
ANSI B 16.5	Steel pipe flanges, flanged valves and fittings
ANSI B 16.9	Factory made wrought steel butt welded fittings
ANSI B 16.11	Forged steel fittings (Socket welded and threads)
ANSI B 16.21	Non-metallic gaskets for pipe flanges.
ANSI B16.25	Butt welding ends.
ANSI B16.28	Steel short radius fittings
ANSI B 36.10	Welded and seamless wrought steel pipe
ANSI A 234	Carbon and ferritic alloy steel fittings
API 617/619/672	Centrifugal Compressors
BS:1571 (Part I & II)	Acceptance test for positive displacement compressor and exhausters.
IS: 6206	Guide for selection, installation and maintenance of air Compressor plants with operating pressures up to 10 bars
IS: 5727	Glossary of terms related to compressor exhausters
IS: 5456	Code of practice for testing of positive displacement type air

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	compressors and exhausters.
ISO: 1217	Displacement compressor acceptance tests
BS: 726	Compressor performance tests.
Pneurop /HEI	Performance testing of liquid ring vacuum pump
IS: 778	Gun metal gate, globe and check valves for general purpose
IS: 780	Sluice valves for water works purpose 150 to 300 mm size
IS: 1703	Ball valves (Horizontal plunger type) including floats for water supply.
IS: 2685	Code of practice for selection, installation and maintenance of sluice valves.
IS: 2906	Sluice valves for water works purpose (350 – 1200 mm size)
IS: 5312	Swing check type reflex (Non- return valve)
BS: 1868	Specification for steel check valves (flange and butt welding ends).
BS: 1873	Steel globe and globe stop and check valves (flanged and butt welding ends).
BS: 5152	Specification for CI globe, stop and check valves for general purpose.
BS: 5353	Carbon and alloy steel plug valves
BS: 5153	CI check valve for general purpose
BS: 5154	Copper alloy globe stop and check and gate valves for general purpose.
BS: 5158	CI and carbon steel plugs for general purpose.
ANSI B 16.10	Face to face and end to end dimension of Ferrous valves.
ANSI B 16.34	Steel valves flanged and butt welding ends
API 598	Valve inspection and test
API 600	Steel gate valves
API 602	Compact design carbon steel gate valves for refinery
ASME PTC 10	Testing of Centrifugal Compressor
Standards for Ash slurry pipes	
IS: 3589	Line pipe

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Standard No	Description
ERW steel pipes to SAIL commercial quality	Line pipe.
Centrifugal Pump Standards	
IS: 6536	Pumps for handling volatile liquids
API 610	Centrifugal pumps for general refinery services
	Standards for Hydraulic Institute of USA.
IS: 3177	EOT Crane
IS: 807	Code of practice for design, manufacture, erection and testing (structural portion) of cranes and hoists.
IS:3177	Crane duty motors
IS: 1520	Horizontal centrifugal pumps for clear, cold fresh water
IS: 5120	Technical requirements for roto-dynamic special purpose pumps.
IS: 5639	Pumps handling chemical and corrosive liquids
IS: 5659	Pumps for process water
IS-11989	Specification for Air Dryers
IS-2825	Code for Unfired pressure vessels
ISO 8753.1	Filter quality classes

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3 SYSTEM DESCRIPTION

3.1 Bottom Ash Removal System

[The function of ash handling system is to evacuate ash from different zones with its specified evacuation rate/time till its life period with minimum maintenance. Description of the system is as follows: -

- i) Bottom ash resulting from the combustion of coal in the boiler shall fall into the over ground water impounded [double/triple] "V" type hopper with steel construction having [...] number feed gates. Each unit shall be provided with one (1) number refractory lined, water impounded, level maintained, triple section, type steel- fabricated bottom ash hopper having a hold up volume to store bottom ash and Economizer ash generated for a period of eight (8) hours. Under each V Section, there shall be [two (2)] outlets.*
- ii) Each outlet shall be fitted with a Hydraulically operated feed gate, clinker grinder, feed sump, jet pump and a set of piping and valves designed for adequate capacity for removal of the ash in slurry form. The Bottom Ash hopper discharge gates shall be opened once in a shift of eight (8) hours and the stored Ash shall be removed by means of jet pumps and transported in slurry pipe lines to the Ash slurry sump for its further disposal to the Ash pond by means of Ash slurry disposal pumps. Out of [...] outlets, only [...] outlets (... on each V Section) will be operating and other [...] shall be in standby mode.]*
- iii) The slurry formed shall be transported to the common ash slurry sump through pipes (running on pipe racks). Bottom ash system operation will be controlled from bottom ash local panel. Bottom ash and Economizer ash generated in eight (8) hours will be cleared in about [...] hour. Bottom ash and Economizer ash generation per unit will be calculated at 100% PLF considering generation of bottom ash and economizer ash as [30%] of total ash with worst coal.*
- iv) Under different furnace expansion condition necessary sealing to be maintained between furnace and atmosphere through water fill seal trough around bottom ash hopper with a provision of continuous make up and overflow.*

3.2 Coarse Ash Removal System

- i) From economizer hoppers of each unit, coarse ash will flow to respective bottom ash hopper through adequately sized sloping pipe duly assisted by jets (Flushing nozzles) placed at strategic locations on the tank for easy slurry flow.*
- ii) The coarse ash slurry along with bottom ash slurry will be transported to the common ash slurry sump in the same manner as bottom ash Slurry. Effective*

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sealing and hopper expansions are to be made by means of water trough type expansion joint

3.3 Fly Ash Removal System

- i) Fly ash will be collected in Electrostatic Precipitator (ESP), Air preheater (APH) Hoppers and Stack Hoppers. There will be requisite no. of hoppers in ESP and APH. Owing to highly efficient ESP, ash collection in stack hopper is expected to be negligibly small.*
- ii) Dry Fly Ash Unloading System shall consist of two stages. The first stage shall include extraction of dry Fly Ash from the various ESP and APH hoppers to the intermediate surge hopper by vacuum conveying system and in the second stage, Ash shall be conveyed/ transported from intermediate surge hoppers to the FA storage silos. In first stage, vacuum will be created by mechanical exhausters (vacuum pumps) suitably designed. There will be one cylinder operated fly ash intake valve below each fly ash hopper. On opening of the valve, fly ash will enter a fly ash conveying line by gravity. There will be one air intake / check valve in each branch conveying line, which will allow requisite amount of air to be drawn into the system.*
- iii) Vacuum pump of liquid ring type will create the requisite vacuum in the system. [...] Nos. mechanical exhausters (vacuum pumps) shall be provided. Out of the above, [...] nos. (.W+..S) shall cater for dry FA system and [...] nos. (.W+..S) for wet FA system for [210/215/220/250] MW unit. [...] nos. of bag filters shall be provide for each unit, out of which [...] nos. shall be located on each intermediate surge hopper and [...] nos. on collection tank with effective storage capacity of thirty minutes. The bag filter will be of pneumatic pulse jet type and high pressure instrument air pulsing will be used to dislodge collected fly ash from the bags to the intermediate surge hopper. The air leaving the bag filter will be passing through dedicated vacuum pumps before air is released to atmosphere. Wetting unit shall be envisaged in the air line from bag filters to the vacuum pumps with Dust sensors at the suction of every Vacuum Pump (mechanical exhauster) so as to avoid ingress of any fly ash dust into the mechanical exhausters.*
- iv) In Second stage, fly ash from intermediate surge hopper (ISH) will be transported to the fly ash silos through pressure conveying system which includes [...] nos. Air Compressors (.W+..S) for [210/215/220/250] MW.*
- v) In wet conveying mode, dry fly ash shall be conveyed from ESP and Air preheater Hoppers to Wetting Head and Collecting channel by vacuum conveying method, where it is mixed with water and resultant ash slurry is discharged by HP Water to ash slurry sump through ash slurry through trench or carbon steel pipe over pipe racks. Wetting head should be use for mixing of water and ash before collecting channel.*

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- vi) In dry Conveying mode, the total fly ash of [210/215/220/250] MW from ESP and Air preheater hoppers shall be conveyed to ISH and then from ISH, ash will be conveyed to FA Silos in pressure conveying mode by means of [...] Nos. parallel streams (..W+..S).*
- vii) There shall be [...] numbers intermediate surge hoppers (ISH) for [210/215/220/250] MW units and each surge hopper shall have a capacity for storage of fly ash from [each unit] over a period of thirty minutes. The Intermediate Surge Hoppers shall be equipped with primary collectors/secondary collectors/target box along with bag filter as applicable to vacuum extraction system. Air blowers for each unit shall be provided to aerate Ash inside the buffer hoppers and ESP hoppers to facilitate free flow of Ash.*
- viii) From each Intermediate Surge Hopper, ash will be transported to any of the ash storage silos (common for [...] units of [210/215/220/250] MW) through the pressure conveying streams.*
- ix) The [...] numbers (..W+..S) fluidizing blowers shall be provided for the units for easy dislodging of ash from all the fly ash hoppers and ISH.*
- x) There will be [...] silos for the collection of fly ash, each of 16 hours storage of fly ash generated.*
- xi) Fly ash generated per shift (8 hours) per unit will be calculated at 100% PLF considering fly ash generation to be 90% of total ash with worst coal. Fly ash generated in eight (08) hours will be cleared in about [...] hours.*
- xii) From Fly ash storage silo, presently, there will be provision for unloading directly on trucks from each silo. Each Fly ash storage silo will be provided with the following:*
 - Two (2) numbers Rotary Drum Conditioners cum Un-loaders for providing necessary water spray for dust suppression during loading of ash on open trucks.*
 - Two (2) numbers telescopic spouts arrangements with scavenger fan complete with suction bag filter shall be provided for unloading of fly ash in closed tanker. Both the outlets for ash handling shall be provided with manual chain wheel operated plate valve and cylinder operated plate valve and feeder with control.*
 - Two (2) additional blanked flanges shall be provided considering probable future requirement for ash transportation directly to Ash Utilization Project. Unloading of dry ash into railway wagon in future is also envisaged, for which rail track under the silo shall also be provided.*
 - Silo fluidizing arrangement comprising [...] blowers for silos and all related accessories. [...] Nos. blowers shall be able to fluidize ash of one (1) silo under full load condition. So, even when, [...] silos operate together, [...] blower will remain stand-by.*

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- Suitable number of bag filter & vent fan (with 100% stand by) for venting within the stipulated limits of ash emission (less than 50 mg/Nm³).
- Access doors at suitable & strategic locations.
- Ash level detection and Radio frequency type sensing device.
- Relief valve to take care of any positive or negative excursion of pressure within the silo.

3.4 Bottom Ash, Coarse Ash & Fly Ash (Wet) Slurry Transport

- Coarse ash & bottom ash slurry from Bottom Ash hopper through hydraulically operated feed gate, clinker grinder, feed sump & jet pump and fly ash slurry from collecting channel are discharged to ash slurry sump which is common for both the units.
- The Ash slurry sump will be rectangular pyramidal shape suitably compartmentalized and lined with alloy cast iron liners. It will be of over ground construction & slurry pumps located on ground floor should have flooded suction from the Ash slurry sump. The emergency overflow of the Ash slurry sump will lead to the nearest drain sump.
- Each unit will have [...] Nos. slurry piping's for discharging of BA & CA slurry to ash slurry sump. Each slurry pipe shall be dedicated to one (1) outlets, there shall be Two outlets per V Section. Out of total [...] slurry pipes [...] slurry pipe lines (one from each hopper) from each unit will be operating simultaneously for decanting the bottom ash whereas other [...] slurry lines shall be in standby mode.]
- Any type of slurry (BA & CA or Wet FA) of any unit will have the flexibility of being led to any one of two compartments of the slurry sump. There shall be [...] sets of slurry pumps (each set being Single/Double stage depending on final design) common for both the units out of which [...] sets will be working (for [...] units) and [...] set will be common standby. Each pump will be of identical duty conditions.
- Disposal of Sludge produced while water treatment in Clarifier into the Ash slurry sump shall be under bidder scope. All the necessary pumps, piping, fitting's etc. and accessories for the same shall be provided by the bidder. Sludge pumps shall be envisaged as 100% standby.
- At least 1st stage shall have scoop controlled Fluid Couplings to vary the duty point within (-) 45% to (+) 10% of design duty point. Space shall be kept in ash slurry pump house for future one stage in case new ash pond is identified or for future increment of existing ash dyke.
- There shall be [...] slurry pipes running from slurry pump discharge to ash dump area out of which [...] will be working for [...] units and [...] will remain as common standby. The slurry concentration for Fly Ash shall be

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around 30% and for Bottom Ash shall be around 25%.

- viii) Considering future rising of Dyke height, the slurry pumps shall be capable of delivering slurry to a dyke height of at least 17m from existing grade level.*
 - ix) All pipe/fittings & supports shall be suitable to take that load area at hydro-test condition.*
 - x) Necessary slurry line flushing arrangement shall be provided.*
- Mechanical ventilation (supply exhaust fans) for different areas in Ash slurry pump house and switchgear rooms.*

3.5 Ash Dump Area - Equipment and Facilities

- i) Ash pond area which is approximately [...] km away from ash slurry sump will be divided in [...] segments to cater for upcoming units. The ash pond will be maintained by filling and cutting alternate segments. The slurry pump head shall be designed to enable discharge at furthest point in the dyke area up to ultimate dyke height ([...] Meter, from present existing earth level).*
- ii) Ash slurry pipes will discharge into the ash pond and ash particles will settle inside the ash pond. An ash water recovery, collection and transfer system is to be provided near ash pond area.*
- iii) Main slurry pond shall gradually get filled up with deposited ash, thus adequate number of discharge points shall be provided along the perimeter of ash disposal area and provisions shall be there to shift the slurry discharge amongst the discharge points from time to time such that an efficient filling of the entire ash pond is ensured. Proper garlanding on the ash dyke shall be made for this purpose.*
- iv) Entire ash slurry will be retained within this Ash Dump. It is also intended to retain the entire precipitation received by the Dyke area within the reservoir itself.*
- v) The recovery water system shall consist of a stilling pond near ash pond area for collection of runoff water from ash slurry, the recovery water pumping system ([...] slurry sump pumps, [...] working for [...] units and one common standby, each pump rated for 80% recovery of ash water [per unit] considering both bottom ash and fly ash are disposed in slurry form) for recycling the entire quantity of decanted water for being consumed back in the plant.*
- vi) The recovery water pumps shall be located on a barge over stilling pond with flexible piping and cables connected to fixed layout.*
- vii) The decanted water will be clarified through adequate capacity clarifier at Dyke end. The clarified water will be stored into clarified water tank and from there it will be pumped back to the main plant/Ash water tank for both the Units.*

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- viii) *The system shall have provision of chemical dosing system as necessary for coagulation and efficient settlement of ash carryover as well as chemical treatment.*
- ix) *The pipe lines shall be complete with basalt lined bends, specialties, fittings, fixtures, pipe couplings, gaskets, nuts, bolts, clamps, embedments, structural steel supports for piping system and other accessories.*
- x) *Adequately sized motor operated or solenoid operated & pneumatically actuated metal to metal seated knife edge gate valve/100% tight shut off rubber lined knife edge gate valves/plug valves shall be provided at the suction and discharge of combined Ash slurry disposal pumps.*

3.6 Bottom Ash Hopper Overflow System

- i) *Overflow water from Bottom Ash Hopper and seal trough of [each unit], will led to Overflow Transfer Sump with storage capacity of 10 minutes and from there transferred to the ash slurry sump via collecting channel.*
- ii) *[...] numbers Overflow Transfer Pumps will be employed for [each unit] out of which [...] will be working, [...] as working standby. There will be continuous supply of LP water for Bottom Ash water cooling to 60 °C.*

3.7 Common Ash Laden Water Clarification System

- i) *[Ash water clarification plant receives recovery water from the Ash Dump Area and any other drains the Bidder intends to route to this plant.*
- ii) *All effluents originating from the Ash Handling Plant and leading to the station drain shall have to meet all pollution criteria as laid down by IS-2490, Part I and other stipulations State Pollution Control Board.*
- iii) *All sludge produced by this common clarification Plant shall be sent to the common Ash disposal area.]*

3.8 Common Water Supply System

- i) *The total requirement of water for the Ash Handling System shall be met from following sources namely:*
 - *[Cooling Tower Blow down]*
 - *Clarified Water from WTP Clarifier.*
 - *[Decanted recovery water from the ash dump area.]*
 - *[Clear Water from Oily Water Separator.]*
- ii) *Common slurry sump make up will be fed from ash water tank through Ash Water Pumps.*
- iii) *[...] nos. H.P. water pumps shall be provided for both units ([...] workinh + [...] standby). Each pump set will be able to cater to the total requirement of HP water during Bottom Ash & Fly Ash removal of one unit.*

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- iv) *There shall be [...] LP water pumps for both units ([...] workinh + [...]) standby) to cater various LP water requirements.*
- v) *[...] numbers Economizer Water Pumps shall be provided for both units ([...] working + [...] stand by) to cater to water requirements for removal of Economizer ash to Bottom Ash Hopper in slurry form.*
- vi) *[...] numbers seal water pumps, common for [both units], taking suction from the Ash Water tank shall supply water at different sealing points.*
- vii) *All pumps listed above shall be complete with drive motors, base plates, foundation bolts, inserts, embedment and accessories as specified and as required. Complete Ash water pipe lines, valves, fittings, pipe rack, structural steel supports for piping system and other accessories as specified and as required.*

viii) Consumers Requiring Ash Water

- *Jet pumps for Bottom Ash & Coarse Ash Cleaning*
- *Intermittent demand for de-sludging, line flushing, jetting etc*
- *High pressure requirements at different points of Bottom ash hopper*
- *Continuous make up for seal trough & BA hopper*
- *Intermittent demand for seal trough flushing and Gate Housing Flushing.*
- *Continuous demand for refractory cooling*
- *Slurry sump make up*
- *Spray water at rotary drum conditioner cum unloader.*

All of the above requirements will normally be met by recycled ash water i.e. through HP/LP water/ Economizer pumps fed from Ash Water sump and the deficit will be met by make - up water.

ix) Consumers Requiring Clean & Clarified Water

- *Seal water for clinker grinder required during Bottom ash removal*
- *Cooling Water requirement for Fly Ash Conveying blowers/ compressors and Instrument Air Compressor & Fluid Couplings*
- *Seal water for ash slurry pumps and other different pumps and Mechanical Exhauster.*
- *Water for Wetting heads, air washer, FA Slurry /trench jetting, combined ash slurry make-up, combined ash slurry, sump agitation.*

All of the above requirements will be met from clarified water supply header (for Ash Handling system) & seal water pumps.

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3.9 Dry Fly Ash Storage Silos

- i) Storage silo for dry fly ash of capacity as per data sheet with adequate margins shall be provided. Storage silo shall be of flat/conical bottom type with the provision of air slides/fluidizing pads at the bottom. Storage silo shall be provided to store precipitator fly ash with adequate air space. This silo shall be used to collect dry fly ash for the purpose of sale. It shall have facilities for dry ash unloading into covered road tankers and conditioned fly ash in open road tankers.
- ii) Each dry fly ash storage silo shall be provided with following arrangement for unloading the fly ash.
 - Two retractable chutes along with rotary feeder for unloading the dry fly ash into closed road tankers at a rate specified in data sheet.
 - Two ash dust conditioner along with feeder for loading the conditioned ash into open road tankers at a rate specified in data sheet. It shall be possible to vary the water supply depending upon ash flow rate. However max moisture content in the ash shall be limited to 20%.
 - Two blanked connections along with isolation valves shall also be provided in the silo for future installation of pneumatic equipment for transportation of a dry ash to third party and for installation of equipment to slurry the dry ash to dispose off it through ash disposal system.
- iii) The storage silo shall be designed to provide clear headroom of 5.5 mt (from paved floor level to Bottom of Silo beam) for a road tanker to come under the silo and receive the ash from the retractable chutes.
To facilitate locating these chutes over the road tanker opening, it shall be possible to move the chute in all directions in the horizontal plane. It may be noted that unloading system from Silo shall be suitable for both closed tanker/open truck unloading as well as unloading on railway wagons. Silo layout and column location shall be suitable for accommodating two vehicles for simultaneous loading of ash. Clear headroom shall be sufficient for unloading of dry fly ash in railway wagon in future.
- iv) Each retractable chute shall include a shut off device at the silo outlet, a level probe to determine the level of ash within the road tanker, de-dusting and vent air systems, and a motor operated winch system to lower/raise the chute. Retractable chute/Dry ash unloader shall be sourced from reputed manufacturer(s), whose bulk loading spouts/retractable chutes have established field proveness. The unloading chute shall have vent fan with bag filter in suction connected to the tanker to take the displaced air and discharge in clean manner.

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- v) Each storage silo shall be provided with a separate and dedicated floor aeration system.
- vi) The silo aeration system shall be supplied by constant volume blowers. Any manifolds employed for air distribution in the aeration system shall be fitted with blank flanges at the manifold ends, to facilitate maintenance requirements.
- vii) Details of the pressure/vacuum relief valves provided in the storage silos shall be furnished along with the bid.
- viii) Vent filters shall be provided on the storage silos for cleaning the aeration and displaced air before venting out. The Bidders should provide either exhaust fans or to consider positive pressure in silo while selecting parameters of compressors to assist venting. Vent filters and fans shall be installed under cover, and the protected from all potential adverse weather conditions.
- ix) The dust loading from the outlet of the Vent filters shall not exceed 50 mg/Nm³ under any operating condition with 10 per cent bags plugged. Bidders shall justify the selected air to cloth ratio of the bag filters. The Bidders shall also supply details on how the air flow into and out of, the storage silos is balanced during different operating conditions.
- x) Gross Face velocity (considering 10% bag plugged condition) for Silo Vent Filter should never exceed 1.5 m/min.
- xi) All Silo Vent Filters shall be supplied complete with automatic pulse jet bag filter cleaning equipment, venting fan with all necessary instrumentation including diff. Pr gauge, diff pr switch, solenoid operated pulse valve.
- xii) Clean air plenum on Silo Vent Filter with clear man height shall be provided for easy access of bags for maintenance. Silo Vent Filter manhole shall have easy access through platform/stair etc.
- xiii) All Vent filters shall be supplied complete with the automatic Vent filter cleaning equipment, details of which shall be included with the tender.
- xiv) Any manifolds employed for air distribution in the aeration system shall be fitted with blank flanges at the manifold ends, to facilitate maintenance requirements.
- xv) Bidders shall ensure the provision of a proven dust collection system in the storage silo that separate out bulk of the ash from the conveying air before the air is extracted through the bag filters.

3.10 Instruments

Each silo shall be provided with following instruments as a minimum:

- i) Silo ash level transmitter 1 No.
- ii) Level switch with the telescopic chutes (meant for unloading into closed

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tankers): 1 No.

iii) Differential pressure gauge across the Vent filter: 1 No

iv) Differential pressure switch across the Vent filter: 1 No.

The bidder shall include any other instrument required to make the system safe, efficient and reliable.

3.11 Instrument Air Supply System

i) [...] numbers compressor [W+ S] for each units and one (1) common stand-by) , with [...] number of Air Drying Plant [...] working for [...] units, one (1) common stand-by and one (1) maintenance stand-by) will be installed in the Ash Handling Plant for supplying Instrument Air (I.A.) for different valve actuation purpose, bag filter cleaning, etc of the Ash handling system.

Necessary tapping with suitable isolation valve will be provided on this Ash Handling Plant's I.A. header at strategic location so that same can be interconnected with Main Plant I.A. header, if it is feasible to do so. The instrument air supply for remote location e.g. silo shall have suitable air receiver along with moisture separator aided with maintenance free auto drain trap.

3.12 Drain Pumping System

i) Drain Pit Sump Pumps shall be provided in bottom ash hopper area (drain pit located near Bottom Ash Hopper Area of each unit). Total four (4) numbers "Ejector" type pumps located inside individual pits and shall be motivated by HP Ash Water Pumps shall be provided for [...] units (one working and one stand by for each unit). The drain pit pumps shall pump the slurry back to the bottom ash overflow transfer sump of respective units.

ii) Vertical, centrifugal, single stage, semi-open or open and non-clogging type impeller drain pumps shall be provided in Slurry Sump Area, Vacuum Pump House and near ash silo area.

- In ash slurry sump area, total two (2) number drain pumps for [two units] (one working and one stand by) shall be provided.
- In ash silo area, total two no drain pumps for [two units] (one working and one stand by) shall be provided.
- In vacuum pump house area, total four no drain pumps for two units (one working and one stand by for each unit) shall be provided.]

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4 DESIGN CRITERIA

a) Overall design criteria for the system

Following aspects are to be given primary consideration in selecting the Ash Handling Plant

- i) Present system to be installed shall have capability of handling entire ash produced in [...] units during BMCR operation considering worst coal firing and with reasonable design margin of 5%.
- ii) Selection of system configurations with minimum consumption of water. Recovery of water to the best possible extent and minimum make up into the system is to be attempted. However, it may be noted that operation of the plant should not be affected in case there is no recovery water from ash dump area
- iii) Quality of effluent outgoing from the plant (if at all) shall conform to latest norms of Environment Pollution Control as detailed later under "Pollution Consideration"
- iv) While laying out the present phase of plant equipment it shall be borne in mind that there shall be provision for space for future extension
- v) Clinker Crusher, jet pump and other pumps & installation etc, if not specified otherwise will be on/above ground level
- vi) Design of the Ash Handling Plant shall be carried out considering 8 hrs shift ,100% PLF and following ash generation rates (% of total ash):
 - i) Bottom Ash and Economizer ash [...]%
 - ii) Fly Ash and Air Pre-Heater ash [...]%
- vii) Bulk Density of ash & other general design guidelines & standard equipment sizing criteria may be considered as follows:

S.No	Detail	Value
A	Density	
i)	Bottom Ash for Volume Sizing	[650] kg/m ³
ii)	Bottom Ash for Strength Computation	[1600] kg/m ³
iii)	Fly Ash for ESP/APH/Economizer hopper volume and hopper outlet area computation as well as volume for intermediate surge hopper.	[750] kg/m ³
iv)	Fly Ash for Silo Volume Computation	[450] kg/m ³

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S.No	Detail	Value
v)	Fly Ash for Strength Computation	[1600] kg/m ³
B	Ash Concentration	
i)	Concentration of Bottom Ash slurry	[30]% (w/w)
ii)	Concentration of Fly Ash slurry	[30]% (w/w)
iii)	Concentration of Combined Bottom and Fly Ash Slurry	[25]%
C	Velocity Considered in Pipes for Various Duties	
i)	Maximum Velocity in Air & Water Lines shall be as indicated in other relevant BOP packages suiting the service requirement.	[...]
ii)	Minimum/ Maximum Velocity in Bottom Ash Slurry Lines	2.3/2.8 m/sec
iii)	Minimum/ Maximum Velocity in Fly Ash Slurry Lines	1.8/2.8 m/sec.
iv)	Combined Ash Slurry (Minimum/ Maximum)	2.3/ 2.8 m/sec
v)	Tip Speed for Ash Disposal Pump (Max)	1676 m/min
vi)	Ash Disposal Pump Speed to be limited to	1000 rpm
D	Friction factor ' C ' to be considered:	
i)	Friction factor ' C ' for Ash Slurry Lines	140
ii)	Friction factor ' C ' for Sludge Lines	130
iii)	Friction factor ' C ' for Recovery Water Lines	110
iv)	Friction factor ' C ' for Bottom Ash Over Flow Lines	120
v)	Friction factor ' C ' for Water Lines (as per relevant package)	110

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S.No	Detail	Value
E	Basis for selection of capacities of various tanks/sumps - (effective maximum pumping capacity)	
i)	Bottom Ash Over Flow Tank	for 10 minutes
ii)	Slurry Sump (each compartment)	for 5 minutes
iii)	Ash Water Tank	for 30 minutes

b) Other Design Considerations

Ash handling plant shall be designed considering ash generated at 100% PLF with worst coal firing with minimum removal rate as specified corresponding sections.

A margin of 10 % shall be built up on the actual pump capacity and head (considering Hazen-William) for selection of all types of pumps parameters.

A margin of 5% to be considered on the actual friction drop for arriving at ash slurry disposal pump head (considering Hazen-William)

A margin of 15% shall be considered on selection of motor rating over and above the maximum requirement of driven equipment in entire operating range if not specified otherwise. For slurry pumps and other variable speed driven equipment motor rating shall be more than equipment power requirement at maximum speed of the speed variation in addition to satisfying the above.

Data to be considered for design of clarifier for bottom ash overflow water and ash recovery water:

- i) Minimum particle size of ash in bottom ash overflow water to settler: 30 microns
- ii) Suspended solids in bottom ash overflow water to settler: Min TSS to be considered 1000 ppm. TSS after settler shall be maximum 100 ppm.

c) Pollution Considerations

- i) Liquid Effluent: For liquid effluent generated (if at all) in the Ash Handling Plant, the provisions of MINAS (Minimum National Standard) - COINDS/21/1986 is followed before discharging water to the recipient environment. In case there is any specific requirement of the state pollution authorities over & above MINAS stipulations, the same shall be taken care of in the Effluent Treatment Plant.

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- ii) Thermal Pollution: The system design is such that a large surface area (provided in the Ash Dump) shall adequately cool the recovery water. Besides, it will be noted that there is, as such, no direct discharge of water to the recipient environment without treatment. Therefore, the stipulations of thermal pollution shall be met.
- iii) Particulate Emission: Vent filters, Air scrubbers shall be provided at logistic locations to arrest any sort of particulate emission in the ambient to restrict the SPM within permissible limit.
- iv) Noise Pollution: Average evaluated sound pressure levels shall be within 85 dB (A) measured at a distance of one (1) meter. from the equipment concerned as per Noise Rating Curve ISO 85.

d) Fly Ash Handling System

It is contemplated to convey the fly ash from respective fly ash hoppers (ESP & Air Pre-heater) up to the Intermediate Surge Hopper (ISH) by pneumatic vacuum system in the first stage conveyance of fly ash. EPC Bidder shall keep the bottom level of ESP hopper adequately high to enable small truck movement for ash collection in emergency.

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5 EQUIPMENT AND SYSTEM DATA SHEET

5.1 Water Impounded Bottom Ash Hopper & Economizer Ash Tank

S.No	Detail	Description
1	Maximum water level in bottom ash hopper	<i>As per Bottom ash Hopper seal plate assembly</i>
2	Maximum allowable ash level in Bottom ash hopper	<i>600 mm below the maximum water level.</i>
3	Hopper Body	<i>Tested quality mild steel plates of thickness not less than 10mm (IS 2062) except top 1100 mm of hopper including seal trough shall be constructed of 6mm thick SS 316. The entire inner BA Hopper walls shall be lined with monolithic castable refractory of minimum 230 mm thickness.</i>
4	Refractory anchors	<i>Stainless steel, AISI:316</i>
5	Sluicing/Arch Breaking/wash nozzles	<i>Body: SS Nozzle tip: tool steel or SS of hardness not less than 550 BHN or SS with ceramic inserts</i>
6	Refractory Cooling water header inserted in refractory	<i>Stainless steel</i>
7	Seal trough	<i>Stainless steel SS: 316, Seal trough of the bottom ash hopper should be integral construction. It shall be sized to maintain clearance between the seal plate and the trough during any vertical downward, side to side & front to rear expansion of boiler.</i>
8	Refractory	<i>Castable refractory of minimum 230 mm thickness. Protection measures such as embedded impact bars shall be provided to prevent damage to refractory in area of clinker impact.</i>
9	Temp. of Bottom Ash	<i>[...] °C</i>
10	Minimum effective ash storage capacity	<i>8 hours (Bottom Ash + Economizer Ash)</i>

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S.No	Detail	Description
11	Minimum angle between hopper wall & horizontal	45 Deg. (Approx.)

- i) No pits in the boiler bottom are allowed to accommodate bottom ash handling equipment.
- ii) Thermal shock of exposed refractory to be prevented. A cooling water distribution header with deflection shield shall be provided all round the top of ash hopper, for cooling the portion of refractory all round the top of ash hopper.
- iii) To assist in the hopper emptying process, flushing nozzles shall be provided in the inclined section of the hopper walls.
- iv) The areas of hopper subjected to severe abrasion & erosion shall be suitably protected by wear plates. The protection is mandatory requirement for outlet opening of BA hopper.
- v) Each hopper section shall include a hinged access door. Circular doors shall have a diameter or not less than 750 mm, rectangular access doors shall have dimensions of at least 900 x 600 mm. Each hopper section shall also be provided with two (2) nos. 150 mm size inspection windows for viewing both the slopes.
- vi) The seal trough shall incorporate an overflow system, make-up system, drainage system and high pressure water nozzles to facilitate complete flushing of the seal trough.

5.2 Bottom Ash Hopper Discharge Gate

S.No	Detail	Description
1	Quantity / Nos.	[...]
2	Opening Size	Minimum [... x ...] mm
3	Drive of Feed Gate	Hydro-pneumatic, to ensure smooth & guided opening / closing to limit friction & wear.
4	Inclination of feed gate	Same as that of BA hopper.
5	Wear protection liners	Shall be provided on gates inside of gate housing & sliding surface coming in contact with gate.
6	Accessories of Ash gate housing	Yes/No

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S.No	Detail	Description
7	Access door	600 mm diameter (min)
8	Lancing or Poke Door	Yes/No
9	Venting System	Yes/No
10	Flusing nozzles on either side of feed gate	Yes/No
11	Flushing & drain connections along with valves for sump of ash gate housing.	Yes/No
12	Material of Construction	
	Gates	Cast Iron IS: 210, Gr. FG-260.
	Gate wear liners	6mm thick SS:316/SS:410
	Gate spindle	SS
	Housing wear plates / impingement plates	25 mm thick Alloy Cast Iron IS:210, Gr.FG-260.
	Housing	10 mm thick (min.) Mild Steel IS: 2062.

5.3

Jet Pumps

S.No	Detail	Description
1	Quantity	[...]
2	Rated capacity (M3/hr)	[...]
3	Material of Construction	
	Inlet section, throat & discharge/tail piece	Alloy cast iron as per IS: 4771 type 1(a) min. 4.5% Nickel with min. hardness of 500 BHN or equivalent material with same hardness.
	Nozzle inlet	CI Grade FG-260 as per IS 210
	Nozzle tip	Ceramic lined stainless steel/tungsten carbide. Min 500

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S.No	Detail	Description
		BHN

5.4 Clinker Grinder/Ash Crusher

S.No	Detail	Description
1	Function	To reduce bottom ash clinkers to (-) 25mm to facilitate pumping through the proposed slurry pipe lines.
2	Location	[...]
3	Crushing Capacity	[...]
4	Grinder speed	Not to exceed 40 RPM
5	Bearing of clinker grinder	Grease lubricated, heavy duty roller bearings. Clear water sealing to be provided at gland seals
6	Type	Single or double roll: Rolls shall be suitable for auto reverse rotation also in the event of jamming.
7	Drive Arrangement	Electric reversible drive motor, fluid coupling and gear box. Drive motor speed not to exceed 1000 rpm & shall be sized for frequent start stop-reverse-stop & start duty.
8	Wear plates	Wear plates shall be provided on clinker grinder inlet and other wearing surfaces of the grinder chamber.
9	Base Frame	Common steel fabricated base frame for grinder motor and drive shall be furnished.
10	Material of Construction	
	Grinder Chamber	Carbon steel (IS: 2062) min 10mm thick.
	Wear Plates	12-14% Mn. Austenitic steel plates to IS: 276. 10mm thick.
	Grinder Rolls & teeth	Hadfield's Manganese steel (ASTM A128, 12-14% Mn) casting, work hardened to 400 BHN at site/High chromium alloy CI. Grinder teeth shall

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S.No	Detail	Description
		be weld able.
	Grinder Shaft	Stainless Steel 304/ EN-24.
	Shaft Sleeve	Hardened stainless steel 410/416.
	Clinker outlet chute/Ejector feed sump	10mm thick mild steel (IS: 2062) lined with wear resistant liners.

5.5 Air / Oil Converter Tank

Shall be designed as per ASME Section-VIII Pressure Vessel Code/Other equivalent standards; this steel pressure vessel shall be galvanized inside & outside along with all protuberances; Corrosion allowance of minimum one (1) mm; fitted with relief valve, drain valve; all air & water/oil pipe works with four way double coil center off type Solenoid Valves, isolation valves, pressure hoses etc. Solenoid valve shall have manual override and entire arrangement shall ensure keeping feed gate at intermediate position if required.

5.6 Bottom Ash Hopper Cooling Water Overflow Tank

S.No	Detail	Description
1	Effective storage capacity	Minimum (10) minutes of bottom ash hopper overflow.
2	Tank	Shall be of self supporting type or underground sump.
3	Material of Construction	Tested quality mild steel plates of thickness not less than 10mm (IS: 2062) and suitably stiffened with rolled steel sections. Or underground RCC sump

5.7 Flushing Boxes

- i) One Flushing Box of suitable capacity for each BA Hopper shall be designed for effectively discharging of the ash
- ii) The flushing boxes shall be provided with jetting nozzles at strategic points.
- iii) The flushing boxes shall be installed under each Economiser hoppers also. The temperature of ash in economizer ash hoppers is 350°C (approx) and BA Hoppers will be 1050°C (approx).

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- iv) The design shall ensure a water seal against atmospheric air leakage into economizer ash hoppers at the time of ash removal.
- v) The material of construction of various parts shall be as follows:

S.No	Detail	Description
1	Body	10 mm thick M.S to IS:2062
2	Liners	8 mm thick replaceable stainless steel SS-410 liners of hardness 400 BHN on complete base area and impingement area of the wall
3	Nozzles	Body : Cast Iron/Mild Steel Tip: Anti corrosive tool steel/ stainless steel/SS with ceramic inserts hardness not less than 550 BHN
4	No. of nozzles per flushing apparatus	[...]

5.8 Expansion Joints For Economizer Hoppers

- i) The expansion joints shall be of water seal type construction to accommodate the thermal expansions of economizer hoppers
- ii) Approximately 350 mm sealing shall be provided to prevent ingress of air into economizer hoppers
- iii) Necessary make up water and drain connections shall be provided in the expansion joints
- iv) The material of construction of the body of the expansion joint shall be 10 mm thick MS to IS: 2062

5.9 Fly Ash Collection Chute/ Hopper Isolation Valves (Knife Gate)

- i) Body : Cast Iron FG 260 hardened to 180-200 BHN.
- ii) Gate: 10mm thick MS with minimum 35 microns of hard chrome on both sides/ SS with stellite to achieve hardness of 300-350 BHN.
- iii) Seat: Replaceable stainless steel hardened & smooth finished (250 BHN minimum)
- iv) Body & seat hydro-test pressure 6 kg/ sq cm or 2 times the working pressure, whichever is higher

5.10 Fly Ash Intake Valves

- i) The design shall be such that the isolation disc shall be completely out of the

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path of the high velocity air stream of the conveying system. Valve body should be provided with hand hole & easily removable cover for inspection. Dust seals & renewable bushings are to be provided for the operating shaft of the valve. Valve shall be positive closure type & shall immediately close if there should be a failure of operating air.

- ii) For special fluidizing type ash intake valves (for 1st & 2nd field ESP hoppers) the same shall be fitted with fluidizing arrangements & manual poke rods to assist breaking any possible arch formation. The valve body & seat shall be of alloyed wear resistant material having at least 350 BHN Hardness.

S.No	Detail	Description	
1		Ash Feed Valves	Branch Isolation Valve
2	Type and Quantity	Swing/slide plate type for Vacuum system, Plate type/ butterfly / dome / cone type for Pressure system.	
3	Mode of actuation	Solenoid operated pneumatically actuated with provision of manual override facility.	
4	Body	Alloy Cast Iron to Gr. Fg 260, with hardness of 250 BHN (Min.) & properties equivalent to Gr. FG 260 to IS:210	
5	Plate/Disc	10 mm thick SS with 300-350 BHN hardness for plate	Min 3 mm thick stainless steel with 300-350 BHN hardness
6	Seat	Seat replaceable or SS smooth finish with 250BHN (Min)	

5.11 Vacuum Breaker

- i) Vacuum breaker shall be employed to open automatically at the end of fly ash handling operation, to prevent any residual vacuum prevailing in the ash transport pipeline. In case of emergency line vacuum rising to shut off the vacuum breaker shall be opened beyond a tolerable limit as per control logic. The vacuum breaker shall be mounted on the pneumatic ash transport line.
- ii) The vacuum breaker shall be of slide plate type or popup type with automatic operation by pneumatic cylinder and piston assembly with solenoid valve. The body shall be made of Alloy Cast Iron with a hardness of 250 BHN (min.) and the plate be min. 3 mm thick SS 304/410.

5.12 Air Intake Valves

- i) The air intake valves shall be spring loaded or check type and be

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provided/mounted on fly ash branch pipe (in case of vacuum extraction system) for air entry as may be required for necessary assistance to ensure the ash extraction.

- ii) The exact number and size shall be as per system requirement. The valve body shall be made of Cast Iron (CI FG220)/Gun Metal/Cast Steel and disc shall be constructed of SS-410 or Gun Metal. All air intake valves shall be provided with suitable rain-hood protection.

5.13 Ash Transporter/Air Lock/Pump Tank

- i) The vessel shall be designed for not more than one lakh cycles of operation annually for the specified ash evacuation rate.
- ii) Ash transporter /air locks/pump tanks shall be provided with necessary inlet and outlet valves of the type specified elsewhere in the specification.
- iii) The ash transporter /air locks/pump tanks vessel shall be constructed with tested quality mild steel plates as per IS:2062. They shall be able to withstand the abrasive action and hot condition of fly ash. The Ash transporter /Air locks/pump tanks shall be supported independently on steel columns or hanger support.
- iv) A full explanation to the air lock/pump tank operation cycle shall be supplied with the tender, listing all operations i.e. loading, fluidizing, and discharging. Calculation justifying size of venting connection is to be provided by Bidder.
- v) Aeration pads, if felt necessary by the bidder to assist the flow of ash through the air-lock valves shall be provided.

S.No	Detail	Description
1	Design pressure	1.5 times the design pressure of associated Air Blower/ Compressor or 2 times the operating pressure whichever is higher. Design calculations shall be submitted for Owner's approval
2	Material of construction	Tested quality IS:2062
3	Nos. provided	One working set and one standby set for each Combination filter Separator cum buffer hopper.
4	Aeration pads	As per requirement (Ceramic tiles/ sintered bronze/woven SS mesh)

5.14 Intermediate Surge Hoppers

- i) Fly ash from the various collection chutes/hoppers shall be conveyed to bag filter cum buffer hopper. Aeration pads shall be provided in the bottom sloping portion of ISH to prevent compaction and to fluidize the fly ash

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during discharge from the ISH. ISH are to discharge the fly ash extracted from various fly ash collection chutes to pressure transporter system.

- ii) Each Buffer Hopper should be provided with a Vacuum/pressure relief Valve. Pressure relief to atmosphere from the buffer/surge hoppers shall be through vent filter. Intermediate Surge hopper shall have provision of emergency manual unloading of ash.

S.No	Detail	Description
1	Number	[...]
2	Material of construction	10 mm thick MS plate as per IS 2062 or RCC construction with 20mm thick abrasion resistant alloy C.I or 10mm thick SS liner of 300 – 350 BHN at sloping surface and outlet area.
3	Discharge	[...]
4	Aeration pads	As per requirement (Ceramic tiles/sintered bronze/woven SS mesh)
5	Vent/ equalizing valve	Yes/No
6	Capacity	[...]

5.15 Wetting Heads

- i) Adequately sized wetting head shall be provided above collecting channel for wetting the dry fly ash and separating it from conveying air. The wetting head shall be provided with a water supply of sufficient quantity and pressure for feeding the nozzles that will produce spray of water, ensuring rapid wetting of the incoming ash. Nozzles shall be so directed as to prevent spray from entering the ash discharge pipe.
- ii) The bidder shall provide sufficient length of discharge pipe below the wetting unit to collecting channel to ensure proper mixing of ash with water.
- iii) Wetting head shall be compact in design and provisions shall be made for easy replacement of nozzles. Flanged connections shall be provided for all inlet and outlet connections of the wetting head with suitable hand holes.

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S.No	Detail	Description
1	Purpose	For wetting the dry fly ash using water spray to convert into slurry.
2	Quantity	To match with vacuum extraction stream
3	Fluid to be handled	Ash and water mixture and air
Material of Construction		
4	Casing	2.5% Ni-CI 300 BHN (min.)
5	Nozzle	Replaceable anti-corrosion tool steel or stainless steel 500-550 BHN or of SS with ceramic inserts.
6	Water chamber	CI grade:FG260 to IS:210
7	Tail pipe to collect tank	Alloy CI; 400 BHN
8	Inlet Liner	Alloy CI 450 BHN

5.16 Collecting channels

The collecting channel shall be located below the wetting heads and serve the purpose to separate and vent out air and discharging the ash slurry to the ash disposal sump by HP Water through pipe lines. In case of vacuum system this will also serve the purpose of separating and venting out the entrapped air discharged by wetting head and before discharging the entrapped air into atmosphere, it shall be passed through an air washer to achieve a sustained outlet dust emission of 50 mg/Nm³ (Max.) at exhaustor discharge with the ash handling system operating at designed capacity. The dust emission figure shall be guaranteed.

- The collecting channel shall be located at an elevation which will provide sufficient static head to overcome frictional and other losses in the wet ash flow discharge line up to ash slurry sump and to prevent entry of water upward from seal box.
- For maintenance purposes suitable stair case, maintenance platform, walkway with handrails at necessary levels shall be provided.
- The sizing of collecting channel, inlet/outlet connections etc. shall be corresponding to the maximum anticipated discharge flow requirements. The

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collecting channel shall be complete with drain, overflow and vent pipe connections along with pipes and requisite size and lengths.

S.No	Detail	Description
1	Location	Below wetting head
2	Material of construction	
a.	Tank	Tested quality MS 10mm thick IS:2062, Gr-A
b.	Baffle	Tested quality MS 12mm thick IS:2062, Gr-A
c.	Liners / Impingement plate	Alloy CI (300 – 350 BHN) 20mm thick (min.)Or SAILHARD/TISCRAAL 10 thk 400 BHN
d.	Quantity	To suit no. of vacuum streams

5.17 Air Scrubber (Washer)

These shall be of steel construction and the location of air entry & discharge flanges shall be such that the air receives the nozzle spray thereby eliminating any dry fly ash to escape to the mechanical exhaust inlet. The quenched fly ash in the form of lean slurry shall be led to a seal pot with vacuum leg. The design of air scrubber shall ensure negligible amount of mist and dry ash carryover with the outlet air. The sizing of air scrubber shall be based on particle size of twenty (20) micron & below and for FA Stream Capacity.

The air scrubbers shall be located at a higher level with respect to collecting channel. The seal pots of each unit will be located at an elevation such that a vacuum leg of adequate length is arrived at and simultaneously the seal pot discharge water pipes can be run in an overhead pipe rack and led to the Slurry sump in sloped gravity flow fashion aided by jetting nozzles.

5.18 Bag Filters

- The bag filter units, one at the end of every vacuum conveying FA stream and on each FA silos with 1 working and 1 standby shall be provided.
- Gross Face velocity (considering 10% bag plugged condition) for bag filter should never exceed 1m/min.
- The performance of the bag filter shall not get affected with 10% of the

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bags plugged. The material of bag shall be capable of continuous exposure of temperature 150°C min and momentary contact 170°C.

- iv) The bag filter unit shall be designed to achieve as sustained outlet dust emission less than 50 mg/Nm³
- v) All bag filters shall be supplied complete with automatic pulse jet bag filter cleaning equipment with all necessary instrumentation including diff. Pr gauge, diff pr switch, solenoid operated pulse valve.
- vi) Clean air plenum on bag filter with clear man height shall be provided for easy access of bags for maintenance. Bag filter manhole shall have easy access through platform/stair etc.

5.19 Drive Motor

- i) Drive motor shall be connected to the Air Compressors directly or through any suitable type of power transmission system.
- ii) The continuous motor rating (at 50°C ambient) shall be at least ten percent (10%) above the maximum load demand of the compressor in the entire operating range to take care of the system frequency variation. Total maximum load demand shall include air compression power plus any power consumed in auxiliaries like cooling fan etc. When the driver is not directly coupled to the compressor, due account shall be made for losses in power transmission in addition to the above 10% extra margin.
- iii) The bidder shall include all instruments required to make the system safe, efficient and reliable.

5.20 Transport Air Compressor

- i) Air compressors shall be designed for continuous operation with high efficiency to satisfy the system requirements. Satisfactory operation in parallel shall be ensured without any uneven load sharing, undue vibration, noise etc.
- ii) The design shall incorporate every reasonable precaution for the safety of all operation and maintenance personnel. Each compressor unit should have all moving parts protected by a guard.
- iii) The scope of supply shall include all the necessary compressed air system complete with compressors, coolers, necessary isolating and non return valves, pressure relief valve, water separators, silencers and vent pipe work.
- iv) In order to have flexibility in operation the compressor discharge shall be interconnected with suitable valve arrangement.

S. No	Description	Details
1	Location & Type	Indoor, Screw Type compressor/ Twin Lobe Blower

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S. No	Description	Details
2	Number:	[...]
3	Applicable Codes	BS:1571(Part I & II), IS:6206, IS:5727, ASME power test code PTC 9., IS 5456 , ISO 1217
4	FAD of each set of working compressors at ambient conditions	Sufficient to meet the ash removal @[...] TPH. At least 10% margin shall be provided on compressor capacity over and above the maximum flow requirement. For each [...] MW unit, each compressor capacity shall be suitably balanced with corresponding vacuum conveying capacity with margin as stated above.
5	Design conditions	500 °C & 100 % RH
6	Site ambient conditions	[...]
7	Type of lubrication	Oil
8	Type of cooling	Air/water [for water cooling - DM close cycle cooling water system to be employed, Type of water-passivated DM water]
9	Duty	Continuous
10	Type of intake filter	Dry type
11	Dryness of air	Air temperature to be maintained above the dew point throughout the conveying process till silo.

5.21 Fluidizing Air Blowers

- The blowers shall be oil lubricated and preferably air cooled.
- The Blowers shall be constant volume/positive displacement type and each blower shall be provided with suction filters, pressure relief valves with the corresponding vent pipe work, necessary isolating and non-return valves, inlet and/or outlet silencer so that blower unit can comply with the noise

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level requirements and all other accessories of drive and mounting for ESP and buffer hoppers.

- iii) Necessary heating arrangement with a suitable bypass shall be provided at the discharge of the blowers to raise the temperature of aeration air to a temperature of at least 150°C. Schemes shall also include for thermal insulation of all air pipe work from the blower/heater outlet to the point of contact of fly ash.
- iv) All air blowers and their drives shall be completely interchangeable.

S.No	Detail	Description
1	Purpose	For fluidizing the ash in intermediate surge hopper, ESP hoppers, and ash silo.
2	Quantity	[...]
3	Design	[...]
4	Duty	[...]
Design condition : 50°C and 90% RH		
Material of Construction		
5	Casing	CI Gr. 260 to IS:210
6	Shaft	EN 8
7	Rotors	CI Gr. 260 to IS:210
8	Piping	MS ERW as per IS 1239/3589, insulated to limit surface temperature to 600C.
9	Following Instruments shall be provided	
	Pressure gauge at the blower outlet	1 No.
	Pressure switch at the blower outlet	1 No.

5.22 Fluidizing Air Heater

S.No	Detail	Description
1	Application	Hopper (ESP/ Buffer Hopper / Silo) Fluidizing Air Heating
2	Working Atmosphere	Heavily dusty, tropical, power plant atmosphere.
3	Design ambient dry bulb Temperature	45 °C

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S.No	Detail	Description
4	Whether exposed to direct rain and sun	[...]
5	Type	Electrical, (heating elements shall be segregated into two banks).
6	Quantity Required	[...]
7	Rate of Air Flow	[...]
8	Air Pressure	[...]
9	Inlet Air Temperature for design purpose	Outlet temperature of Blower considering minimum ambient temperature specified at blower inlet.
10	Design Outlet Air Temperature	To suit system requirement to maintain the discharge temperature of the air at least 50°C above the water vapor dew point but not less than 150°C.
11	Type of Duty	[...]
12	Supply Details	[...]
13	Air Heater Load Condition	Balanced three (3) Phase
14	Insulation between heating element body and supporting plate	Secondary Insulation Bushing
15	Temperature indicator	
a)	Type	Bimetallic type/ equivalent
b)	Size	150 mm dial
c)	Range	To Suit duty Condition.
d)	Quantity required for each air heater	[...]
16	Temperature Switch	To be provided for each heater where number of heaters working is more than one.
a)	Type	Bidder to indicate for approval

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S.No	Detail	Description
b)	Contact rating	3 amps. at 240V A.C
c)	Suitable for cutting off heating element individually	Yes/No
d)	Quantity Required	[...]
e)	Range	To Suit duty condition
17	Temperature Element	
a)	Type & Make	[...]
b)	Range	[...]
c)	Quantity required for each Air Heater	[...]
18	Indicating Lamp	
a)	Quantity Required	[...]
b)	Location	Integral with the body of heater
c)	Indication	Heater 'ON' / 'OFF'
19	The bidder shall include any other instrument required to make the system safe, efficient and reliable.	
20	Terminal Box	
a)	Location	Bidder to indicate
b)	Withstand capability for fault level	50 KA (each) at 415 V unless specified otherwise
c)	Power Cable details	To be furnished during order finalization
21	Earthing	
a)	Type	Bolted Type
b)	Locations	Two (2) nos. on opposite side of the base of Air Heater Assembly One (1) no. on terminal box.
c)	Details of Earthing Conductor	8 SWG Galvanized Iron Wire
22	Whether cable gland and lugs are	Yes

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S.No	Detail	Description
	in scope of supply	
23	Mounting bracket included in scope of supply	Yes
24	Testing	
a)	Hydraulic Test Pressure of shell	5.0 kg/cm ² g
b)	Air leak test pressure of assembly	1.5 kg/cm ² g
25	Thermal Insulation	At the heater internal and external surfaces - such that the external cladding temperature is not exceeding 60 Deg. C. Insulation (mineral wool) material density during application not less than 150 Kg/ Cu. m

5.23 Vacuum Pumps For Fly Ash Extraction

- Vacuum pumps shall be sized to meet evacuation criteria as indicated in accompanying data sheet. A minimum margin of 10% over the above capacity shall be considered for sizing of the vacuum pumps.
- The design shall also take into account the possibility of vacuum pumps sucking in the gas containing SO₂ and SO₃
- Silencers shall be provided so that each vacuum pump complies with the noise level limits stipulated by statutory authority. Moisture Separator shall be provided to separate liquid and air and to reduce noise.

S. No	Detail	Description
1	Type	[...]
2	Total Numbers (Working and standby)	[...]
3	Design condition	Vacuum pump shall be sized for 600°C gas temperature and 340 °C seal water temperature with gas as 100% dry basis. However motor capacity shall be suitable to handle same capacity of air at 200 °C
4	Guaranteed figure	[...]

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S. No	Detail	Description
5	Sizing of vacuum pumps	To cater to the ash removal rates as specified. A minimum margin of 10% over the above capacity shall be considered for sizing the vacuum pumps. In case the first field of ESP goes out of service, the second field shall collect the ash of first field and so on. The design shall take care of this aspect.
6	Material of Construction	
	Casing with cones/ Port Plates	Ni Cast Iron (min 2.0% Ni)
	Shaft	Carbon Steel EN8
	Impeller	Stainless Steel
	Shaft Sleeves	Stainless Steel
	Type of coupling between Pump & Motor	V Belt drives along with belt-guards.
	Accessories	Necessary moisture separator and silencer, Vibration isolation pad, Vacuum breaker, Acoustic enclosure if applicable.
	Location, Duty	Indoor, Continuous.
	Inlet seal water temperature	34 ° C
	Noise level	85 dB (max) at a distance of 1M from equipment

5.24 Instrument Air Compressors and Drives

- Each compressor unit should have all moving parts protected by a guard.
- The scope of supply shall include all the necessary compressed air plant complete with compressor coolers, necessary isolating and non-return valves, pressure relief valve, water separators, silencers and vent pipe work.
- Water separators shall be complete with automatic drain traps. Each separator shall be rated for twice the individual compressor flow at 1 bar above maximum operation pressure. Each water separator shall have flanged connections.
- The wall thickness of the cylinders shall be sufficient to withstand the

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maximum cylinder pressure and to permit successive re-boring without hazard.

- v) [Cooling water requirement (for water cooling - DM close cycle cooling water system to be employed, Type of water- passivated DM water) if any, should be furnished by bidder. The cooling water supply shall be given by the Owner at one mutually agreed point only].

S.No	Detail	Description
1	Type of Compressor	Oil Free Screw Compressor
2	Duty	Continuous
3	Location	[....]
4	Qty	[....]
5	Design Ambient Temperature	50 °C, 100% RH
6	Design Requirement	Instrument quality air as per Instrument Society of America Standards 7.34 to meet the requirements of instruments, valves, actuators, bag filter cleaning etc. A 10% margin shall be provided on compressor capacity over and above the maximum flow requirement.
7	Drive	Electric Motor(Six(6) starts per hour)
8	Drive motor rating	The continuous motor rating (at 50°C) shall be at least ten per cent (10%) above the maximum load demand of the compressor in the entire operating range to take care of the system frequency variation. Total maximum load demand shall include air compression power plus any power consumed in auxiliaries like cooling fan etc. When the driver is not directly coupled to the compressor, due account shall be made for losses in power transmission in addition to the above 10% extra margin
9	Annunciation	Local/Remote as required
10	Discharge Pressure	8 Kg/sq.cm or based on detailed calculations (whichever is higher)
TESTING AND INSPECTION		

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S.No	Detail	Description
	Hydrostatic Tests	Yes
	Spot Radiography of Welds	Yes
	Bend Test for receivers (as per BS-5169)	Yes
	Performance tests at Full load; full discharge pressure; and full RPM as per BS-1571, Part-2 or equivalent.	Yes
	Type test for motor	Yes

5.25 Air Receivers

- i) Air receiver of ample size shall be provided, so that delivered air pressure is kept within $\pm 5\%$ of rated pressure without excessive start/stop operation in the working cycle and shall cater to plant instrument air requirement, in case compressor trips.
- ii) Air receivers shall be located convenient to compressor discharge. The receivers and associated fittings shall comply with BS: 5169 and BS: 1123 or other approved standards. Manufacturing of Air Receiver for Instrument Air Compressor Will Be As Per Class-II.
- iii) The receivers shall each be supplied complete with test certificate, safety relief valve, pressure gauge, flanged inlet and outlet connections, inspection manhole (in accordance with BS: 5169-1975, or similar national/international equivalent), screwed drain connection, automatic drain trap with balance line, drain trap isolating valve, isolating valve and manual drain valve, nameplate, support frame or legs, and a set of suitable foundation bolts.
- iv) As far as possible the design, manufacture and performance of air receivers shall be in accordance with the following latest applicable standards :
 - IS: 2825 - Code for unfired pressure vessels.
 - ASME-Sec. VIII Div.-1 Code for unfired pressure vessels.
 - BS: 487 - Fusion welded steel air receivers.
 - IS: 7938 - Air receivers for compressed air installations. \

5.26 Air Drying Plants (desiccant type)

- i) General Performance Requirements
 - The air drying plants receiving compressed air saturated with moisture shall be capable of operating continuously to provide reliable moisture free compressed air. Dew point of the outlet air shall be as mentioned in the Data Specification Sheet or lower throughout the operation.
 - The delivered compressed air shall not contain any trace of oil, grease or any other impurities and air shall be free from all corrosive

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contaminants and hazardous gases, flammable or toxic. Size of particles in the delivered air shall not exceed one (1) Micron. The delivered air shall be 100% oil free.

- For calculating moisture load, relative humidity and dry bulb temperature at air drying plant (ADP) inlet shall be taken as 100% and 50 °C respectively.
- For the capacity and air flow rate through drier, the data specification sheet shall be referred to.
- Air drying plant shall be complete with pre and after filter including all piping, valves, instruments and other, accessories as required for safe and satisfactory operation of the plant.
- Driers shall be suitable for part load operation while maintaining the outlet air dew point as specified above. Necessary instruments and controls shall be provided to ensure that the specified dew point is maintained irrespective of input variations.
- The Bidder shall assume full responsibility in the operation of the air drying plant as a whole.

S.No	Detail	Description
1	General Information	
a)	Installation	Indoor, Skid-mounted
b)	Duty	Continuous
c)	Quantity required	Three (3) Numbers [One with each Instrument Air Compressor]
d)	Type of Drying	Desiccant Type
e)	Service	Instrument Air
f)	Annunciation	Audio Visual
2	Performance Specification	
a)	Capacity	Same as each Instrument Air Compressor
b)	Inlet Air Pressure	To suit compressor rating

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S.No	Detail	Description
c)	Outlet dew point at 1 ata	(-) 20 °C
d)	Maximum allowable air pressure drop	0.2 kg/sq.cm
3	Quality of Instrument Air	
a)	Dust Particle size	Less than one (1) micron
b)	Oil Content	100 % oil free

5.27 Ash Transportation Lines

- i) The capacity of transport air compressors shall be decided to match the capacity of extraction system i.e. the capacity of extraction and transportation system shall be similar.
- ii) The bidder shall furnish detailed calculations of compressor sizing along with the bid.
- iii) Each compressor shall have an inlet filter of dry type to protect the compressor. The filter inlet area should be large enough to ensure frequent filter changes are not required.
- iv) Cooling water requirement, if any, should be furnished along with the bids. The cooling water supply shall be given by the Owner at one point only.
- v) Bidder shall include an inlet and/or outlet silencer so that each compressor unit complies with the noise requirements outlined in Specification.

5.28 Pneumatic Ash Conveying Pipe Line

Parameters	Details
Pipe size (I.D.)	As required.
Type of Pipes for vacuum conveying	Class-D cast iron pipes centrifugally cast conforming to IS: 1536 or BS: 1211. Pipes of non standard size without conforming ARE/BS will not be accepted.
Type of Joints	

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Parameters	Details
Pipe to Pipe, Pipe to Fitting, Pipe to valve & valve to Fitting, Fitting to Fitting,	Flanged/sleeve coupling/bevel
Fittings (Bends, elbows laterals and spool piece etc.)	Ni-hard/chrome-alloy cast iron or equivalent. Minimum hardness 450 BHN and wear back thickness minimum 20 mm. For slurry line MS fittings with 20mm basalt lining is also acceptable. For basalt line fittings a pipe spool of one meter long having basalt lined at discharge end of bend/ elbow shall be provided. For impact bend a short spool of alloy CI shall be provided adjacent to fitting at discharge end.
Sleeve Couplings	
Material of Construction	
Sleeve	9.0 mm thick carbon steel ASTM-36/CI FG 260:IS:210
Flanges/End rings	Carbon steel to ASTM –A-108/Cast IRON FG-260, IS:210
Gasket	To suit ash temperature
Material	Nitrile (NBR) BS:2494 Grade G/Neoprene; silicon rubber/graphite asbestos
Nuts & Bolts	Hot dip galvanized as per IS:4759. Bolts, nuts and washer should be of similar material to those used for coupling housing/sleeves to minimize the possibility of galvanic corrosion.
Inspection and Testing	Yes
Pipes shall be tested hydraulically as per relevant standard.	
Fittings shall be tested hydraulically at twice the operating pressure or 1.5 times the design pressure whichever is higher.	

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5.29 Fly Ash Silo

Parameters	Details
Numbers provided	[...]
Capacity (each)	[...]
Capacity of Retractable chute	[...]
Capacity of Rotary Un-loader	[...]
Max. water content in unloader	[...]
Fluidizing Pads	Ceramic tiles/Sintered Bronze/ Woven SS Mesh
Particulate emission at vent filter outlet	Below 50 ppm
Unloader hood in silo	Yes /No

5.30 Rotary Drum Unloader cum Dust Conditioner

- The rotary drum un-loaders cum conditioners are located below the silo opening on an intermediate level concrete platform such that trucks can move freely underneath it.
- At the inlet of the rotary unloader there shall be a variable capacity feeder which can be controlled. These feeders accurately control the discharge of the silo into the unloader.
- At the upstream of the orifice feeder there shall be cylinder operated knife gate valves. The unloader inlet section is stationary and provided with a seal between the revolving drum & the inlet section.
- The drum will be provided with suitable guards to ensure operators' safety. Scrapper plate shall be of steel construction lined with special wear resistant alloy. There shall be expansion joint provided on the unloader to eliminate distortion & uncontrolled field variations. There shall be access doors to all parts of the unloader e.g., inlet section of the drum & discharge box.

5.31 Horizontal Centrifugal Pumps

- The ash slurry pumps, HP pumps, LP pumps, Economizer Water Pumps, sludge pumps, seal water pumps shall essentially be horizontal and centrifugal type.

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S.No	Parameters	Description	
i)	Description	Ash slurry disposal pumps, and sludge pumps	HP, LP, Seal water, Economizer Water Pumps and other horizontal water pumps
ii)	Type	Horizontal, single stage centrifugal type(all identical pumps shall be interchangeable)	Horizontal, single or multi stage centrifugal type (all identical pumps shall be interchangeable)
iii)	Duty	Continuous	
iv)	Fluid to be pumped	Highly abrasive slurry. Pump shall be designed to handle maximum ash lump size expected at the outlet of clinker grinder	Raw Water/Clarified
v)	Parameters: -Flow & Head	As per design guidelines contained in accompanying specifications	
vi)	Suction condition	Flooded suction with suction lift of 2m	
vii)	Pump speed (max.)	1,000 rpm	1,500 rpm
viii)	Impeller tip speed	1676 meters / min. (max.)	As per manufacturers standard
ix)	Type of coupling	Variable speed Hydraulic coupling with speed reduction by means of speed reduction gear box in first stage. Speed variation + 10% - 45% with respect to rated design point in case of ash disposal pumps	Directly driven through coupling.

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S.No	Parameters	Description	
		For the subsequent stage through belt drive.	
x)	Material of Construction		
	Casing	Outer casing shall be of cast steel to ASTM-A216 or spheroidal Graphite Ductile iron to ASTM-A536, 65-45-12. Inner casing (Volute liners) shall be of chrome nickel cast iron (composition to NI hard-IV) of 550 BHN. Or 24% chromium cast iron of 550 BHN. Bottom Ash Overflow Pump : CI FG 260(in case single casing pump)	2-2.5% Ni-Cast Iron to IS: 210, Grade FG-260.
	Impeller	Chrome nickel cast iron (composition to NI-hard IV) of 550 BHN Or 24% chromium cast iron of 550 BHN.	Bronze Gr.I to IS:318/SS
	Wear plate / liners wear rings	- do-	Bronze Gr.I to IS: 318/SS or equivalent.
	Shaft	Carbon steel to AISI - 1040 / EN-8	Carbon steel to AISI K-1040 / EN-8
	Shaft Sleeve	Hardened and ground stainless steel (550-	As per manufacturer standard.

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S.No	Parameters	Description
		BHN) SS 410 BHN for BA overflow pump
	Base Plate	Steel to IS: 226 up to 20mm thickness and IS:2062 and over 20mm thickness.
xi)	Drive Motor Rating	20% margin over and above the maximum load demand in the entire operating range of pump at 50 Deg. C. 10% for water pump with HT drives & 15% with LT drives.
	Drive Motor Speed	Not exceeding 1500 rpm
xii)	Ash Slurry Pump efficiency	To be selected by Bidder. However for the purpose of evaluation, no credit shall be given for the pump efficiency in excess of 70% with handling of ash slurry for ash slurry disposal pumps, BA slurry transportation pump and BA overflow pump.

Note:-

The ash slurry disposal pumps shall also be required to handle clarifier sludge from the water treatment plant and the same shall be taken into consideration while sizing the pumps

5.32 Vertical Sump Drainage Pumps

	BA overflow Pumps, Sump drainage pumps for Vacuum Pump House Area, Silo Area, Slurry Sump Area
Type	Vertical, Centrifugal, single stage, semi-open or (open non-clogging) type impeller with no bearing inside sump.
Duty	[...]
Fluid to be pumped	[...]
Capacity and total dynamic head (Guaranteed)	[...]
Suction Condition	Submerged

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Number of pumps	[...]
Pump speed (Max.)	1500 rpm (Max.)
Type of coupling between pump & Motor	Directly driven through flexible or rigid coupling/V-belt driven
Location of pump thrust bearing	In Motor Stool
Material of Construction	
(i) Casing	Alloy Cast Iron (350 BHN) (Min 2.7% Ni; 1% Cr.)
(ii) Impeller	Alloy Cast Iron (350 BHN) (Min 2.7%, Ni, 1% Cr.)
(iii) Impeller shaft	Stainless steel -410
(iv) Line shaft	EN - 8 to BS:970
(v) Column pipe and discharge pipe	Fabricated steel to pipe IS:2026 (Minimum 6 mm Thk)
(vi) Shaft sleeve	Hardened stainless steel to 400 BHN
(vii) Base plate	Steel to IS:2062
Motor details	
Rating	[...]
Speed	1500 rpm(max)

5.33 Valves, Pipings & Fittings

a) Slurry Disposal Line Valves At Dyke Area

- Valve shall be knife gate construction.
- The size of all valves shall be the same as that of parent pipe.
- Material of construction shall be as follows:
 - Plate : MS: IS 2062 Gr A with chrome plating.
 - Body : CI grade FG 260 to IS : 210

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Note: Blank/ through spouts arrangement is also acceptable for discharge points at ash pond. This shall be subjected to acceptance during detail engineering.

b) Bottom Ash and Other Ash Slurry Line Valves

Adequately sized pneumatic cylinder operated metal to metal seated knife edge gate valves/plug valves shall be provided at the outlet of Jet pumps handling bottom ash; at the suction and discharge of combined ash slurry disposal pumps and BA over flow water pumps suction/discharge.

The selection of the type of valve shall be done based on the line pressures. It shall be ensured that the metal to metal seated knife edge gate valves strictly meet the testing requirements of MSS-SP 81 code for seat leakages.

Valves shall be provided with a mechanical indicator and limit switches to indicate open or closed position of the valve locally and remotely.

For working pressure up to 10 kg/cm² - Metal to metal seated knife gate valve shall be selected.

For working pressure above 10 kg/cm² – Plug type regular pattern valve or resilient sealed knife gate valves shall be used.

Material of construction shall be as follows:

S.No.	Parameters	Description
i)	Body/Cover	Cast iron FG-260 to IS: 210 (min. 10 mm thickness) with Ni hard deflection cone (minimum 400 BHN hardness) for knife edge gate valves. OR Carbon steels to ASTM - A - 216 Gr. WCB (0.3% carbon max.) for plug valves.
ii)	Gate/Plug	Stainless steel with min. 350-400 BHN Hardness on wear surface for knife edge gate valves (gate edge) OR Carbon steel to STM-A-216 Gr. WCB case hardened to 400-450 (port) and BHN suitably impregnated for low friction.

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S.No.	Parameters	Description
iii)	Stem	Stainless steel (SS-304) for knife edge gate valves OR IS: 1875 Class C made out of ASTM-A-105 (forged carbon steel) and will be suitably impregnated for low friction or BS:970-709M40.

c) Ash Slurry Sump Isolation Plug Valves, Sump Liners and Agitating Nozzles.

The ash slurry sump shall have isolated compartments. Each compartment shall serve one (1) number stream of ash slurry disposal pumps. The bottom ash slurry shall be led to a common distribution trough at the top of the slurry sumps which will have manually operated plug valves enabling the slurry to flow to the desired compartments (corresponding to the pump steams in operation).

It shall be possible to operate slurry sump isolation valves from platform at top of sump. The valve shall be provided with gear operator if effort required to operate the valve exceeds 25 kgf

Material of construction for slurry sump isolation valves shall be corrosion and abrasion resistant and shall be of quality most suited to proposed application. Suitable measures to protect the bearings from ash ingress shall be provided.

Valves shall be suitable for outdoor duty.

All the slurry distribution troughs and sump compartments shall be provided with abrasion liners in the areas of slurry impingement.

Alloy CI, 350BHN lining for the inner walls of the slurry sump shall be provided by Bidder. The lining should be minimum 20 mm thick, on side walls and 30 mm thick at bottom".

Bidder shall provide adequate number of high velocity water jetting/agitating nozzles in the slurry trenches/sumps to avoid setting of ash particles at the bottom of the trenches/sumps. The material of jetting/agitating nozzles shall be anti corrosion tool steel/or SS-410/416 of hardness 500-550 BHN.

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d) Water and Air Piping, Fitting and Accessories

All piping shall be provided with vents at the highest points and drains at the lowest points along with vent valves and drain cocks. Vents shall not be less than 15mm in size. Drains shall not be less than 25 mm size. The piping shall be arranged to provide clearance for the removal of equipment requiring maintenance and for easy access to valves and other piping accessories required for operation and maintenance.

Piping shall generally be routed above ground but where specifically indicated/approved by the Engineer the pipes may be arranged in trenches or buried. Bidder shall provide either coal tar or Bitumen tapes on conventional coat and wrap system for corrosion protection of buried piping as per relevant codes and standards.

Overhead piping shall have a normal minimum vertical clearance of 3 meters above walk ways and working areas and 8 meters above roadways unless otherwise approved by the Engineer.

Pipe Size in pump suction side shall be at least one pipe size larger than the corresponding pump discharge connection.

The pipe supports shall be spaced as follows:

Pipe Size (NB)	25	50	80	100	150	200	300	400	500
Spacing in meter	2.1	3.0	3.7	4.3	5.2	5.8	7.0	8.2	9.1
Data Sheet:									
WATER PIPES									
S.No.	Detail	Description							
i)	Type of Pipes	a) Up to & including 150 NB				MS, ERW pipes to IS:1239 Heavy grade			
		b) 200 NB to 450 NB				MS ERW to IS 3589. FE 410 grade.			

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		c) 500 NB and above	Rolled and welded from MS plate to IS: 226 Dimensional tolerances as per IS: 3589 Or SAIL or Equal make spiral welded pipes.
ii)	Pipe Sizes	As required.	
iii)	Thickness of Pipes	a) Pipe specs. as per IS:1239	Pipe thickness shall be of Heavy grade.
		b) Pipe spec. as per IS:3589 (ERW)	Min 6.35 mm thick for 200 NB to 400 NB size and Min. 7.14 mm thick for 450 NB size.
		c) Pipe spec. as per IS:3589 (ERW) from IS 226 plates/spiral welded	Min. 8mm thick
iv)	Type of Line joints.		
		a) 50 NB and below	Butt welded as per ANSI B 16.25
		b) 65 NB and above.	Butt welded to ANSI: B16.25
v)	Quantity	As required	
vi)	Fittings (Bends)		
		a) For sizes up to & including 65NB	Short radius bends and material same as that of parent pipe.
		b) For sizes 80 NB to 300 NB	SR & LR elbow and material same as that of parent pipe
		c) 350 NB & above.	Miter bends with Miter angle not exceeding 22.5°.

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		Material shall be same as that of parent pipe and dimensional tolerance shall be as per BS: 534.
vii)	Flanges	Slip on flat face type with drilled and pressure rating as per valve and other specialties. Material of construction shall be as per IS:226 upto 20mm thickness and IS: 2062 for higher thickness.
Air Pipes		
i	Type	ERW pipe as per IS:1239, heavy grade with galvanizing as per IS:4736 for pipes upto and including 150NB. For pipes of sizes above 150 NB it shall be as per CI I (i b) & CI no. I (iii B) above
ii	Pipe Sizes	As required
iii	Pipe Thickness	as per IS:1239, heavy grade for pipes upto and including 150NB. For pipes of sizes above 150 NB it shall be as per as mentioned above for water pipes.
iv	Type of Line joints	65 NB and above : Screwed, 80 NB and above : Sleeve Welded. However valve etc. shall be screwed and with flange.
v	Quantity	As required
vi	Fittings (elbows)	As per ASTM-A-234 Gr. WPB (GI)
vii	Flanges	Raised face type G.I screwed and pressure rating as per valve and other specialties. Material of construction on shall be IS: 226 upto 20 mm thickness and IS: 2062 for higher thickness.

e) Water and Air Line Valves

Water and Air Line Valves and Specialties (As per specification indicated elsewhere suiting the service requirement) for fluidizing air line valves design and construction shall take special consideration for temperature of service fluid.

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f) Gate/Globe/Check/Plug/Butterfly Valve

S. No	For sizes 50 mm and below and working pressure up to 15 kg/cm ² (g)	
i)	Body/Wedge/Disc	Gun Metal
ii)	Trim & Seat	Gun Metal
iii)	Stem	Brass
S. No	For sizes 65 mm and above and working pressure up to 15 kg/cm ² (g).	
i)	Body/Wedge/Disc	C.I. to IS 210 Gr. FG 260
ii)	Trim & Seat	SS/ Gun Metal
iii)	Stem	SS 410
iv)	Hand wheel	C.I. to IS 210 Gr. FG 220
S. No	For all sizes and Working pressure above 15 kg/cm ² (g).	
i)	Body/Wedge/Disc	Cast/Forged carbon steel
ii)	Wedge/Disc/Plug	Cast carbon steel with 13% Cr lined
iii)	Trim and Stem	Stainless steel
iv)	Quantity	As required.

g) Ash Slurry Disposal Pipes

The minimum wall thickness of slurry piping shall be 9.52 mm (minimum)/as per Class D (in case of Cast Iron pipe). Tolerance in pipe thickness shall be as per relevant IS/BS standard.

The bottom ash slurry transportation piping shall continue without bends, branches or merging for a distance of at least 8-10 pipe diameter length from jet pump outlet.

The ash slurry disposal pipelines shall be provided with adequately sized drain connections with blind flanges as per the final layout requirements.

Bidder shall conduct line surge studies for the ash disposal pipelines and submit these to the Engineer for review. Suitable arrangements as required to protect the system based on approved line surge studies shall be included in Bidder's scope.

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h) Fittings

All fittings (bends, elbows, laterals & spool pieces etc.) used in ash slurry disposal piping up-to ash dyke shall be basalt lined with flanged ends.

These fittings shall be as per good engineering practice and of large radius (Min. 3D) construction.

Alloy C.I. or Basalt lined spool pieces (as the case may be) of minimum 1.5 meters length shall be provided at the discharge of every fitting immediately after slurry pump discharge.

i) Couplings

For ease of rotation and replacement of ash slurry disposal pipes at regular intervals of time for maintenance purpose, sleeve type couplings shall be provided.

Straight length of pipes without any intermediate coupling shall not exceed 30 meters. It shall be possible to replace or rotate (as applicable) any fitting and any particular spool or pipe during maintenance without unduly disturbing neighboring healthy joints and pipe spools. Bidder shall furnish calculation for selection and spacing of couplings taking into account forces due to expansion contraction, deflection, lateral displacement etc.

The coupling shall be capable of taking a minimum of 2° angular deflection and sufficient gap between ends of pipes at couplings shall be provided to take care of expansion in piping.

S.No	Parameters	Description	
i)	Ash slurry disposal pipe	MS ERW steel pipes to SAIL commercial Quality, 9.5 thk (min)/IS:3589	
ii)	Fly ash slurry pipe	MS ERW steel pipes, 9.5 thk (min) as per IS:3589 Gr FE 410	
	I. Pipe Fittings (Bends, Elbows, Laterals And Spool Pieces Etc.)		
	Material and Hardness:	i) Up to Ash dyke ii) Over Ash Dyke	20 mm thick cast basalt lined MS fittings (MS shell of min 6 mm thickness) or Alloy CI, 400 BHN

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S.No	Parameters	Description
		iii) Bottom ash slurry and fly ash slurry handling lines Ni-chrome-alloy cast iron or equivalent. Min. hardness 400 BHN. Integral wear back of minimum 20 mm thickness. Or 20 mm thick cast basalt lined MS fittings (MS shell of 6 mm thickness)
	Cast basalt fittings	Hardness : 8 mhos (minimum)
		Bending strength : 300 kg/cm ² (minimum)
		Compressive strength : 4500 kg/cm ² (minimum)
	II.Type of Joints	Sleeve type coupling joint in straight length, flanged joints at fittings, bends, elbows, laterals etc.
	III.Couplings	
	Type:	Sleeve type couplings with minimum 9.0 mm thick sleeve.
	Material of Construction	
	Sleeve:	Carbon Steel to ASTM A-36/CI FG 260: IS 210
	Flanges/ End rings:	Carbon Steel to ASTM A-108 steel / Cast Iron FG – 260
	Nuts & Bolts:	Hot dip galvanized/spray galvanized as per IS: 4759. Bolts, nuts and washers should be of similar material to those used for coupling housings/sleeves to minimize the possibility of galvanic corrosion

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6 QUALITY ASSURANCE, INSPECTION & TESTING

The Bidder shall adopt Quality Assurance Programmes as per relevant standards subject to Owner's approval, to ensure that the equipment and services under the scope of work, whether manufactured or performed within the Bidder's works or at his sub-vendor's premises or at the Owner's site or at any other place of work, are in accordance with the specifications. Such programmes shall be outlined by the Bidder and shall be finally accepted by the Owner after discussions before the award of the contract. The QA programme shall be generally in line with IS/ISO-9001. The Quality Assurance Programme of the Bidder shall generally cover the following:

- a) Organization structure for the management and implementation of the proposed Quality Assurance Programme.
- b) Quality System Manual.
- c) Design Control System.
- d) Documentation and Data Control System.
- e) Qualification data for Bidder's key personnel.
- f) The procedure for purchase of materials, parts, components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.
- g) System for shop manufacturing and site erection controls including process, fabrication and assembly.
- h) Control of non-conforming items and system for corrective actions and resolution of deviations.
- i) Inspection and test procedure both for manufacture and field activities.
- j) Control of calibration and testing of measuring testing equipment.
- k) System for Quality Audits.
- l) System for identification and appraisal of inspection status.
- m) System for authorizing release of manufactured product to the Owner.
- n) System for handling, storage and delivery.
- o) System for maintenance of records, and
- p) Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component.

6.1 General Requirements - Quality Assurance

- a) All materials, components and equipment covered under this specification shall be procured, manufactured, erected, commissioned and tested at all the

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stages, as per a comprehensive Quality Assurance Programme. A programme of inspection/tests to be carried out by the Bidder for some of the major items is given in this technical specification. This is, however, not intended to form a comprehensive programme as it is the Bidder's responsibility to draw up and implement such programme duly approved by the Owner. The detailed Quality Plans for manufacturing and field activities shall be drawn up by the Bidder and will be submitted to Owner for approval.

- b) Manufacturing Quality Plan (MQP) will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Bidder's/ Sub-vendor's Quality Control Organization, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. The Quality Plan shall be submitted to the Owner for review and approval. The format for MQP shall be submitted by the Bidder for the approval of the Owner before the award of Contract.
- c) Field Quality Plans (FQP) will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Bidder's "Site Quality Control Organization", during various stages of site activities starting from receipt of materials/equipment at site. The format for FQP shall be submitted by the Bidder for the approval of the Owner before the award of Contract.
- d) The Bidder indicate in the QP the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., These Quality Plans and reference documents/standards etc. will be subject to Owner's approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved Quality Plans, Owner shall identify customer hold points (CHP), i.e. test/checks which shall be carried out in presence of the Owner or his authorized representative and beyond which the work will not proceed without consent of Owner in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to the Owner along with technical justification for approval and dispositioning.
- e) The material shall be dispatched from the manufacturer's works after the same is accepted by the Owner.
- f) All material used for equipment manufacture including casting and forging etc. shall be of tested quality as per relevant codes/standards. Details of results of the tests conducted to determine the mechanical properties; chemical analysis and details of heat treatment procedure recommended and actually followed shall be recorded on certificates and time temperature

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chart. Tests shall be carried out as per applicable material standards and/or agreed details.

- g) All welding and brazing shall be carried out as per procedures drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Owner.
The welding/brazing procedures shall be followed as per Indian/International Standards.
- h) All brazers, welders and welding operators employed on any part of the contract either in Bidder's/sub-vendor works or at site or elsewhere shall be qualified as per ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Owner.
- i) Welding procedure qualification & Welder qualification shall be as per Indian/International Standards. However, where required by the Owner, tests shall be conducted in presence of Owner for the site erection. Any other statutory requirements for the equipment/systems shall be complied with.
- j) On all back-gauged welds MPI/LPI shall be carried before seal welding.
- k) Unless otherwise proven and specifically agreed with the Owner, welding of dissimilar materials and high alloy materials shall be carried out at shop only.
- l) No welding shall be carried out on cast iron components for fabrication or repair.
- m) All non-destructive examination shall be performed in accordance with written procedures as per International Standards but qualified operator. NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job.
- n) All plates of thickness above 40 mm and all bars stock/Forging above 40 mm diameter shall be ultrasonically tested.
- o) The Bidder shall list out all major items/ equipment/ components to be manufactured in house as well as procured from sub-vendors.
- p) For components/equipment procured by the Bidders for the purpose of the contract, after obtaining the written approval of the Owner, the Bidder's purchase specifications and inquiries shall call for quality plans to be submitted by the suppliers. The quality plans called for from the sub-vendor shall set out, during the various stages of manufacture and installation, the quality practices and procedures followed by the vendor's quality control organization, the relevant reference documents/ standards used, acceptance level, inspection of documentation raised, etc. Such quality plans of the successful vendors shall be finalized with the Owner.

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- q) If required, the Owner shall carry out quality audit and quality surveillance of the system and procedures of the Bidder's or their sub-vendor's quality management and control activities. The Bidder shall provide all necessary assistance to enable the Owner carry out such audit and surveillance. The Bidder shall also take requisite corrective measures for restoring/ improving the system in line with the outcome of such quality surveillance and audits.
- r) The Bidder shall carry out an inspection and testing programme during manufacture in his work and that of his sub-vendor's and at site to ensure the mechanical accuracy of components, compliance with drawings, conformance to functional and performance requirements, identity and acceptability of all materials, parts and equipment. Bidder shall carry out all tests/inspection required to establish that the items/equipment conform to requirements of the specification and the relevant codes/standards specified in the specification, in addition to carrying out tests as per the approved quality plan.
- s) Quality audit/surveillance/approval of the results of the tests and inspection will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specification when erected or does not give complete satisfaction in service and the above shall in no way limit the liabilities and responsibilities of the Bidder in ensuring complete conformance of the materials/equipment supplied to relevant specification, standard, data sheets, drawings, etc.
- t) For all spares and replacement items, the quality requirements as agreed for the main equipment supply shall be applicable.
- u) Rectification procedures to be adopted to make the job acceptable shall be subject to the approval of the Owner.
- v) In case any deviation is observed with respect to relevant document or good engineering practices, and the same is considered by the Bidder to be acceptable, as it is or with certain rectifications/ modifications, based on his detailed technical analysis, then the Bidder shall refer the same to Owner along with reason for deviation, proposed corrective action, technical justification for suitability of the proposal and preventive measures for avoiding recurrence of similar deviations. Based on his evaluation, the Owner may accept the proposal as it is or with modifications or may reject the same. Such proposals shall be raised in suitable Non-conformity report format (NCR). The NCR can be raised irrespective of the CHP stages in the QP.
- w) Burn in and Elevated Temperature Test Requirement for Electronics Solid State Equipment:
- x) All solid state electronic systems/equipment shall be tested as a complete system/equipment with all devices connected for a minimum of 168 hours (7

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Days) continuously under energized conditions prior to shipment from manufacturing works, as per the following cycle.

Elevated Temperature Test Cycle

During the elevated temperature test which shall be for 48 hours of the total 168 hours of testing, the ambient temperature shall be maintained at 50 °C. The equipment shall be interconnected with devices which will cause it to repeatedly perform all operations it is expected to perform in actual service with load on various components being equal to those which will be experienced in actual service.

During the elevated temperature test the cubicle doors shall be closed (or shall be in the position same as they are supposed to be in the field) and inside temperature in the zone of highest heat dissipating components/modules shall be monitored. The temperature rise inside the cubicle should not exceed 10°C above the ambient temp at 50 °C.

Burn in Test Cycle

The 48 hours elevated temperature test shall be followed by 120 hours of burn in test as above except that the temperature shall be reduced to the ambient temperature prevalent at that time.

During the above tests, the process I/O and other load on the system shall be simulated by simulated inputs and in the case of control systems; the process which is to be controlled shall also be simulated. Testing of individual components or modules alone shall not be acceptable.

In case the Bidder/ sub-vendor is having any alternate established procedure of eliminating infant mortality of components, the detail procedures followed by the Bidder/ sub- vendor along with the statistical figures to validate the alternate procedure may be submitted to the Owner for his consideration.

The Bidder/Sub-vendor shall carry out routine test on 100% item at Bidder/sub-vendor's works. The quantum of check/test for routine and acceptance test by Owner shall be generally as per criteria/sampling plan defined in referred standards. Wherever standards have not been mentioned quantum of check/test for routine / acceptance test shall be as agreed during detailed engineering stage.

6.2 QA Documentation Package

The Bidder shall submit the QA Documentation in *[two hard copies and two CD ROMs]*, as identified in respective quality plan with tick (√) mark.

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Each QA Documentation shall have a project specific Cover Sheet bearing name & identification number of equipment and including an index of its contents with page control on each document.

The QA Documentation file shall be progressively completed by the Bidder/ sub-vendor and the same shall be submitted to the Owner in [2 hard copies and 2 CD-ROMs], within two weeks of dispatch of the equipment.

11.2.1 Typical contents of QA Documentation is as below:-

- a) Approved Quality Plan.
- b) Material mill test reports on components as specified by the specification and approved Quality Plans.
- c) Manufacturer / works test reports/results for testing required as per applicable codes and standard referred in the specification and approved Quality Plans.
- d) Non-destructive examination results /reports including radiography interpretation reports. Sketches/drawings used for indicating the method of traceability of the radiographs to the location on the equipment.
- e) Heat Treatment Certificate/Record, if applicable (Time- temperature Chart).
- f) All the accepted Non-conformance Reports (Major/Minor) / deviation, including complete technical details / repair procedure).
- g) Inspection reports duly signed by the Inspector of the Owner and Bidder for the agreed Customer Hold Points.
- h) Certificate of Conformance (COC) wherever applicable.

Similarly, the Bidder shall be required to submit two sets [(two hard copies and two CD ROMs)], containing QA Documentation pertaining to field activities as per Approved Field Quality Plans and other agreed manuals/ procedures, prior to commissioning of individual system.

6.3 Inspection, Testing and Inspection Certificates

- a) The word 'Inspector' shall mean the Owner's Inspection engineer and/or agency acting on behalf of the Owner to inspect and examine the materials and workmanship of the works during its manufacture or erection.
- b) The Owner's Inspection Engineer and/or agency acting on behalf of the Owner shall have access at all reasonable times to inspect and examine the materials and workmanship of the works during its manufacture or erection and if part of the works is being manufactured or assembled on other premises or works, the Bidder shall obtain for the Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, permission to inspect as if the works were manufactured or assembled on the Bidder's own premises or works.

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- c) The Bidder shall give the Owner [fifteen (15)] days written notice of any material being ready for inspection/testing. Such tests shall be to the Bidder's account except for the expenses of the Inspector's. The Owner's Inspection Engineer and/or an outside inspection agency acting on behalf of the Owner, unless the witnessing of the tests is virtually waived and confirmed in writing, will attend such tests within [fifteen (15)] days of the date on which the equipment is noticed as being ready for test/inspection failing which the Bidder may proceed with test which shall be deemed to have been made in the inspector's presence and he shall forthwith forward to the Owner duly certified copies of test reports in [two (2) copies] for his review and approval.
- d) The Owner's Inspection Engineer and/or Owner's inspection agency acting on behalf of the Owner shall within fifteen [(15) days] from the date of inspection as defined herein give notice in writing to the Bidder, on any objection to any drawings and all or any equipment and workmanship which is in his opinion is not in accordance with the contract. The Bidder shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall inform in writing to the Owner, giving reasons therein, that no modifications are necessary to comply with the contract. After due consideration, the Owner may accept or reject the same.
- e) When the factory tests have been completed satisfactorily at the Bidder's or sub-vendor's works, the Owner shall issue a certificate to this effect within [fifteen (15) days] of completion of tests. The completion of these tests or the issue of the certificates shall not bind the Owner to accept the equipment should it, on further tests after erection be found not to comply with the contract.
- f) In all cases where the contract provides for tests whether at the premises or works of the Bidder or any sub-vendor, the Bidder, except where otherwise specified, shall provide free of charge such items as labour, material, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Owner, to carry out effectively such tests on the equipment in accordance with the Contract and shall provide the facilities to accomplish testing.
- g) The inspection by the Owner's Inspection Engineer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Bidder in respect of the contract.
- h) To facilitate advance planning of inspection in addition to giving inspection notice, the Bidder shall furnish quarterly inspection programme indicating schedule dates of inspection at Customer Hold Point and final inspection stages. Updated quarterly inspection plans will be made for each three

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consecutive months and shall be furnished before beginning of each calendar month.

- i) All inspection, measuring and test equipment used by Bidder shall be calibrated periodically depending on its use and criticality of the test/measurement to be done. The Bidder shall maintain all the relevant records of periodic calibration and instrument identification. Wherever asked specifically, the Bidder shall re-calibrate the measuring/test equipment in the presence of Owner's Inspection Engineer agency.

6.4 Shop and Site Tests

- a) Shop tests will include all tests to be carried out at Bidder's works, at works of his sub-vendor and at works where raw material supplied for manufacture of equipment is manufactured.
- b) All materials will be of tested quality supported with correlated test certificates.
- c) Shop and Site tests will include electrical, mechanical, performance and hydraulic tests in accordance with relevant IS or any other approved standard or any other tests called for by the Owner under these specifications to ensure that the plant being supplied fulfills the requirements of the specifications. For equipment not covered by any IS or other approved standards, the tests to be carried out will be in accordance with the quality plan to be agreed to between the Bidder and the Owner.

6.5 Site Tests

The successful Bidder will prepare and submit detailed quality plans in the format prescribed by Owner setting out the quality practice and procedures to be adopted by him for assuring quality for each equipment under this specification from the receipt of material at site, during storage, erection, pre-commissioning to final commissioning of the plant. These procedures will necessarily include all checks/tests conducted at site for preservation, assembly, alignment, positioning of the equipment, foundation preparation, welding/bolting, heat treatment, non-destructive examination, hydraulic test, running test, performance test etc. The above will be discussed and finalized by the Bidder with the Owner.

The Bidder will also furnish detailed quality procedure proposed by him for storage, preservation, painting, acid cleaning, alkali boil out, steam blowing, hydraulic test, air/gas tightness test etc. to the Owner. The same will be discussed and finalized by the Bidder with the Owner.

6.6 System Checking / Reliability Trials:

- a) Successful Bidder will carry out tests at site to prove to the Owner that each equipment of the supply complies with requirements stipulated and is erected in accordance with requirements specified. Before the plant is put

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into trial operation the Successful Bidder will be required to conduct tests to demonstrate to the Owner that each item of the plant is capable of correctly performing the functions for which it was specified and its performance, parameters etc. are as per the specified/approved values. These tests may be conducted concurrently with those required under commissioning sequence.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

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(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)**

**VOLUME-II,
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION- ELECTRICAL**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

Document Number	Rev No.	Description	Page No.	Date of Issue
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1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of Ash Handling Plant complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 List of Attachments

The following List of attachments is enclosed along with this specification.

[Note: List of attachments is depends on specific project scope of work. R & M consultant may attach the attachments as per project specific scope of work. For reference all attachments are considered in this package as per scope of work considered]

Legend: O: USE, X: NOT USE

Sl.No	Attachment Number	Description	Rev No	Application
1	E1	Motor	R1	O
2	E2	Motorized Actuators	R1	O
3	E3	LV Transformers(Dry type/Oil type)	R1	O
4	E4	415V Switchgear, MCC and DBs	R1	O
5	E5	415V Non Segregated Bus Duct	R1	O
6	E6	220V DC system	R1	O
7	E7	HV Cables	R1	O
8	E8	LV Cables	R1	O
9	E9	Illumination system	R1	O
10	E10	Cable Carrier System	R1	O
11	E11	Earthing and Lightning Protection system	R1	O

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

12	E12	6.6kV Switchgear	R1	O
13	E13	Variable Frequency Drives	R1	O

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E1
TECHNICAL SPECIFICATION FOR MOTORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E1

1.0 MOTOR

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Electric Motor complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS : 325	:	Specification for three phase induction motor.
IS : 900	:	Code of Practice for installation and maintenance of induction motors
IS : 996	:	Single phase AC motors
IS : 1231	:	Dimensions of three-phase foot-mounted induction motors
IS : 1271	:	Thermal evaluation and classification of electrical insulation.
IS : 2223	:	Dimensions of flange mounted ac induction motors.
IS : 2254	:	Dimensions of vertical shaft motors for pumps
IS : 3177	:	Crane duty motors
IS : 4029	:	Guide for testing three phase induction motors.
IS : 4691	:	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	:	Specification for rotating electrical machinery.

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IS : 4728	:	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	:	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	:	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	:	Designation of Method of Cooling of Rotating electrical machines.
IS : 8223	:	Dimensions and output ratings for foot mounted rotating electrical machines with frame numbers 355 to 1000.
IS : 8789	:	Values of performance characteristics for three phase induction motors.
IS : 12065	:	Noise level of motors.
IS : 12075	:	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	:	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	:	Temperature rise measurement of rotating electrical machines
IS : 12824	:	Type of duty and classes of rating assigned.
IS : 14222	:	Requirements and method of Impulse withstand test
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IEC: 60034	:	Rotating electrical machines.
NEMA, MG-1	:	Motors and Generators
ISO : 1940-1	:	Mechanical vibration – Determination of permissible residual unbalance

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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All motors shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment.
- b. AC Motors shall be of [constant speed, squirrel cage, three/ single phase, induction type.] Motors shall be rated for [continuous duty/intermittent duty]. They shall also be suitable for long period of inactivity. They shall also be suitable for direct online starting (DOL starting).
- c. DC motors provided for emergency service shall be shunt / compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.
- d. Power supply for AC motors shall be as follows:

Table: 2.0

1.	[Below 0.22 kW]	:	240V, 1 Phase, 50Hz
2.	[From 0.22 kW up to & including 160 kW]	:	415V, 3 Phase, 50Hz
3.	[Above 160 kW]	:	6.6kV, 3 Phase, 50Hz

- e. All AC motors shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- f. DC motors shall be rated for 220V DC supply with voltage variation of -15% to +10%.
- g. The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, break down and full load torques are available for the intended service.

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- h. Moreover, motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
- i. Motors shall be capable of developing the rated full load torque even if the supply drops to 70% of the rated voltage.
- j. For 6.6kV motors, locked rotor current not to exceed [600%] of full load current, including positive tolerance, except for BFP. For BFP the starting current shall be [450%] of FLC. For 415 V motors Locked rotor current not to exceed [600%] of full load current with IS tolerance.]
- k. For DC motors, the starters shall be provided to limit the starting current to [2] times of the full load current.
- l. Maximum continuous motor ratings shall be at least [10%] above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.
- m. Accelerating torque at any speed with the lowest permissible starting voltage shall be at least [10%] motor full load torque. Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.
- n. The motors shall be suitable for bus transfer schemes provided on the 6.6kV and 415V systems without any injurious effect on its life. If motors are connected to an automatic bus transfer system, they may be subjected to 150% of the nominal voltage during changeover of buses due to the phase difference between the incoming voltage and motor residual voltage. In such cases, motors shall be capable of restarting under full load after momentary loss of voltage.
- o. Motors shall be of [energy efficient of type Eff-2] as per IS: 12615/equivalent IEC/ International Standards.
- p. Motor shall be designed to keep torsional and rotational natural frequencies of vibration of the motor and driven equipment at least 25% above the motor operating speed range.

1.3.1 System Grounding

Table: 3.0

(a)	6.6 kV	:	Low Resistance Grounded to limit the earth fault current to [300 Amps]
(b)	415 V	:	Solidly Grounded
(c)	220V DC	:	Ungrounded

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1.3.2 Fault Level

Table: 4.0

(a)	6.6 kV	:	[40 kA for 1 second]
(b)	415 V	:	[50 kA for 1 second]
(c)	220V DC	:	[25 kA for 1 second]

1.3.3 Degree of Protection

Table: 5.0

(a)	Indoor Motors	:	[IP 54]
(b)	Outdoor Motors	:	[IPW 55]
(c)	Cable Box located in Indoor Area	:	[IP 54]
(d)	Cable Box located in Outdoor Area	:	[IPW 55]

1.3.4 Winding Insulation

Table: 6.0

(a)	For 6.6 kV AC Motors	:	[Class – F]
(b)	For 415V AC Motors	:	[Class – B]
(c)	For 220V DC Motors	:	[Class – B]

1.3.5 Winding Conductor Material

Table: 7.0

(a)	For 6.6 kV AC Motors	:	Copper
(b)	For 415V AC Motors	:	Copper
(c)	For 220V DC Motors	:	Copper

1.3.6 Bearing

Table: 8.0

(a)	For Drive End	:	[Roller]
(b)	For Non Drive End	:	[Roller / Ball]

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1.3.7 Temperature Rise

Table: 9.0

(a)	For Air Cooled Motors	:	[70 °C] over ambient temperature [Class B]
(b)	For Water Cooled Motors	:	[80 °C] over inlet cooling water temperature [Class B]

1.3.8 Motor Earthing

Table: 10.0

(a)	Motors above 90 kW	:	[50 x 6 mm GI Flat]
(b)	Motors above 30 kW and up to 90 kW	:	[25 x 6 mm GI Flat]
(c)	Motors above 5 kW and up to 30 kW	:	[25 x 3 mm GI Flat]
(d)	Motors up to 5 kW	:	[8 SWG GI Wire]
(e)	Terminal Box	:	[8 SWG GI Wire]

1.3.9 Space Heater

Table: 11

(a)	For Motors 30 kW rating and above	:	Space heater suitable for 1Phase, 240V AC, 50 Hz supply
(b)	For Motors below 30 kW rating	:	No Space heater provided.

1.3.10 Painting

Table: 12

a)	Paint Type	:	Epoxy based with approved class
b)	Paint Thickness	:	[Within 100 to 150 micron.]
c)	Paint Shade	:	[RAL5012 BLUE]

1.4 Specific Requirements

1.4.1 Locked Rotor Withstand Time

- The starting time of the motor shall be at the minimum permissible voltage.
- For motors with starting time up to 20 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot

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condition at highest voltage limit shall be at least 2.5 second more than starting time.

- c) For motors with starting time more than 20 second and up to 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 second more than starting time.
- d) For motors with starting time more than 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- e) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.

1.4.2 Starting Voltage Requirement

I.	All motors (except mill motors):
a)	[85% of rated voltage for motors up to 4000 kW]
b)	[75% of voltage for motors above 4000 kW]

II.	For mill motors:
a)	[85% of rated voltage for motors above 1000 kW]
b)	[90% of rated voltage for motors below 1000 kW]

The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at [125%] rated speed in reverse direction.

The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

1.4.3 Winding and Insulation

a)	6.6 kV AC motors	:	Winding material shall be of copper. Insulation shall be of [Class F with winding temperature rise limited to Class B]. They shall withstand 1.2/50 microsecond switching surges of "4U + 5 KV" (U= Line voltage in KV). The coil inter-turn insulation shall be suitable for 0.3/3 micro second surge of 32 / 12 KV followed by 1 min
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			power frequency high voltage test of appropriate voltage on inter turn insulation.
b)	415V AC & 220V DC motors	:	Winding material shall be of copper. Insulation shall be of [Class B with temperature rise limited to Class B.]
c)	Conveyor motors		Short circuit rings of conveyor motors shall be either joint less or welded type. Brazed joint is not acceptable.

1.4.4 Motor Control

a) For HV Motors

- i. Motors of rating above [160 kW] shall be suitable for 6.6 KV voltage
- ii. Frequent starting motors of rating above [160 kW] shall be suitable to be controlled by vacuum contactors

(b) For LV Motors

- i. Motors of rating less than [132 kW] shall be operated by Contactor from respective MCCs. Motors of rating up to [18.5 kW] shall be provided with MPCBs and Electronic overload relays. Motors of rating above [18.5 kW] and below [45 kW] shall be provided with MCCBs and Electronic overload relays. Motors of rating [45 kW] and above but less than [132 kW] shall be provided with MCCBs and CT operated Electronic over load relays.
- ii. Motors of rating [132 kW] and up to [160 kW] shall be suitable to be controlled by Air circuit breakers from switchgear, PMCCs and shall be provided with comprehensive numerical motor protection relays.
- iii. Only for firefighting system, motor rated [upto 200kW] shall be fed from 415V switch board.

1.4.5 Starting duty

Motors shall be suitable for [3 nos. consecutive Cold starts ups and 2 nos. consecutive Hot starts ups.] Motors shall be suitable for three equally spread starts per hour when the motor is under normal service condition.

1.4.6 Bearings

- a) Anti-friction type radial and thrust bearings (ball, roller) and sleeve bearing shall be rated for minimum standard life of 40,000 hours taking bearing and driven equipment loads (in case the drive is not having

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separate thrust bearing) into account. If bearings are lubricated, loss of grease shall be scarce and it shall not creep along shaft into motor housing. Facility of removal of excess grease shall also be provided for grease lubricated bearings.

- b) Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if Anti-friction bearings can take vertical thrust, thrust & guide bearings are not required.
- c) Bearing shall be effectively sealed against dust ingress and shall be pressure grease gun lubricated. The bearing and housing shall be so designed that greasing shall be possible while the motor is running, without removal of covers.
- d) Where bearing supports are attached to the motor casing, adequate bracing shall be provided on these supports to reduce vibrations and ensure life of bearings.
- e) If the bearings are oil lubricated, a drain plug shall be provided for draining residual oil and oil level gauge shall be provided to show precisely oil level required under standstill and running conditions.
- f) Unless otherwise approved, bearing lubricating system shall be such that no external forced oil or water is necessary to maintain required oil supply to keep bearing temperature within design limits.
- g) Lubricants shall be selected for prolonged storage and normal use of motors in tropical climate and shall contain corrosion and oxidation inhibitors. Greases shall have suitable bleeding characteristics to minimize setting. The selected lubricants shall be indigenously available.
- h) Motors rated above 1000 kW shall have insulated bearings to prevent flow of shaft currents.

1.4.7 Temperature Rise

- a) For Air Cooled Motors, temperature rise of insulation should be limited to [70 °C] over ambient temperature by resistance method.
- b) For Water Cooled Motors, temperature rise of insulation should be limited to [80 °C] over inlet cooling water temperature mentioned elsewhere, by resistance method.

1.4.8 Cooling

[All motors shall be either Totally Enclosed Fan Cooled (TEFC) or Totally Enclosed Tube Ventilated (TETV) or Closed Air Circuit Air Cooled (CACA) type. However, motors rated 3000 kW or above can be Closed Air Circuit Water Cooled (CACW)]

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1.4.9 Enclosure

- a) All motor enclosures shall conform to the degree of protection of [IP54] for indoor and IPW-55 for outdoor installation unless otherwise specified. Motor for outdoor or semi outdoor service shall be of weather proof construction. Motors of large output rating located indoor could have screen protected drip proof (SPDP) enclosure conforming to [IP-23.]
- b) For motors located in outdoor & corrosive locations, FRP canopy shall be provided. In case steel canopy is provided, the same shall be epoxy painted to meet the surrounding atmosphere. Motors located in hazardous areas such as Hydrogen plant shall have flame proof enclosures of Group – IIB conforming to IS: 2148.
- c) For hazardous locations such as fuel oil facilities area, the enclosure of motor shall have flame proof construction conforming to IS 2148.

1.4.10 Noise Level and Vibration

Noise level shall be limited to 85 dB (A) at 1.5 meters from the motor. However the same shall be as per IS: 12065 unless otherwise specified. The peak amplitude of vibration shall be within the specified limits laid down in IS: 12075. Motors shall withstand vibrations produced by driven equipment. HV motor bearing housings shall have flats in both X and Y directions suitable for mounting 80mmX80mm vibration pads. Vibration pads with screwed holes for mounting vibration probes shall be provided at both DE and NDE.

1.4.11 Temperature Monitoring

[In HV motors, at least four numbers simplex/ two numbers duplex platinum resistance type temperature detectors shall be provided for each phase of stator winding]. Each bearing shall be provided with dial type thermometer with adjustable alarm contact and two numbers duplex Platinum resistance type temperature detector (3 wire, 100 ohm at zero °C). In case of CACA and CACW motors dial type temperature indicator shall be provided (one each for hot and cold air temperature monitoring for CACA and CACW and one each for inlet and outlet water temperature monitoring for CACW). If alarm and trip are required for cooling air temperature, temperature switch shall be provided. The contact rating shall be minimum 0.5A at 220V DC and 5A at 240V AC. Flow switches shall be provided for monitoring cooling water flow of CACW motor and oil flow of forced lubrication bearing. Low voltage motors rated 100 kW and above shall be provided with two PT100 RTDs per phase of winding.

1.4.12 Earthing

Motor body shall have two earthing points on opposite sides. Motor terminal boxes shall also have separate grounding terminals.

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1.4.13 Termination

- a) HV motors can be offered with either Elastimold termination or dust tight phase segregated double walled (metallic as well as with insulated barrier) cable boxes. In case Elastimold terminations are offered, then protective cover and trifurcating sleeves shall also be provided. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided in case of cable boxes. The main cable box / terminal box shall withstand [a fault current up to 40 kA for 0.25 seconds for HV motors and 50 kA for 0.25 seconds for LV motors]. Separate terminal boxes shall be provided for space heaters and RTDs and NCT (if applicable).
- b) [All terminal boxes shall be capable of being turned through 360 degrees in steps of 90 degrees unless otherwise specified.]
- c) For HV motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

1.4.14 Differential Protection

For motors rated 6.6kV, [2000 KW & above,] neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box for differential protection.

1.4.15 Tropical Protection

- (a) All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- (b) All fittings and hardware shall be corrosion resistant.
- (c) Space Heater
- (d) Suitable single phase space heaters operated at 240V, 50Hz, 1Phase AC supply shall be provided on motors rated for 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided.
- (e) The space heater shall be sized to maintain the motor internal temperature above dew point when the motor is in idle condition.

1.4.16 Rating Plate

Motor shall have Stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / NEMA-MG-1 and following additional information:

- (a) Type of bearing and recommended lubricants along with location of insulated bearing.
- (b) Temperature rise under normal/abnormal conditions.

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(c) In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.

(d) Year of Manufacture

1.4.17 Drain Plug

Motor shall have drain plugs so located that they shall drain the water, resulting from the condensation or other causes from all pockets of the motor casing.

1.4.18 Dowel Pins

Motor shall be designed to permit easy access for drilling holes through motor feet or mounting flange for installation of dowel pins after assembling the motor and driven equipment.

1.4.19 Painting

The complete motor assembly including fan shall be painted with corrosion proof paints of approved class.

1.4.20 Lifting provision

Motor weighing 25 Kg or more shall be provided with eyebolt or other adequate provision of lifting.

1.4.21 Local Push Button Station (LPBS)

- a) Each motor shall be provided with push button station as per process requirement i.e. Start/Stop or Emergency Stop.
- b) The degree of protection of LPBs shall be IPW 55 for outdoor and IP 54 for indoor applications.
- c) All Push Buttons shall be push to actuate type and stop Push Button shall be lockable in off position as per the scheme requirement.
- d) The Emergency local stop push button of Stay put type shall be provided with Press to lock & turn to release keyless mechanism.
- e) All PBs shall be provided with 2 numbers NO and 2 numbers NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to switchgear module for direct tripping and another contact to control system.
- f) Terminals to be suitable for 2 cores of 2.5 Sq.mm. cable with 20% spare terminals.
- g) All LPBS shall be of Poly Carbonate /FRP / Die Cast Aluminium material.

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I) TestsType Test

For each type & rating of HV and LV motors of rating above [50 kW], the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last[five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- (a) Visual and dimensional check
- (b) Winding resistance measurement
- (c) No load test
- (d) Mechanical vibration
- (e) Direction of rotation versus phase sequence
- (f) Insulation resistance measurement
- (g) High potential test
- (h) Locked rotor test
- (i) Speed/torque test
- (j) Over speed test
- (k) Temperature rise test
- (l) Determination of characteristic
- (m) Degree of protection test for the enclosure.
- (n) Noise level
- (o) Shaft current and bearing insulation test (Applicable for HV motors)

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

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IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.5 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

Dimensional General Arrangement drawing

- a) [Motor sizing calculation
- b) Foundation Plan & Loading
- c) Cable end box details
- d) Space requirement for rotor removal
- e) Thermal withstand curves hot & cold
- f) Starting and speed torque characteristics at 80% & 100% voltage
- g) Complete motor data
- h) Erection & Maintenance Manual
- i) Test reports
- j) QAP]

1.6 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	Technical Particulars	Unit	Parameters	Remarks
1	Motor application		[As per requirement]	
2	Rated Output, kW	kW	[As per requirement]	
3	Maximum continuous kW obtainable without exceeding specified temperature rise	kW	[By Bidder]	
4	Motor type		Squirrel cage induction motor	
5	Duty Cycle (IEC 60034-1)		[S1]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
6	Rated voltage	kV	6.6 kV for HV motors 415 V for LV motors 220V DC for DC motors	
7	Phase/frequency	Hz	50	
8	Allowable variation in supply conditions			
a)	Voltage		6.6 kV	
b)	Frequency		50	
c)	Combined			
9	Method of starting		DOL	
10	CT details for differential protection	Yes/No	For motors of rating > 2000kW	
11	Full load amperes	A	[By Bidder]	
12	Locked rotor current amperes	A	HV(Except BFP): 6 times without tolerance BFP: 4.5 times without tolerance LV: 6 times with IS specified tolerance DC : 2 times with no positive tolerance at rated terminal voltage.	
13	Method of Cooling (IC code)		[As per requirement]	
14	Enclosure (IP Code)		Indoor : IP54 Outdoor : IPW55	
15	Construction (horizontal or vertical)		[As per requirement]	
16	Max. temperature, by resistance method	Deg C	120 deg (Class B)	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
17	Insulation class		HV: Class F LV: Class B	
18	Motor insulation system (describe material used)		[By Bidder]	
19	Bearings		[By Bidder]	
a)	Type			
b)	Quantity			
c)	Lubrication system pressure and flow			
20	Temperature detector (type & quantity)			
a)	Winding		[As per requirement]	
b)	Bearing		[As per requirement]	
21	Space heaters		30 kW and above	
a	Watts (Rating/Operating)	W	[By Bidder]	
b	Volts (Rating/Operating)	V	[By Bidder]	
22	GD ² of motor		[By Bidder]	
23	Power factor		[By Bidder]	
a)	Full load	p.u		
b)	3/4 load	p.u		
c)	1/2 load	p.u		
d)	No load	p.u		
24	Efficiency		[By Bidder]	
a)	Full load	%		
b)	3/4 load	%		
c)	1/2 load	%		
25	Impedance data		[By Bidder]	
a)	locked rotor reactance per phase	Ohm		
b)	Rotor resistance per phase	Ohm		

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S. No.	Technical Particulars	Unit	Parameters	Remarks
c)	stator resistance per phase	Ohm		
26	Net motor weight	Kg	[By Bidder]	
27	Terminal box dimensions H/W/D	Mm	[By Bidder]	
28	Rotor removal clearance	mm	[By Bidder]	
29	Winding connection (star or delta)		HV: Star LV: Delta	
30	Noise Level	dB(A)	[As per requirement]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E2
TECHNICAL SPECIFICATION FOR MOTORIZED
ACTUATORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E2

1.0 MOTORIZED ACTUATORS

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Motor Operated Actuator complete with all accessories for efficient and trouble-free operation of valves, dampers and gates for R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS : 325	Specification for three phase induction motor.
IS : 900	Code of Practice for installation and maintenance of induction motors
IS : 996	Single phase AC motors
IS : 1271	Thermal evaluation and classification of electrical insulation.
IS : 2223	Dimensions of flange mounted ac induction motors.
IS : 4029	Guide for testing three phase induction motors.
IS : 4691	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	Specification for rotating electrical machinery.
IS : 4728	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	Designation of Method of Cooling of Rotating electrical machines.

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IS : 8789	Values of performance characteristics for three phase induction motors.
IS : 9334	Electrical Motor Operated Actuators.
IS : 12065	Noise level of motors.
IS : 12075	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	Temperature rise measurement of rotating electrical machines
IS : 12824	Type of duty and classes of rating assigned.
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package
IEC: 60034-1	Rotating electrical machines.
NEMA, MG-1	Motors and Generators

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All motor operated actuators shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.
- Depending on the required type of services, the rating of motor operated actuators shall be selected. For isolating service, the actuator shall be [rated for three successive open-close operations of the valve/ damper or 15 minutes continuous operation whichever is higher.] Whereas for regulating service, the actuator shall be suitably [time rated for required number of duty cycle or 150 start per hour whichever is higher].
- The actuator shall be accompanied with constant speed, squirrel cage, three/ single phase, induction motor. The motor shall be designed for high

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torque and reversing service. They shall also be suitable for direct online starting (DOL starting).

- d. Motors of actuators shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- e. The motor operated actuator shall be sized for performing open / close operation at rated speed against designed differential pressure at [90%] of rated voltage. The motor shall have [10%] design margin on the shaft design power.

The actuator shall meet the following performance requirements:

- i. Open & Close the valve completely and make leak tight valve closure without jamming.
- ii. Attain full speed of operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- iii. The motor reduction gearing shall be sufficient to lock the shaft when the motor gets de energized and prevent drift from torque switch spring pressure.
- iv. The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.
- v. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

1.4 Specific Requirements

1.4.1 Construction

- a) The actuator shall essentially comprise of drive motor, limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, space heater and internal wiring.
- b) The actuator enclosure shall be totally enclosed, dust tight, weather proof with [IPW 55] degree of protection.
- c) All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

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- d) Gear train shall be made of metal (fiber gears are not acceptable). Self locking feature shall be provided to prevent drift under torque switch (wherever applicable) spring pressure when motor is de energized.
- e) Manual wheel shall disengage automatically during motor operation.

1.4.2 Type

- a) The actuators shall have integral starters along with overload relays with built-in single phase preventer.
- b) A 415 V, 3 phase, 3 wire, 50 Hz power supply will be provided from power plant 415 V switchgear through MCCB. Control voltage of the starter circuit shall be 110 V AC or depending on manufacturer's practice. But the same shall be derived from incoming 415 V, 3 phase, 3 wire supply.

1.4.3 Motors

- a) Type: The drive motor shall be three phase, squirrel cage induction motor suitable for direct on line starting with starting current limited to six times the rated current
- b) Enclosure: The motor shall be totally enclosed, self ventilated with [IPW 65] degree of protection.
- c) Insulation: The motor winding shall be insulated with [Class – B] insulation having temperature rise limited to [Class – B].
- d) Bearing: The motor bearing shall be [double shielded, grease lubricated and antifriction type].
- e) Earthing: At least two earthing terminals shall be provided for the motor body. Separate earthing terminal should be provided for terminal box.
- f) Protection: The following electrical protections should be provided for the motor:
 - i. Single Phasing Protection
 - ii. Overload Protection
 - iii. Overheating Protection through thermostat
 - iv. Wrong Phase Sequence Protection
- g) Limit Switches: Each actuator shall be accompanied with following switches:
 - i. Four nos. positional limit switches (2 for open & 2 for close), each adjustable at any position from fully open to fully closed positions of the valve / damper.
 - ii. Two torque limit switches, one for each direction of travel, self blocking & adjustable torque type.

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- iii. Four nos. end travel limit switches, two for each direction of travel.
 - iv. A single shaft shall actuate all contacts of limit switches at each position.
- h) Interface: Open/close command termination logic with position and torque limit switches, positioned circuit shall be suitably built in the PCB inside the actuator.
- i. For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided. Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the DCS shall be energized to initiate opening and closing, by 24V DC signal from the external control system. Potential free contact provided by the IPR shall be utilized in the control circuit of the contactor of motorized actuators.
 - ii. For modulating drive, the command to actuator shall be in form of 4- 20mA signal. The necessary positioning circuit and motor protection shall be provided.
 - iii. Open/close command termination logic shall be suitably built inside actuator.
- i) Hand Wheel: Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall disengage automatically when the motor is energized.
- j) Position Indicator / Transmitter: The actuator shall have
- i. One built in local position indicator for 0 – 100% travel.
 - ii. One position transmitter of modulating / inching type for remote indication suitable to stabilize 4-20mA signal and operated with [24V DC].
- k) Space Heater: Space heater of suitable rating shall be provided. The power supply shall be derived from main power supply available in the actuator.

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- l) Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be done with [2.5 sqmm] copper wires. All wiring shall be well identified at both ends with ferrules.
- m) Terminal Box:
- i. The terminal box shall be weather proof with removable front cover and cable glands suitable for cable connection. The terminals shall be suitable for connection of [2.5 sq.mm copper conductor].
 - ii. Necessary double compression cable glands with nickel coating and tinned copper lugs for cables shall be provided.
 - iii. The terminal block shall be suitable for 650V grade power cable.
- .
- n) Rating Plate : Motor and actuator shall have Stainless steel nameplate(s) showing all particulars as per relevant IS/ IEC and following additional information:
- i. Type of bearing and recommended lubricants.
 - ii. Temperature rise under normal/abnormal conditions.
 - iii. Degree of Protection
 - iv. In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.
 - v. Year of Manufacture

1.5 Tests

The actuator and all components thereof shall be subject to routine factory tests as per relevant IS standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

1.5.1 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum [7] days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc.]

1.5.2 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished with requisite no. of copies for approval of the Owner.

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- b) The equipment shall be dispatched from works only after receipt of owner's written approval of shop test reports.

1.6 Drawings Data and Manuals

The drawings, data & manuals for the motorized actuators shall be submitted as indicated below:

1. [Actuator Data Sheet
2. General arrangement drawing
3. Internal wiring Diagram and Control Schematic.
4. Torque switch and Limit switch contacts development.
5. QAP for Test Reports
6. Manufacturer's Catalogue.
7. Instruction manuals on Installation methods.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		Integral
2.	Application		[As per project specific]
3.	Motor type		Squirrel Cage
4.	Supply voltage	V	415 V, 3 ph, 3 wire.
5.	Phase, frequency	Hz	3ph, 50 Hz
6.	Motor rated voltage	V	415V/230 V
7.	Control Voltage	V	[110 V AC]
8.	Voltage and its variation	V	± 10%
9.	Frequency and its variation	Hz	+ 3 to -5%
10.	Combined V & f variation	%	10%

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S. NO.	DESCRIPTION	UNIT	DATA
11.	Degree of Protection		IPW 65
12.	Winding Insulation		Class B
13.	Temperature Rise (over ambient temperature)	°C	Class B
14.	Painting		[RAL 5012]
15.	Motor Starting		
a)	Method		DOL
b)	Starting Current		6 times

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II**

SECTION-II, PART-B, ANNEXURE-E3

TECHNICAL SPECIFICATION FOR LV TRANSFORMERS

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E3

1.0 LV TRANSFORMER (DRY TYPE/OIL TYPE)

1.1 General

This specification is intended to cover [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV Transformers (Dry type/Oil type) complete with all accessories for efficient and trouble free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

CODE	NAME OF STANDARD
IS:334	Dimensions for porcelain Transformer bushing
IS:335	New insulating oil for transformers and switchgears
IS:1271	Classification of insulating materials for Electrical Machinery and apparatus in relation to their stability in service.
IS 2026	Specification for power Transformer (all parts)
IS:2071	Method of high voltage testing
IS:2099	High voltage porcelain bushings
IS:2147	Degree of protection.
IS:2705	Current transformers
IS:3202	Code of practice for Climate proofing of electrical equipment
IS:3637	Gas operated relays
IS:3639	Fittings and accessories for power Transformers
IS:5561	Electric Power connectors
IS:6600	Guide for loading of oil immersed transformers

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CODE	NAME OF STANDARD
IS: 11171	Dry type transformers
IS:10028	Code of practice for selection, Installation and maintenance of transformers Part I, II and III
CBIP	Manual on transformers
IEC60076	Power Transformer
IEC 60214	Tappings
IEC 60726	Dry-type power transformers
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
ANSI C57.12.51	Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160 Volts
ANSI C57.12.55	Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard
ANSI/IEEE C57.98	Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
ANSI/NFPA 70	National Electrical Code
IEEE C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.94	Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers

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CODE	NAME OF STANDARD
NEMA ST 20	Dry Type Transformers for General Applications
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The transformers shall be dry type (AN) for indoor location and shall be oil type (ONAN) for outdoor location.
- b) The oil type transformer shall be installed in hot, humid and tropical atmosphere with ambient temperature equal to 50°C. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- c) The transformer shall be capable of continuous operation at specified rating under the following condition:
 - i) Voltage variation - $\pm 10\%$
 - ii) Frequency variation - $[+3\%, -5\%]$
 - iii) Combined voltage and frequency variation (absolute sum) - $[10\%]$
- d) The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.
- e) The noise level shall be limited to the value specified by NEMA Standard Publication No. TR-1-1993 when measured in accordance with conditions outlines in ANSI/IEEE C57.12.90-1999/IS13964/CBIP publication.
- f) The design shall be such as not to cause any undesirable interference with radio or communication circuits.
- g) Transformers shall accept without injurious heating, combined voltage and frequency variation which produce an over fluxing condition of 120% for one (1) minute.

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- h) Each transformer shall be sized based on actual load with 10% margin and considering voltage regulation factor. It shall be sized by considering 100% load connected on the bus considering other transformer outage. An appropriate load factor of 0.9 for continuous and 0.2 for intermittent shall be considered.
- i) The impedance of the transformers shall be chosen such that the fault level on the LV switchgear does not exceed 50kA including the motor contributions and also voltage dip while starting the motor does not exceed 15% at motor terminal.

1.4 Specific Requirements of Transformers

1.4.1 Enclosure (for dry type)

- a) The encapsulated cast resin transformer shall be housed in naturally ventilated floor mounted cold rolled sheet steel cubicle with louvers backed by fine brass wire mesh. The enclosure shall be of bolted type fabrication and degree of protection shall be at least IP32. The minimum sheet steel thickness shall be 2 mm.
- b) Enclosure shall be provided with lifting lugs and grounding terminals at both ends. Further the enclosure door shall have pad locking provision.
- c) The enclosure door shall be interlocked with service transformer incoming breaker such that.
 - The door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position.
 - [6.6] kV side circuit breaker can be closed only when the doors are closed.
- d) Necessary illumination with controls shall be provided in the enclosure.
- e) Thermostatically controlled space heater inside the enclosure of suitable rating shall be provided if necessary.

1.4.2 Tank (for oil type)

- a) For LV transformers, the tank shall be of conventional type.
- b) Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.
- c) Tank shall be designed to permit lifting, by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.
- d) Tank together with radiators, coolers, conservator, bushings vessel and other fittings, shall be designed to withstand full vacuum without permanent distortion.
- e) The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

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- f) The material used for gaskets shall be cork-neoprene or approved equivalent. Gasketed joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather. Spare gaskets shall be provided for all openings as shipping gaskets will not be reused.
- g) Tank shall be provided with all necessary valves.
- h) Tank shall be provided with a pressure release device which shall operate at a pressure below the test pressure for the tank and radiators. This device shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall be rain proof after blowing and shall be provided with a device visible from ground to indicate operation. An equaliser pipe connecting the pressure relief device to the conservator shall be supplied. This device shall be provided for all transformers. Pressure relief device shall be equipped with remote monitoring/alarm contacts

1.4.3 Core

- a) The transformers shall be three phase core type. The core shall be built up with high grade, non-ageing, low loss, high permeability grain oriented cold rolled silicon steel laminations especially suitable for core material. Laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.
- b) CRGO sheets shall be coated with insulation varnish. Insulation shall be able to withstand the curing temperature and shall reduce eddy current to minimum. The core shall be protected from corrosion with a rust-resistant coating.
- c) The core clamping brackets shall be designed to provide an even distribution of clamping forces to the core, yokes and legs and shall be rigidly braced to reduce sound levels and losses.

1.4.4 Winding

- a) The coils shall be manufactured from electrolytic copper conductor with sufficient number of radial supports and fully insulated for rated voltage.
- b) The insulating material shall conform to Class F. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and shall withstand even the severest of temperature fluctuations.
- c) Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. The windings shall be arranged to ensure a free circulation of the air and to reduce the hot spots in the winding.

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- d) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.
- e) The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer, under short circuit stresses, switching or other transients.
- f) All coils rated 1200V or higher shall be subjected to partial discharge tests to ensure a properly cured and void free casting.

1.4.5 Encapsulation (for dry type)

- a) HV and LV coils shall be separately cast under vacuum in fibre glass reinforced epoxy resin compound. The insulation shall be fire resistant, non-inflammable, non-hygroscopic and resistant to temperature fluctuations.
- b) The epoxy shall contain filler material providing characteristics superior to unfilled epoxy including higher temperature rating, better heat conductivity, better arc resistance and adhesion to the conductor, plus a coefficient of expansion closer to that of the conductor material. The epoxy resin shall be self extinguishing.
- c) Encapsulated winding shall be free of internal voids, surface irregularities, etc. No surface finishing of encapsulated winding shall be undertaken after the process of encapsulation.

1.4.6 Insulating Oil (for oil type)

- a) The transformer shall be filled with mineral insulating oil suitably inhibited to prevent sludging.
- b) The quality of oil to be supplied for the transformer shall conform to the parameter specified in IS: 335 with latest amendments. No inhibitors shall be used in oil. Prior to filling oil shall be tested as per IS: 335 for tan delta, specific resistivity, breakdown voltage, moisture content etc.
- c) Transformer shall be dispatched oil filled. 10% excess oil for topping up shall be supplied in non-returnable container suitable for outdoor storage.
- d) Oil preservation shall be by means of conservator tank complete with silica gel breather and oil seal.
- e) Oil preservation shall be by means of bellows/ diaphragm sealed conservator tank with silica gel breather to avoid direct connection between atmosphere and transformer oil. It shall be complete with level gauges, pipes , drain valve etc. The level gauges shall be so placed that same can be readable standing from ground.
- f) Necessary device shall be kept to provide annunciation in the event of rupturing of bellow.

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1.4.7 Tappings (OCTC)

- a) Off-circuit taps as specified shall be provided on the high voltage winding.
- b) The transformer shall be capable of operation at its rated KVA on any tap provided the voltage does not vary by more than $\pm 10\%$ of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be provided.
- e) Off circuit tap changer switch where provided shall be 3 phase, hand operated, by an external handle with position markings and pad locking facility and mechanical stops to prevent over cranking beyond extreme positions.
- f) Arrangement shall be such that switch can be operated at standing height from ground level.
- g) The operating handle can be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator with pad locking facility.

1.4.8 Fittings and Accessories:

The following fittings and accessories shall be provided :

- a) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the purchaser's earthing conductors. Suitable earthing terminals on cable boxes shall also be provided.
- b) Terminal marking and rating plates shall be as per the specified standard.
- c) In case of oil type, the conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of -5°C up to an oil temperature of 100°C , with oil level varying within the minimum and maximum visible levels with necessary accessories.
- d) In case of oil filled type, Valves shall be supplied on the transformer tank and radiators.
- e) Pressure relief device: Pressure relief device shall be provided for transformers rated 2 MVA and above which shall be of sufficient size for rapid release of any pressure that may be generated within the tank and which may result in damage of the equipment
- f) Gas and Oil Actuated Relay (Magnetic Reed Type Gas & Oil Relay):

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A double float type magnetic reed type gas and oil relay as per applicable standard shall be provided for all oil filled transformers. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. These contacts shall be wired up to the transformer marshalling box. The relay shall be provided with shut off valves on the conservator side as well as the tank side.

g) Temperature Indicators

i Oil temperature indicator (OTI)

All oil type transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device. The contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC.

ii Winding Temperature Indicator (WTI):

A device for measuring the hot spot temperature of the winding shall be provided. The accuracy class of winding temperature indicator shall be $\pm 20^{\circ}\text{C}$ or better.

iii Oil Level Indicator:

A magnetic type oil level indicator shall be provided to indicate oil level in the tank.

iv RTD/transducers for remote annunciation:

In addition to the above mentioned indicators, the Oil and winding temperature measurement, RTDs / transducers shall be provided for remote indication in the DCS. RTDs shall be duplex platinum type with nominal resistance of 100 ohms at zero degree centigrade.

h) Bushing Current Transformers for stand by earth fault protection shall be provided in the neutral bushing and lead shall be brought to Marshalling box.

i) Radiator (oil filled type): Tank mounted radiators banks shall have bolted flanged connections and pipe extensions to permit withdrawal of

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transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes (unless otherwise approved) to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. The interconnecting pipes shall be provided with drain plug and air release vents.

- j) Conservator (For oil filled type): The transformers rated below 7.5MVA shall be provided with conventional single compartment conservator with dry air filling the space above the oil.

1.4.9 Bushings

- a) The bushing shall conform to the requirements of IS:2099 and IS:3347.
- b) All transformer bushings shall be of porcelain (for oil filled)/ epoxy (for dry type).
- c) The neutral terminal of 433V winding shall be brought out on a bushing along with the 433V phase terminal to form a 4 wire system for the 433V. Neutral CTs shall be located in the lead coming out of the winding and location of these CTs shall not be inside the tank.
- d) The neutral terminal of secondary shall be brought out through an outdoor. Further this neutral terminal shall be connected by a copper flat of size [50 mm x 6] mm, which shall be brought down upto 100 mm above ground. The copper flat shall be insulated and supported from the tank body.

1.4.10 Terminal arrangement

- a) Cable boxes
- Wherever cable connections are specified, suitable cable boxes shall be provided and shall be air insulated.
 - Cable boxes shall have drilled gland plate of adequate size to receive cables and to allow easy termination.
 - Removable drilled gland planes shall be provided in the cable boxes.
 - The additional supports for the cable boxes shall be galvanised iron.
 - The contractor shall provide earthing terminals on the cable box, to suit [50mmx6] mm GI flat.
- b) Bus duct
- Wherever Bus duct termination is specified a flanged throat or equivalent connection shall be provided for termination of bus duct enclosure. The winding termination shall be outdoor type bushing. The material of the bus duct termination arrangement of the transformer shall be nonmagnetic. The bus duct may be either phase-segregated or non-segregated.

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- ii. Tolerance permissible for the height of terminals and bus duct flange location specified for bus duct termination over ground level is $\pm 5\text{mm}$. Contractor has to ensure that radiator, conservator and explosion vent do not obstruct the path of the bus-ducts.

1.4.11 Marshalling box

- a) A sheet steel weather, vermin and dust proof marshalling box shall be furnished. The sheet steel used shall be at least 2.0 mm (CRCA) thick. The box shall be free standing floor mounted/tank mounted type and have a sloping roof. The degree of protection shall be IP-55 in accordance with IS:2147.
- b) The marshalling box shall have a glazed door of suitable size for convenience of temperature indicators reading.
- c) All incoming cables shall enter the marshalling box from the bottom.

1.4.12 Wiring

- a) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- b) Wiring shall be done with 650V PVC wires in conduit or PVC armored cable. *[Minimum wire size shall be 1.5 sq.mm stranded copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.]*
- c) Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. *[Terminals shall be stud type, suitable for terminating 2 nos. 2.5 mm2 stranded copper conductor and provided with acrylic insulating cover.]*
- d) All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- e) Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

1.4.13 Painting

- a) All steel surfaces shall be thoroughly cleaned by sand blasting and / or by chemical agents, as required to produce a smooth surface free of scales, grease and rust.
- b) The external surfaces, after cleaning, shall be given a coat of high quality red oxide or yellow chromate primer followed by filler coats.
- c) The transformer finished with two coats of epoxy based powder coated paint. The paints shall be carefully selected to withstand tropical heat,

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rain etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

- d) Painting shade shall be subject to owner's approval.
- e) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.14 Name Plate

Nameplates of approved design shall be furnished at each cubicle (one no. each at front as well as at backside of cubicle) and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black background. Self-tapping screws shall hold the nameplate. *[Nameplate size shall be minimum 20 x 75mm for instrument/device and 40 x 150mm for panels. Caution notice on suitable metal plate shall be affixed at the back of terminal Box.]*

1.5 Tests

1.5.1 Type Tests

For each type & rating of LV Transformers, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within *[last five]* years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within *[last five]* years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- a) Temperature rise test
- b) Dielectric test

1.5.2 Routine Tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The following tests shall be performed on each transformer as a minimum:

- a) After assembly, each core shall be pressure tested for one minute at 2KV (r.m.s.) A.C. between all bolts, side plates, structural steel works and the core.

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- b) The wiring for auxiliary power and control circuitry shall be subjected to withstand one minute power frequency test with 2.0KV (r.m.s.) to earth
- c) Measurement of winding resistance
- d) Measurement of voltage ratio and check of phase displacement
- e) Measurement of short circuit impedance and load loss
- f) Measurement of no load loss and current
- g) Dielectric routine tests
- h) Excitation loss and current measurements shall be made at 90%, 100% and 110% of the rated voltage as routine test.
- i) Partial discharge test
- j) Tan delta test

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings/ Data and Manuals

Drawings, data, and manuals for the transformers shall be submitted as indicated below:

- a) *[General Arrangement Drawing]*
- b) *Dimensioned general arrangement drawing showing enclosure, core coil assembly, terminal arrangement, marshalling box and various fittings.*
- c) *Transport/shipping dimensions with weights, wheel base detail etc.*
- d) *Foundation plan & loading.*
- e) *Bus duct/cable termination arrangement.*
- f) *Control schematics and wiring diagrams.*
- g) *Test reports and QAP*
- h) *Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.*
- i) *Instruction manuals on Transformer and its various fittings The manual shall clearly indicate method of installation, checkups and tests to be carried out before commissioning of the equipment.]*

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Note: The drawings, data and manuals listed are minimum requirement only. The Bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted.

1.7 Ratings and Requirements

Table 2.0

6.6/0.420 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Application	[As per project requirement]	[As per project requirement]
2.	Location	Indoor	Outdoor
3.	Type	[Dry Type: epoxy cast resin transformer]	[Oil type transformer]
4.	Reference standard	IS 11171	IS 2026
5.	Rated power (indicative)	[As per project requirement]	[As per project requirement]
6.	Rated winding voltage ratio (line to line)	6.6/0.433 kV	6.6/0.433 kV
7.	Number of phases	3	3
8.	Winding	2	2
9.	Rated frequency	50 Hz	50 Hz
10.	Type of cooling	AN	ONAN
11.	Insulation Class	Class F or Better	Class F or Better
12.	Temperature rise Over ambient temperature of 50°C		
a.	For Winding by	90°C or lower as permissible for class	55°C

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	resistance method	of insulation offered	
b.	For Oil by Thermometer method	Not Applicable	50 °C
13.	Insulation level (LI/AC)		
a.	HV- (LI/AC)	60 KVp/20 kVrms	60 KVp/20 kVrms
b.	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
14.	Vector group	[Dyn11]	[Dyn11]
15.	Short-circuit impedance on principal tap	[As per project requirement]	[As per project requirement]
16.	Parallel operation of transformer	Momentarily	Momentarily
17.	Type of taps provided	OCTC, full capacity	OCTC, full capacity
18.	Taps provided on	H.V. winding	H.V. winding
19.	Range of taps	[+/- 5 % in steps of 2.5%]	[+/- 5 % in steps of 2.5%]
20.	Method of Tap charge control-		
a.	Manual local	Yes	Yes
b.	Electrical local	No	No
c.	Electrical remote	No	No
d.	Automatic	No	No
21.	System earthing		

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a.	H.V.	Non-effectively earthed			Non-effectively earthed
b.	L.V.	Effectively earthed			Effectively earthed
22.	Terminal arrangement				
a.	H.V.	6.6kV(UE) Cable/ busduct			6.6kV(UE) Cable/ busduct
b.	L.V.	Non-segregated phase bus duct			Non-segregated phase bus duct
23.	Neutral for earthing	GS flat connector			GS flat connector
24.	Transformer bushing	HV	LV	LV - N	Same as Dry type transformer
25.	Voltage class KV(r.m.s.)	7.2	1.1	1.1	
26.	Creepage distance mm	[As 25mm/kV]			[As 25mm/kV]
27.	Min. Ph-Ph/ Ph-E clearance mm	As per Standard			As per standard
28.	System fault Level				
a.	HV Side	40 KA (r.m.s.)			40 KA (r.m.s.)
b.	LV Side	50KA (r.m.s.)			50KA (r.m.s.)
29.	Max. Noise level	As per NEMA std. TR-1			As per NEMA std. TR-1
30.	Auxiliary supply	415 V, 3 ph, 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)			415 V, 3 ph 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)
31.	LV neutral side	[As per project]			[As per project]

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	current transformer for standby earth fault protection	requirement]	requirement]
32.	Guaranteed no load loss (kW)	[By Bidder]	[By Bidder]
33.	Guaranteed load loss (kW)	[By Bidder]	[By Bidder]
34.	Efficiency		
a	At full load	[By Bidder]	[By Bidder]
b	At 75% load	[By Bidder]	[By Bidder]
c	At 50% load	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II**

SECTION-II, PART-B, ANNEXURE-E4

**TECHNICAL SPECIFICATION FOR 415V SWITCHGEAR,
MCC & DBs**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E4**1.0 415V SWITCHGEAR, MCC AND DB****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Switchgear MCC and DBs, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2551	Danger notice plates
IS :2705	Current transformers-specification
IS :3156	Voltage transformer specification
IS :3231	Specification for electrical relays for power system protection
IS: 8084	Specification for interconnection busbars for AC voltages above 1kV up to and including 36kV.
IS :8623	Specification for low-voltage switchgear and control gear assemblies
IS :8686	Specification for static protective relays
IS :10118	Code-of practice for selection installation and maintenance of switchgear and control gear
IS :12021	Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 v ac
IS : 13947 (Part 1)	Specification for low-voltage switchgear and control gear
IS : 13947 (Part 2)	Specification for low-voltage switchgear and control gear –part 2: circuit breakers
IS : 13947 (Part 4)	Specification for low-voltage switchgear and control gear -part 4 : contactors and motor feeders

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Codes	Name of Standard
IS : 13947 (Part 5)	Low-voltage switchgear and control gear specification Part 5 : control circuit devices and switching elements
IEC 61439	Low voltage switchgear and control gear assemblies.
CEA	CEA regulations for installation and operation of meters 2006.
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) All 415V Switchgear, MCC and DB shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- b) All 415V Switchgear, MCC and DB shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-) 5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC system	:	-15% to +10%

- c) 415 V switchgear & MCCs shall be of indoor /outdoor, double front/single front [Preferably single front] and fully draw out type. ACB feeder may be of single tier/two tier configuration depending upon rating. DBs (ACDB / DCDB) shall be of single / double front [Preferably single front] and fixed type. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration shall be provided.
- d) All AC motor starters shall be suitable for Direct on Line (DOL) starting. Motors rated below [132]kW shall be provided with combination starters consists of MCCB/MPCB, contactors and electronic over load relay and

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the motor starter shall comply with Type – 2 coordination conforming to relevant code and standards. Motors rated [132] kW and above shall be breaker controlled and shall be provided with comprehensive motor protection relay. Motors rated above [160]kW shall be fed from MV Switchgear [Only for firefighting system Motor rated up to 200kW shall be fed from 415V switch board].

- e) For 415 V switchgear & MCCs Feeders rated [630A] and above shall be equipped with Air Circuit Breaker (ACB). Outgoing/Incoming feeders rating below [630] A shall be MCCBs.
- f) For DBs Incomer rated 630A and above shall be ACB. Incomer below 630A shall be MCCB. Outgoing feeder may be MCCB/MCB depending upon the bus fault level.
- g) All ACB shall be draw out type & should have Service, test and disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- h) Local/remote selection shall be provided for all incoming/Outgoing ACB module. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local(Switchgear).
- i) Two out of three breaker logic shall be considered for switchgear/MCC. However mechanical interlock shall be considered for income of MCCB operated DBs.
- j) Also, Local/remote selection switch shall be provided for all motor modules for control from Remote(DCS). Also for breaker operated motor, breaker shall be closed in Test position from local(Switchgear).
- k) All motors shall be provided with Emergency stop push button.
- l) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary MCCB/MCB shall be provided for each MCC, 2 x 100% per section. However breaker shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from bus bars. This control supplies shall be monitored.
- m) All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 415V switchgear, MCC and DBs shall have following minimum features.

- a) All 415V switchgear, MCC and DBs shall be metal enclosed, indoor, floor mounted and free standing type. The panels shall be suitable for cable entry at bottom and busduct connection at top.

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- b) Between 415V Switchgear and dry type transformers, non segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with busduct manufacturer in this regards is covered in this specification.
- c) All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d) Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels
- e) Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f) The switchgear enclosure shall confirm to the degree of protection IP-54 (for outdoor). For indoor, enclosure shall confirm to IP52, however for Busbar chamber of switchboards rated above 1600A, degree of protection shall be IP-42.
- g) Paint shade for complete panels excluding end covers shall be [RAL 9002] and [RAL 5012] for extreme end covers for all board.
- h) The switchgear assembly shall comprise a continuous, line-up of single / multi tier cubicles. The installations of circuit breakers however shall be limited to the bottom two tiers only. Working height shall be limited to [250 mm to 1800 mm] from the floor level.
- i) Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc
- j) A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgears having more than one bus section.
- k) Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable

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terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.

- l) For MCC/DB a full height vertical cable chamber with cable supports shall be provided in each section to facilitate unit wiring.
- m) 2x100%, 415V/110V AC control transformer shall be provided for control, Indication and annunciation supply for contactor operated motor feeder. All the necessary auxiliary and main contactor shall be provided suitable for this control supply.
- n) Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module.
- o) Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- p) Supplier shall provide total 20% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- q) Motors of rating 30 kW and above shall be provided with anti-condensation heaters. Necessary provision for supply of motor space heating shall be considered in the switchgear.
- r) The incoming connection to transformer of more than 1000kVA and inter-connecting sections between switchboards shall preferably be of bus ducts.
- s) It should be possible to carryout maintenance on a feeder with adjacent feeders alive.

1.4.2

Bus and Bus taps

- a) The main buses and connections shall be of high [conductivity Aluminum / Copper] alloy sized for specified current ratings with temperature rise limited [to 40°C over ambient temperature of 50°C].
- b) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminum contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance. Adequate contact pressure shall be ensured by means of two bolts connection with plain & spring washers and locknuts. Temperature rise shall not exceed 105 degree for silver plated joints over an ambient temperature of 50 degree.
- c) Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- d) Bus insulators shall be flame-retardant, track resistant type with high creepage surface. All buses and connections shall be supported and braced to withstand the stresses due to maximum short-circuit current and also to take care of thermal expansion.

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- e) Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f) Power shall be distributed to each module or compartment by a set of vertical bus bars. The vertical bus bars shall run behind the modules. Necessary tee off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.
- g) The clearance between the individual bare phase power bus bars and between the phase and earth bus bars in air shall be not less than [25.4] mm.
- h) Three phase, neutral (with at least [50] % rating of main Bus bar and continuous earth bus shall be provided. Bus bar and tapping shall be provided with color coded PVC sleeves.

1.4.3

Air Circuit Breaker

- a) All Circuit Breakers for incoming feeders and Bus couplers shall be [four] poles; single throw, motor operated and air break type. Circuit breaker for outgoing feeders shall be triple pole, single throw and air break type. However for supply feeders it shall be [four] pole.
- b) Circuit Breakers shall be [draw out type] having Service, Test & Disconnected positions with positive indication for each position.
- c) Circuit breakers of identical rating shall be physically and electrically interchangeable.
- d) Bolted disconnected links shall be provided for all outgoing feeders for isolation of neutral, if necessary.
- e) For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open – close – open operation of the circuit breaker shall be possible after failure of power supply to the motor when the spring is charged after a closing operation.
- f) Mechanical safety interlock shall be provided to prevent the circuit breaker from being racked in or out of the service position when the breaker is closed.
- g) Automatic safety shutters shall be provided to fully cover the female primary disconnects when the breaker is withdrawn.
- h) Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indicator, an operational counter and mechanism to indicate spring charge / discharge condition.
- i) In addition to the auxiliary contacts required for normal breaker operation and indication, each breaker shall be provided with followings for interlocking purpose:-
 - i. Position / cell switch with 4 No + 4 NC contacts.

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- ii. Limit / auxiliary switches shall be convertible type that is facility for changing N.O. contact to N.C. and vice-versa.
- iii. Mechanical stopper to prevent accidental falling while withdrawing.
- j) Breaker cannot be racked in from 'isolated' to 'test' position with the door open together with provision for defeat of this interlocking, however, the door can be closed only when the breaker is brought back to 'isolated' position. Insertion of breaker into 'Service' position not possible if the shutters are not free.
- k) Door can be opened only when breaker is OFF and is in 'Isolated' position. Remote closing of breaker not permitted with door open.
- l) Anti pumping relay / device to ensure that there can be only one closing operation for each closing command.
- m) Suitable trolley arrangement shall be provided for breaker/starter modules. Two trolleys per switchgear room shall be provided so that top most breaker module of all types, sizes and rating can be withdrawn on trolley and lowered for maintenance purpose.
- n) Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage.

1.4.4 Contactors, MCCB and MPCB

- a) Incomers for MCCs and DBs rated below 630A shall be MCCB.
- b) Incomer and bus coupler rated below 630A shall be mechanically Interlocked.
- c) Motor starter contactors shall be of air break, electromagnetic type. Suitable for DOL starting of motor, and shall be of utilization category AC-3 for ordinary and AC-4 for reversing starters. DC contactor shall be of DC-3 utilization category.
- d) The contactors shall be three pole, air break type designed for [duty class III category A.C. –3 with non-bouncing silver / silver alloy.]
- e) Each contactor shall be provided with two (2) normally open and two (2) normally closed auxiliary contacts unless otherwise specifically stated. Rating shall be decided by the bidder.
- f) Reversing contacts shall be electrically and mechanically interlocked.
- g) Contactors with delayed dropout feature shall be provided for some essential auxiliaries. These contactors shall not dropout on power failure if the voltage is restored within 3 seconds.

1.4.5 Electronic over load relays

- a) Electronic overload relays shall conform to IEC:292-1 and shall be triple pole, ambient temperature compensated with adjustable setting, inverse time lag, built in single phase preventer and hand/auto reset type

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provided as per requirement along with necessary command, feedback cable, coupling relays etc.

- b) Provided with 1 NO and 1NC contact of rating same as the auxiliary contact of the contactors.
- c) The relay shall be able to withstand prospective short circuit current without damage or injurious heating till the motor protection MCCB/MPCB clears the fault.
- d) Relays may be direct acting or CT operated, depending on current rating. CTs shall be included in the scope of supply.

1.4.6 Bus Transfer scheme:

Each switchgear of two incomer and bus coupler shall be provided with the following provisions.

- i) Dead bus closing.
- ii) Manual live change over (Momentary paralleling)
- iii) Automatic bus transfer scheme.

1.4.7 Current Transformer

- a) Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made.
- b) CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c) CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d) All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e) CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Voltage Transformer

- a) Voltage transformers(VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b) VTs shall be of the single-phase type. VTs shall be protected on their primary side by MCCBs with interrupting ratings corresponding to breaker rating and by MCB (with auxiliary contacts) on the secondary sides.

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- c) VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d) It shall be possible to replace VTs without having to de-energise the main busbars.
- e) VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.9 Transducer

For all the incoming and the outgoing of 415V Switchgear / MCC/ DB Feeders requiring remote metering and/or current monitoring shall be provided with multi-functional transducers. The output shall be 4-20 mA DC which shall correspond to the normal range.

1.4.10 Secondary Wiring

- a) The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b) Fuse /MCB and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c) Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d) Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with [stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring.]
- e) Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.11 Terminal Blocks

- a) Terminal blocks shall be 660V grade box-clamp type with marking strips, similar to 10 mm² or equal. Terminals for C.T. secondary leads shall have provision for shorting.
- b) Not more than two wires shall be connected to any terminal. If more than two wires at one terminal are required, separate terminals with function wise shorting links shall be provided. [Spare terminal equal in number to 20% of active terminals shall be furnished.]
- c) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged so that individual wires of an external cable can be connected to consecutive terminals.

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1.4.12 Ground bus

- a) A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b) Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c) C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.13 Space Heater

- a) Each vertical section shall be provided with thermostat controlled space heater 5A, 3 pin socket plug.
- b) In addition, motor feeders rated [30 KW and above] shall be wired up for feeding the motor space heater through suitably rated breaker auxiliary NC contact and/or contactor.
- c) Cubicle heater, Motor heater, and Plug socket circuit shall have individual switch fuse units/MCB.

1.4.14 AC Distribution Boards (ACDBs)

- a) AC Distribution Boards shall have MCCB/MCB at incomer depending upon the short circuit rating. Distribution Boards may be fed from switchgear and shall have two incomers. AC distribution Boards shall be of two types - one with 415V, 4-wire, triple pole and neutral (TPN) outgoing feeders and the other with 240V, 2-wire, single pole and neutral (SPN) outgoing feeders.
- b) For small loads, MCB boards with TPN MCB as incomer and TPN/SP MCBs for outgoing may be considered. The feeder rating and quantity shall be as per requirement.
- c) Board shall be single/double front [preferably single front], metal clad, front matched, dust and vermin proof, fixed type, compartmentalized and extensible on both sides.
- d) Bus bars shall have same cross section throughout the length. Rating of the neutral bus bar shall be 50% of the main bus bar. Earth bus bar shall run in bottom chamber throughout the length of the Board.

1.4.15 DC Distribution Boards

DCDBs shall have two incomers and a bus coupler. Incomers and outgoing feeders of DCDBs shall be MCB/MCCB modules. They shall be fixed type and floor mounted. Other constructional features shall be similar to ACDB.

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The feeder rating and quantity shall be as per requirement.

1.4.16 Control & Indication

The circuit breaker shall be wired up for local & remote operation. Each breaker cubicle shall be equipped with following:

- a) Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In switchgear position, the breaker shall be operated from switchgear only in test position with only protection (no interlock).
- b) Two (2) heavy duty, oil-tight, push buttons for Trip & Close.
- c) Circuit breaker shall be indicated electrically. The following indication colour shall be used.

Breaker open - GREEN

Breaker closed - RED

Spring Charged - WHITE

Breaker Auto Trip- AMBER

- d) However, any other indication shall be provided as per owner's requirement.
- e) Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.
- f) For all MCCB feeders, trip indication lamp shall be provided on front of the compartment.
- g) For all starters, ON, OFF and trip indication lamps shall be provided on front of the compartment.

1.4.17 Relays, Protection & Metering

- a) The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- b) All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner.
- c) All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.

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- d) All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- e) Energy meters shall be provided for incomer of 415V Switchgear and MCC and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than 1.0S.
- f) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- g) All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- h) The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- i) All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- j) Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- k) D.C supply shall be supervised by DC supervision relays.
- l) Trip circuit shall be supervised by Trip circuit supervision.
- m) Tripping shall be done through high speed lock out relays.
- n) All meters/ instrument shall be flush mounted on front panel, at least 96mm² size with 90° linear scales and accuracy class of 2.0.
- o) Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- p) For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- q) Metering and protection shall be as per below table

a)	Incomers	
	Protections	Metering
i	Time graded short circuit protection	Local Current (single phase) indication and remote indication through transducer.

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ii	Over current protection	Voltage Measurement for all three phases and remote indication through transducer.
iii	Earth fault protection	KW, Kwhr
b)	Bus coupler	
	Protections	Metering
i	Over current protection(51)	Local Current (single phase) indication.
ii	IDMT Earth fault protection(51N)	
c)	Contactor controlled motor feeders [90kW and above motor only]	
	Protections	Metering
i	Time graded short circuit protection	Local Current indication and remote indication through transducer.
ii	Over current protection	
c)	[Motor Feeders [of 132KW and above only]]	
	Protections	Metering
	Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload etc.	Local Current indication and remote indication through transducer.
[Other feeders]		
a)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection	[Voltage – phase to phase,]
	Fuse failure protection	
b)	Motor feeders (MPCB/MCCB with Contractors)	
	Protections	Metering
	Electronic Overload relay (with single phase preventor), short circuit protection (through fuse/MCCB/MPCB as specified)	
c)	Incoming feeders for ACDB/DCDB	
	Protections	Metering

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	Short circuit protection (if MCCB)	[Voltage (single phase and, Phase Current (1 Phase))] Local indication only.
d)	Outgoing feeders of ACDB/DCDB	
	Protections	Metering
	Short circuit protection (through fuse/MCCB)	

1.5

Tests

I) Type Test

For each type & rating of 415V Switchgear, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted are as follows:

- Measurement of insulation resistance of Circuit Breaker in closed and open positions.
- Measurement of milli-volt drop across Circuit Breaker main contacts and other joints.
- Measurement of Circuit Breaker/Contactor operating time for close & open at nominal voltage and 80% of rated voltage.
- Measurement of resistance, IR value and drop-off/pick-up voltage of close and trip coils.
- Healthiness of limit switch contacts.
- Spring charging motor functional checks.
- Verification of phase sequence and checking of clearances of busbars between phase to phase and phase to earth.
- Measurement of milli-volt drop across busbar joints

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- i) Torque tightness test.
- j) High voltage test on busbar.
- k) Measurement of CT/PT polarity, ratio and knee point voltage.
- l) Electrical and mechanical interlock checks.
- m) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- n) Secondary injection of all metering circuits.
- o) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below

- a) [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening.
- b) Bill of Materials.
- c) Technical Data sheet and Catalogue.
- d) Foundation drawing details with bottom view of switchgear.
- e) Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f) Control Schematics & Wiring diagram.
- g) Inspection and Test Plan (ITP).
- h) Suggestive list of protective relays.
- i) Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

415V switchgears, MCC and DB shall comply with the particulars indicated in the following tables.

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Table- 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		415 Volts, 3 Phase, 4 wire 50 Hz.
2.2	System neutral earthing		Solidly earthed
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		a) 2.5kV b) 1.5kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		90°C for busbars having non-silver plated joints 105°C for busbars having silver plated joints
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	50
b	Dynamic Rating	kA (peak)	105
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		Cu/Al
2.14	Fully draw out (FD)/ Fixed (F)		FD for Switchgear/MCC; F for DBs.
2.15	Entry –Top (T)/Bottom (B)		Top for busduct, bottom for cables
2.16	Degree of protection		IP 52
2.17	Colour finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	GS
2.19	Minimum clearances in air of live parts	mm	As per standard
3.0	Starters		
3.1	Type	DOL	DOL
3.2	Contactor rated duty		AC3 for DOL
3.3	Single phasing preventer required.	Yes / no	Yes
3.4	Thermal overload relay reset	Manual / Auto	Settable for either to Manual or Auto
4.0	Circuit breakers		
4.1	Maker's name		[By bidder]
4.2	Voltage, frequency & no.of phases , poles		415 V, 50 Hz, 3 Ph, 4 Pole
4.3	Rated operating duty		O-3min-CO- 3min -CO
4.4	Circuit breakers type		ACB
4.5	Short circuit withstand current for 1 sec. Duration	kA	50
4.6	Rated making current	kAp	105
4.7	Rated current at site reference ambient temp	A °C	[By bidder]

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S. No.	DESCRIPTION	UNIT	DATA
4.8	Type of operating mechanism		Spring charged motor and manual
4.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
4.10	Control voltage		
a	Spring charging motor	V AC/DC	[220V DC/240V AC]
b	For closing/tripping	V AC/DC	220V DC
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	As per IS
b	Closing at normal voltage	%	As per IS
c	Trip coil	%	As per IS
4.12	Power required for closing at normal voltage	W	[By bidder]
4.13	Power required for tripping at normal voltage	W	[By bidder]
4.14	Spring charging motor details:		
a	Rating	kW	[By bidder]
b	Rated voltage	V, AC/DC	[By bidder]
c	Spring charging	Sec.	[By bidder]
	Electrical and mechanical anti-pumping features been provided	Yes/No	Required
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		415 V, 50 Hz & 3 P for outgoing, 4P for incoming and supply feeders
5.2	Rated operating duty		As per IS
5.3	Rated breaking capacity	kA (rms)	50

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S. No.	DESCRIPTION	UNIT	DATA
5.4	Rated making current	kA (Peak)	105
5.5	On/off operation		
5.6	Manual	Yes/No	Yes
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	Yes
5.8	Auxiliary contacts required	Yes/No	[As per project specific]
6.0	Contactors		
6.1	Make		[By Bidder]
6.2	Rated duty	AC3/A C4	AC3 for DOL AC4 for RDOL
6.3	No of poles		3
6.4	Utilization category		[By Bidder]
6.5	Rated voltage of auxiliary contacts	V	[By Bidder]
6.6	Rated voltage of coil	V	[By Bidder]
6.7	Rated breaking capacity	Factor of rated current	[By Bidder]
6.8	Rated making capacity	Factor of rated current	[By Bidder]
6.9	Limits of operation		As per IS/IEC
a	Supply voltage variation		[By Bidder]
b	Supply frequency variation for closing		[By Bidder]
c	Drop out voltage		[By Bidder]
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		

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S. No.	DESCRIPTION	UNIT	DATA
7.1	Voltage Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
7.2	CT Ratio		Primary current/1A or 5A
7.3	Measuring CTs		CI - 1.0 instrument safety factor 5.0
7.4	Protection CTs		CI 5P20
7.5	Measuring VTs		(min)/phase CI1.0
7.6	Protection VTs		CI 3P
8.0	Control transformers		
8.1	Make		[By Bidder]
8.2	Type		Dry Type
8.3	Applicable standards		As specified in the specification
8.4	Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
8.5	Class of insulation		Class-B or Better
8.6	Rated output	VA	[As per project specific]
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		[By Bidder]
10.2	Make		[By Bidder]
10.3	Type designation		[By Bidder]
10.4	Setting range		[By Bidder]
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		[By Bidder]
11.2	Make		[By Bidder]
11.3	Type		[By Bidder]
11.4	Current setting range		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	[By Bidder]
12.0	Under voltage relay		
12.1	Make		[By Bidder]
12.2	Type		[By Bidder]
12.3	Voltage rating	V	[By Bidder]
12.4	Setting range	V	[By Bidder]
13.0	Auxiliary relays and timers		
13.1	Make		[By Bidder]
13.2	Type		[By Bidder]
13.3	Coil voltage	V	[By Bidder]
14.0	Control/selector switch		
14.1	Make		[By Bidder]
14.2	Type designation		[By Bidder]
15.0	Meters		
15.1	Applicable Standards		As specified in the specification.
15.3	Accuracy Class		Class 1.0 or Better
15.4	Make		[By Bidder]
15.5	Type		Multi function with RS 485 connectivity
16.0	Voltmeter		
16.1	Make		*[By Bidder]
16.2	Type		Moving coil
16.3	Applicable standards		As specified in the specification.
16.4	Accuracy class		Class 1.0
17.0	Ammeter		

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S. No.	DESCRIPTION	UNIT	DATA
17.1	Make		As specified in the specification.
17.2	Type		Moving coil
17.3	Applicable standards		As specified in the specification.
17.4	Accuracy class		Class 1.0
18.0	Indicating lamps		
18.1	Make		As specified in the specification.
18.2	Type		Clustered Led
18.3	Voltage	V	As specified in the specification.
18.4	Wattage of lamp	W	As specified in the specification.
19.0	Push buttons		
19.1	Make		As specified in the specification.
19.2	Type designation		As specified in the specification.
19.3	Contact rating	A	As specified in the specification.
20.0	Space heater		
20.1	Make		As specified in the specification.
20.2	Type		As specified in the specification.
20.3	Rated voltage	V	As specified in the specification.
21.0	Wiring and terminal blocks		
21.1	Voltage grade		1.1 kV
21.2	Insulation		[By Bidder]
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	2.5 for CT & PT 1.5 for Others
b	Control wiring	Sq.mm	1.5 for Others

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S. No.	DESCRIPTION	UNIT	DATA
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		Sliding type
	II) For Fixed Type		Stud & nut type
21.5	Minimum current rating of terminal blocks	A	10

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E5
TECHNICAL SPECIFICATION FOR 415V NON
SEGREGATED PHASE BUS DUCTS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E5**1.0 415V NON SEGREGATED PHASE BUS DUCT****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Non Segregated Phase Busduct, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS 8084	Interconnecting Bus bar for AC Voltage above 1KV up to and Including 36kV
IEC 60947	Low Voltage Switchgear and Control gear
ANSI/IEEE C37.20	Metal-Clad and Station-Type Cubicle Switchgear
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear
IEC 60439	Low-voltage switchgear and control gear assemblies.
BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) The 415V Non-segregated phase bus duct shall serve as an interconnection between the 415V Switchgear and 11/0.433kV LV Transformer. The Non-segregated phase bus duct shall be installed

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indoor/Outdoor in a hot, humid and tropical atmosphere. All panels associated with Non-segregated phase bus duct shall be located indoors/Outdoors.

- b) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- c) For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be as specified in Clause 1.7 Rating and requirements.
- d) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the required short-circuit currents.
- e) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- f) The bus ducts shall be self cooled and shall not be equipped with blower or any other type of forced ventilation.
- g) The equipment rating shall be based on an ambient temperature. Same phase disposition shall be maintained throughout the run of the bus duct. Phase crossover units, if required, shall also be provided inside the Busduct itself.
- h) Bus ducts shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current.

1.4 Specific Requirements

1.4.1 General

- a) 415V Non Segregated Phase Busduct is provided for connection between low voltage side of 11/0.433kV cast resin dry type /oil type transformers and associated 415V Switchgears shall be of TPN (3 phase and neutral) along with necessary bends, flexible at both transformer & switchgear ends, flanges, phase crossover chambers (if required), support structures & accessories including terminations at the equipment ends.
- b) The 415V bus duct shall be metal enclosed, non-phase segregated enclosure type, self cooled and insulated for 1.1kV voltage. The cooling medium inside the duct shall be air.

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- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) The 415V non-segregated phase bus duct will be installed indoor or partially indoor & outdoor depending upon the location of equipment being interconnected in a hot, humid and tropical atmosphere. All panels associated with LV non-segregated phase bus duct will be located indoors.
- e) The continuous current rating and momentary peak withstand current rating of the Busduct between transformers & their associated switchgears shall be same as that of the associated switchgears and as indicated in the specification.
- f) All supporting steel structures shall be hot dip galvanized.
- g) The bus ducts shall be provided with space heaters to control moisture. Slicagel breather if required same shall be provided.

1.4.2 Enclosures

- a) The enclosure shall be rectangular and shall be made of [aluminium alloy/Mild steel] of grade [19000H2] as per IS-5082. The entire bus duct shall be designed with dust, weather and vermin-proof construction. The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- b) *[Phases shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminum alloy) of 3mm for bus rating including and above 3000A whereas enclosures for normal bus current rating (<3000 A) shall be sheet steel fabricated type of 2.5mm thick].*
- c) Enclosures shall be provided with flange ends with drilled dimensions to suit the flanges at the switchgear and transformer ends.
- d) Circumferential neoprene rubber gaskets shall be provided for dust tight joints with adjacent enclosure section.
- h) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion / contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.

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- i) All outdoor bus-enclosures shall be so designed & constructed as to prevent accumulation of rain water on top sheet. Similarly all Gasketed flanged joints shall be suitably protected against direct splashing of rain water in case of outdoor runs. The connection flanges shall be sufficiently stiffened so as not to bend while tightening the bolts.
- j) Outdoor portions of the bus duct, if any, shall have continuous rain hood of non magnetic material or with suitable arrangement for rainwater prevention.
- k) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, switch gear terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets.
- l) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between indoor and outdoor portions of the bus duct.
- m) In case, the bus duct penetrates the firewall, the wall frame assembly and the seal shall be designed for the same fire rating as the firewall.
- n) Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct. Space Heaters shall be provided in the bus duct.
- o) Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- p) Shipping length of the Busduct shall be not more than three (3) meters in length.
- q) Minimum Degree of protection of Busduct enclosure shall be IP-52 for indoor and IPW-55 for outdoor section of the Busduct.

1.4.3 Bus Conductor

- a) The bus conductor shall be of high conductivity, [Aluminium alloy / Aluminium].
- b) The bus conductors shall be given a coat of matt black paint to facilitate heat dissipation. However the sizing of the bus conductor shall consider the conductor as bare.
- c) The bus conductor shall be designed for bolted connections throughout the run.
- d) Flexible connection shall ensure an efficient and trouble-free connection.

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- e) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminium contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- f) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.
- g) The bus bar shall be sleeved with FRLS heat shrinkable, colour coded PVC sleeves at intermittent points for phase identification.
- h) The material of the conductor shall be aluminium alloy of grade [63401WP] as per IS: 5082. The temperature rise of conductor shall be 40 degree over design ambient temperature of 50 degree. Also, the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.

1.4.4 Disconnect Link

- a) Removable bolted disconnected link shall be provided in the bus for the purpose of isolation.
- b) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- c) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- d) A minimum clearance of [300 mm. (12")] shall be provided between the disconnected bus sections with the link removed.

1.4.5 Insulators

- a) The bus conductor supporting insulators shall be flame retardant, non-hygroscopic, high impact and high dielectric strength material with an anti tracking contour.
- b) Material of insulator shall be [Epoxy SMC moulded /FRP].
- c) Spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the short circuit current assigned to the bus duct.
- d) Bus support insulators shall be interchangeable, high creepage, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.

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- e) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- f) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator.
- g) Space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus duct.

1.4.6 Connections & Terminations

- a) All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the switchgear, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the switchgear and auxiliary transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.

1.4.7 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- c) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- d) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.
- e) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.

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- f) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

1.4.8 Ground bus

- a) The ground bus of two numbers of separately run [50x10 mm] minimum GS flat shall be provided along the run of the bus duct. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.
- b) Ground bus shall be finally to connected to power plant earth grid at one end.

1.4.9 Wiring

All wiring for space heaters shall be done with insulated stranded copper conductor of not less than [2.5 mm² cross-section]. Each wire shall be identified at both ends with wire designation as per bidder's wiring diagram and shall be brought out to a terminal box outside the bus duct.

Terminal blocks shall be box-clamp type minimum 10 mm² with marking strips.

At [least 20% spare terminals] shall be furnished in the terminal block.

1.4.10 Name Plate

Suitable name plate shall be furnished with each piece of equipment.

[Materials for name plate shall be plastic / lamicaid, 3 mm thick, using white letters on black background.]

1.4.11 Space Heater

Thermostatically controlled Space heaters shall be provided in the bus ducts, wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation. At least one number space heater with thermostat shall be provided at each transformer and switchgear end.

The space heaters shall be suitable for continuous operation on single phase supply, and shall be automatically controlled by thermostats. Necessary wiring up to junction boxes mounted on bus duct and from junction boxes to switchboards shall be provided.

1.4.12 Painting and Finish

- a) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as

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possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint

- b) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- c) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- d) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].
- e) The interior surface finish shall be as per manufacturer's standard.
- f) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- g) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.
- h) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- i) The paint shade shall be subject to owner's approval.

1.5 Tests

l) Type Test

For each type & rating of 415V Non segregated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test

1.6 Drawings and Documents

Drawings, data & manuals for the 415V Non segregated phase bus duct shall be submitted as indicated below:

- a) [Dimensional GA drawing]
- b) Data sheets
- c) Typical calculation for arriving at the size of conductor and the insulator spacing.
- d) Type test report (short circuit, temperature rise test) for similar bus duct manufactured by the proposed manufacturer.
- e) Foundation layout and requirements
- f) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

1.7 Ratings and Requirements

Major technical parameters of 415V non segregated Bus Duct are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table: 2.0

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.	Type of bus duct		Non segregated phase bus duct	
2.	Rated voltage and No. of phase	V	415V, Triple Pole , Neutral(3Phase & 4 Wire)	
3.	Applicable standard		IS 8084	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
4.	System Frequency	Hz	50	
5.	Design ambient temperature	Degree	50	
6.	Rated Current	A	[As per project Requirement]	
7.	Designation (from & to)		[As per project Requirement]	
8.	Type of cooling (NSPBD)		Natural air	
9.	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
10.	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
11.	One minute power frequency voltage withstand	KV (RMS)	2.5	
12.	Continuous current rating at 50°C design ambient air temperature	A	[As per project Requirement]	
13.	Material a) Bus bar b) Enclosure		a) [Aluminum] b) [Aluminum alloy/MS]	
14.	One second short circuit withstand rating	KA (RMS)	50	
15.	Momentary short circuit withstand current	KA (Peak)	105	
16.	Bus bar Support		[FRP/ SMC]	
17.	Degree of protection		IP 52 for indoor IP W55 for outdoor	
18.	Earthing Conductor Material		GS	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
19.	Heating		Thermostat controlled space heater	
20.	Fittings of silica gel breather and drain plug		Required	
21.	Finish of Bus Enclosure		a) Inside: Matt Black b) Outside [RAL 5012]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E6

TECHNICAL SPECIFICATION FOR 220V DC SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E6**1.0 220 V DC SYSTEM****1.1 General**

This specification is intended to cover the *[design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of 220V DC system with its all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS- 266	:	Specification for Sulfuric Acid
IS- 1069	:	Specification for Water for Storage battery
IS- 1146	:	Specification for rubber and Plastic Containers for Lead Acid Storage Batteries
IS-1652-1991	:	Stationary Cells and Batteries, lead acid type (with Plante positive plates) – Specification
IS- 3116	:	Specification for Sealing Compound For Lead Acid Batteries
IS- 8320	:	General requirements and methods of tests for lead acid storage batteries.
IS- 6071	:	Specification for synthetic separators of lead acid storage batteries.
IS-10918-1984	:	Specification For Vented Type Nickel-Cadmium Batteries.
IS-14782-2000	:	Code of Practice for maintenance and testing of large Lead Acid Batteries in Generating Station and Substation.
ANSI-C-	:	Guide for surge withstand capability test.

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37.90a		
IEC - 60623	:	Secondary Cells and Batteries Containing Other Non-Acid Electrolytes – Vented Nickel- Cadmium Prismatic Rechargeable Single Cells.
IEEE-1115-2000	:	Recommended Practice For Sizing Nickel-Cadmium Battery For Stationary Application.
IEEE-485-1997	:	Recommended Practice For Lead Acid Battery For Stationary Application.
IEEE-946-1992	:	Recommended Practice For The Design Of DC Auxiliary Power Systems For Generating Station.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IS:5	:	Colours for ready mix paints.
IS : 694	:	PVC Insulated Cable for working voltages upto and including 1100V
IS : 1248	:	Specification for Direct acting indicating analogue electrical measuring instruments.
IS:13947 Pt-1	:	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS : 13947	:	Specification for low voltage switch gear and control gear
IS : 3231	:	Electrical relays for power system protection.
IS : 3842	:	Application guide for Electrical relays for AC System
IS : 3895	:	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	:	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	:	Code of practice for phosphating of Iron and Steel
IS:6619	:	Safety Code for Semi-conductor Rectifier Equipment.
IS:6875	:	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 VAC or 1200VDC

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IS : 9000	:	Basic environmental testing procedures for electronic and electrical items.
IS:13703	:	Low voltage fuses for voltages not exceeding 1000 V AC, 1500VDC.
EEUA-45D	:	Performance requirements for electrical Alarm Annunciation system

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity (IE) Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) 220 V DC Systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The system shall be suitable for operation in a highly polluted environment.
- b) The permissible voltage variation for 220V battery shall be from -15% to +10%.
- c) The battery shall be of storage type [Lead Acid Plante Positive Plate/Ni-Cd] Type. The Battery shall be of high discharge performance type. The plates shall be designed for maximum durability during all service conditions including high rate of discharge & rapid fluctuation of load.
- d) While estimating the battery size, temperature correction factor [based on lowest expected temperature 5 Deg C], margin on capacity [10%] and aging factor [1.0 for Lead Acid Plante and 1.2 for Ni-Cd] shall be considered.
- e) Cell Voltages for Lead Acid batteries:

i.	Nominal Discharge Voltage/cell	2.0 V
ii.	Float Voltage/cell	2.2 V
iii.	Boost Voltage/cell	2.7 V
iv.	Capacity for ten(10) hour rate at 27°C any time during the entire duty	1.85 V/Cell

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	cycle	
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f) Cell Voltages for Ni-Cd Batteries

i.	Nominal Discharge Voltage/cell	1.2 V
ii.	Float Voltage/cell	1.42 V
iii.	Boost Voltage/cell	1.7 V
iv.	Capacity for five(5) hour rate at 27°C any time during the entire duty cycle	1.14 V/ Cell

- g) 2x100% sets, 220V of either Lead-Acid Plante Type or Nickel-Cadmium battery banks with 2 x100% float cum boost charger catering to 100% of unit as well as station loads shall be provided.
- h) Permissible voltage variation for 220V battery shall be from 190V to 240V.
- i) The Ampere-Hour capacity of DC Storage Battery shall be based on [Three] hours' continuous DC supply at rated voltage to essential auxiliaries.
- j) Batteries shall be suitable for being boost charged to fully charged condition from fully discharged condition within 10 hours.
- k) Lead acid batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.2V/cell.
- l) Ni-Cd batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42V/cell.
- m) The float-cum-boost charger shall be rated to cater to the following:
- Trickle charging current of the battery
 - Equalizing charging of the Battery
 - Boost charging of the Battery
 - Continuous load on the DC system
 - 25% spare capacity over above loads.

1.4 Specific Requirements

1.4.1 Constructional requirements of battery

a) Containers

Container shall be made of transparent glass for lead acid and polypropylene for Ni-Cd batteries. It shall be robust, heat resistance, leak

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proof, non-absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container. The marking for the electrolyte level should be for the upper and lower limits. Container shall be closed / sealed lid type.

The pole sealing arrangement should be such that no acid particle gets entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

b) Vent Plugs

Vent plug shall be provided in each cell. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the spring type hydrometer can be inserted into the vent to take electrolyte sample.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuation of load. The construction of plates shall conform to latest revisions of standards as applicable for type of battery.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative posts shall be clearly marked.

The plante positive plates shall be supported from the ledges of the SAN container. They should not be supported at the bottom of container. Sufficient space shall allowed to allow the creepage of the plates.

d) Sediment Space

Sufficient sediment space shall be provided so that the cells shall not have to be cleaned out during normal life and prevent shorts within the cells.

e) Cell Insulators

Each cell shall be separately supported on PVC / Porcelain / Hard rubber insulators fixed on the racks with adequate clearances between adjacent cells. Minimum distance between adjacent cell shall be more than the bulge allowed for two cells in accordance with relevant IS standard.

f) Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS: 266 and distilled water conforming to IS: 1069 for lead

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acid batteries and battery grade potassium hydroxide for Ni-Cd batteries. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately in a separate non-returnable container. 10% extra electrolyte shall be furnished to cover spillage in transit or during erection.

g) Connectors and Fasteners

Lead or Lead coated copper connectors (For Lead acid Plante Type batteries) and Nickel coated copper connectors (for Ni-Cd batteries) shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated/Nickel coated to prevent corrosion. The thickness of lead coating of connectors should not be less than 0.025 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulated shrouds. End take-off connections from positive and negative poles of battery shall be made by single core cables having stranded aluminum conductors and XLPE insulation. Necessary supports and lugs for termination of these cables on battery shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 30 minutes discharge current of the respective battery and through fault short circuit current which the battery can produce and withstand for the period declared. Suitable number of inter rack connectors shall be supplied by the bidder to suit the battery room layout during the detail engineering.

h) Battery Racks

Steel racks with anti-corrosive epoxy paint for all the battery shall be provided. They shall be free standing type mounted on porcelain / hard rubber / PVC pads insulators. Battery shall be located in the single tier arrangement. However battery having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The battery rack and support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

i) Manufacturer's Identification Systems

The following information shall be indelibly marked on outside of each cell:

- i. Manufacturer's name and trade marks
- ii. Country and year of manufacture
- iii. Manufacturer type of designation
- iv. AH capacity at 10 hour discharge rate
- v. Serial number

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1.4.2 Constructional Requirements of battery charger

- a) The Charger shall be indoor, floor mounted, self supporting sheet metal enclosed cubicle type. All necessary base frames, anchor bolts and hardware shall be supplied. The charger shall be fabricated using cold rolled sheet steel shall not less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied. The lugs for cables shall be made of electrolytic copper with tin coat. The chargers shall be tropicalised and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The chargers shall have hinged double leaf doors provided on front / or backside for adequate access to the charger internals. All the charger cubicle doors shall be properly earthed. The degree of protection of charger enclosure shall be at least IP-42.
- b) All indicating instruments, control and selector switches and indicating lamps shall be mounted on the front side of the charger.
- c) Electronic equipments shall be of modular design consisting of plug in modules in standard 19 inches metallic racks with metallic card guides. The cards should be provided with proper handles. Card to card wiring should be preferably through a motherboard. Unplanned jumpering and track modifications are not permitted and track modifications are not permitted. Mechanical interlocks to prevent wrong insertion of cards should be provided. Each card shall have its junction and test points identified. Maintenance aids such as extension printed wiring boards and jumper leads shall be provided.
- d) The layout of charger equipment shall be such that their heat losses do not give rise to excessive temperature within the charger panel surface. Location of the electronic modules shall be such that temperature rises of the location, in no case, shall exceed 10°C over ambient air temperature outside the charger.
- e) Printed Circuit Boards (PCB)
PCB shall be made of glass epoxy of 1.6 mm thick, fire resistant, bonded with 99.8% pure copper foil, free of wrinkles, blisters, scratches and pinholes. The contact surface of the edge connectors of the PCBs shall be plated with hard gold to a minimum thickness of 5 microns. Component identification shall be printed on PCB by silk screen method. All PCBs shall be tropicalised and masked.
- f) Contactors

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All battery chargers shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. The operating coil shall be rated for 415 Volts AC.

g) Thermal Overload Relay

A thermal overload relay incorporating a distinct single phase protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

h) Rectifier-Transformer and Chokes

The rectifier-transformer and chokes shall be dry and air cooled (AN) type. The rating of the rectifier transformers and chokes shall correspond to the rating of the associated rectifier assembly. The rectifier-transformers and chokes shall have class-B insulation with temperature rise limited to class A insulation value.

i) Rectifier Assembly

The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective charger. The rectifier cells shall be provided with their own heat dissipation arrangement with natural air cooling. The rectifier shall utilize diodes / thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink shall not be permitted to exceed 85 °C absolute duly considering the maximum charger panel inside temperature. Calculations to show what maximum junction temperature shall be and what the heat sink temperature shall be when operating at 200% and 100% load current continuously duly considering the maximum surrounding air temperature of 50°C outside the panel have to be submitted. Necessary surge protection devices and rectifier type fast acting fuses shall be provided in each arm of the rectifier connections.

1.4.3 System Concept for 220 V DC system

- a) First float cum boost charger shall be normally ON in float mode, supplying the D.C. load and at the same time trickle charging the battery and shall (a) provide occasional equalizing charge (b) boost charge the battery up to 2.7/1.7 Volts per cell as required.
- b) The characteristics shall be such that if load is high and exceeds the charger capacity, the excess load shall be supplied by the battery.
- c) The second float-cum-boost charger shall be normally in stand-by (auto float/charge) mode and shall come into the circuit automatically (a) to take over the functions of first float cum boost charger in case of its failure (b) to provide occasional equalizing charge as required, (c) boosting charge the battery up to 2.7/1.7 Volts per cell.

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- d) The float-cum-boost charger shall also have provision for float, equalizing, and boost charging the battery through manual selection. On failure of station A.C. supply, float-cum-boost charger shall go out of service and battery shall take over to supply emergency loads.

1.4.4 Operational requirements of charger

- a) The float-cum-boost charger shall be sized to restore the fully discharged battery to full charge condition in ten (10) hours with 10% margin over maximum charging rate and also to operate as a float charger.
- b) The batteries & chargers shall be so designed that the maximum fault level on DC DB is limited to 15KA (Indicative only; the actual value shall be decided by the contractor after substantiating the same by calculation.)
- c) The battery shall be trickle charged at 2.15 to 2.25 V per cell and 1.4 to 1.42V per cell for lead acid and Ni-Cd battery respectively. All chargers shall also be capable of boost charging the associated battery at 2.0 to 2.7 V per cell for lead acid and 1.53 to 1.7V for Ni Cd at the desired rate. The chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50 °C.
- d) Necessary interlocks shall also be provided to avoid accidental boost mode operation when loads are connected to the bus.
- e) The battery chargers as well as their automatic regulators shall be of static type. Battery chargers shall be capable of continuous operation at the respective rated load in trickle mode i.e. trickle charging the associated lead acid battery/Ni-Cd battery while supplying the DC loads.
- f) Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle / float or Boost charging.
- g) All battery chargers shall be provided with facility both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage / current control, whether automatic or manual. Means shall be provided to avoid current / voltage surges of harmful magnitude/ nature which may arise during changeover from Auto to Manual mode or vice versa under normal operating condition.
- h) Soft start feature shall be provided to build up the voltage to the set value slowly within fifteen (15) seconds. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the charger nor shall it cause blowing of

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any of the charger fuses. The charger shall not trip on overload or external short circuit. After clearance of fault, the charger voltage shall build up automatically when working in automatic mode.

- i) When on automatic control mode, during trickle / float charging, the charger output voltage shall remain within (\pm) 1% of the set value for AC input voltage variation of (\pm) 10%, frequency variation of (+) 3 / (-) 5%, a combined voltage and frequency variation of 10% (absolute sum) and a continuous DC load variation from zero to full load. Uniform and step less adjustment of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire trickle / float charging output range specified. Step less adjustment of the load limiter setting shall be possible from 80% to 100% of the rated output current for trickle / float charging mode.
- j) During boost charging, the battery chargers shall operate on constant current mode (when automatic voltage regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50% to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be vernier type.
- k) Energizing the chargers with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere shall be less than fifteen (15) seconds.
- l) Momentary output voltage of the charger, with the battery connected shall be within 94% to 106% of the voltage setting during sudden load change from 100% to 20% of full load or vice versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above mentioned change.
- m) The charger manufacturer may offer an arrangement in which the voltage setting device for trickle/ float charging mode is also used as output voltage limit setting device for Boost charging mode, and the load limiter of the trickle / float charging mode is also used as Boost charging current setting device.
- n) Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.

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1.4.5 Auxiliary Equipment

- a) DC Voltmeter, DC ammeter and AC voltmeter in 96 mm square shall be provided for each charger. The instruments shall be 240 scale, antiglare glass, flush mounted type, dust proof and moisture resistant. The instrument shall have easily accessible means from zero adjustments. The instruments shall be of 1.5 accuracy class.
- b) In addition to above, following metering provision shall be given for remote metering / recording at PLC/DCS
 - i. Battery Voltage
 - ii. DC voltage of float & Boost charger
 - iii. DC current of float & Boost charger
 - iv. DC load voltage
 - v. DC load current
 - vi. DC Voltage and Current at FCBC
 - vii. Centre Zero Ammeter with Shunt to read Discharge/Charge current
 - viii. Ammeter for Battery Trickle Charge current
 - ix. DC Bus Voltmeter indicating - +ve to Earth, -ve to Earth and +ve to -ve with Selector switch.

The following indications shall be provided

- i. AC Supply – R,Y,B Healthy
- ii. DC supply – Available
- iii. Charger in Float Mode
- iv. Charger in Equalising mode
- v. Charger in Boost mode
- vi. Charger tripped on fault
- vii. D.C Earth fault sensing & alarm

Suitable soft link to be provided for interfacing with DDCMIS.

c) Air Break Switches

All chargers shall have AC input and DC output switches of air break, single throw, load break and fault make type. The contacts of the switches shall open and close with a snap action. Switches shall be rated for 120% of maximum continuous load. 'ON' and 'OFF' position of the switch shall be clearly indicated.

d) Control and Selector Switches

Control and selector switches shall be rotary, stay put type with escutcheon plates showing the functions and positions. The switches shall be of sturdy construction and suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred. The contact ratings shall be at least the following:

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- i. Make and carry continuously - 10 Amps
- ii. Breaking current at 220V DC - 0.5 Amp (inductive)
- iii. Breaking current at 240V AC - 5 Amp. at 0.3 p.f.

e) Fuses

Fuses shall be of HRC cartridge fuse link type. Fuses shall be mounted on fuse carriers which are mounted on fuse bases. Wherever it is not possible to mount fuses on fuse carriers, fuses shall be directly mounted on plug in type bases. In such cases one insulated fuse pulling handle shall be supplied for each charger. Kick-off fuses (trip fuses) with alarm contacts shall be provided for all DC fuses.

f) Indicating Lamps

Three (3) indicating lamps shall be provided to indicate AC supply availability. The indicating lamp shall be of panel mounting, LEDs and capable of clear status indication under the normal room illumination. The lamps shall be replaceable from front. The lamp covers shall be preferably screwed type, unbreakable and moulded from heat resistant material.

g) Blocking Diode

Blocking diode shall be provided in the output circuit of each charger to prevent current flow from the Battery into the charger.

h) Annunciation System

Following annunciation shall be provided for local and remote indications in all chargers(List is indicative only)

- i. AC supply failure
- ii. Rectifier fuse failure
- iii. Surge circuit fuse failure
- iv. Filter capacitor fuse failure
- v. Load limiter operated
- vi. Charger fail / trip
- vii. Battery on Boost
- viii. Battery on Trickle
- ix. DC output fuse failure
- x. Positive grounded
- xi. Negative grounded
- xii. Battery fully discharged
- xiii. AC input under voltage
- xiv. DC voltage low
- xv. DC voltage high
- xvi. DC system earth fault

The annunciation system shall have audio-visual arrangement and shall incorporate acknowledge, reset and test push buttons. On occurrence of fault, the corresponding window lights up and shall stay in lighted

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condition till the fault is cleared and the reset push button is pressed. At least 20% spare annunciation windows with accessories shall be provided.

i) Lamp / Space Heaters / Receptacles

The charger panels shall be provided with:

- i. Internal illumination lamp with door switch.
- ii. Space heater with thermostat control.
- iii. 3-pin 5A receptacle with plug.
- iv. Lamp, heater and receptacle circuits shall have individual switch fuse units/MCB.

1.4.6 Battery Accessories

Each battery shall be furnished complete with following:

- a) First charge of electrolyte plus 10% extra.
- b) Teak wood racks with 3 coats of anti-acid paints.
- c) Stand insulators 5% extra.
- d) Cell inter-connectors 5% extra and one extra end take-off.
- e) Lead-coated connection hardware 5% extra
- f) Cell numbering tag with fixing arrangements
- g) Insulated cable clamps with hardware
- h) Six (6) extra cell with all accessories but without acid
- i) In addition to the above each battery shall be furnished with a set of following accessories.
- j) One (1) Interconnector bolt wrench
- k) One (1) Hydrometer syringe
- l) One (1) Thermometer with specific gravity correction scale.
- m) One (1) Cell testing voltmeter with leads.
- n) One (1) Pocket thermometer
- o) One (1) set of Acid resisting funnels
- p) One (1) set of Acid resisting jugs of adequate capacity
- q) One (1) set of Rubber aprons
- r) One (1) set of Rubber gloves
- s) PVC spill trays under the battery cells
- t) Spanner for cells

Catalogues and Instruction manuals of battery and battery charger to be furnished.

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1.4.7 Painting

- a) All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.
- b) After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality lead oxide primer and stoved after each coat.
- c) The equipment shall be finished in Siemens Gray RAL: 9002 color with two coats of epoxy based powder coated paint except end covers and RAL 5012 for end covers. The coating shall be done electro statically followed by stoving.
- d) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.8 Installation

- a) The battery room floor shall be acid resistant type and walls shall have acid resistant tiles up to a suitable height. Alternatively acid resistant paints are also acceptable. Adequate ventilation shall be provided in the battery room for the removal of hydrogen.
- b) The Battery charger along with D.C. distribution board shall be located in separate rooms.
- c) After erection and connection of the Battery Charger, the contractor shall complete the charging discharging cycles recommended by the manufacturer. The contractor shall rig up a suitable discharge resistor for this purpose.
- d) Connection from Battery terminals shall be made by means of cables. Lead coated terminal connector shall be furnished for this purpose.

1.5 Tests

1) Type Test

For each type of Battery and battery charger, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

All Battery, Battery chargers, Inverters and its components thereof shall be subject to shop tests as per relevant IS/IEC standards. The tests on Battery chargers shall include but not limited to the following:

- a) Voltage regulation check from 0 to 100% loads with $\pm 10\%$ input voltage variation.
- b) Ripple content measurement.
- c) D.C short circuit test to prove ability of current limit.
- d) Measurements of transient overshoot/undershoot during switching ON/load throw-off.
- e) Current limiter operation.
- f) Special tests for electrical equipment, when specified in relevant Indian / International standard shall be carried out on at least one item of each rating.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports. Drawings, Data & Manuals:

1.6

Drawings, Data & Manuals

1. Following drawings/ data and Manuals to be submitted for approval:

- a) [Dimensional battery layout diagram and plan & section.
- b) Connection details of take-off terminals.
- c) Dimensional general arrangement drawings of battery charger clearly showing device dispositions, cable entry, space requirement, etc.

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- d) Sectional views of battery charger.
- e) Charger foundation plan and loading.
- f) Charger schematics and wiring diagrams.
- g) Test reports
- h) Detailed bill of materials
- i) Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.
- j) Instruction manuals of battery and battery Charger. The manual shall clearly indicate method of installation, check-ups, and tests to be carried out before commissioning of the equipment.
- k) Bidders shall note that the drawings, data and manuals listed herein are minimum requirements only. The Bidders shall ensure that other necessary write-ups, curves and information required to fully describe the equipment are submitted with their bids].

1.7 Rating and Requirement

S.No	Technical Particulars	Unit	Parameters	Remarks
1.0	General			
1.1	Bidder's Name			
1.2	Make			
1.3	Application		[For Main plant/BOP]	
2.0	Battery			
2.1	Make and country	:	[By bidder]	
2.2	Type	:	Lead acid(Plante)/Ni Cd	
2.3	Reference standard		As specified in specification	
2.4	Rated system voltage	: (Volts)	220V DC	
2.5	Rated capacity for one hour discharge at 27°C	: (Ah)	[As per project specific]	
2.6	Rated capacity for 10 hour discharge rate at 27°C	: (Ah)	[As per project specific]	
2.7	Nominal voltage per cell	: (V)	2.2V /1.42V	
2.8	End cell voltage	: (V)	1.85/1.14V	
2.9	Number of cells per battery	:	Based on type of battery.	
2.10	Short circuit current	: (kA)	[By bidder]	
2.11	Mounting type	:	[By bidder]	

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S.No	Technical Particulars	Unit	Parameters	Remarks
2.12	AH efficiency at rated load	: (%)	[By bidder]	
2.13	Watt hour efficiency	: (%)	[By bidder]	
3.0	Constructional details		[By bidder]	
3.1	Container			
a	Material			
b	Thickness	Mm		
3.2	Separator			
a	Type			
b	Material			
c	Thickness	Mm		
3.3	Electrolyte			
3.4	Quantity for first filling plus 10% extra			
3.5	Specific gravity at twenty seven (27) degree Centigrade			
a	With all cells fully charged			
b	At the end of discharge			
3.6	Method of supporting elements		[By bidder]	
a	Edges of plates and Inner surfaces of container	Mm		
b	Bottom of negative plates	Mm		
c	Top of plates	Mm		
d	Sediment space	Mm		
3.7	Weather explosion-proof cent plugs are provided		[By bidder]	
3.8	Distance between centre's of cells when erected	mm	[By bidder]	
3.9	Expected life span of battery	Year	[By bidder]	
3.10	Proposed Layout (attach layout)		[By bidder]	
4.0	Battery Charger			
4.1	Number of rectifiers	:	[By bidder]	
4.2	Reference standard	:		
4.3	Make and country			
4.4	Type	:		

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S.No	Technical Particulars	Unit	Parameters	Remarks
4.5	Rectifiers with thyristors Y/N	:	[By bidder]	
4.6	Rated input AC voltage	: (V)	415V, 3ph, 4 wire	
4.7	Frequency	: (Hz)	50	
4.8	Output DC current	: (A)	[By bidder]	
4.9	Rectifier efficiency	: (%)	[By bidder]	
4.10	DC voltage setting adjustment of AVR for float charging		[By bidder]	
4.11	Boost mode:		[By bidder]	
a	Starting rate	: (V)		
b	Finishing rate	: (V)		
4.12	Protection class of cubicles	:		
4.13	Residual ripple	: (%)	[By bidder]	
4.14	Current limiting feather provided	: (Yes/No)	[By bidder]	
4.15	Soft starting feather provided	: (Yes/No)	[By bidder]	
4.17	Voltage and current setter in different mode provided	: (Yes/No)	[By bidder]	
4.18	Type of cooling	:	Natural	
4.19	Paint shade: Indoor and outdoor		[RAL 5012]	
5.0	Constructional details		[By bidder]	
5.1	List of major accessories			
5.2	Diode			
a	Make			
b	Type			
c	Rating			
d	Voltage	V		
e	Current	A		
5.3	Rectifier Transformer			
a	Make			
b	Rating	kVA		
c	Connection			
	Primary Winding			
	Secondary Winding			

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S.No	Technical Particulars	Unit	Parameters	Remarks
d	Voltage			
	Primary Winding	V		
	Secondary Winding	V		
e	Percentage of tap provided			
	Primary Winding	%		
	Secondary Winding	%		
5.4	Control/ Selector switch			
a	Make			
b	Type designation			
c	Voltage Grade	V		
d	Current rating	A		
e	Make and carry			
f	Brake			
g	Spring return or stay out			
h	Type of handle			
i	No. of positions			
j	No. of poles/ ways			
k	Angular Movement			
m	Special features if any			
5.5	Indicating Lamp			
a	Make			
b	Type			
c	Voltage	V		
d	Series resistor value	Ohm		
6	Thickness of battery charger panel sheet steel;	Mm		
5.6	Weight & dimensions		[By bidder]	
a	Length	Mm		
b	Depth	Mm		
c	Height	Mm		
d	Weight	Kg		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E7
TECHNICAL SPECIFICATION FOR HV CABLES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E7

1.0 HV CABLEs

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of HV cables complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part II)	:	XLPE insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques
IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the

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		cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All HV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The HV power cables shall be 6600V unearthed grade, single/multi core stranded Aluminum conductor, extruded XLPE insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-2). These cables shall conform to IS 7098 (Part II).
- d) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- e) HV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- f) HV cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)
 - v. Installation conditions.
 - vi. Voltage drop under normal running and starting condition
 - vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
 - viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
 - ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.

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1.4 Specific Requirements

1.4.1 Type of Cable

- a) HV cables shall be 6600V unearthed grade, heavy duty, stranded aluminium conductor, XLPE insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-2) cables conforming to IS: 7098 part II.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum to form compact conductor having a resistance within the limits specified.

1.4.3 Conductor Shield

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be provided over the conductor by applying non metallic semi conducting tape or by extrusion of semi conducting tape or by extrusion of semi-conducting compound or a combination of the two. The semi conducting polymer shall be cross linked for XLPE cables.

1.4.4 Insulation

The insulation of the HV cables shall be XLPE type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

1.4.5 Insulation Shield

A non magnetic semi conducting shield shall be put over the insulation to confine electrical field to the insulation. The XLPE cable insulation shield shall be strippable.

The metallic layer of the insulation shield shall be grounded at least at one location in the cable's run. In the case of single conductor cable, care should be taken with regard to ampacity when grounding at more than one point.

For all the cables having insulation shield, it shall have some form of stress relief measure at every splice at termination. This can be stress cones, moulded devices, heat shrink or cold shrink kits. All kits must be suitable for the voltage class and cable size.

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1.4.6 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.7 Armour

HV cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.8 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.9 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than 500m or as per required length.

1.4.10 Identification of cores:

HV power cables shall be identified by color code.

1.4.11 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers

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shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.

b) Workmanship shall be neat, clean and of the highest grade.

c) Special Properties:

All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:

- i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
- ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
- iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
- iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
- v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
- vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
- vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.12 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.13 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]
- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.

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f. ISI marks

g. Nominal cross sectional area of the conductor & no of cores

h. Sequential marking

i. Owner's identification mark]

1.4.14 Fire Proof sealing system

i) General

- a) Fire proof sealing system shall consist of Fire-stops/fire-seals for sealing of cable/cable tray and conduit/pipe penetrations, both horizontal and vertical, through brick or RCC walls/floors, to prevent the spread of fire from one area, which is separated from others by fire-resistant barriers.
- b) 'Fire-breaks' provided on long runs of cable racks/trays to prevent the propagation of fire along the cable rack, within a single fire-area or fire- zone.
- c) The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop/fire-break.
- d) The FPS system shall comply in all respects with the requirements of the codes and standards listed below

IEEE-634 ASTM-E-814

ANSI-IEEE-383 IEC-331 IEC-332

ii) Fire stop/ seal

The FPS system adopted for cables or cable trays penetrating through walls and floor constitute a openings, or cables passing through embedded conduits / pipes / pipe- sleeves, fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

iii) Fire Break

The fire proofing system, other than fire-stops, adopted to retard flame propagation long runs of horizontal or vertical cable trays in the same fire zone or area, in an event of a fire, shall constitute a 'fire-break' and shall be provided by applying a suitable fire –resistance coating on cables and cable trays for the required length, with or without a fire resistant panel, at the point of the fire break to obtain the fire-rating specified.

iv) Application of fire proof sealing system

Fire stops shall be provided for cable penetration openings listed below

The passage of cables/cable trays pipe sleeves/embedded conduits through walls / floors.

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Vertical raceways, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

Cable entry through openings in floor slabs below HT/LT switchgear, MCCs, various Control and relay panels and other bottom entry panels, shall be effectively sealed by fire stop

Location of fire breaks

Firebreaks shall be provided on both cable rack and trenches at all cable tray Intersections and tee-offs.

On linear runs of cable trays between fire stops or fire breaks, fire breaks shall be provided at intervals of 15 metres on horizontal cable runs and 5 m on vertical cable runs.

Fire breaks in linear runs of cable trenches between intersections and tee-offs shall be provided at intervals of 30 metres.

Bidder shall furnish the test certificates for the fire stops and fire breaks after award of contract for Owner/Owner's Representative review. If the certificates are not satisfactory all the tests shall be conducted free of cost. The offered system i.e. fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Owner / Owner's Representative.

v) Test on fire stops

The fire stops shall be subjected to the following type tests:

- a. Fire Rating Test
- b. Hose Stream Test

Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

Preconditioning of fire stop test specimens before conducting the fire rating and hose stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the fire rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable

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penetration fire stop, with a maximum temperature limit on the unexposed surface of 200°C.

Tests on fire breaks

Firebreaks shall undergo the following tests as per ANSI-IEEE-383:

- Ampacity test
- Flame test

1.5 Tests

1.5.1 Type Test

For each type & rating of HV cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 H.V. Power cable, 6600V unearthed grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		6.6 V	
2.	Voltage Grade		6.6/6.6kV Unearthed	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE cables		90°C	
5.	Maximum conductor temperature for		250°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE cables			
6.	Conductor		Aluminum	
7.	Insulation		XLPE	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		Armoured	
11.	System Grounding		Resistance Grounded	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		40 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E8
TECHNICAL SPECIFICATION FOR LV CABLES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E8

1.0 LV CABLES

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV cables for power & control applications complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS:1554(Part I)	:	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100V
IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part I)	:	XLPE insulated PVC sheathed cables for working voltage up to 1.1kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques

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IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All LV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The LV power cables shall be 1100V grade, single/multi core stranded Aluminum conductor, extruded XLPE/PVC insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1). These cables shall conform to IS 7098 (Part I) for XLPE and 1554(part 1) for PVC insulation.
- d) The control cables shall be 1100 V grade, multi core, stranded annealed high conductivity copper with extruded PVC insulated inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1).
- e) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- f) The continuous and short time current carrying capacity of PVC insulated cables shall be based on maximum operating temperature of 70°C and 160°C respectively.
- g) LV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- h) Power cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)

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- v. Installation conditions.
- vi. Voltage drop under normal running and starting condition
- vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
- viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
- ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.
- x. The minimum size of cables to be used shall be as follow :
 - Aluminium conductor : 6 Sq. mm.
 - Copper conductor : 2.5 Sq. mm

1.4 Specific Requirements

1.4.1 Type of Cable

- a) LV power cables shall be 1100V grade, heavy duty, stranded aluminium conductor, XLPE/ PVC insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS: 1554(Part 1) for PVC insulation and IS 7098(Part 1) for XLPE insulation.
- b) Control Cables shall be 1100 V grade, heavy duty with annealed high conductivity stranded copper conductor, PVC insulated, FRLS PVC inner sheathed, armoured and FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS : 1554.
- c) LV power cables of size above 35 sq. mm may be provided with XLPE insulation. Bidder shall clearly indicate the type of insulation provided in the technical bid.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum for LV Power cables and Copper for control cables to form compact conductor having a resistance within the limits specified. All the cables of size 25mm² and above shall have sector shaped conductors.

1.4.3 Insulation

The insulation of the LV power and control cables shall be [XLPE/PVC] type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

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1.4.4 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.5 Armour

LV power and control cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.6 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.7 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than the following:

- a) Power cables: 500m
- b) Control cables: 1000m

1.4.8 Identification of cores and spares:

LV power cables shall be identified by color code. However LV control cables shall be identified by the number of its cores.

[Multi-core control cables shall have 20% spare core, minimum one spare.]

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1.4.9 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.
- b) Workmanship shall be neat, clean and of the highest grade.
- c) Special Properties:
All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:
 - i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
 - ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
 - iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
 - iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
 - v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
 - vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
 - vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.10 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.11 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]

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- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.
- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.5 Tests

1.5.1 Type Test

For each type & rating of LV power and control cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 L.V. Power and control cables, 1100 V grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		415 V	
2.	Voltage Grade		1.1 kV	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE/PVC cables		For XLPE: 90°C For PVC: 70°C	
5.	Maximum conductor temperature for		For XLPE: 250°C For PVC: 160°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE/PVC cables			
6.	Conductor		For power cable: Aluminum	
			For Control Cable: Copper	
7.	Insulation		For power cable: XLPE/PVC	
			For Control Cable: PVC	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		For power cable: Armoured	
			For Control Cable: Armoured	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
11.	System Grounding		415 V system is solidly grounded.	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		50 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E9

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E9

1.0 ILLUMINATION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Illumination System complete with luminaries and all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS 1913	:	Electrical lighting fittings- General and safety requirements
IS 2418 - Part I	:	Tubular fluorescent Lamp
IS 3480	:	Flexible steel conduits for electrical wiring
IS 3646 (Part I to III)	:	Code of Practice For Interior Illumination
IS 4012	:	Dust proof electric lighting fittings
IS4013	:	Flame proof enclosure
IS 6665	:	Code of practice for industrial lighting
IS 5077	:	Decorative light fittings
IS 9537 - Part II	:	Rigid steel conduits for electrical installations

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IS 9583	:	Emergency lighting units
IS 9900	:	High pressure mercury vapor lamp
IS 9974	:	High pressure sodium vapor lamp
IS 10322	:	Luminaries for street lighting
CBIP Manual	:	Substation Equipment, Illumination and Layouts
IES (Illuminating Engineering Society of North America)	:	Application and Reference Volume
IEC 60598	:	Luminaries
CEA	:	CEA regulations and standard technical specification.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All illumination systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The illumination systems shall be suitable for operation in a highly polluted environment.
- b. Lighting fixtures shall be suited for the following range of frequency and voltage variations:
 - i. Voltage Variation : $\pm 10\%$
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

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- c. All emergency DC lighting systems shall be suited for voltage variation from -15% to + 10% of rated voltage.
- d. The design of the lighting systems shall be such that it shall ensure average lux levels specified for different areas.
- e. The illumination system shall comprise of the following:
 - i. Normal AC lighting
 - ii. Normal cum emergency lighting system
 - iii. 220V DC Emergency lighting system
 - iv. Maintenance 24V AC lighting system
 - v. Portable emergency lights with self contained battery packs.

1.4 Specific Requirements

1.4.1 Scope of work

The scope of work shall include design, preparation of Lighting design and manufacture, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with Lighting system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Switchgear room and cable gallery.
- iv) All roads within battery limit.
- v) Perimeter and boundary illumination of the above premises.
- vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room and cable gallery.
- v) FOPH area.
- vi) Transfer towers & Conveyor galleries.
- vii) All roads within battery limit.
- viii) Perimeter and boundary illumination of the above premises.

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- ix) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- c) Balance of plant Area:
 - i) Lighting system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- e) AHP Area:
 - i) Switchgear rooms.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard control room
 - ii) GIS building (if applicable)
 - iii) Transformer area
 - iv) All roads within battery limit.
 - v) Perimeter and boundary illumination of the above premises.
 - vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

1.4.2 Illumination System Description

The plant illumination system shall comprise of the following categories:

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a. Normal AC lighting

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply from the normal lighting distribution boards (LDB). All the lighting fixtures connected to this system shall be available as long as the 415V station / unit auxiliary service supply is available.

b. Normal cum emergency lighting system

Certain lighting fixtures considered essential shall be connected to this system. In this system the lighting circuits shall be fed from lighting distribution board connected to 415V Normal cum Emergency Switchgear. The lighting fixtures connected to this system shall be available whenever normal supply is available in the plant and also whenever DG set supplies the power to 415V Normal emergency switchgear.

These lighting fixtures will go off for a few seconds when normal supply fails but will be automatically restored when the emergency AC bus is re-energized by automatic transfer to standby DG supply.

[20% of the total fittings shall be fed from Emergency lighting for areas such as Switchgear room and control rooms etc.]

c. Emergency 220 V D.C. Lighting

The Emergency DC Lighting System shall be located strategically in critical operating areas and at emergency exits. Emergency DC lighting shall also be provided in the Control rooms, Switchgear/ MCC rooms and other strategically important areas. These fixtures shall be fed from respective Emergency DC Lighting Panels. The Emergency DC Lighting Panels (DC ELLP) shall be fed from 220V DC Distribution Boards (DCDB).

These lights shall remain normally OFF but on failure of AC supply these lights shall be automatically ON. Tube lights with Electronic choke suitable for 230 V, AC / DC operation or other Energy Efficient Lamps may be used for DC emergency lighting.

d. Maintenance 24 V AC Lighting System

For lighting facilities comprising portable hand lamps and/or connection of portable hand tools etc., required during the routine maintenance work, 24V single phase 3 pin sockets with switches shall be provided at selected points in the areas listed below. Such sockets for routine maintenance shall be clearly identified by colour coding in order to distinguish them from the normal 240V power outlets. Necessary outlets shall be made on the inside walls of the building near equipments.

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- i. Boiler area: Near inspection manholes on the boiler platforms and near boiler drum at different levels on all four sides.
- ii. TG building: Near HP & LP heaters, turbine flash tank, blow down tank, near condenser water box and near bus duct termination of generator end.
- iii. ESP columns: Near inspection manholes
- iv. Near de-aerator.
- v. Cable galleries.

Any other areas considered necessary identified during detailed engineering.

e. Portable Emergency Lights

This system shall be provided by portable self-contained battery / automatic charger / inverter fed compact fluorescent lamps in isolated buildings / areas where station D.C. supply is not available. These portable emergency light units shall be switched on automatically on loss of normal AC supply. *[Battery packs for portable emergency lights shall be rated for minimum 3 hours duty and the battery shall be of Ni-Cd.]*

f. Exit lights

Emergency escape signs shall be provided at the exit doors, escape routes, intersection corridors, at different floor levels/directions, windowless rooms, toilets, firefighting equipment, lifts, control rooms, switchgear rooms and the areas considered necessary by bidder. *[9W CFL]* lamp shall be used for exit lamps.

The contractor shall design emergency exit lighting system based on plant layouts and install escape lights at suitable locations considering the various escape routes. Emergency exit lights will be fed from normal-cum-emergency lighting panel, wherever available, *[and will be with in-built battery (Ni-Cd) back up of 3 hours operation.]*

1.4.3

Illumination Calculation

- a. Standard Lumen method shall be adopted for interior and exterior lighting in order to determine the number of lighting fixtures for obtaining the desired average level of illumination.
- b. The coefficient of utilization shall be considered to take care of Lumen loss due to:

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- i. Effect of room dimensions.
 - ii. Absorption of light in luminaries.
 - iii. Absorption of light at various room surfaces i.e. ceiling wall etc.
 - iv. Floor cavity, ceiling cavity.
 - v. Mounting height.
- c. Moreover a maintenance factor shall also be considered to account for the fall of illumination due to aging, pollution like dust deposits etc.
 - d. Voltage drop at the fixture terminals from the MLDB shall [not exceed 3%]. Circuit loading of each lighting Panel shall be done in such a way that almost balanced loading in all the phases i.e. R, Y and B is achieved. At least two sub circuits shall be used for illumination of a particular area. Sub circuit loading of each lighting panel shall be restricted to 2000 Watts.
 - e. Design of lighting system shall be such that the average lux level as specified is achieved. The Bidder shall submit illumination calculation/layout for the purchaser's review.

1.4.4 Lighting Distribution System

- a. Separate lighting transformers shall be provided inside the lighting distribution boards located at required location. Lighting distribution system shall be distinct and separate from the LV main distribution. Lighting transformers shall be encapsulated cast resin dry type.
- b. AC lighting panels shall have 240V single-phase, 2 wire incomer controlled by earth leakage circuit breaker and number of single phase outgoing circuits controlled by MCBs. The lights connected to a circuit or few circuits shall be 'ON' automatically through photocell for outdoor lighting. Provision shall be made for switching 'ON' the rest of the lights. Lighting fixtures in indoor areas shall be controlled from the respective lighting panels
- c. Normal 240 V AC Lighting System
For this system, lighting points shall be supplied at 240 V AC through 415 V, 3-phase, 4-wire, 50 Hz, LDB. The supply shall be derived from 415 V, 3-phase, 4-wire, 50 Hz switchgear through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant. Different circuits shall be used from different source. The whole lighting network shall be balanced as far as possible.
- d. Normal/Emergency 240V AC System
For these systems, the distribution shall be by 415V, 3-phase, 4-wire, 50 Hz supply. This supply shall be derived from 415 V, 3-phase, 4-wire, 50

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Hz normal emergency switchgear for NE & lighting through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant.

e. Emergency 220 V DC Lighting System

The power supply shall be obtained from the nearest 220 V DC switchboard. DC lighting panel will have one (1) incomer controlled by double pole MCB, Outgoing circuits will be controlled by DP MCB. Upon failure of the normal-cum-emergency AC supply, emergency DC lighting fixtures will be made automatically ON. The change over in the reverse direction shall also be automatic.

f. Maintenance 24V AC Lighting System

24 V AC supply for maintenance purposes (for hand lamps and/or hand operated tools) shall be supplied from 24 V AC distribution panel, which receives 240 V power supply from 415 V/240V transformer modules of N/E switchgear. 24 V AC distribution panel consists of one incomer controlled by MCB, one 240/26.5 V dry type transformer of adequate rating and number of outgoing circuits controlled by MCB.

1.4.5 Illumination levels and choice of lighting fixtures

The area-wise distribution of average illumination levels and type of luminaries shall be as indicated below:

[Note: These are indicative only. However as per specific Existing project, Bidder may refer section I of this specification for exact details of type of fixtures.]

Table 2.0

Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
A - TURBINE GENERATOR BUILDING				
1.1	General (auxiliary equipment areas)	200	Industrial well glass fixture, dust & jet proof, die cast aluminium body, stove enamel finish, vitreous enamel reflector integral mounted control gear/industrial bulk head with integral mounted control gear.	1x70 W/ 1x150 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.2	Cable vault	100	Industrial type FTL with vitreous enamel reflector	Energy Efficient FTL
1.3	All switchgear room area (including off-site building control room)	250	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.4	TG Building operating floor	250	Industrial high bay with anodized aluminium reflector with all accessories including control gear	1x400 W Metal Halide lamp
1.5	Unit control room and Switchyard control room	400	Decorative recessed with wide angle mirror optic antiglare type	Energy Efficient FTL
1.6	Battery rooms	150	Corrosion-proof	Energy Efficient FTL
1.7	TG building ground, mezzanine floor and misc. floors	200	Industrial well glass with integral control gear	1x150 W/ 1x250W Metal Halide lamp
1.8	Air washer room and A/C plant room	200	Totally enclosed vapor proof with clear acrylic cover	Energy Efficient FTL
1.9	Unloading and maintenance bay	300	Industrial high bay with anodised aluminium reflector	250 W HPSV lamp (for mounting height > 9m)

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.10	Electrical laboratory, chemical laboratory etc. (air-conditioned)	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
B -	BOILER AREA			
1.1	Boiler area and platforms, ESP area and platforms	100	Dust proof / dust tight well glass fixture	70 W Metal Halide lamp
1.2	Feeder floor areas	150	Dust proof / dust tight increased safety well glass	70 W Metal Halide lamp
1.3	ESP control room	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
C -	VARIOUS OFF-SITE BUILDING			
1.1	Equipment room (pump house)	200	Industrial type with vitreous enamel reflector upto mounting height of 8 M	150 / 250 W HPSV lamp
1.2	Switchgear room	250	Industrial high bay for mounting heights above 8M	Energy Efficient FTL
1.3	Outside working areas	70	Flood light medium beam	250 W HPSV lamp
1.4	Stores	100	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.5	Fuel Oil Tank Farm	50	General Purpose flood light with weatherproof fixture	250 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.6	Fuel oil decanting pump house, Hydrogen storage area, Coal conveyor areas	150	Flame-proof well glass	1 x 70 W HPMV lamp
D -	GENERAL			
1.1	Corridors, walkways, staircase, etc.	100	Industrial type with vitreous enamel reflectors/channel mounted box type	Energy Efficient FTL/1 x 70 W HPMV lamp
1.2	Lockers, toilets, wash rooms, etc.	100	Channel mounted box type	Energy Efficient FTL
1.3	Elevator well	50	Industrial bulk head	1 x 100 W incandescent lamp
1.4	Building periphery lighting	50	Industrial well glass with integral mounted control gear/industrial bulk head with integral mounted control gear/flood light fittings with timer control	70 W HPSV lamp / 400 W HPSV lamp
1.5	Office Rooms	300	Decorative recessed type FTL	Energy Efficient FTL
1.6	Transformer yard and Switchyard	50 on equipment, 20 general	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
1.7	Street lighting	20	Street weatherproof fixture with timer control	150 / 250 W HPSV lamp
1.8	Parking area	70	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
E	DC LIGHT FITTINGS			

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.1	Control room	400	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp
1.2	Other areas	250	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp

1.4.6 Area wise distribution of Lighting system in plant

Area wise lighting distribution shall be as below:

Table: 3.0

Area/building	Percentage Distribution of Lighting		
	Normal	Normal & Emergency	220V DC
Turbine Generator Building (all the bays)	80%	20%	10%
Control rooms	80%	20%	10%
Boiler Area (Grade level & Platforms)	80%	20%	5%
Service building	90%	10%	5%
Various pump houses and electrical switchgear rooms such as AHP, CHP, FOPH switchgear room, etc.	90%	10%	5%
Electro static precipitator	90%	10%	5%
Switchyard and Transformer yard	80%	20%	5%

1.4.7 Lighting System Design

The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of

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lighting specified in following paragraph. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

a. Indoor Lighting

The recommended values of illumination level for various areas in the plant are indicated in the table above. Lighting layouts shall be designed such that the ratio of minimum to average illumination shall not be less than [0.6]. Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/buildings in the plant.

i. Maintenance Factor:

- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Industrial areas with normal interiors such as workshops, stores : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors such a crusher house and junction towers : 0.5

ii. Reflection factor for wall/ceiling

- White and very light colors : 0.7
- Light colors : 0.5
- Middle tints : 0.3
- Dark colors : 0.1

iii. The working plane shall be considered at 0.85 m from the floor level.

iv. The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1 meter.

b. Outdoor Lighting

- i) The recommended illumination levels for outdoor areas are indicated in the above table.
- ii) Mounting height, spacing of flood lights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.05.

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- iii) Maintenance factor shall be generally 0.6 under average conditions.
- iv) Flood lights for area lighting shall be mounted on building structures. For outdoor lighting i.e. around the power plant building and transformer yard provision to be made with 400W outdoor type lamps mounted on wall/structures.
- v) Automatic switching ON/OFF shall be shall be provided through timers/photo cells.
- vi) For road illumination inside the boundary limit lighting poles shall be provided and the distance between the poles shall not exceed 30m.
- vii) Aviation obstruction lights shall be provided on tall installations (Chimney, Cooling Towers etc) as per Airports Authority and international standards. Aviation warning lights shall be high intensity type-A flashing LED type with varying intensity for day and night.
- viii) In an area, the lighting fixtures shall be arranged in different phase / LPs such that even in case one lighting panel is faulty complete lighting is not affected. In any location the lighting shall be arranged from two phases.
- c. The circuit loading on each circuit shall be restricted to 80% of the MCB rating.
- d. The voltage drop from LDB and any fixture shall not exceed 3%.
- e. All lighting design calculations, layouts, conduit wiring diagrams, LDBs and LPs drawings and technical data sheets etc shall be furnished for Owner/ Owner's consultant's approval.

1.4.8 Lighting system equipment

- a. Lighting Distribution Boards (LDB) & Lighting Panels (LP)
 - i. The Lighting Distribution board shall be fed through 415V/433V lighting transformers with off circuit taps $\pm 5\%$ in steps of 2.5%. The lighting transformer shall be cast resin dry type , vector group of [Dy1], class F insulation with temperature rise limited to class F and shall be housed in a suitable enclosure. In general, the transformers shall conform to the specification covered under 'Service transformers. The lighting distribution boards shall consist of MCCB incomer and required number of double pole MCB controlled out going feeders to LPs. The LDB shall be designed for the required short circuit level of [20] kA. All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-52. Outdoor panels shall be weather proof type with IPW-55 protection. The

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thickness of sheet steel enclosures shall be CRCA, 2 mm minimum for load bearing and 1.6 mm for other members.

- ii. Number of outgoing feeders in each LDB shall be provided as per requirement including the minimum 3 nos spare feeders for "Purchaser use". Each outgoing MCB in LDB's shall be of 15 A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB
 - iii. Individual control in office buildings shall be through single pole flush type switches/MCBs. In those areas where group controls are required, rotary switches shall be provided
 - iv. External area lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers/photo cell.
 - v. In high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder / platform / approach shall be provided for maintaining / replacement of light fittings.
 - vi. Each of the LDBs shall be provided with voltmeter and ammeter along with selector switches, "SUPPLY ON" indicating lamps, etc. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.
 - vii. Two ground pads with bolts and nuts shall be provided on each board for connection to 50x6/25x3 mm GS flat.
- b. Lighting Fixtures and Lamps
- i) Fluorescent fixtures with electronic ballast shall be generally provided for a room height upto 5m. Type of fixture shall be industrial type with gasket, clear acrylic cover and enamelled reflector or decorative type to suit the aesthetics. For areas with false ceiling, recessed mounted decorative fixtures with mirror optic louvres shall be used. In control room / computer rooms, decorative mirror optic fluorescent light fittings with antiglare features shall be provided. The surface finish shall be smooth, unobtrusive and scratch resistant.
 - ii) Reflector shall be of sheet steel or aluminium, minimum 20 SWG thick and securely fixed by fastening device of captive type.
 - iii) Fixture shall be suitable for 19 mm conduit entry and 16 SWG GI earth wire connection.
 - iv) Fixture shall be furnished complete with lamps and integrally mounted accessories. These shall include holders, ballast, capacitor, starter, ignitors (separate type) etc.

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- v) For corrosive areas, corrosion proof lighting fixture shall be provided. For hazardous areas, light fittings, conduits, junction boxes etc. shall have to meet the corresponding area classification requirement.
- vi) Medium bay or high bay type of lighting fixtures with HPMV/HPSV lamps shall be used depending on the mounting heights for indoor areas having room height more than 5m. Medium/ High bay fixtures shall be provided with vibration damper wherever required.
- vii) For areas like boiler and outdoor areas such as roads, street, transformer areas and open yards, weatherproof HPSV flood/ street lighting fixtures shall be used. For areas like boiler platforms, weatherproof well glass type HPSV fixtures with wire guards shall be used.
- viii) All type of fluorescent lamps including Compact Fluorescent Lamp (CFL) shall be bi-pin rotary type and either cool daylight or white.
- ix) Mercury / Sodium vapour lamp shall be colour corrected type with screwed cap.
- x) Lamps shall be suitable for use in position and capable of withstanding small vibrations.
- xi) Ballasts shall be of heavy duty, low loss and polyester-filled type with copper winding.
- xii) Ballasts for Mercury / Sodium vapour lamps shall be provided with suitable tappings to set the voltage within range specified.
- xiii) Ballasts shall be free from hum. Ballasts which produce humming sound shall be replaced, free of cost.
- xiv) In multi-lamp fixture, each lamp shall be provided with individual ballast.

c. Switches, Receptacles

- i. In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms, etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided
- ii. 240V, 50 Hz, 3 pin Power Receptacles (5A, 15A) shall be provided in all building/areas of the plant. Inside a building, receptacles shall be provided at interval of 30m or part thereof for hand tools, water coolers, exhaust fans etc. Inside each cabins at

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least two receptacles shall be provided and the same shall be indoor/outdoor/flameproof as per the location. Minimum 2 nos of 5A and 1 no 15A receptacles shall be provided in each room. Receptacles shall be heavy duty, complete with individual plug and switch as described below:

Table: 4.0

S.No.	Type	Description
1	RA	5A, 240V, 2 Pole, 3 Pin with third pin earthed - Suitable for flush mounting in office areas and control room. The switch shall also be flush mounting piano type.
2	RB	15A, 240V, 2 Pole, 3 Pin with third pin earthed - Wall/column mounted, metal clad gasketed construction, suitable for 19 mm conduit entry, screwed metal cover tied with metal chain, weatherproof construction suitable for indoor/outdoor installation. This shall be provided at an interval of 30m, or minimum one in each room.
3	RC	63A, 415V, 3 Phase, 5 pin interlocked plug and switch with fifth pin earthed. Wall/column mounted, metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 4 Core 35 sq.mm AYWY cable. These receptacles shall be provided at an interval of 50m throughout the Plant Area.
4	RD	100A, 415V, 3 phase, 5 Pin interlocked plug and switch with fifth pin earthed Wall/column mounted metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 3.5 Core, 95 sq.mm AYWY cable.

d. Cables and Wiring

- i. Wiring from lighting DBs/panels to individual fixtures, plug points, fans, etc. shall be of single core, 2.5sq.mm, 1100 V grade PVC stranded copper conductors through surface mounted or concealed medium duty GI conduits confirming to IS 1239 with earth wire. The wires in the conduits shall not exceed 60% of the conduit area.
- ii. 1100V grade stranded copper conductor, PVC insulated, colour coded, wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, outdoor areas like transformer yard and road lighting, cabling shall be adopted. The

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specification of cable shall conform to the details indicated in "Cabling System" section.

- iii. Minimum size of wires in case of conduit wiring shall be 2.5sq.mm copper in case of lighting and 4sq.mm copper in case of receptacle wiring
- iv. Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits. Wires of AC and DC lighting system shall be carried out in separate conduits
- v. For outdoor lighting, the cable shall be buried at a minimum depth of 750 mm from ground level or run in cable trays. The buried cables shall have suitable bedding, protective covers and markers
- vi. Material used for saddles, clamps, JBs, etc. shall be galvanized
- vii. Office buildings, laboratory buildings shall have concealed wiring with 2.5sq.mm wires using PVC conduits. In heat zones, i.e. in the areas where ambient temperature is 600 C and above, heat resistant control cables shall be used in hot dip galvanised rigid steel surface mounted conduits

e. Fans and Regulators

- i. The fans shall have three well balanced blades, double ball bearings and shall be reasonably free from noise. Fan motor shall be totally enclosed type with copper winding and class-E insulation. Sweep shall be given as 1200 /1400 mm.
- ii. Regulators shall have minimum five steps. Electronic Regulators with smooth control shall be provided.

f. Flame-Proof Equipment

- i. The enclosure of all flameproof equipment for use in hazardous areas where gases/vapors of Group I, IIA, IIB are present, shall be of cast iron/cast aluminum, stove enamel finished. Chemical corrosion resistant epoxy finish shall be provided in corrosive areas. The construction shall comply with relevant applicable standards
- ii. If the enclosures are additionally required to be weather proof, neoprene gaskets shall be provided to make the enclosure dust and weather proof providing a degree of protection of IPW 55.
- iii. All ferrous parts, exposed to atmosphere shall be suitably plated/galvanized

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- iv. All internal wiring shall be connected to terminal blocks provided in terminal enclosure on incoming side.
- v. Flameproof cable gland entries shall be provided suitable for the cable sizes. The number of required cable entries for junction/terminal boxes as required for branching, terminating of cables for lighting distribution shall be provided. All unused cable entries shall be closed by flameproof plugs.
- vi. Flameproof receptacle unit (socket with associated switch/MCB and plug) shall have interlocking feature such that plug cannot be inserted or taken out with switch/MCB in "ON" position.
- vii. Adequate mounting lugs with necessary hardware shall be provided for mounting the equipment on wall/structure.
- viii. These enclosures shall have inscription warning against opening the enclosure unless the circuit is isolated. Equipment rating and ON/OFF positions of switches/MCBs shall also be designated.
- ix. The BIDDER shall indicate that the enclosures have been tested and certified by relevant statutory authorities for use in hazardous areas.

g. Lighting poles and towers

- i. Lighting poles for street lights and flood lights shall be of swaged and welded steel, pole of height 9M/11M and shall conform to relevant standard. Poles shall be hot dip galvanized internally and externally after fabrication as per IS 2629 / IS 2633 / IS 4759 standards. The Poles shall be designed to withstand the maximum wind speed as per IS 875. The steel sheet used to manufacture steel poles shall be of minimum thickness of 3 mm and shall conform to relevant standard . Junction boxes shall be provided with weather proof flush doors and locking facility. Bidder shall design and furnish the foundation drawings for the poles to withstand basic wind speed of minimum [50]meter/sec.
- ii. The supply of poles/Towers shall be complete with base plate, foundation bolts, hot dip galvanized brackets / necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
- iii. Towers for mounting flood lights shall be e of continuously tapered poly gonal cross section and shall be supplied with all acesssories. Steel structure for towers shall be made of hot dip galvanized steel. A steel ladder and platform at the top shall be provided. The length of each step of the ladder shall be at least

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300 mm and spacing between two adjacent steps not more than 300 mm. The structure shall be suitable for mounting the required number of flood lights, weights of maintenance crew and specified wind pressure. The factor of safety shall be [2] for each part and section. The Contractor's structural design drawings shall be approved by the Purchaser before fabrication.

1.4.9 Name Plate

Name plates shall be furnished for identification of devices and circuits. All switches, controls and indications shall be permanently and legibly marked in English regarding the functions.

1.4.10 Painting

All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.

After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoved after each coat.

The equipment shall be finished in approved color shade by owner with two coats of epoxy based powder coated paint. The coating shall be done electro statically followed by stoving.

Sufficient quantity of touch-up paint shall be furnished for application at site.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

Tests on Lighting Distribution Boards / Panels shall include:

a. Wiring continuity tests.

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- b. High voltage and insulation tests.
- c. Operational tests.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *Lighting panels & distribution boards.*
- b) *Receptacles & Junction boxes.*
- c) *Street light poles & towers.*
- d) *Lighting fixture complete with lamps and accessories.*
- e) *Non-integral/separate type control gear box for lighting fixtures, as applicable.*
- f) *Lux level calculations for each area.*
- g) *Data sheets for lighting fixture, lamps, accessories with light distribution curves, co-efficient of utilization charts etc. Type and routine test certificates of transformer and cables.*
- h) *Control schematic and wiring diagram of 415V AC/220V DC lighting panel with automatic changeover from AC to DC and vice-versa, 415V normal AC Street/area lighting panel with automatic ON/OFF feature.*
- i) *Technical leaflets and data sheet on each piece of equipment/ device such as MCB, switch, fuse, receptacle etc. Type and routine test certificates of transformer and cables.*
- j) *QAP and relevant test certificates*

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- k) Lighting layouts showing the disposition of fixtures, lighting panels/boards, circuit distributions, conduit & wire routing.
- l) Key Single Line Diagram for lighting distribution, board wise single line diagram with feeder loading, cable schedule and interconnection chart, design calculation for lighting.]

1.7

Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC DC	240V, 1Ph, 50Hz 220V DC
1.2	Variation in Supply		
	a) Voltage	%	±10
	b) Frequency	%	±5
	c) Combined voltage & frequency	%	10
1.3	Design Ambient Air Temperature	°C	50
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	50KA for 1 sec
	b) At 220V DC (For DC LP)	kA(DC)	[10] kA for 1 sec
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		G.I
b	Conductor size	SWG	12
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		[By bidder]
2.2	Rated Voltage, phase and Frequency	AC	415V, 3phase, 4 wire, 50Hz
2.3	One Minute Withstand Voltage	V	2500
2.4	Mounting Type		

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S. No.	DESCRIPTION	UNIT	DATA
	a) LDBs		Floor Mounted
	b) Single Phase LP		Wall/Structure mounted
2.5	Type and no of circuits & feeder rating		[As per project requirement]
2.6	Colour shade		[RAL 5012]
2.7	Lighting Transformer		
	a) Type		Epoxy cast resin dry type
	b) Voltage Ratio	V	415/415V
	c) Taps	%	+/-5%
	d) Vector Group		[Dyn1]
	e) Impedance	%	[5%]
	f) Rating	KVA	[As per project requirement]
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		[By Bidder]
3.2	Luminaries		[By Bidder]
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		[By bidder]
	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		[By bidder]
	a) Luminaires		
	b) Accessories		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Schedule of fitting and Accessories		[As per project requirement]
5.0	Technical details of luminaries		[By bidder]
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
i)	After 100 burning hours	Lumen s	
ii)	After 1000 burning hours	Lumen s	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		[By bidder]
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
i)	Ballast	Hrs.	
ii)	Starters	Hrs.	
5.3	Capacitors		[By bidder]
a	Power factor		
5.4	Luminaries		[By bidder]
a	Weight of luminaries	Kgs	
b	Earthing terminal		
i)	Material		G.I
ii)	Suitable upto conductor size	SWG	12
c	Internal wiring size	Sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		[By bidder]
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		[By bidder]
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		CTs VTs
8.1	Make		[By bidder]
8.2	Type		[By bidder]
8.3	Output	VA	[By bidder]
8.4	Accuracy Class		[By bidder]
8.5	Literature enclosed	Yes/No	[By bidder]
9.0	Meters		VOLTMETER AMMETER WATTMETER
9.1	Make		[By bidder]
9.2	Type		[By bidder]
9.3	Accuracy Class		[By bidder]
9.4	Literature enclosed	Yes/No	[By bidder]
10.0	Relays (if any provided)		[By bidder]
10.1	Make		

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S. No.	DESCRIPTION	UNIT	DATA
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a)Normally open		
	b)Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		[By bidder]
11.2	Suitable for use in hazardous area		
	a)Area classification		[Fuel oil pump house, Main oil tank area]
	b)Gases/Vapor group		[By bidder]
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	[By bidder]
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	[By bidder]
12.0	Lighting Control Switches		[By Bidder]
12.1	Make		
12.2	Decorative		
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		[By Bidder]
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	

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S. No.	DESCRIPTION	UNIT	DATA
14.0	Lighting wires		[By Bidder]
14.1	Make		[Point wiring with respect to different length shall be furnished]
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	Conduits		[By bidder]
15.1	Make		
15.2	Rigid Steel		Galvanized
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		[By bidder]
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		Yes
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		[By bidder]
17.1	Make		
17.2	Type of Poles/Towers		

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S. No.	DESCRIPTION	UNIT	DATA
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		[By bidder]
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E10
TECHNICAL SPECIFICATION FOR CABLE CARRIER
SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E10

1.0 CABLE CARRIER SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Cable Carrier system complete with all accessories for efficient and trouble free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS 800	Code of Practice for structural Steel
IS 1646	Code of Practice for Fire Safety of buildings
IS2667	Fittings for Rigid steel Conduits
IS 3419	Fittings for Rigid Non – Metallic Conduits
IS 3837	Accessories for Rigid Steel Conduits
IS 4649	Adaptors for Flexible Steel Conduits
IS 5216	Guide for Safety Procedures and Practices in electrical Work

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Cable and cable trays shall be installed in an ambient temperature of 50 °C and relative humidity of 95%.
- b) The cable carrier system shall be designed considering the following:
 1. Facility for easy laying of cables.
 2. Access to maintenance.
 3. Neat and aesthetic appearance.
 4. Safety of equipment & personnel.
 5. Ground water seepage.
- c) Cables shall be laid in prefabricated ladder/perforated type trays and in conduits. Direct burial of cable shall be mostly avoided.
- d) Upper cable trays and all vertical cable trays shall be provided with tray covers.
- e) Cable filling in the trays or racks shall not exceed 80%. Conduits if used, the wires in the conduits shall not exceed 40% of the conduit area.
- f) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V cables shall be laid in top trays and cables of subsequent voltage grade in lower tier of trays. Instrumentation cables shall be laid at bottom most tray.
- g) At least 300mm clearance shall be provided between HV and LV cables & LV and control/Instrumentation cables.
- h) Support system for cables shall be prefabricated type.
- i) Single core cables shall be laid in trefoil touching formation. Trefoil clamp shall be provided in a staggered manner.
- j) 1100V grade power cables of [120] mm² size and above shall normally be laid in single layer in trays/on racks.
- k) 1100V grade power cables below [120] mm² may be run in double layers in case of space restrictions.
- l) Control and instrumentation cables can be laid up to a maximum of three layers in each tray/rack.

1.4 Specific Requirements

1.4.1 Scope of work:

The scope of work shall include Design, Preparation of Cable Tray, Trench/Duct bank/Conduit Layout, supply of Cable tray and its Accessories, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the Cable Carrier System

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for following package. The below list indicates area where cable carrier system to be provided but not limited to:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- iv) Laying and Termination of power & control cables for all the equipments of TG package.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room.
- v) FOPH area.
- vi) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- vii) Laying and Termination of power & control cables for all the equipments of Boiler package.

c) Balance of Plant Area:

- i) Cable Carrier System for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
- ii) Laying and Termination of power & control cables for all the equipments of BOP package.

d) CHP Area:

- i) CHP Switchgear room
- ii) Conveyor.
- iii) Crusher House
- iv) Stacker and Reclaimer
- v) Any other area covered in this package.
- vi) Laying and Termination of power & control cables for all the equipments of CHP package.

e) AHP Area:

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- i) AHP Switchgear room.
- ii) Silo Area.
- iii) Any other area covered in this package.
- iv) Laying and Termination of power & control cables for all the equipments of AHP package.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard
 - ii) Transformer yard
 - iii) Inter plant cabling.
 - iv) Any other area covered in this package.
 - v) Laying and Termination of power & control cables for all the equipments of eBOP package.
- g) All civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification. Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Bidder.
- h) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work.
- i) For Terminal Points and Exclusions of Cable Carrier system and Specific scope of work Bidder may refer section I of this specification.

1.4.2 General Installation Requirements:

- a) Cable trays shall be fabricated from 14 gauge mild steel sheets. Cable trays shall be of hot dip galvanized Steel of ladder/perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings to be submitted by Bidder. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanized.
- b) Constructional details, supporting arrangement and installation details for cable trays shall be furnished by Bidder.
- c) Each 2.5 meter section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.
- d) Cable tray covers shall be fabricated from 16 gauge MS sheets. Cable tray covers shall be hot dip galvanized and same shall be provided for all outdoor cable trays and vertical raceways/trays. Covers for vertical raceways shall be in individual, easily removable sections to facilitate cable maintenance.

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- e) Cable Tray of Standard width of 600mm shall be followed. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.
- f) Cable trays shall be ladder type with maximum rung spacing 250 mm depth 100 mm and rung width not less than 50 mm.
- g) Cable trays in areas subjected to excessive coal dust, or mechanical damage shall have hot-dip galvanized sheet metal tray cover installed on front tray in vertical run and inverted 'V' type on upper tray in horizontal run. Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.
- h) Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal / vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.
- i) Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/termination kits, lugs, glands, ferrules, tapes etc. and other accessories, grounding of cable armor. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.
- j) Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.

1.4.3 Cable Routing/Laying

- a) Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some

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cases cables may have to be laid underground and for short runs in conduits for protection while crossing roads and other facilities.

- b) For interplant connections, the cables may be routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.
- c) For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.
- d) In boiler area, trench shall be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.
- e) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.
- f) Cables for redundant equipment/system shall be run in separate trays in separate route.
- g) Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.
- h) Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).
- i) The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall and fire proof doors.
- j) The floor of the cable spreader rooms shall have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably planned to avoid water entry through this place.
- k) Cables shall generally be laid on cable trays either in concrete trenches or overhead supported from building steel/structures. Cables shall be run in concrete trenches in those electrical rooms at ground level, which are without any spreader room below. In mechanical equipment areas (Indoor), overhead cable trays shall generally be used.

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- l) For inter plant connections, the cables shall be routed through an overhead cable bridge pipe cum Cable Bridge. For isolated but long outdoor cable route with very few cables of 3/4 nos., the cables may be directly buried with prior permission from the purchaser.

1.4.4 Installation of Cables

- a) The Bidder shall install, terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.
- b) The HV power cables of 6.6kV shall be laid in trays or racks as follows:
- In single layer only.
 - 3 core cables to be laid in touching formation.
 - Cables in trefoil groups of the same circuit shall be laid as indicated below so as to ensure balanced current distribution:

Y Y Y Y

R B B R R B B R and so on.

- c) 1100V grade power cables shall be laid in single layer in trays depends on size of cables. Cable of up to 120 sqmm shall be laid in two layers. Beyond this size single layer will be followed.
- d) Control and Instrumentation cables can be laid up to a maximum of three layers in each tray.
- e) The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.
- f) Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there shall not be more than 2 nos. 90 Deg. Bends between pull points.
- g) Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension, minimum bending radius and no. of bends.

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- h) All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :
- Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.
 - Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.
 - For all HV, LV, Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.
- i) All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.
- j) The portion of galvanized steel, which, if required, undergoes any welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.

1.4.5 Cable Termination and Joints (if applicable and not covered in cable specification)

- a) The Bidder shall supply cable termination and jointing kits in requisite quantity for HV. Power Cables, LV. Power, Control Cables, etc. along with all accessories & consumables required for making termination and joints complete . All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/joints are intended.
- b) The straight through joints of HV. cables shall be heat shrinkable and pre moulded push on type. The end termination kits for HV. cables shall be of {Raychem/3M/Elastimold} type. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.
- c) Glands and lugs required for termination of HV, LV. shall be supplied by the Bidder in required quantity.
- d) Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer etc. Cable glands shall match with the sizes of different HV/LV/Control cables.

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- e) Cable lugs shall be suitable for termination of different cross-sections of L.V./Control cables and shall be of following types:
 - i. Aluminium tubular terminal end for solderless crimping to aluminium conductors.
 - ii. Copper tubular terminal end for solderless crimping to copper conductors.
 - iii. Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.
 - iv. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.
 - v. The terminations shall with tinned copper only.
 - vi. For mill area, the cable shall be routed through GI pipes embedded in Ground.
 - vii. In heat zone areas as far as possible the cables shall be taken away from the area to avoid heat. If cabling in the heat zones can not be avoided, the cables shall be terminated in junction box of IP 67 protection class away from the heat zones and small length of cables may be laid from junction box to the respective equipment to facilitate easier replacement in case of fire. Bunching of cables in the heat zones and boiler areas shall be avoided and laid in separate groups.

1.4.6 Identification

- a) The complete cabling system shall be properly identified. Methods for identification of cabling system will be furnished to the Bidder and the Bidder shall strictly adhere to the said methods.
- b) Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- c) Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate, projected above ground level.
- d) Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) meters in cable tray/trench runs. Cable tags shall also be provided

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inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant / purchaser or his representative.

- a) Checking of continuity / phasing and IR values for all the cables before and after HV test
- b) Checking of continuity / phasing and IR values for all the cables before and after HV test.
- c) HV test and measurement of leakage current after termination of cable kits (for HT cables).
- d) Checking of earth continuity for armour.
- e) Check for mechanical protection of cables.
- f) Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
- g) Check earthing of cable structures.
- h) Check safe head room in gallery area
- i) Check clearance from ventilation duct and light fittings for cable structures.
- j) Check proper fixing of cable structures.
- k) Check for proper drainage and removal of water (if any).

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall

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obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[General arrangement drawing Cable Tray]*
- b) *[Cable Tray Accessories like Tee, Cross, Bends, Coupler, Reducer etc]*
- c) *[Cable Tray support materials]*
- d) *[Technical Data sheets for cable carrier system].*

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		[By bidder]
2.	Size of Tray	mm	[600/450/300/150]
3.	Material		Galvanised Steel
4.	Application		[As per project requirement]
5.	Type of Tray		[Ladder/Prerforated]
6.	Thickness of Tray	mm	2mm
7.	Thickness of Galvanization		[100 microns]
8.	Tray Cover Size	mm	[As per project requirement]
9.	Cable Tray Accessories		[By bidder]

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SL NO.	DESCRIPTION	UNIT	DATA
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	a) [100] b) [50x 50 x 6]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E11

**TECHNICAL SPECIFICATION FOR EARTHING AND
LIGHTNING SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E11

1.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Earthing and Lightning Protection System complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanizing of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:9537	Conduits for electrical installation.
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
CEA	CEA Regulations and standard technical specification for main plant package.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Earthing system design shall consist of earth grids and electrodes buried in soil in the whole plant area, embedded in concrete inside all the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.
- b) The main objectives of earthing system is to:
 1. Provide safety to personnel from contact of dangerous potential caused by ground fault.
 2. Ensure sufficient grounding current for effective relaying.
 3. Stabilize circuit potential with respect to ground.
- c) The earthing conductor shall be designed for fault current of [50 kA] for duration of 1 second.
- d) It is the responsibility of the Bidder to undertake the soil resistivity measurements at site and select suitable size of conductor based on the soil resistivity.
- e) Ground conductor shall be of galvanized steel for above ground and mild steel for embedded and below ground earthing.
- f) Main earth grid conductor shall be mild steel (MS) of [40] mm dia.
- g) Suitable corrosion allowance shall be considered over ground conductor size depends upon soil resistivity.
- h) The main purposes of lightning protection system are to :
 1. Provide protection to structures from lightning strokes.
 2. Provide a low resistance-conducting path to lightning discharge.
 3. Lightning protection shall be provided as per IS: 2309 for Boiler area and other tall structures within the battery limit.

1.4 Specific requirements

1.4.1 Scope of Work

The scope of work shall include Design, Preparation of Earthing and Lightning Layout, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the safety earthing and Lightning Protection system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

- a) TG Area:
 - i) TG Platforms.

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- ii) TG area Grade Levels Maintenance area.
- iii) All equipments, structures etc of TG package.
- iv) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- b) Boiler Area:
 - i) Boiler Platforms
 - ii) Boiler Grade Levels covering coal mill and Maintenance area.
 - iii) ESP Platforms
 - iv) ESP/FOPH switchgear room.
 - v) FOPH area.
 - vi) All equipments, structures etc of Boiler package.
 - vii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- c) Balance of plant Area:
 - i) Earthing and lightning protection system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- e) AHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard, Transformer yard and BTG area are provided with earth mat of [40] mm dia MS Rod conductor buried below 600mm from ground level. Areas like AHP, CHP, Boiler and TG, and all other

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BOP area below grounding system are covered in this eBOP package and above ground earthing for AHP, CHP, Boiler, TG and Mechanical BOP are covered in respective package itself. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system for above ground are covered in respective packages and below ground is covered in this eBOP package in same way as earthing system.

1.4.2 Earthing system

- a) Earthing system shall be designed in accordance with IS 3043 and Indian Electricity Rules and Acts.
- b) Fault current for the earthing system shall be designed for [50] KA for duration of 1 sec.
- c) All electrical equipment, non-current carrying metal parts, structures, building steel, lightning protection system, transformer neutrals shall be connected to station ground grid.
- d) Treated earth pits including riser shall be provided for transformer neutral earthing.
- e) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- f) Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.
- g) All off site area of AHP , CHP etc shall be provide with peripheral earthing with at least two connection to main station earth grid through treated earth pit.

1.4.3 Ground Grid Conductor

- a) Ground grid conductor of mild steel rod shall be used.
- b) *[The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.12 mm (on diameter of conductor) per year over the design life of 40 years.]*
- c) However bidder shall consider as per CBIP norms “ Manual on Earth mat design” the corrosion allowance as below:
 - For soil resistivity greater than 100 ohm-meter: No allowance.

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- For soil resistivity greater than 25- 100 ohm-meter: 15% allowance.
- For soil resistivity less than 25 ohm-meter: 30% allowance.

1.4.4 Underground Grid

- The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80.
- [The ground grid conductors shall be buried in earth at a depth of 600 mm]. The length of ground conductors below earth shall be sufficient to ensure a ground resistance less than one (1) ohm.
- The ground grid conductor shall be so laid as to provide short and direct connection to building steel and major electrical equipment.
- Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.
- All ground grid conductor connections shall be welded type.
- Ground grid shall be interconnected with the ground grid of neighboring areas at least at two (2) points for further reducing the ground grid resistance.
- Suitable pigtails shall be provided and shown in the [layout drawing] for connection with ground grid of neighboring areas.
- A minimum earth coverage of [300] mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.
- In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.
- Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.
- Grounding conductor around the building shall be buried in earth at a minimum distance of [1200] mm from the outer boundary of the building.
- The Bidder shall carryout the grounding of all electrical equipments and connection to main earth grid.

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1.4.5 Ground Electrode

Ground electrodes shall be [40] mm dia. and [3] metre long M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductors. All connections to the conductors shall be done by arc welding process.

1.4.6 Above Ground Connections

- Galvanized steel flats shall be used for all connections above earth.
- Inside building, ground conductors shall be run for each floor supported on building steel and/or cable trays. These ground conductors in turn shall be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.
- Two separate and distinct ground connections shall be provided for each electrical equipment in compliance with I.E. Rules.
- All steel columns and structures shall be connected to the earth mat through earth leads.

All connections above ground shall be welded type except connection to equipment/structures which shall be bolted type.

1.4.7 Risers

Risers are required for connecting the equipment and structures with the ground mat. Risers are to be provided from underground mat to above ground levels where the ends shall be left free for connecting to the equipment. Each riser shall be 1 No. [40] mm dia. M.S. rod and shall project above grade level/concrete floor level by minimum 300 mm. They are to be clamped or supported along the outer edge of the concrete foundation. Connection to the ground mat shall be done by arc welding.

1.4.8 Equipment Ground Lead

- Equipment ground connections shall be sized to carry the ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.
- The minimum ground conductor sizes for various equipment and structures are given in below.

Table 2.0

DESCRIPTION	SIZE	MATERIAL
a) Main Grounding Grid Conductor	[40] mm dia Rod	Mild Steel
b) Riser/Pigtail From Grounding Grid/Mat	[40] 40 mm dia Rod	- Do -

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DESCRIPTION	SIZE	MATERIAL
c) Electrode	[40] mm dia, [3000] mm long Rod	- Do -
d) Conductor used for connection of various equipment/structures as listed below		
HV motors, Earthing ring, Earthing lead to earth pits etc.	[50 x 10] mm	Galvanised steel
Structures, Control Panels, Cable Trays etc.	[50 x 10] mm Flat	- Do -
415V Power Control Centres, Motor Control Centres, Distribution Boards etc.	[50 x 10] mm Flat	- Do -
Local Panels, Lighting Panels	[25 x 6] mm Flat	- Do -
Motors :		
Above 90 kW	[50 x 10] mm Flat	Galvanised steel
Above 30 kW Upto 90 kW	[25 x 6] mm Flat	- Do -
Above 5 kW Upto 30 kW	[25 x 3] mm Flat	- Do -
Upto 5 kW	[8] SWG	- Do -
Miscellaneous Items, viz. Push Button Station, Junction Boxes etc	[8] SWG	- Do -

{The Above size of Earth flat is indicative only. Bidder shall refer Volume II Section I for size of earth flat used for existing plant or as per design.}

1.4.9

Jointing and Connection

- All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.
- The bending of the large diameter ground conductor where necessary shall be done by gas heating.
- The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- The connections between the riser/pigtail and earthing conductors

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(galvanized steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.
- g) Equipment/structures ground connections shall be coated with weather resistant paints/cold galvanizing paints after proper checking / testing.
- h) Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

1.4.10 Earthing system installation

- a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
- b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750 mm.
- c) The earthing conductor crossing the road / track shall be laid in hume pipe or laid at a greater depth to avoid damage.
- d) When earth conductor passes through floors, walls, etc suitable pipe sleeves shall be provided and the same shall be sealed after installation.
- e) The connection between earthing pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
- f) Metallic conduits and pipes shall not be used as earth continuity conductor.
- g) Street lighting poles, flood light poles & towers, their junction boxes shall be connected to the earthing conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.
- h) The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.
- i) Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten [10] metres. Fence gate shall be separately grounded with flexible connection to permit movement.

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- j) [50 x 10] mm galvanized steel flats(minimum size) shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing. These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground. Earthing conductors can be embedded in concrete floor of the building wherever necessary without having direct contact with the reinforcement rods. At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- k) All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.
- l) Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.
- m) Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.
- n) A continuous [50 x 10] mm (minimum size) G.S. flat earthing conductor shall run along the cable trays and supporting structure of all cable routes. This earthing conductor shall be attached to each section of cable tray/trays through [50 x 10] mm G.S. flats. The earthing conductor shall be securely connected to the earth mat at both ends.
- o) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
- p) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.
- q) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- r) The cable sheaths, screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.
- s) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- t) Main plant earth grid and switchyard earth grid shall be interconnected each other by minimum two numbers of leads.

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1.4.11 Lightning Protection System Design

- a) Lightning protection design and installation work shall be provided on the basis of IS 2309 Code of Practice.
- b) Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down conductors and pipe electrodes.
- c) The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than value specified in IS shall be provided with lightning protection. However, Boiler areas, station building, switchyard building shall be provided with lightning protection irrespective of the arrived risk index.
- d) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.
- e) Down conductors shall run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.
- f) A Lightning electrode shall be provided at the connection point of the down conductor with the station ground.
- g) Galvanized steel rods and flats shall be generally used for air termination and connections. All connections shall be welded type.

1.4.12 Air Terminations

- a) The vertical air terminal rods shall be installed at the roof of Turbo generator building, Boiler and chimney etc to protect these objects from lightning strokes.
- b) The projected length of the Air termination rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.
- c) The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building, the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.
- d) All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size [50 x 6] mm galvanized steel flats.
- e) For chimney air termination, rods interconnected by circumferential conductors will be provided at the apex of flue and also upon outer shell of the chimney. The air termination system will be formed by lead coated copper conductors to prevent melting and corrosion of conductors due to flue gas.
- f) For cooling towers, air termination system will comprise of horizontal

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circumferential conductors at the top

1.4.13 Down Conductors

- a) Galvanized steel down conductors of suitable size [25 x 6] shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.
- b) Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.
- c) The connection between each down conductor and rod electrode (by means of 40 mm mild steel rod riser) shall be made by others. However Bringing down comer with test link at a level of 1500mm approximately from above ground level shall be boiler contractor scope of work.
- d) The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleared on outside of the building wall and column/structure at about 750 mm intervals unless stated otherwise in the drawing.
- e) At all supports for down conductor along the column/wall of the buildings etc. the portion embedded inside the building concrete should not touch the reinforcement bars.
- f) All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.
- g) The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

1.4.14 Switchyard Lightning protection

- a) For switchyard lightning protection shall be provided by lightning masts and/or shield wires.
- b) In case of lightning protection by shield wire, the shield wires provided shall be of GS wire strung across the pinnacles of the gantry tower structures. The size of shield wire shall be based on the lightning impulse current expected and the time duration for which it is likely to flow. Allowance shall be given in the final size to account for corrosion of the shield wire during service at rate of [0.03] mm per annum. However, minimum size of the shield wire shall not be less than [70]sq.mm. The zone of coverage for the shield wire shall be considered as 60 deg between the two shield wires and 45 deg for end shield wires. The down conductors from shield wires shall be run along the towers and

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connected to rod/pipe electrodes.

- c) In case of lightning protection by lightning protection masts, the down conductors from the masts/peaks/shield wires shall be run along the tower and connected to the test links mounted on the towers at 1500m from the ground level. Conductors from the test links shall be connected to the rod/pipe electrodes which in turn are connected to the main earth grid in the switchyard. Calculations for sizing and determining topography and number of lightning masts shall be furnished for approval.

1.4.15 Electrodes (for Lightning Protection)

The electrodes shall be [40 mm] diameter [3000 mm] long mild steel rod. These shall be driven into the ground.

All the electrodes shall be interconnected by means of one (1) [40 mm] dia mild steel rod which shall be laid under ground at a minimum depth of [600 mm] below finished grade level unless stated otherwise. This ground mats/electrode in turn shall be connected to main grounding grid.

1.4.16 Riser (for Lightning Protection)

All risers connected to grounding mat shall be [40 mm] mild steel rods and shall be projected 300 mm above grade level unless stated otherwise.

1.4.17 Jointing & Connection

- a) All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.
- b) The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- c) The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.
- d) All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.
- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- g) The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- h) The steel to copper connection shall be brazed type.

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- i) The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.
- j) The sizes and materials of earthing conductors to be used in lightning protection system are listed below :
- k) Note: The above sizes are indicative only. Actual size shall be as per Bidder design or as per existing plant details as provided in Section I in case of replacement work as called for.

Table 3.0

DESCRIPTION	SIZE	MATERIAL
a) Vertical Air Termination	[20] mm dia Rod	Galvanised steel
b) Horizontal Conductor	[50 x 6] mm flat [25 x 6] mm Flat	-----do-----
c) Down Conductors	[25 x 6] mm Flat	-----do-----
d) Ground electrode / riser	[40] mm dia Rod	Mild Steel
e) Interconnection with earth mat	[40] mm dia Rod	Mild Steel

1.5

Tests

l) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the

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Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

The following test shall be conducted:

- a) Measurement of earth resistance for each electrode.
- b) Measurement of total earth resistance.
- c) Measurement of earth loop resistance for E/F path of biggest LV drive.
- d) Check tightness of all earth connections
- e) Check earthing of all metallic equipments, cable trays, bus bar supporting structures, building column (if steel all elect equipments, pipe lines etc. as per the drawing / specification)

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[Earthing Material like conductor , flat , welding description etc]*
- b) *[Air termination rod and its accessories etc]*
- c) *[Technical Data sheets for Earthing and Lightning system].*

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1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II**

**SECTION-II, PART-B, ANNEXURE-E12
TECHNICAL SPECIFICATION FOR 6.6kV SWITCHGEAR**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E12

1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of 6.6 Switchgear, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 226	Structural steel (standard quality)
IS : 375	Switchgear bus bars, main connections and auxiliary wiring, marking and arrangement
IS : 722	AC electricity meters
IS : 728	Galvanized steel structures
IS : 2099	Specification for bushings for alternating voltages above 1 000 volts
IS : 2147	Degree of protection
IS : 2516	Alternating current circuit breakers
IS : 2544	Specification for porcelain post insulators for systems with nominab l voltages greater than 1 000 volts
IS : 2705	Current transformer specification
IS : 3043	Code of practice for earthing
IS : 3156	voltage transformers specification
IS : 3231	specification for electrical relays for power system protection
IS : 3427	A.C. metal enclosed switchgear and control gear for rated voltages above 1 kV and upto to and including 52 kV.
IS : 4710	Switches and switch isolators above 1000 V but not exceeding 11000 v.
IS : 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
IS : 6875	Control switches push buttons

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Codes	Name of Standard
IS : 8084	Specification for interconnecting bus-bars for ac voltage above 1 kV up to and including 36 kV
IS : 8686	Specification for static protective relays
IS : 9046	Specification for ac contactors for voltages above 1000 v up to and including 11 000 v
IS : 9224	Low voltage fuses
IS : 9385	HV fuses
IS : 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
IS : 9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1 000 v
IS : 10601	Dimensions of terminals of high voltage switchgear and control gear
IS : 11353	Guide for uniform system of marking and identification of Conductors and apparatus terminals.
IS : 13118	Specification for high voltage ac circuit breakers
IEC 6044-1	Current transformer
IEC 6044-2	Voltage transformer
IEC 6056	High voltage alternating current circuit breakers
IEC-60099-1	Non-linear resistor type gapped arrestor for AC systems
IEC-60099-4	Metal oxide surge arrestor without gap for AC system
IEC 60129	A.C disconnectors and earthing switches
IEC 60255	Electrical Relays
IEC-60298	High voltage metal enclosed switchgear and control gear.
IEC 60529	Degrees of protection provided by enclosures
IEC-62271-100	High voltage alternating current circuit breakers.
CEA	CEA regulations
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All 6.6kV Switchgear shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- b. All 6.6kV Switchgear shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-)5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC System	:	(+)10% to (-)15%

- c. All motors rated above 160kW shall be feed from 6.6kV switchgear.
- d. Motor rated [160-600kW] shall be provided with [vacuum contactor/vacuum circuit breaker] and motor rated above [600kW] shall be provided shall be provided with vacuum circuit breakers.
- e. 6.6kV switchgear shall be Indoor, metal clad, floor mounted, Single front and fully draw out type. Design and construction shall be such as to allow extension at either end. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels
- f. All 6.6 kV Circuit breaker shall be draw out type & should have Service, Test and Disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- g. Local/remote selection shall be provided for all incoming/Outgoing Circuit Breaker modules. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local (Switchgear).
- h. Two out of three Incomer logic for 6.6kV Switchgear shall be provided. For Unit and station board one Incomer shall be there from Unit Transformer and Station Transformer respectively. Tie feeder shall be provided between Unit and station switchgear such that in case of loss of supplies to unit switchgear from UAT, the same shall be restored from respective station switchgear. In order to achieve the same, fast bus transfer shall be provided at Unit switchgear.
- i. All motors shall be provided with Emergency Stop Push buttons.
- j. Control and Indication voltage level shall be 220V DC.

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- k. Maximum system fault level at 6.6kV bus including initial motor contribution shall be 40kA for 1 sec.
- l. 6.6kV System shall be earthed through resistance to limit fault current to 300A.
- m. Surge arrestor shall be provided for each motor feeder/Transformer feeder.
- n. The switchgear will be located in a clean but hot humid and tropical atmosphere.
- o. Duty involves direct-on-line starting of large induction motors with motor starting current varying 6 times the full load current. For BFP starting current varying 4.5 times of full load current.
- p. For continuous operation at specified ratings, temperature rise of the various switchgear components shall be limited to the permissible values stipulated in the relevant standards and this specification.
- q. The switchgear and components thereof shall be capable of withstanding the mechanical forces and thermal stresses of the short circuit current without any damage or deterioration of material.
- r. All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 6.6 kV switchgear shall have following minimum features.

- a. 6.6 kV switchgear shall be of indoor, metal clad, single front, single tier, floor mounted, horizontal drawout type with vacuum circuit breaker and free standing type. The Panels shall be suitable for cable entry at bottom and bus duct connection at top.
- b. Between 6.6kV Switchgear Incomer and transformer, segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with bus duct manufacturer in this regards is covered in this specification.
- c. All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d. Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and Covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels.

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- e. Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f. The switchgear enclosure shall confirm to the degree of Protection of the [IP4X] for indoor installation. However degree of protection of LV chamber shall be [IP-52]. No louvers/Opening shall be provided on the top of panel. All the other louvers if provided shall have very fine brash or GI mesh screen.
- g. Paint shade for complete panels shall be [RAL 5012] for extreme end covers for all board.
- h. The working zone shall be restricted to [750mm to 1800mm] from floor level. Total height of the switchgear panels shall not exceed [2600 mm].
- i. Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc.
- j. A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgear having more than one bus section.
- k. Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.
- l. Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module at any one cubicle. Further distribution to all verticals shall be in the scope of bidder.
- m. Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- n. Supplier shall provide total 10% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- o. Switchgear shall have provision to receive 415V, 3ph, 4wire supply. Single phase 240V balanced supply shall be derived from 415V, 3ph, 4 wire supply. Each cubicle shall be provided with thermostat controlled space heaters suitable for operation from 240 V \pm 10%, single phase, 50 Hz, + 3% - 5% supply and 5A, 240V AC, 3 pin plug socket and cubicle lamp. The space heaters shall be located at the bottom of the switchboards. Cubicle heater, plug/socket/lamp circuits shall have individual switch fuse units. Motors shall

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be provided with anti- condensation heaters at 240V.Necessary provision for supply of motor space heating shall be considered in the switchgear.

- p. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on control cabinet built on the front of the cubicle.
- q. Controls and interlocks as required for the safe switching, operation and maintenance of the switchgear shall be provided. Mechanical interlocks shall be provided in addition to electrical wherever possible.
- r. It should be possible to carryout maintenance on a feeder with adjacent feeders alive.
- s. The Fast Bus Transfer (FBT) panel shall be totally enclosed, floor mounted panel conforming to degree of protection IP-42. The minimum thickness of cold rolled sheet steel used shall be 2.0 mm. The ABT panel shall consist of a lineup of control boards, with cable entry provisions from bottom of panel. The height of FBT panel inclusive of mounting channel, anti-vibration pads etc. shall be restricted to [2400 mm].
- t. The switchgear shall be [natural cooled].
- u. The circuit breakers, contactors, bus VTs shall be mounted on withdrawable truck which shall roll out horizontally from service position to isolated position.

1.4.2

Bus and Bus Taps

- a. The main buses and connections shall be of high conductivity [aluminum / aluminum alloy].Control and auxiliary buses shall be of electrolytic copper/copper wires.
- b. Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- c. Bus insulator shall be flame-retardant, non-hygroscopic, track resistant type with high creepage surface. This shall be of non-carbonizing material such as epoxy bonded fiberglass. Bus bars shall be color coded for easy identification.
- d. The bus bar supports shall be able to withstand stresses due to maximum short circuit and also take care of any thermal expansion.
- e. Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f. The continuous rating of the main bus bars shall be same as that of the incomer circuit breaker and shall carry this continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].

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- g. The busbar chamber shall be provided with inter panel barrier with epoxy cast seal off bushings through which the buses will pass through so as to prevent fire from one panel to another.

1.4.3

Circuit Breaker

- a. The circuit breaker shall be of vacuum type.
- b. The circuit breakers shall be fully draw-out type, having service, test and disconnected positions with positive indicators for service & test positions.
- c. The breakers shall have motor operated spring charged mechanism. It shall be possible to charge the springs manually, if, required. Breakers shall be trip free and shall have an anti-pumping device. The operating duty cycle shall be 0 -3 min.-CO-3 min.-CO.
- d. For motor, spring charging shall take place automatically after each breaker closing operation. One 'open-close-open' operation of the circuit breaker shall be possible after failure of power supply to the motor.
- e. Automatic safety shutters shall be provided to ensure the inaccessibility of live parts after the breaker is drawn out. There shall be distinct overall door for the breaker compartment and shall be lockable.
- f. Truck shall have distinct service, Test and Isolated positions. It shall be possible to close the breaker compartment door in isolated position also. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions.
- g. Outgoing breakers shall be suitable for switching transformers and motors at any load. Motor feeders shall be suitable for frequent direct on-line starting of motor.
- h. Mechanical safety interlocks shall be provided to prevent
 - i. The circuit breaker from being racked in or out of the service position when the breaker is closed.
 - ii. Racking in the circuit breaker unless the control plug is fully engaged
- i. Breakers shall be adequately de-rated to account for design ambient temperature and temperature inside the cubicle.
- j. Equipment and component rating and quantities shall be suitably selected according to the requirements with adequate margin.
- k. Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage

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1.4.4 Contactor

High voltage contactor shall be of AC-3 utilization category and shall be of vacuum type. Fuse and contactor shall be mounted on withdrawable truck. The contactor shall be latched type and shall be complete with mechanical trip indicator, anti pumping relay, surge suppresser, single phasing preventor etc.

1.4.5 Bus Transfer scheme:

The 6.6kV Unit Switchgear shall be connected to their respective unit auxiliary transformer through bus duct. These buses of unit switchgear shall also be connected to 6.6kV buses of station switchgear through tie feeders and breakers located at the unit and station end. Automatic Fast bus transfer scheme shall be provided between 6.6kV unit and station switchgear such that in case of loss of supplies to unit switchgear from UT, the same shall be restored from respective station switchgear. The automatic bus transfer system shall consist of fast, slow etc. transfer in Auto/ Manual mode.

In addition to above, each switchgear shall be provided with the following provisions-

- Dead bus closing
- Manual live change over (Momentary paralleling)
- Automatic slow bus transfer.

1.4.6 Current Transformers

- a. Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made. They shall have sufficient thermal and mechanical capacity to withstand the maximum momentary current rating of the breakers.
- b. CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c. CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d. All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e. CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.
- f. Accuracy class of CT shall be 5P20 for protection, PX for differential protection and 0.5 for metering.

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1.4.7 Voltage Transformer

- a. Voltage transformers (VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b. VTs shall be of the single-phase type. VTs shall be protected on their primary side by fuse and by MCB (with auxiliary contacts) on the secondary sides.
- c. VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d. It shall be possible to replace VTs without having to de-energise the main busbars.
- e. VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Transducer

For Incoming and outgoing feeders remote metering transducer shall be provided. The output shall be 4-20 mA DC which shall correspond to the normal range. All the transducer shall be dual output type.

1.4.9 Secondary wiring

- a. The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c. Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d. Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with *[stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring (applicable for internal panel wiring).]*
- e. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.10 Terminal blocks

- a. Terminal blocks shall be of 1100 V grade, stud type with marking strips. Terminals for CT secondary leads shall have provision for easy shorting, earthing and shall be suitable for connecting 2 cables of 2.5 mm² copper.
- b. Sufficient terminals shall be provided on each terminal block to ensure that

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not more than two outgoing wires are connected per terminal. All spare contacts of auxiliary relays, timers etc. shall be wired up to the terminals. [20%] spare terminals shall be provided on each terminal block.

- c. Terminal blocks shall be located to allow easy access. Wiring shall be grouped such that the individual wires of a cable can be connected to consecutive terminals.

1.4.11 Ground bus

- a. A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b. Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c. C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.12 Control & Indication

- a. The circuit breaker shall be wired up for local & remote operation. Each breaker shall be equipped with following:
- b. Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In Local position, the breaker shall be operated from switchgear only in test position.
- c. Each cubicle shall be provided with Auto/ Manual Switch. Trip selection switch and Trip-Neutral- Close (TNC) switch.
- d. Circuit breaker shall be indicated electrically. The following indication color shall be used.
Breaker closed – Red
Breaker opened – Green
Spring Charged – White
Breaker Auto trip – Amber
- e. However any other indication shall be provided as per owner's requirements.
- f. Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.

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- g. Breakers shall be controlled locally and/or remotely as per plant operational requirement. Necessary Interposing relays & feedback signal shall be provided based on the DCS IO list.
- h. Breaker control supply shall be of 220 V DC. Breaker spring charging motor shall be suitable for 220 V DC.

1.4.13 Cable termination

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection.

1.4.14 Bus duct connection

Bus duct connection shall be generally from top of the switchgear.

All connection bus work shall have the same continuous rating as associated switchgear bus and shall be fully braced for the short circuit current mentioned in specification.

All provision such as matching flange and other accessories shall be furnished for connection to bus duct.

1.4.15 Painting

All sheet steel surfaces shall be chemically cleaned, degreased and pickled in acid to produce a smooth, clean surface free of scale, grease and rust. After cleaning, the surface shall be given a phosphate coating followed by a coat of high quality primer and baking in the oven.

The paint shade shall be subject to owner's approval. Sufficient quantity of touch up paint shall be furnished for application at site.

1.4.16 Relays, Protection & Metering

- a. The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/ diagnostic facilities shall be provided.
- b. All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner. All numerical relays shall be compatible with IEC 61850.
- c. All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.
- d. All AC operated relays shall be suitable for operation at 50 Hz. AC voltage

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operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

- e. Energy meters shall be provided for incomer of 6.6kV Switchgear and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than [0.2S]. The accuracy class of CT and VT for energy metering shall have accuracy class of [0.5]
 - f. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
 - g. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
 - h. The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
 - i. All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
 - j. Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
 - k. D.C supply shall be supervised by DC supervision relays.
 - l. Trip circuit shall be supervised by Trip circuit supervision.
 - m. Tripping shall be done through high speed lock out relays.
 - n. All meters/ instrument shall be flush mounted on front panel, at least 96 mm² size with 90 degree linear scales and accuracy class of [2.0.]
 - o. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
 - p. For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
 - q. Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- r. Metering and protection shall be as per below table

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	Protections	Metering
a)	Incomers, Tie Feeders and all Outgoing Feeders except Motor and Transformer Feeders	
	<ul style="list-style-type: none"> • IDMT Over current relay (51) • Instantaneous O/C relay(50) • Inverse time over current relay residually connected for Earth Fault detection (51N). • Inverse time over current relay (51NS) connected to transformer neutral for stand-by earth fault. (Applicable for 6.6 kV Unit and Station Incomer only) 	<ul style="list-style-type: none"> • Current in all the three phases (Metering at Switchgear end) • Voltage of all three phases • (Metering at Switchgear end) • kWh meter • (Metering at Switchgear end) • kVARH meter • (Metering at Switchgear end) • Current in all the three phases • (Remote metering through dual output type transducers) • Voltage in all the three phases • (Remote metering through dual output type transducers) • Watt transducer • (Remote metering through dual output type transducers) • VAR transducer • (Remote metering through dual output type transducers)
b)	Bus Couplers	
	Protections	Metering
	<ul style="list-style-type: none"> • IDMT Over current relay (51) • IDMT Earth fault relay (51N) 	Current on all the 3 phases
c)	[Motor Feeders]	
	Protections	Metering
	<ul style="list-style-type: none"> • Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload with unbalance current features etc. • Differential Motor Protection for Motor rating above & equal to 	<ul style="list-style-type: none"> • Current on all the 3 phases from Local & Remote. • KW meter shall be provided.

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	<p>2000kW.</p> <ul style="list-style-type: none"> Winding and Bearing temperature protection by means of RTDs connecting the same to DCS. The motor protection relay shall check the actual no. of repeated starts and compare the same with the manufacturer's permitted number of starts and prevent further starting attempts once the same is exceeded. Under voltage relay. CBCT for sensitive Earth fault (if required) 	
d)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection (Fuse failure protection No Voltage protection)	Voltage on all the 3 phases from Local & Remote.
e)	Transformer Feeder (6.6/ 0.433kV)	
	Protections	Metering
	<ul style="list-style-type: none"> IDMT Over current relay (51) Instantaneous O/C relay (50) Residual Earth fault protection (51N) CBCT for sensitive Earth fault (if required) Transformer Mechanical Protection (Buchholz protection for oil type transformer/WTI high alarm and trip/ OTI high alarm & trip (for oil type) Stand By Earth fault protection (51N) Connected to transformer Neutral 	Current on all the 3 phases from Local & Remote.

1.5 Tests

I. Type Test:

For each type & rating of 6.6kV Switchgear, the Bidder shall submit the reports

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of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening for Owner's approval. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II. Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative. However the following minimum routine tests shall be conduct.

- Power-frequency voltage tests on the main circuit
- Dielectric tests on auxiliary and control circuits
- Measurement of the resistance of the main circuit
- Partial discharge measurement
- Mechanical operation tests
- Heat Run test
- Pressure tests of gas-filled compartments
- Tests of auxiliary electrical, pneumatic and hydraulic devices
- Verification of correct wiring

III. Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV. Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

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1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below.

- a. *[General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening]*
- b. *Bill of Materials.*
- c. *Technical Data sheet and Catalogue.*
- d. *Foundation drawing details with bottom view of switchgear.*
- e. *Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.*
- f. *Control Schematics & Wiring diagram.*
- g. *Inspection and Test Plan (ITP).*
- h. *Suggestive list of protective relays.*
- i. *Transport/shipping dimensions and weights].*

1.7 Ratings & Requirements

6.6kV Switchgear shall comply with the particulars indicated in the following tables.

Table 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		<i>[By Bidder]</i>
1.2	Place & Country of manufacture		<i>[By Bidder]</i>
1.3	Specifications and Standards		As per Table 1.0
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		6.6 kV/7.2 kV, 3 Phase, 3 wire, 50 Hz.
2.2	System neutral earthing		Non Effectively earthed (Fault current Limited to 300A by neutral grounding resistor)
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz

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S. No.	DESCRIPTION	UNIT	DATA
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		20kV 60kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		Continuous current without exceeding the temperature of [90 °C]. For silver plated joints maximum temperature shall be limited to [105 °C].
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	40 kA for 1 Sec
b	Dynamic Rating	kA (peak)	100 kA
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		[Cu/Al]
2.14	Fully draw out (FD)/ Fixed (F)		FD / Single front
2.15	Entry –Top (T)/Bottom (B)		Top for bus duct, bottom for cables.
2.16	Degree of protection		[IP4X] and for LV chamber shall be [IP-52].
2.17	Color finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	[Aluminum]
2.19	Minimum clearances in air of live	mm	As per standard

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S. No.	DESCRIPTION	UNIT	DATA
	parts		
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		6.6kV,50hz,3 phase,3 pole
3.3	Rated operating duty		O-3min-CO- 3min -CO
3.4	Circuit breakers type		VCB
3.5	Short circuit withstand current for 1 sec. Duration	kA	40
3.6	Rated making current	kAp	100
3.7	Rated current at site reference ambient temp	A	[By bidder]
3.8	Type of operating mechanism		Spring charged motor and manual
3.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
3.10	Control voltage		
	Spring charging motor	V AC/DC	[220V DC]
3.11	Closing Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.12	Opening Coil		
a	Voltage	V	220 V
b	Permissible Voltage Variation	%	85% to 110%
c	Closing Current at rated Voltage	A	Within Limit
3.13	Operating time		
	Opening time	ms	< 65
	Breaking time	ms	< 15
	Total tripping time	ms	< 80 (total break time)
	Total Closing time	ms	< 80 ms

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S. No.	DESCRIPTION	UNIT	DATA
3.14	Number of breaks per pole		One
4.0	Contactor		
	Voltage class	kV	7.2
	Short time Rating		[By bidder]
	Duty		AC3
5.0	Fuse		
	Voltage class	kV	6.6
	Rupturing capacity	kAp	100
6.0	Current Transformer		
a	Make		[By bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]
e	Basic Insulation level	kV	7.2/20/60
6.1	CT for differential protection		
	Class		PS class
	Secondary resistance at 75 ° C		[By bidder]
	Knee Point Voltage		[As per purchaser requirement]
	Excitation Current		< 30mA
6.2	CT for Metering		
	Class		[0.5]
	Secondary resistance at 75 ° C		[By Bidder]
6.3	CT for Protection		
	Class		[5P20]
7.0	Voltage Transformer		
a	Make		[By Bidder]
b	Type		Resin Cast
c	Rated frequency		50Hz
d	Class of Insulation		[Class E]

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S. No.	DESCRIPTION	UNIT	DATA
e	Voltage ration		[By Bidder]
8.0	Meters		
a	Make		[By Bidder]
b	Type		[By Bidder]
8.1	Voltmeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
8.2	Ammeter		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Applicable standards		As specified in the specification
d	Accuracy class		Class 1.0
9.0	Indicating lamps		
a	Make		[By Bidder]
b	Type		[By Bidder]
c	Voltage	V	As specified in the specification.
d	Wattage of lamp	W	[By Bidder]
10.0	Push buttons		
a	Make		
b	Type		As specified in the specification.
c	Contact rating	A	[By Bidder]
11.0	Space heater		
a	Make		
b	Type		As specified in the specification.
c	Rated voltage	V	As specified in the specification.

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S. No.	DESCRIPTION	UNIT	DATA
d	Power rating	W	[By Bidder]
12.0	Wiring and terminal blocks		
a	Voltage grade		1.1 kV
b	Insulation		[By Bidder]
c	Minimum size of conductor for:		
	• Power wiring	Sq.mm	2.5 for CT & PT for internal panel wiring only and 4 for external wiring
	• Control wiring	Sq.mm	1.5 (for internal panel wiring only)
f	Type of terminal blocks:		
g	I) For Withdraw able Type		Sliding type
h	II) For Fixed Type		Stud & nut type
i	Minimum current rating of terminal blocks	A	10
13.0	ABT Panel		
a	Make		
b	Type		[By bidder]
c	Panel thickness	mm	2
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		Catalogue shall be furnished by the bidder.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E13

**TECHNICAL SPECIFICATION FOR VARIABLE FREQUENCY
DRIVES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E13

1.0 VARIABLE FREQUENCY DRIVE

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Variable Frequency Drives complete with all accessories for efficient and trouble-free operation of of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS-3700	:	Essential ratings and characteristic of semi-conductor devices
IS-3715	:	Letter symbols for semi-conducting devices
IS-4411	:	Code of designation of semi-conducting devices
IS-5001	:	Guide for preparation of drawings for semi-conductor devices
IS-5469	:	Code of practice for the use of semi-conductor junction devices
IS-5621	:	Hollow Insulators for use in electrical equipment
IS-6209	:	Methods for partial discharge measurement.
IS-6297	:	Transformers and indicators for electronic equipment
IS-8789	:	Performance parameters for motors
IS-12729	:	Switchgear and control gear for voltages exceeding

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		1000V- General requirements
IS-13408	:	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IEC 146	:	Semi Conductor converters
IEC 168	:	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V
IEC 270	:	Partial discharge measurement
IEC 297	:	Dimension of panels and racks
IEC 326	:	General requirements and measuring methods for printed wiring boards
IEC 352	:	Solder less wrapped connection
IEC-61800-3,4&5	:	EMC requirements and specific test methods
IEC-60664-1	:	Insulation coordination for equipment within low-voltage systems
IEC/EN-60204-1	:	Safety of machinery-electrical equipment of machines
IEC/EN-60529	:	Degrees of Protection Provided by Enclosures (IP Code)
IEC/EN-61000-3-12	:	Electromagnetic compatibility
IEEE 444	:	Protection standards for converters
IEEE 519	:	Harmonic control & reactive compensation of static power converters

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DIN 41488	:	Electrical engineering dimensions
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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) All VFDs shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The VFDs shall be suitable for operation in a highly polluted environment.
- b) All VFDs shall be suited for uninterrupted operation under the following variations in bus voltage and frequency:
 - i. Voltage Variation : +/-10%
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency
- c) The VFD shall be of modern design for similar applications in power plants. The system shall be commutated inverter type with minimum [six] pulse design, [IGBT based] and PWM controlled or better control system.
- d) VFD shall consist of Input section (rectifier and filter), control section and output section (PWM module, base drive circuits).
- e) VFD shall include an input filter for limitation of the harmonic current. General requirements of VFD shall conform to IEC 61800-2 and IEEE-519.
- f) VFD shall follow EMC directives as specified in IEC-61000.
- g) VFD model shall be suitably selected based on actual cable length from VFD to motor terminals. Shielded cables suitable for VFD applications shall be provided by the bidder.
- h) For [12 pulse] VFD, required 3 winding transformer and necessary cabling shall be provided by the bidder.
- i) Bidder shall provide inverter duty motor to withstand voltage stresses produced by PWM action

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1.3.1 Performance requirements:

- a) The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration / wear / noise.
- b) The system shall be suitable for the load characteristics and the operational duty of the driven equipment.
- c) The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment:
 - i. Variable torque changing as a function of speed i.e. speed squared.
 - ii. Constant torque over a specific speed range.
 - iii. Constant power over a specific speed range where the torque decreases when speed increases.
- d) The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The system shall be designed for linear continuous speed control from [10% to 100%] of driven equipment's rated speed and shall be of a modern proven design.
- e) The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800-4 and it shall be considered in the design of the motor.
- f) Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 115% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than one minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- g) During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit up to 60 seconds.
- h) The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.
- i) The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95 % of the minimum operational speed for more than 10 seconds.
- j) Maximum noise level of motor shall be measured as per relevant IS standard.

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- k) Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for startup adjustments and troubleshooting/ maintenance.
- l) Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

The drive system shall ensure following:

- i. VFD induced torque pulsation are limited to maximum 1% (even at low speed) so there is minimal stress to the equipment
- ii. Motor is protected from dv/dt stresses.
- iii. No appreciable increase in motor audible noise.

1.3.2 Control requirement:

- a) The VFD and motor characteristics shall be suitable for load specific torque-speed characteristics.
- b) Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.
- c) The system shall also be equipped with a facility which shall restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart the converter shall be capable of synchronizing on to a rotating motor and develop full acceleration torque within 10 seconds.
- d) The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.
- e) The drive motor shall be speed controlled corresponding to 4-20 mA reference input signal unless otherwise specified upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed at the last speed reference available prior to the loss of signal.
- f) It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/manual selection shall be from VFD panel unless otherwise specified.
 - i. With the selector switch in "manual" mode, the operator shall be able to set the speed through keypad, mounted on front of the drive panel or from speed increase/decrease push buttons from the field. Motor operated potentiometer shall be provided as a speed set point device.
 - ii. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's DCS (Process Control) system. Necessary equipment required for interfacing with DCS shall also be provided in the drive panel.

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- g) The required provision for the interface with remote I/O (*as per requirement*) shall be through hardwired connection (with potential free contacts and transducers)
- h) Drive system shall have provision for interface with upper level automation such as electrical control system.
- i) The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.
- j) Bypass Feature
 - i. Bypass breaker / contactor-HRC fuse complete with protection, annunciation and metering shall be provided.
 - ii. All Variable frequency drives (VFD) having bypass feature shall have motor protection relay along with necessary control and metering etc. Switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended by opening its isolation devices.
 - iii. Safety interlock between inverter and bypass breaker/contactors shall be provided such that closing of healthy device is inhibited in case of external fault.

1.4 Specific Requirements

1.4.1 Constructional Requirements

- a) Panel Construction
 - i. The panel shall include suitable semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors (if required), filters (if required), control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of integrated standards.
 - ii. Upstream breaker include suitable semi conducting power devices (Diodes / IGBT) modules will be provided on the front door.
 - iii. Safety Interlock shall be provided so that power cabinet cannot be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.
 - iv. The drive shall be suitably housed in sheet steel panels fabricated with 2 mm thick cold rolled sheet steel. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. The maximum and minimum operating height shall be 1800 mm and 400 mm respectively.

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- v. Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600 mm clear from bottom of the cable gland plate.
- vi. Bus bars shall be of electrolytic copper, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.
- vii. All the switches component and accessories which are essential for normal and emergency operation shall be mounted on the door and shall be operable externally. Digital meters shall be preferred. Analogue instruments, where provided, shall be switchboard type, back connected, 72x72mm. Scale shall have red mark indicating maximum permissible operating rating.
- viii. All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.
- ix. All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with PVC insulated, fire retardant, copper conductor wire. 1.5 mm² size wire shall be used for control circuits, 2.5 sq.mm for CT/PT circuits and 0.75 mm² for electronic circuits. The control fuse rating is 10 Amps or less and 2.5mm² size for control fuse rating above 16A for electrical circuits and 0.7 mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered. Minimum 20% spare terminals shall be provided.
- x. All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipment and power electronic equipments shall be used.
- xi. All low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.
- xii. DC link capacitor and pre charging and discharging circuit shall be preferably mounted in the rear of the panel. Suitable removable type hooks shall be provided for lifting the panel.
- xiii. Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.
- xiv. All equipment shall be complete with double compression glands, lugs etc.

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b) Cooling

- i. The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Bidder shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N + 1) shall be provided.
- ii. Necessary starters shall be provided within the VFD panels for the ventilation fans, any other auxiliary motor etc.
- iii. The system provided shall be interfaced with drive starting and shut down such that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., shall be incorporated in the overall sequence logic.
- iv. MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easily accessible location.

1.4.2 Motor

The motor shall be designed, constructed and tested in accordance with the Specification for high Voltage Induction / Synchronous Motor, in addition to the following requirements:

- a) The motor shall be suitable for VFD control.
- b) The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- c) The motor shall be designed to operate continuously at any speed in the operating range for the driven equipment (ie; ID fan / Coal feeder).
- d) The permitted voltage variation shall take into account the voltage drop across the AC drive and all other system components upstream the motor.
- e) Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications.
- f) The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- g) The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4.

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- h) The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

1.4.3 Static Power Converter

- a) The static power converter shall consist of a line side converter for operation as a rectifier and a load side power converter for operation as a fully controller inverter. Power converter shall be fast switching, most efficient and low loss type.
- b) The converter shall be co-ordinated with the transformers. The converter shall be able to withstand a three phase short circuit current until interrupted by normal breaker operation.
- c) Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- d) All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- e) The current rating of the converters semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range. If the parallel connection of semi conductor is applied, the above current rating shall not be less than 140% of the above values.
- f) All power diodes shall be of silicon type with minimum V_{BO} rating at 2.5 times the rated operating voltage.
- g) The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise nor reducing its service factor due to harmonic currents generated by the inverter operation.
- h) The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions / tools.
- i) The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

1.4.4 Converter Transformer

- a) The converter transformer, if provided, shall be copper wound dry type. Insulation class of dry type transformer shall be H with temperature rise of body limited to 75°C. Dry type transformer shall preferably be mounted inside the drive system panel. The impedances of converter input transformers with more than one secondary winding for minimum 18 pulse systems shall be selected to ensure equal load / current sharing

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between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

- b) The transformation ratio, impedances, taps and secondary voltage shall be chosen by the drive vendor to optimize system performance.

1.4.5 DC link reactor

- a) Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.
- b) Unless otherwise specified, the reactor shall be dry type, air cored, air-cooled or fan cooled type located within the panel.
- c) Reactor shall be suitable for withstanding earth fault continuously and for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.
- d) Noise level shall not exceed value specified in NEMA TR-1

1.4.6 Output filter

- a) VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance free and self-healing type.
- b) The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

1.4.7 Protection, Control, Metering, Indication and Annunciation

- a) The Bidder shall provide all the necessary system control, protection, alarm equipment and metering for the entire drive system and its auxiliary equipment.

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- b) Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.
- c) Protective Relays:
For details on protective relays used, refer to Technical Specifications on MV Switchgear
- d) Operator Control Panel
- i. Each drive shall be equipped with a front mounted operator control panel consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to start/Stop, Local/Remote, auto/manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.
 - ii. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
 - iii. Operator console shall have facility /port to connect external hardware such as Lap-Top etc. Console shall have facility for upload and download of all parameter settings from one drive to another identical drive for start up and operation.
 - iv. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing up stream breaker after all required process parameters are achieved.

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- v. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.
 - vi. Suitable interface with DCS to be provided for control and status signals of VFD.
- e) Local Motor Control Station
- i. The local motor control station shall be installed near the motor. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.
 - ii. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current.
 - iii. Requirement of controls and indications required in the Local Control Station shall be as specified in the data sheet.
- f) Protective Features:
- The system offered shall incorporate adequate protective features, properly coordinated for the drive control and for motor but not limited to the following:
- i. Incoming line surge protection
 - ii. Under / Over voltage protection
 - iii. Phase loss, phase reversal protection.
 - iv. Programmable Over current protection and under load protection.
 - v. Motor differential protection for motor rated above 1000 kW
 - vi. Inverter Fault.
 - vii. Over frequency operation.
 - viii. Ventilation loss,
 - ix. Over temperature of equipment.
 - x. Over speed of motor.

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- xi. Specific motor protection, including motor winding, bearing temperatures, over-current, overload, negative phase sequence, locked rotor and earth fault protections etc.
- xii. System Earth fault protection.
- xiii. Excitation system protection for synchronous motor
- xiv. Over and under frequency, rotor earth fault, field failure protection for synchronous motor
- xv. Additional protection for drive system

g) Control features

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

- i. Start/Stop
- ii. Speed control (Raise/lower)
- iii. Forward/Reverse(if Specified)
- iv. Auto/Manual /test mode
- v. Local/remote
- vi. Emergency stop
- vii. Start/stop for by pass starter (where specified)
- viii. Trip-Remote Breaker
- ix. Excitation control system for synchronous motors
- x. Sequential switching of filters

h) Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

- i. Input AC Current
- ii. Input AC voltage
- iii. Input AC frequency
- iv. Output voltage
- v. Output current VFD / Bypass
- vi. Output frequency
- vii. Motor thermal state

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- viii. Drive thermal state
- ix. Motor speed
- x. Motor energy meter
- xi. DC Link voltage
- xii. Hour Run
- xiii. Voltage and current meter for excitation system for synchronous motor.
- xiv. KVAR, power factor meter for synchronous motors
- xv. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

i) Indications

Bidder shall provide indications as required for normal operation and for easy maintenance, which shall not be limited to the following indications both at local and at plant DCS.

- i. Motor running
- ii. Motor stopped
- iii. VFD System Fault
- iv. System ready to start
- v. AC mains ON
- vi. Motor over speed
- vii. Rectifier output 'ON'
- viii. Motor zero speed
- ix. Remote breaker trip
- x. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e., door mounted keypad or through hardwired indicating lamps/LEDS.

Potential free contacts of items i- iv shall be wired separately for remote indications in DCS.

j) Audio-visual annunciations

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- i. The system shall incorporate audio-visual annunciations for protection, for various fault conditions, for the Drive motor, Supply cables, DC Reactor and the Converter, output transformer etc.
- ii. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.
- iii. Audio-visual window annunciations shall be provided on the front of the panel All annunciations as required for normal and satisfactorily operation of the drive system shall be included as per Bidder standards. These annunciations can be part of operator console panel or separately mounted type.
- iv. Bidder shall include audio-visual alarm as required for normal operation and maintenance of the system but not be limited to the following,
 - Rectifier fuse failure
 - Main AC failure
 - Inverter fuse failure
 - Inverter overload
 - Inverter high temperature
 - Cooling system failure
 - Motor failed to start
 - Transformer failure
 - Excitation system failure for synchronous motor
 - Battery monitoring healthiness
 - Communication and measurement system un healthy
 - Motor temperature high
 - Harmonic filters monitoring
- i. Common potential free contacts shall be provided for above annunciations and these shall be wired up to terminals of DCS I/O panels for remote alarm and monitoring.

k) Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available for a period of minimum 4 days (96 hours) after a shut down even though no supply

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would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

1.4.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle lamps (CFL) etc. shall operate on 240 volts single phase AC.

All control circuit shall operate at voltage of 110V AC or 220V DC.

Bidder shall include supply of all control transformers, protective devices, required accessories etc. and any other control supply voltage as required for the system.

1.4.9 Maintenance features

The controller design shall incorporate the following maintenance features:

- a) Modular construction
- b) All components shall be easily accessible.
- c) Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

1.4.10 Painting

- a) All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.
- b) After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The color shade of the final paint shall be as per manufacturer's standard, unless otherwise specified. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

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- c) All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

Final paint shade shall be light gray and dove gray 631 and 632 as per IS-5 for indoor and outdoor equipment respectively unless otherwise specified

1.5 Tests

The Routine and Type Tests to be performed on the drive system in the presence of the purchaser or consultant shall be as follows:

1.5.1 Type Tests

For each rating and type of VFD, the Bidder shall submit for Owner's approval, the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

All type tests shall be conducted as per relevant standards and test certificates of similar panels conducted within last 5 years shall be furnished.

1.5.2 Routine tests

- a) Visual Inspection
- b) It involves checking of the various equipments/components fault diagnostic unit, Wiring, Terminals, earthing ratings etc. in line with the approved drawings and visual inspection shall not be limited to the following:
- c) Insulation Test
- d) Light Load and Functional Test
- e) Load characteristics test
- f) Load duty test
- g) Checking of Auxiliary Devices
- h) Checking the properties of the control equipment

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- i) Checking the Protective Devices
- j) Checking of control and functional requirements
- k) High voltage test
- l) Leakage and pressure test for cooling water system where provided
- m) Shaft current/bearing insulation
- n) Automatic restart/re-acceleration

Additional tests on switchgears and dry type transformers shall be carried out based on the requirement defined in the technical specification.

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data and Manuals

The engineering services scope and the documentation to be issued with the bid are described hereafter. The list shows the minimum requirements for the documentation, so that any additional documentation considered as necessary will be added to this.

- a) Engineering, manufacturing, delivering and test schedule
- b) Sub-Supplier lists.
- c) General arrangement drawings(plan, elevation, section view) with dimensions
- d) Foundation drawing including loading data.

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- e) Technical Data sheets.
- f) Electrical and control wiring diagram.
- g) Terminal arrangement drawing, interconnection wiring diagram.
- h) Cross sectional drawing.
- i) Inspection and test plan.
- j) Manufacturing Quality Plan.

1.7 Ratings and requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table 2.0

Sl. No	Technical Parameters		
		6.6 kV	415 V
1	Manufacturer Name	[By Bidder]	[By Bidder]
2	Model No.	[By Bidder]	[By Bidder]
3	Application		
4	Quantity		
5	Enclosure Protection Rating	IP-31	IP-31
6	Output Current Rating at ambient temperature	[as per requirement]	[as per requirement]
7	% derating considered for specific ambient	As per IEC	As per IEC
8	Rated Voltage (volts) Input	6.6 kV AC ± 10%, 3-phase	415 V ± 10%, 3-phase

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Sl. No	Technical Parameters		
		6.6 kV	415 V
9	Output Frequency Range (Hz)	[By Bidder]	[By Bidder]
10	Number of Phases and Frequency (Hz)	3 Phase, 50 Hz (+ 3% to -5%)	3 Phase, 50 Hz (+ 3% to -5%)
11	Rectifier type & Design	[6/12/18 Pulse Diode Bridge]	[6/12/18 Pulse Diode Bridge]
12	Inverter type & Design	[as per requirement]	[as per requirement]
13	Min/Recommended / Max switching frequencies (kHz)	[as per requirement]	[as per requirement]
14	Filters	[as per requirement]	[as per requirement]
	Line Side	[as per requirement]	[as per requirement]
	Load Side	[as per requirement]	[as per requirement]
15	Output Modulation Method	PWM	PWM
16	Speed Accuracy (+/ - %)	[as per requirement]	[as per requirement]
17	Response time (speed)	< 5ms with nominal Torque	< 5ms with nominal Torque
18	Response time (Torque)	[By Bidder]	[By Bidder]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
19	Type of cooling	[Natural/forced/water] cooled	[Natural/forced/water] cooled
20	Whether VFD is suitable for outdoor installation	No	No
21	Drive Control Capabilities		
	Start/Stop Push button	ON/Speed Increase/Speed decrease From DCS	ON/Speed Increase/Speed decrease From DCS
	Modbus control	Yes	Yes
22	Load parameters at rated voltage & frequency		
	Output Frequency (Hz)	[0 to ± 120Hz]	[0 to ± 120Hz]
	Full Load current (Amp)	[By Bidder]	[By Bidder]
	VFD Heat dissipation (w)	[By Bidder]	[By Bidder]
23	VFD Efficiency		
	At Full rated Torque	[Approx 98% (Only drive)]	[Approx 98% (Only drive)]
	At 75% of full load torque	[By Bidder]	[By Bidder]
	At 50% of full load torque	[By Bidder]	[By Bidder]
24	Drive Power factor range		
	At rated speed, Torque	[≥ 0.98 (Fundamental)]	[≥ 0.98 (Fundamental)]

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Sl. No	Technical Parameters		
		6.6 kV	415 V
25	DC Voltage	[1.35 times of supply voltage]	[1.35 times of supply voltage]
26	Fundamental power factor	≥ 0.98(At nominal Load)	≥ 0.98(At nominal Load)
27	Switching Frequency	[By Bidder]	[By Bidder]
	Drive Dimensions	[By Bidder]	[By Bidder]
	Length	[By Bidder]	[By Bidder]
	Height	[By Bidder]	[By Bidder]
	Depth	[By Bidder]	[By Bidder]
	Weight	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-C
DETAILED TECHNICAL SPECIFICATION-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications - Instrumentation
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules- Mechanical
	---	Part-B	Technical Schedules- Electrical
	---	Part-C	Technical Schedules- Instrumentation
	---	Part-D	Not Used

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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
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SECTION-II: DETAILED TECHNICAL SPECIFICATION

- A. Detailed Technical Specification-Mechanical
- B. Detailed Technical Specification-Electrical
- C. Detailed Technical Specification-Instrumentation
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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

- A.** Technical Schedules - Mechanical
- B.** Technical Schedules - Electrical
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- D.** Not used

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM (AHP)
(PACKAGE NUMBER: R&M-SP-05)**

**VOLUME-II,
SECTION-II, PART-C
DETAILED TECHNICAL SPECIFICATION-I&C**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

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1

GENERAL

This specification is intended to provide the technical guidelines for the fully coordinated Control & Instrumentation (C & I) system for the Ash Handling C&I and its Auxiliaries of [210/215/220/250] MW, Coal fired Subcritical Thermal Power Plant.

The technical specification shall serve as the guide specification for the proprietary controls of Ash Handling System and its Auxiliaries, equipments as also various stand alone system controls included as part of sub-packages, as in case of system auxiliaries.

It is to be noted that where equipment or system for the Ash Handling system and its auxiliaries are described, it shall be understood that the quantities described are per unit basis, i.e., identical sets to be furnished for each of the units (If plant have multiple units). Where equipment or systems for common facilities are described, it shall be understood that the quantities described are the total quantities required.

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2 SYSTEM DESCRIPTION

C&I system shall consist of all local instruments Viz. Pressure Gauge, Temperature Gauge, limit switch, Ash hopper switch, Ash overflow transfer tank displacer switch, other field sensors, Local panel & push button station, AHP control room equipment, as required erection hardware & interconnecting cables required for the control & monitoring of the entire Ash handling Plant. A dedicated PLC based control system shall be provided for each of Part-A (BAH), Part-B (FAH) for operation, control, interlocking, tripping and all associated equipment whenever required under specified abnormal conditions.

All 6.6 KV drives shall be provided with fluid coupling temperature/ bearing Temperatures measurement & shall be measured with Duplex RTD. Redundant Temperature Measurement sensor shall be provided for all bearing temperature measurement. Stator winding temperature measurement element shall be duplex type and all temperature measuring points shall be connected to PLC. Winding temperature high alarm shall be generated in the PLC system. 6.6 KV drives shall also be provided with vibration monitoring devices and shall be connected with PLC.

2.1 General Requirements

1. The control and instrumentation system for Ash handling Plant shall be designed and constructed to meet all the specification requirements. All instruments/ equipments offered shall be capable of satisfactory operation for prolonged period of time and shall perform accurately and safely under the environmental & operating conditions described in the specification.
2. All equipment, and accessories furnished under the specification shall be from the latest proven control and instrumentation product range of qualified manufacturers whose successful performance has been established by a considerable record of satisfactory operation in power stations. C&I devices & systems shall employ latest state-of-the art technology to guard against any obsolescence. In any case, it shall be required to ensure supply of spare parts for lifetime of the plant.
3. Design requirements as specified in the specification shall be followed while selecting the control and instrumentation items.
4. Each component and system shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/ card, power supply, peripheral etc. shall be established, considering its failure rate/ Mean Time Between Failures (MTBF), Mean Time To Repair(MTTR), such that the availability of the complete C&I system is assured for 99.8%.

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5. To ensure smooth and optimal maintenance, easy interchange ability and efficient spare parts management of various C&I items/ PLCs, it shall be ensured that each C&I item/ PLC is of same make, series and from same family of hardware (as far as practicable).

2.2 PLC system

PLC system shall be redundant with respect to Power Supply, Processor and Communication. Redundant Input card shall be used for measurement of Critical points related to protection of the equipment. All output commands to MCC/ SWGR shall be provided through interposing relay .The control panel shall be IP 55 protection class.

The control system shall have hooter with required hardware and driven from PLC output. Test, Accept and Reset Push Button shall be connected to the PLC system and programmed for alarm annunciator.

A table top mounted PC loaded with editable programming software and HMI shall be provided and placed on a table located on the side of the control panel. There shall be facility of operation from LCD based Operator's station.

2.3 Interfacing With Plant DCS

Interface facility shall be provided for the interface requirements with plant DCS. AHP PLC shall be linked with plant DCS through redundant Unidirectional OPC link in addition to some hardware interface signals. Proper co-ordination shall be maintained with the DCS vendor in achieving the successful & complete interface.

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3 DESIGN PHILOSOPHY

This section covers the design philosophy which shall be used for all control & instrumentation system for Ash Handling System & its auxiliaries.

1. Pressure indicators shall be used wherever indicating type Pressure transmitters are not envisaged. The applications include:
 - a) Suction and discharge lines of pumps, including header section, if two or more pumps are employed for the same service.
 - b) All input and output lines of process equipments.
2. Pressure Switches shall be avoided as far as possible and in place, smart pressure transmitters with soft limit value monitoring in control system shall be used. The applications shall include the following:
 - a) On all process lines / Equipments where parameter abnormality / status including pre trips alarms to be communicated to the operator in control room.
 - b) For all permissive and protection conditions governed by safety operation of the equipments. e.g. pressure adequate, pressure very high / very low conditions.
 - c) For all interlock conditions, governing starting of standby equipment or subsequent equipments for safety operation of the system.
 - d) Inlet and outlet of filters / strainers.
3. Differential Pressure Switches (indicating type) shall be used across filters/strainers for remote monitoring.
4. Smart Pressure Transmitter shall be used for all control applications and as demand by the process. Pressure stubs with isolating valves shall be used.
5. Differential Pressure Transmitter shall be used for all the requirements of differential pressure, flow, level measurement. Pressure stubs with isolating valves shall be used.
6. Temperature indicators (Thermometers) shall be used for following applications
 - a) On all process lines where local indication is warranted by the system either for monitoring or testing.
 - b) On the inlet/outlet of equipments such as Coolers for both the fluid media.
7. Differential temperature indicator shall be used across suction and discharge service.

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8. Temperature Elements: RTDs shall be used for casing metal temperature monitoring and bearing temperature monitoring of HT drives/motors.
- a) Six nos. (2 nos. per phase) Resistance temperature detectors (RTD's) shall be used for all HT motors, for winding temperature monitoring. Each element shall be 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Ash Handling Control system.
 - b) 1 no. duplex PRT-100 type RTD shall be used for each bearing of HT equipment and its driving equipment (motor).
 - c) All RTDs shall be PRT-100 type with each element being 3-wire type, duplex with thermowell assembly. RTDs shall be terminated in the external terminal box, for connection to Ash Handling Control system.
 - d) For process temperature up to 200 degree C, RTD shall be used.
 - e) Temperature measurement shall have upscale / down scale protection features not to cause major process upset in case of sensor failure.
9. Level gauges shall be used on all tanks and the maximum length of one gauge glass shall not exceed 1 meter. The gauge glasses shall be stacked to cover the complete height of the tanks including over flow level. There shall be an overlap of minimum 100mm, when more than one level gauge is required.
10. Level switches: The instrument shall be used for the following applications:
- a) On all equipments (storage vessel) where parameter abnormality/status has to be communicated to the operator in the control room.
 - b) All permissive, interlock and protection conditions governed by the safe operation of the equipment.
 - c) The instrument shall be external cage type with SW connection with isolation facility for surface mounted tanks and top mounted with still pipe for all sumps. Still pipes shall be used with adequate supports.
 - d) Radar type level switches shall be used for bulk material bunkers/hoppers.
11. Level Transmitters Stubs with impulse pipes, root valves for mounting Level transmitters shall be used on process equipments where continuous remote monitoring and/or control of level is envisaged. Wherever necessary standpipes or float chambers and also makeup line shall be used for filling up the constant level vessel.
- a) The instrument shall be differential pressure type or torque tube type for other applications.

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- b) Radar type level transmitter shall be used for bulk material bunkers/hoppers.
- c) Admittance or Radar type shall be for sludge and slurry applications.
- 12. Flow Glasses shall be used at the outlet of the pipe lines and shall be employed under the following conditions:
 - a) Coolers
 - b) The instrument shall be rotary type with glass mounted for indication
 - c) Up to 6 inch on-line flow glasses shall be supplied and above 6 inch bypass type flow glasses shall be used. Sight flow and variable flow indicators shall be used for low pressure and low temperature applications.
- 13. Pneumatically Operated Control Valves shall be used for all control application. If the process demands any other control, then control valves shall be used for those applications also. Where a single control valve cannot meet the turn down ratio as dictated by the process, control valves with split range application shall be used.
 - a) All bypass valves of control valves shall be motor operated valves suitable for inching operation provided with position transmitters.
 - b) All integrated bypass valves shall be motor operated. Electro-pneumatic positioners shall be used for all pneumatic control valves.
 - c) Pressure test points & drains shall be used across each control valve
- 14. The pneumatically operated control valves shall be used with Smart Positioners, diagnostics and HART compatibility. Control Valve diagnostics shall be transmitted through this HART Protocol to control system.
- 15. Solenoid Valves shall be used for all pneumatic control valves hooked up with process interlock requirements and where direct tripping is involved. All solenoid valves shall be uniformly rated for 24V DC or 220V DC. The number of ways for solenoid valve shall be used as indicated below:
 - a) On line two (2) way solenoid valves shall be used, where process line of less than 2 inch with low pressure & temperature application is involved.
 - b) Three (3) way solenoid valves shall be used commonly, where the pressure is admitted or exhausted from a diaphragm valve or single acting cylinder. E.g.: Pneumatic operated spray water block valve.
 - c) Four (4) way solenoid valves shall be used for operating double acting cylinders (If applicable). E.g.: Pneumatically operated on-off type dampers.

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- d) Dual coil, latch, unlatch type Solenoid valves shall be supplied for equipment trips/critical applications.
- 16. Position Transmitters shall be used for all motorized inching valves. Position transmitters shall be 24 V DC, 2 wire, non-contact type.
- 17. Electro-Pneumatic positioners shall be used for all pneumatically operated control valves, power cylinders etc., for converting controller output of 4-20 mA to appropriate pneumatic signal
- 18. Air Filter Regulators along with gauges shall be used in each of the:
 - a) Air supply line to valve positioner/power cylinders
 - b) Air supply line to pneumatic interlocked block valves
- 19. Interposing relay for interface to the following:
 - a) Solenoid valve (if output module cannot directly drive SOV) - Relays with contact rating of minimum 2 Amps.
 - b) DC Starter ((if output module cannot directly drive) - Relays with contact rating of minimum 0.2 Amps.
 - c) Hardwired signal exchange – as required.
- 20. For all HT rotating equipment bearings provision for mounting vibration probes shall be used.
- 21. Junction Boxes/Field termination cabinet: All JBs /FTCs shall be SS. Junction Boxes shall be used for:
 - a) Termination of all sensors located equipment wise.
 - b) Termination of Duplex RTDS
 - c) Termination of limit switch, torque switch, position transmitter and control demand, independently for each valve.
 - d) Area wise or Elevation wise bunching of cables.
- 22. Instrumentation & control cables and Prefabricated Cables with Anti-Rodent treatment shall be used to:
 - a) Connect field instruments to field junction boxes/Local Panels. For switches, both the SPDT contacts of switches shall be wired up to the J.B.
 - b) Connect limit switches, torque switches and position transmitters to their respective field junction boxes.

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- c) Compensating cable shall be supplied for connection between the element and the respective junction boxes / system cabinets as per guidelines.
 - d) Prefabricated cable for connecting between system cabinets, marshalling cabinet to system cabinet, system cabinet to Relay Rack, system cabinets to engineering work stations etc.
 - e) Entire C&I cable within the battery limits.
23. All field instruments including electronics located outside control room areas shall be tropicalized and shall be designed to work in site specific atmosphere/climatic conditions and enclosed in dust tight, waterproof and weatherproof enclosures. In general, transmitters and switches installed at outdoor location shall be mounted in closed type transmitter enclosure. For other areas (indoor), open type racks may be used for installation of transmitters and process switches.
24. All alarm shall be displayed in the control system HMI/LCD. However where local panels are used for local operation/monitoring, PLC driven alarm annunciation system with LED type lamps for local panel shall be used.
25. Pressure, temperature and flow test points shall be used in line with latest performance test code requirements.
- In general, pressure and temperature test points shall be used for the following services:
- a) At the discharge of all pumps
 - b) At the inlet and outlet of each control valve
26. The ranges of the instruments shall be selected based on the following philosophy:
- a) For pressure measurements, the maximum operating pressure shall be within 70 to 80% of the maximum scale range.
 - b) For temperature measurement, the maximum operating temperature shall be within 80 to 90% of the maximum scale range.
 - c) For pressure switches and temperature switches, the set points shall fall within 40% to 70% of the scale range selected.
 - d) For level measurement, the maximum of the range shall cover the overflow point or six inches from the top of the vessel and the minimum of the range shall be six inches above the bottom of the vessel. Also, the gauge glasses shall be stacked with overlap to cover permissive, alarm and trip levels.

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- e) For flow measurement, the maximum range shall be fixed at about 10 to 15% above the maximum operating flow
- 27. Spring-loaded/ Cage clamp type terminals shall be used for termination of instrumentation cables at field JBs, FTCs and local panels.
- 28. Signal Exchange Between Ash Handling Equipments/System and control System
 - a) All the signals required for interlock/alarm/SER purpose (to be implemented in the control System) shall be hardwired.
 - b) All binary outputs provided to local panels/sensors for connection from control System shall be potential free contacts with a rating of 0.2 amps at 220 V DC or 2 amps at 24 V DC or 5 amps at 240 V AC. All check backs to control System shall only be potential free contacts.
 - c) All analog outputs provided to local panels/sensors for connection from control System shall be isolated 4-20 mA DC.
 - d) Command outputs from control System to motorized valve actuator shall be logic level signal (24 V DC) and necessary interposing relays suitable to accept 24 V DC logic level command signal shall be used in MCC module for MOV actuator.
- 29. All indication lamps shall be LED type.
- 30. All interposing relays shall be Plug in type with screw type base & LED for status indication. Relay modules/boards etc. are not acceptable.
- 31. All Limit Switch shall be Non-Contact type. If there is constraints because of process conditions/space, mechanical lever actuated Limit switch may be used.

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4 DESIGN CRITERIA

This section covers the general design criteria to be adopted in designing the Control & Instrumentation system for the Ash Handling System Package.

4.1 General Requirements

Ambient Conditions

Instruments, devices and equipment for location in outdoor / indoor / air-conditioned areas shall be designed to suit the environmental conditions indicated below and shall be suitable for continuous operation in the operating environment of a coal fired Power plant and also during periods of air conditioning failure without any loss of function, or departure from the specification requirements covered under this specification.

Table 4.1
Protection Class Requirement

Ambient Temperature (outside temperature)	Pressure	Relative Humidity	Atmosphere	Required Protection class of panels /cabinets /desks
Outdoor Location				
55 °C max	Atmosphere	100%Max	Air (dirty)	IP 65
4 °C min	Atmosphere	5% Min	Air (dirty)	IP 65
Indoor Location				
55 °C max	Atmosphere	95% Max	Air	IP 54
4 °C min.	Atmosphere	5% Min	Air	IP 54
Air-conditioned Area				
24 +/- 2 °C normal	Atmosphere	95% Max	Air	IP 44
50 °C Max.	Atmosphere	5 % Min	Air	IP 44
a) For Ventilated enclosures, protection class shall be IP 42. b) For hazardous areas the protection class shall be in accordance with the requirements of the relevant NEC code for the location. c) For PCs, OWS, EWS, Servers, Printers and other peripherals, maximum temperature limit shall be 35 °C, For LCD the same shall be 25 °C & for UPS the same shall be 40 °C				

4.2 Codes & Standards

All equipment, system and service covered under this specification shall comply with the requirements of the latest statutes regulations and safety

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codes as applicable in the locality where the equipment/systems shall be installed.

The equipment, systems and services furnished as per this specification shall conform to the codes and standards mentioned in this section. However in the event of any conflict between the requirements of two standards or between the requirements of any standard and this specification, all equipments under this specification shall be given tropical treatment for the climatic conditions prevailing at site as described under project data. Tropical protection shall conform to IS-3202 or any other applicable international standard for protection of Electrical power equipments against climatic conditions.

Reference Codes and Standards

The design, manufacture, inspection, testing, site calibration and installation of all equipment and systems covered under this specification shall conform to the latest editions of codes and standards mentioned below and all other applicable ANSI, ASME, IEEE, NEC, NEMA, ISA, DIN, VDE and Indian Standards and their equivalents.

Temperature Measurement

- Instrument and apparatus for temperature measurement ASME PTC 19.3(1974)
- Temperature measurement by electrical resistance thermometers – IS: 2806.
- Thermometer-element-platinum resistance-IS-2848 / DIN 43760/ IEC 751

Pressure Measurement

- Instrument and apparatus for pressure measurement - ASME PTC 19.2 (1964)
- Bourdon tube pressure and vacuum gauges - IS 3624 – 1966

Flow Measurement

- Instrument and apparatus for Flow measurement – ASME PTC 19.5 (1972) Interim supplement, Part-II
- Measurements of Fluid flow in closed conduit – BS 1042 / ISO 5167.

Electronic measuring Instruments & Control hardware

- Automatic null balancing electrical measuring instruments - ANSI C 39.4 (Rev. 1973)

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- Safety requirements for electrical and electronic measuring and controlling instrumentation - ANSI C 39.5 - 1974.
- Compatibility of analog signals for electronic industrial process instruments - ISA-S 50.1: ANSI MC 12.1 - 1975.
- Dynamic response testing of process control instrumentation - ANSI MC 4.1 (1975): ISA-S26 (1968).
- Surge withstand capability (SWC) tests - ANSI C 37.90a (1974) IEEE Std. 472 (1974). IEC - 254.1.
- Printed circuit boards - IPC TM-650, IEC 326 C
- General requirements and tests for printed wiring boards - IS 7405 (Part-I) - 1973
- Edge socket connectors - IEC 130-11.
- Requirements and methods of testing of wire wrap terminations DIN 41611 Part-2.
- Dimensions of attachment plugs & receptacles ANSI C73-1973.
- Direct acting Electrical Indicating Instruments: IS-1248-1968.

Electronic Cards, Subassemblies & Components

1. Unpackaged

- Vibration IEC 68.2.26
- Shock IEC 68.2.27
- Drop & Topple IEC 68.2.31

2. Packaged

- Vibration, Drop & Static Compression – NSTA

3. Electromagnetic Compatibility

- Electrical Fast Transient – IEC 801.4
- Surge Withstand – IEC 255.4
- Radiated Electromagnetic Field – IEC 801.3
- Electrostatic Discharge – IEC 801.2
- Electromagnetic Emissions – VDE 0871, Class B

Instrument Switches and Contacts

- Contact rating - AC services NEMA ICS Part-2 125, A600

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- Contact rating - DC services NEMA ICS Part-2-125, N600.

Enclosures

- Types of enclosures - NEMA Std. ICS-6-110.15 through 110.22 (Type 4 to 13).
- Racks, panels, and associated equipment - EIA: RS-310-B (ANSI C83.9 - 1972)
- Protection Class for Enclosure, Cabinets, Control Panels and Desks - IS-13947, 1993 & IEC 529.

Apparatus, enclosures and installation practices in hazardous areas

- Classification of hazardous area - NFPA Art. 500, Vol.70-1984.
- Electrical Instruments in hazardous dust locations - ISA-RP 12.11
- Intrinsically safe apparatus - NFPA Art.493 Vol.4.1978
- Purged and pressurized enclosure for electrical equipment in hazardous location - NFPA Art. 496 1982.

Annunciator

- Specifications and guides for the use of general purpose annunciator - ISA RP 19.1-1979.
- Surge withstand capability tests - ANSI C.37.90a - 1974 and IEEE std. 472-1974

Interlocks, Protections

- Relays and relay system associated with electric power apparatus - IEEE std.3.13.
- Surges withstand capability tests - ANSI C.37.90a - 1974 and IEEE Std. 472 - 1974.
- General requirements & tests for switching devices for control and auxiliary circuits including contactor relays - IS-6875 (Part-I) 1973.

Control Valves

- Flow Equation for Sizing Control Valves – ISA S39.2, 1972
- Control Valve Seat Leakage – ANSI / FCI 70.2
- Face to face Dimensions of Control Valves – ANSI B16.10, ISA – S75.03 & ISA – S75.16
- Steel Pipe, Flanges & Flanged Fittings – ANSI B16.34
- Control Valve Capacity Test Procedure – ISA – S75.02

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- Industrial Process Control Valves - IEC 534

Process Connection and Piping

- Codes for pressure piping power piping ANSI B31.1
- Seamless carbon steel pipe ASTM A-106.
- Forged and Rolled Alloy steel pipe flanges, forged fittings, valves and parts - ASTM A-182.
- Material for socket welded fittings - ASTM A-105.
- Seamless Ferritic alloy steel pipe - ASTM A-335.
- Pipe fittings of wrought carbon steel and alloy steel - ASTM A-234.
- Composition bronze or metal castings - ASTM B-62.
- Seamless copper tube, bright annealed ASTM B-168.
- Seamless copper tube - ASTM B-75.
- Dimensions of fittings - ANSI B-16.11
- Valves flanged and butt welding ends - ANSI B16.34.
- Nomenclature for Instrument tube fittings ISA-RP-42.1 - 1982.

Instrument Tubing

- Seamless carbon steel pipe - ASTM - A106.
- Material for socket welds fittings - ASTM - A105.
- Dimensions of fittings - ANSI B16.11
- Code for pressure piping, welding, hydrostatic testing - ANSI B31.1.
- Nomenclature for Instrument Tube Fittings – ISA RP 42.1,198
- Seamless Stainless Steel Tubes ASTM A 312 TP 304

Cables

- Colour coding of single or multi-pair cables - ICEA S-61- 402. (Third edition) NEMA WCS-1979.
- Guide for design and installation of cable systems in power generating stations (insulation, jacket materials) - IEEE Std. 422 - 1977.
- Requirements of vertical tray flame test - IEEE 383 - 1974.
- Standard specification for tinned soft or annealed copper wire for electrical purpose - ASTM B-33 - 81.
- Oxygen index and temperature index test - ASTM D-2863.

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- Smoke generation test - ASTM D-2843 and ASTM E-662.
- Acid gas generation test - IEC-754-1.
- Swedish chimney test - SEN - 4241475 (F3)
- Instrumentation cables and internal wiring IS-1554 (Part-I, 1976) and IS: 5831(1984).
- Mono-mode Fibre – ITU-T G.652 for Optical Fibre Cable
- IEEE 1138, 1994 / IEC 1089 / EIA-455 B for Optical Fibre Cable

Cable Trays, Conduits

- Guide for the design and installation of cable systems in power generating station (cable trays, support systems, conduits) - IEEE Std. 422, NFPA-70-1984.
- Guide for the design and installation of cable systems in power generating station (Cable trays, support systems, conduits) Test Standards, NEMA VE-1 - 1979.
- Galvanizing of Carbon steel cable trays - ASTM A-386-78.

4.3

Power Supply

All instruments and control devices shall be designed to operate on power supplies as follows:

- Electric:
 - 230 volts AC, 50 hertz, single-phase for low torque drives with guaranteed satisfactory operation when equipment is continuously energized at any voltage from 216VAC to 264VAC.
 - 24V DC for PLC.
 - 24 VDC, 110VAC or 230 VAC for Field Instruments.
- Pneumatic:

Clean, dry, and oil free instrument air at 4.2 to 8.6 bars gauge. All necessary pressure reducing controls, where required, shall be furnished by the equipment supplier as specified at some other place under air compressors section.

4.4

Standard Ranges Of Analog Signals

The ranges of analog signals shall normally be as follows:

- (a) Electric -- 4 to 20 mA dc.
- (b) Pneumatic -- 0.2 to 1.0 kg/cm².

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The use of any signal range other than the above shall not be acceptable.

4.5 Contact Ratings

The ratings of all instrument contacts used for alarms and interlocks shall be as follows:

Table 4.2
Contact Ratings

Voltage Rating (volts)	Continuous Rating	Switching Rating (break)
a) 240 AC	480 volt-amperes	1200 volt-amperes
b) 220 DC	60 watts	200 watts
c) 24 DC	12 watts	25 watts

The ratings of all microprocessor-based controller or programmable controller output contacts shall be as required by the controlled devices. Where necessary for higher current ratings or isolation, interposing relays shall be used.

4.6 Reliability and Availability

- Each component and system shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established by considering its failure rate/mean time between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete C&I system is assured for 99.7%.
- Detailed reliability calculations shall be used for each system/ equipment (with the help of a schematic of various sub-system connected in series or in parallel as the case may be and MTBF & MTTR values for the various equipments). Availability calculation shall be as per IEEE Standard-P1046 or equivalent.
- When more than one device uses the same measurement or control signal, the transmitter and other components/ module shall be fully equipped to provide all signal requirements. The system shall be arranged so that the failure of any monitoring device or control components or spurious intermediate grounding in the signal path shall not open the signal loop nor cause the loss or malfunction of signal to other devices using the same signal.
- To ensure availability, adequate redundancy in system design shall be used at hardware, software and sensor level to satisfy the availability criteria. For the protection system, independent sensing device shall be used to ensure adequate safety of plant equipment.

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4.7 Standardization & Uniformity of Hardware

To ensure smooth and optimal maintenance, easy interchange ability efficient spare parts management of various C&I instruments, ensure that all instruments/devices (Processor modules, input/output modules, power supply modules etc.) are of the same family of hardware. For example, all 4-20 mA electronic transducers, control hardware, control valves, actuators instruments/ local devices etc. being furnished shall be manufacturer specific.

4.8 Redundancy

1. Reliability of the Control System shall be established by judicious incorporation of redundancy. In general all critical parts shall have hot standby feature to render the system immune to any single failure.
2. Measurement system (MS), Closed Loop Control System (CLCS) and Open Loop Control System (OLCS) shall all be configured with redundancy at processor modules, communication modules, data bus and power supply modules.
3. Both CLCS & OLCS shall be configured with I/O channels redundancy for each sensor/signals. Where redundant sensors are provided redundant I/O channels shall be used for each sensors/signals.
4. Two out of three measurements philosophy shall be adopted for the control of all closed and critical open loop variables for reliability of operation. The control system shall select the median value for the normal control purpose.

4.9 Operability & Maintainability

1. The design of the control systems and related equipments shall adhere to the principle of 'Fail Safe' operation wherever safety of personnel / plant equipment is involved. 'Fail Safe' operation signifies that the loss of signal or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips are avoided / minimized.
2. The types of failure which shall be taken into account for ensuring operability of the plant shall include but not be limited to:
 - Failure of sensor or transmitter,
 - Failure of main and/or redundant controller/other modules,
 - Loss of motive power to final control element,
 - Loss of control power.
 - Loss of instrument air

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3. The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:

- Standardization of parts.
- Grouping of functions.
- Interchangeability.
- Malfunction identification facility/self surveillance facility.
- Easy modular replacement.
- Fool proof design providing proper identification and other features to preclude improper mounting and installation.
- Appropriate derating of electronic components and parts.

4.10 Metering Bases of Units

The following system of units shall be followed throughout the specification unless otherwise mentioned.

Table 4.3
Metering Bases of Units

S.No	Parameter	Unit
1	Pressure	Kg/sq. cm
2	Differential pressure	mm of H ₂ O column or Kg/sq. cm
3	Draught	mm of H ₂ O column
4	Vacuum	mm of Hg
5	Temperature	Degree Celsius
6	Flow	Tonnes / hr or Kg/hr
7	Flow (Air / Gas)	Tonnes / hr or N. Cu. M /hr
8	Density	gm / c.cm
9	Level	mm or M

4.11 Grounding System

All panels, desks, cabinets shall be used with a continuous bare copper ground bus. The ground bus shall be bolted to the panel structure on bottom on both sides. The bolts shall face inside of panels.

The system ground shall be isolated from the panel ground with suitable isolators. All internal component grounds or common shall be connected to the system ground, which shall be fabricated of copper flat (size 25 mm x 6 mm min, length as applicable).

Shield on instrumentation cables shall be grounded on panel side. When shielding termination is required in cabinets furnished under this

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specification, suitable terminals shall be furnished on copper flat forming system ground. System and shield ground shall be connected to earthing strip at 0.0 meter level using suitable size of cable.

4.12 Drive Control Philosophy

The Drive control & measurement philosophy for the project is detailed in this section.

1. Bi-directional drives (inching or open/close)
 - (a) All bi-directional drives shall be operable from Remote i.e. from CR.
 - (b) Remote manual operation of all drives shall be carried out from OWS.
 - (c) Remote Open/Close commands, generated in control system shall be issued to MCC module through interposing relays. Latching of commands shall be used in control system logic which shall be reset by Limit/Torque switch feedback. The Limit/Torque switch feedback from drive shall be directly wired to Control System.
 - (d) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
 - (e) Following signal exchange shall be envisaged between Drive & Control system:
 - Open Limit Switch (Both NO & NC contacts)
 - Close Limit Switch (Both NO & NC contacts)
 - Open Torque Actuation
 - Close Torque Actuation
 - Position feedback (4-20 mA, two wire electronic type) for inching drive
 - (f) Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in/near MCC room):
 - Switchgear available
 - Switchgear disturbance
 - Open Command
 - Close Command
2. Unidirectional LT drives
 - (a) Unidirectional LT drives shall be operable only from Remote i.e. from CR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
 - (b) Remote manual operation of all drives shall be carried out from OWS.

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- (c) Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays.
- (d) Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
- (e) Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
- (f) Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives greater than 90 KW. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules.
- (g) Following signal exchange shall be envisaged between MCC & Control system (Remote I/O cabinet of control system located in MCC room):
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Start Command
 - Stop Command
- (h) All Numerical relays/Intelligent controllers for LT drives shall be interfaced to Control System through IEC 61850 protocol.

3. Solenoid Operated drives

- (a) Solenoid operated drives shall be operable only from Remote i.e. from CR.
- (b) Remote manual operation of all drives shall be carried out from OWS.
- (c) Remote Open/Close commands shall be generated in Control system & shall be issued to the Solenoid through interposing relays.
- (d) Necessary process interlocks shall be realized in Control system.
- (e) Following signal exchange shall be envisaged between solenoid drive & Control system:
 - Open Limit Position
 - Close Limit Position
 - Open Command
 - Close Command

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4.13 HT drives

1. HT drives shall be operable only from Remote i.e. from CR. In addition, Local pushbutton shall be used only for emergency stopping of drive. Local start operation of the drive is not envisaged.
2. Remote manual operation of all drives shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to MCC module through interposing relays.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided near the drive. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to MCC.
5. Necessary Electrical protections shall be realized at MCC module whereas process interlocks & protections shall be realized in Control system.
6. Current transducer with 4-20 mA type outputs shall be used in the MCC for monitoring the current in Control System for all Drives. Auxiliary power supply to these transducers shall be from the control supply of the respective MCC modules
7. Following signal exchange shall be envisaged between MCC & Control system(Remote I/O cabinet of control system located in MCC room):
 - Switchgear available
 - Switchgear disturbance
 - Master Trip relay Operated
 - On Feedback
 - Off Feedback
 - Trip Feedback
 - Emergency stop feedback
 - Start Command
 - Stop Command
8. Current Feedback

All Numerical relays/Intelligent Controllers for HT drives shall be interfaced to Control System through IEC 61850 protocol.

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4.14 Variable Frequency Drives (VFD)

1. VFD shall be operable from Remote i.e. from CCR/LCR & from VFD Local Display unit. In addition, Local pushbutton shall be used only for emergency stopping of drive.
2. Remote manual operation of VFD shall be carried out from OWS.
3. Remote Start/Stop commands shall be generated in Control system & shall be issued to VFD Panel through interposing relays.
4. Emergency stop of the drive shall be envisaged from the local pushbutton provided in the field. The stop push button (Stay put type) shall be used with a press to lock & turn to release type keyless mechanism. Under locked position the drive operation is inhibited from remote. The local emergency stop push button shall be wired directly to VFD panel.
5. Necessary Electrical protections shall be realized at VFD module whereas process interlocks & protections shall be realized in Control system.
6. Following signal exchange shall be envisaged between VFD & Control system:
 - Switchgear available
 - Switchgear disturbance
 - On Feedback
 - Off Feedback
 - Trip Feedback
 - Emergency stop feedback
 - Start Command
 - Stop Command
 - Current Feedback
 - Speed feedback
 - Speed Setpoint
7. The VFD shall also be interfaced with control system via Modbus soft link.

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5 ASH HANDLING CONTROL SYSTEM

5.1 General

1. The design of the control system and related equipment shall adhere to the principle of "fail safe" operation at all system levels (i.e.) loss of signal, loss of power or failure of any component should not cause a hazardous condition; and at the same time prevent occurrence of false trips and provide reliable and efficient operation of the plant under dynamic conditions and attainment of maximum station availability.
2. The Ash handling plant system shall be divided into following sub-systems:
 - Bottom Ash handling system (BAH)
 - Fly Ash Handling System (FAH)
 - Fly Ash Handling Unloading System
 - Conveying Air System
3. For operation and control of the Ash Handling Plant, system shall be provided with Microprocessor based Programmable Logic Controller based control and instrumentation system which shall cover the total functional requirements of the plant which includes sequence control, interlock & protection, monitoring, alarm, data logging, fault analysis etc. Integral instrumentation for monitoring, Protection and smooth operation of all the Plant and machineries shall be envisaged.

The following signals as minimum shall be hardwired directly from Ash Handling Plant PLCs to DCS:

- Ash Hopper Level Indication
- Ash Flow Indication
- Ash Handling Plant in operation
- Ash Handling Plant in trouble

5.2 Bottom Ash Handling System

1. Control, supervision and monitoring of pumps required for bottom ash system shall be carried out through the AHP PLC. The clinker grinders and valves in the vicinity of the Bottom Ash Hopper shall be operated from the Bottom Ash Local Control Panel, located near the hopper. Separate PLC for BAHS can be considered or RIO of AFP PLC can be placed near BAHS.
2. All drive motors, motorised actuators & pneumatic valves shall be controlled from PLC with starting interlocks & permissive in remote mode and also from local start/stop Push button station in de-interlocked local mode by means of "Local/Remote Selection" switch.
3. The basic operation and control related to the bottom ash handling system shall be carried out as follows:

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a. Bottom Ash Water Recirculation system

The bottom ash water recirculation system comprising dewatering bin, settling tank, surge tank, decanted water recycle pumping facility, ash slurry/sludge return facility, ash water pumping arrangement etc. shall be operated from the AHP PLC through OWS/LVS.

The operation of the Bottom Ash water Recirculation System for the hydro bin shall be done from Bottom Ash water recirculation local panel. This panel shall be interfaced with AHP PLC for monitoring from AHP control room.

b. Bottom Ash Removal System

Bottom ash removal system shall have local manual operation from the Bottom Ash Local Panel to be provided near bottom ash hopper. Bottom ash removal shall be operated/ monitored from AHP PLC as well as Bottom Ash local Panel. Complete annunciation system (driven by PLC) should be available in this local control panel. From the local panel it shall be possible to carry out the ash cleaning operation of BA hopper on receipt of necessary start signal from the PLC and shall also convey appropriate 'cleaning over' signal to PLC after completion of the operation.

4. The control equipment for bottom ash control system shall be located in two areas. One to be located near the bottom ash hopper in outdoor location and the other one at RIO room/Control Room.
5. The local panel shall be outdoor type suitable for vertical column/floor mounting with IP-65 protection category. The panel shall contain a mimic diagram of the system with push buttons and LED indicating lamps for different equipment in the system.
6. Bottom Ash Local Panel shall include but not be limited to the following features/accessories:
 - "Start", "Stop" and "Reverse" push buttons with indicating lamps for clinker grinder motors.
 - Safety feature such as proximity speed switch for detecting clinker grinder jamming by sensing High Torque and thereby stopping it.
 - Open and close push buttons for hopper feed-gate which shall have the features of "stay put" and "inching".
 - Open and close push buttons with indications lamps for each remote operated valve in water line to jet pumps, clinker grinder seal water line and bottom ash slurry line.
 - Mimic diagram depicting the bottom ash cleaning operation along with slurry line interconnection arrangement (if any) with other two units.
 - Indicating lamps for ON and OFF condition of HP & LP water pumps.

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- Fault indication lamps for the above are to be located in Bottom Ash Local Panel.
7. Bottom Ash Local Panel shall be provided with indication lamps for each of the following conditions :
- Water pressure to jet Pump - low
 - Instruments air pressure - low
 - Grinder gland seal water pressure - low
 - Clinker Grinder - tripped (for each grinder motor)
8. The bottom ash removal system shall be furnished with at least the following protective features and safety interlocks to ensure safe operation of the system.
- In the event of jamming of the grinder, the grinder motor shall stop. Jamming if any is to be cleared by reversing the grinder operation.
 - The grinder motor shall trip and corresponding hopper gate shall close under such circumstances.
 - It shall be possible to open the hopper feed gate only when the corresponding clinker grinder is started and running.
 - It shall not be possible to open the jet pump water line valve of one unit when the same for other is already open.
 - For each bottom ash slurry line it shall not be possible to open the valve of one unit, when the interconnecting valve from other unit is already open.
9. The operation of desludging of settling tank and surge tank through sludge pumps shall be provided continuously to avoid any settlement of ash in the subject tanks. There may be necessity for arranging flushing/back washing of this desludging piping and pumping operation. This shall be achieved by complete auto sequencing with provision of manual supervising/overriding.

5.3 Fly Ash Handling System

1. The Fly ash handling control shall be through AHP PLC located in AHP control room & operation shall be through OWS/LCD.
2. Local Pneumatic Control panels shall be provided near each conveying vessel for local control/manual operation & indications.
3. The ash conveying system shall be capable of operating in both Level mode as well as Timer mode.

5.3.1 Measurement philosophy

Following is the indicative list of measurements for the system. These measurements shall be available in OWS/LCD of PLC at the AHP control room.

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- Indication of conveying air pressure on individual supply line after discharge header, after air receiver.
- Indication of instrument air pressure on individual supply line after discharge header, after air receiver.
- Indication of fluidizing blower air pressure at the discharge of each blower.
- Indication of fluidizing blower air pressure at the common discharge header near Main Silo.
- Indication of fluidizing air temperature after heater for buffer hopper.
- Indication of fluidizing air temperature after heater for main silo.
- Indication of level in silos (radar type), buffer hopper (radar type) and feeder vessel (RF type level switch).
- Indication of differential pressure across each Bag filter.
- Indication of Vacuum in all streams

5.3.2 Local Indications

Following local gauges shall be envisaged for the system in addition to other local instruments:

- Local indication of vacuum in all the streams.
- Local indication of cooling water pressure.
- Local indication of pressure of ash conditioning water.
- Local indication of pressure at the discharge header of each compressor.
- Local indication of pressure at discharge line of each air blower.
- Local indication of temperature at discharge line of silo aeration blower.
- Local indication of differential pressure across each Bag filter

5.3.3 Alarms & Interlocks

Following is the indicative list of alarms and interlocks for fly ash conveying system to be executed through PLC. All alarms shall be available in PLC. The system shall be provided with these and other alarms and interlocks as necessary for safe and smooth operation.

1. Alarms

- Vacuum low at the conveying of all ash streams.
- Fly ash conveying air pressure low.
- Instrument air pressure low.
- Conveying air common header discharge pressure low.
- Level in feeder vessel high.
- Control blower discharge pressure low.
- Air blower discharge pressure low.

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- Fly ash level in ash silo high (80%)
- Fly ash level in buffer hoppers high.
- Trouble in any hopper during cleaning operation.
- Any alarm not specifically mentioned but needed for safe and coordinated operation.
- All tripping shall have alarm- annunciation

2. Interlocks/Protections

Protection and safety interlocks for the following conditions shall be provided for safe operation:

- It shall be possible to start and run the fly ash cleaning operation only when the desired vacuum is achieved.
- It shall be possible to start and run the system only if the instrument air pressure is above preset value.
- It shall be possible to start and run the system only if respective/branch isolation valves as applicable in fly ash conveying line are open.
- Any other protection and safety interlocks required but are not mentioned specifically.

5.3.4

Operation Logics

1. The following shall be logic of operation
 - Vacuum in system is above the low set level.
 - Conveying air pressure is above low set value.
 - Instrument air pressure is above low set value
 - Ash silo level is not high (90%)
 - Start Mode selected from OWS/LCD and local pneumatic control panel.
2. Under level mode of operation, the conveying cycle initiation signal shall be generated by the hopper level switch. Under timer mode of operation the initiation signal shall be generated by the suitable delay timer. Under both the modes of operation, the conveying cycle shall be identical.
3. Once all the conditions are achieved, the conveying cycle shall start and the system shall lock into that state until the cycle under operation is completed. During the operation of a cycle, if any of the conditions are not satisfied, then also the conveying cycle shall continue to work as usual, except for the conditions which are to be rechecked. If the recheck condition is not satisfied, the system shall be locked in the annunciated state till the corrective action is taken.
4. The ash conveying cycle from buffer hopper to ash silo shall be as indicated below :

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- First the top intake valve provided below the buffer hoppers shall open for a preset time.
- After the lapse of set time, the vessel inlet valve shall close and valve seat shall inflate which shall be ensured by an independent pressure switch.
- Once the desired seal pressure is achieved, the ash conveying air shall be allowed to enter into the conveying system by opening blow valve.
- Once the minimum conveying time is completed and low vessel pressure is achieved, resetting of timer / pressure switch shall be actuated. The system shall remain inactive till all the conditions as stated above are achieved once again.
- On pressing the purge push button momentarily, the conveying system shall cycle once without opening the ash vessel i.e. without any conveying material.
- The ash evacuated from surge hopper shall be collected in one of the fly ash silos.

5.4 Fly ash Silo unloading System

1. Ash evacuated from Intermediate Surge Hopper; would be collected in one of the two Fly Ash Storage silos. Ash is unloaded to trucks manually through rotary unloaders.
2. The silo unloading panel shall be provided near the ash silos. This panel shall have start/stop push buttons, selector switches & indication lamps for the operator interface. The annunciation window shall be provided for alarm annunciation.
3. The logics, alarms & interlocks for the silo unloading system shall be implemented in AHP PLC.

5.5 Conveying Air System

1. The Conveying & Instrument air systems shall be provided with microprocessor-based control system for each compressor and shall be fully automated, using the manufacturer's standard control package, with single button system start/stop from the AHP Control room and with status/alarm information provided to the operator via the AHP PLC. Local control units with display shall be provided for the compressors to allow local operation & monitoring. In addition, local panel shall be provided for operation & monitoring of other equipments like dryers. All common logics for compressors such as selection, auto change over, duty cycle etc. shall be implemented.

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2. Isolation valves on instrument air distribution headers and sub-headers shall be provided with a pressure gauge, downstream of the valve, located at a suitable operational position.
3. Junction box / local panel shall be provided for terminating the On, Off commands from AHP PLC to each compressor and the On, Off & fault feedbacks from each compressor to AHP PLC. Supply.
4. The control equipment shall be interfaced with the AHP PLC through Modbus/suitable communication, such that the operator can monitor the operation of the compressors and be aware of problems as and when they occur.
5. A protection system shall be provided to shut down the compressor in emergency situations. The protection system shall be independent of the PLC and any proprietary control systems and shall be operational under all operational conditions. An interface to the AHP PLC from the protection system shall be provided to advise the operator that the protection has operated and the cause for its operation.
6. The control scheme shall be suitable for operating the compressors such that all the compressors shall be equally loaded and ensures power consumption is also optimized.
7. Any of the compressor and Air drying Plant may be selectable for "shut down", "working" or "standby" duty.
8. On tripping of working equipment, the standby equipment shall come into operation automatically in case of very low air pressure in the system.
9. All abnormal conditions use for tripping the compressor or Air drier shall be provided with pre-trip audio-visual indication/annunciation in the control panel.
10. Independent switches shall be used for alarms (annunciations) and tripping or interlock.
11. An electrically operated automatic valve shall be provided on cooling water supply line of each compressor & dryer (if applicable) which shall automatically shut off the cooling water supply, in case any of the compressor/dryer is not running for more than set time duration. Suitable interlock shall also be provided for opening the valve before starting of any of the compressor.
12. All important and critical measurements required for protection of equipments shall be provided with adequate redundancy.
13. The Compressed Air system shall have following minimum features:
 - Capacity regulation at constant pressure shall be provided. This mode of constant pressure control shall be provided when the system pressure

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must be held constant with varying capacity requirement. The capacity control of compressor shall be inlet guide vane control.

- Compressor driver motor shall be protected against damage or an inadvertent shut-down resulting from overload.
- Shaft vibration monitoring system shall be provided. Control system shall issue an alarm signal for high shaft vibrations and shall issue a trip/shut-down signal in case of excessive high vibrations. The vibration levels corresponding to alarm and trip shall be settable. Compressor shall also be protected from excessive vibration during start-up and shut-down.
- Selector switches to permit constant generation of air from one compressor and regulation of flow in the other compressor.
- Provision shall be made for auto-start of the stand-by compressor in case of tripping of any of the running compressor with a provision for manual override.

14. The following indications shall be made available in the AHP control room:

- Status of each compressor
- Instrument air pressure low /high
- Conveying air pressure low/high
- Status of each ADP

5.5.1

Measurement Philosophy

Following is the list of minimum required measurements for air Compressors & driers. However, additional measurements required, if any, for efficient operation of the offered system, shall also be included.

1. Measurements for Compressors

- Indication of suction pressure after suction air filters for each compressor.
- Indication of inter stage pressure.
- Indication of temperature of compressed air after intercooler and after after-cooler.
- Indication of pressure of compressed air in each air receiver.
- Indication of pressure of lube oil after oil filter.
- Indication of differential pressure across lube oil filter.
- Oil Level of Indication of lube oil sump.
- Sight glass in common cooling water return line from each compressor.
- Indication of pressure at the supply & return line of common header of cooling water of compressor cooling circuit.
- Indication of Flow measurement at the common discharge airline.

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2. Measurements at AHP LCR

- Indication of Air pressure of individual compressor discharge header and on each air receiver.
- Dew point of Instrument air.

5.5.2

Alarms & Interlocks Philosophy

Following is the list of minimum required alarms & interlocks for operation & monitoring of Compressors & driers. However, additional alarms & interlocks required, if any, for efficient operation of the offered system, shall also be included.

1. Alarms & Interlocks for Compressors

Following audiovisual alarms and interlocks shall be provided for each compressor.

Table 5.1
Alarms & Interlocks for Compressor

S.No	Signal	Alarm/Trip
1	Suction pressure of air after suction filter low	Alarm
2	1 st stage suction air pressure low	Alarm/Trip
3	Temperature of air after Inter cooler, after 2 nd stage & after after-cooler	Alarm/Trip
4	Pressure of air after after-cooler high	Alarm/Trip
5	Temperature of cooling water to each compressor high	Alarm
6	Temperature of cooling water to each compressor too high	Alarm/Trip
7	Flow of cooling water from each compressor low	Alarm
8	Flow of cooling water from each compressor too low	Alarm/Trip
9	Differential pressure across lube oil filter high	Alarm
10	Pressure of lube oil to compressor low	Alarm
11	Pressure of lube oil to compressor too low	Alarm/Trip
12	Temperature of lube oil to compressor high	Alarm
13	Motor winding temperature high	Alarm/Trip
14	Manual tripping	Alarm

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5.6 Operation and Control Philosophy

1. The operation and control of the Ash Handling Plant (AHP) and associated systems shall be performed from its own dedicated PLC located in the Ash Handling Plant Local control Room through two nos. (2) Operator Stations (per unit) and one (1) number Engineering/Operator Work Station (per unit). The One (1) No. 52" LCD per unit shall be configured to display alarm and also serve normal operation.
2. One (1) no. A3 size dot matrix printer (per unit) shall be provided which shall be connected to the data highway and One (1) no. A4 size Colour Laser jet printer (per unit) shall be provided which shall be connected directly to the engineering work station. The required furniture such as operator desk/Consoles, chairs, etc shall be provided. The AHP PLC shall be interfaced to DCS through redundant OPC link by fiber optic cable as well as some signals shall be hardwired to DCS for monitoring purposes.
3. The PLC shall be interfaced to the Switchgears and protection relays through a redundant communication link with open protocol.

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6 PROGRAMMABLE LOGIC CONTROL (PLC)

6.1 General Technical & Design Requirements

Programmable Logic Controller (PLC) shall be microprocessor-based system. The PLC shall be versatile, expandable, user friendly and latest state of art technology. The system shall be envisaged for the purpose of sequential operation, protection and interlock, data acquisition system, alarm functions, closed loop control and data archiving for fully automatic operation. Logic controller shall be used with adequate and reliable protection safeguard for various equipments and to assist the operator for easy safe and efficient starting and stopping of various drives in the process. The system shall be designed by selecting high-grade components of proven quality and proper design of system electronics. The system shall be able to operate satisfactorily with reference to the specified environmental conditions as indicated in the specification.

1. The system shall be modular in construction and expandable in future by adding additional electronic modules, which shall be easily accessible for maintenance and repair. The modules shall preferably be Rack/Rail mounted. The types of modules shall be kept to minimum possible in order to have interchangeability and spares inventory.
2. The system shall have extensive self-diagnostic hardware and software features for easy and fast maintenance of the PLC. Safety barriers shall be used for intrinsically safe input / output circuits.
3. The PLC shall have very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and electromagnetic disturbances expected in a power plant.
4. The system shall be programmed as per the logic requirements required for the functioning of the systems and equipment.
5. Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.
6. On-line replacement of any module shall be possible in such a way that the removal and addition of the module shall be possible without de-energizing the system or causing any interruption in the system while replacing a faulty module except for the inputs /outputs which are being handled by that module. However, in case of triple modular redundant or dual PLC configurations, there shall not be any process upset while replacement.
7. PLC shall be used with 20% hard wired installed spare I/O Channels.
8. The system shall be capable of handling the long-term storage of data for 15 days and retrieval.

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9. The system shall be used with programming and diagnostic facility. Each PLC (Except ESP PLC) shall be used with one no. Laptop of latest configuration with programming software & communication cable.
10. The system shall be facilitated with the time synchronization ports in order to time synchronized with plant DCS.

6.2 PLC System Configuration

The Ash Handling System shall be operated, monitored and controlled through a centralized and dedicated PLC, located in the Ash Handling Plant control room.

The PLC shall be redundant and operated through PC based station (OWS, EWS). A large video display (LCD type) is also shall be envisaged. PLC with work station and the large display shall be located in the control room of AHP. Additionally an OWS (per unit) is envisaged to be installed in the Central Control Room for monitoring. Operation and control shall also be possible from this OWS under predetermined conditions.

Remote Input-Outputs (RIO) concept shall be envisaged. RIO shall be located at different geographical locations (such as bottom ash RIO room/ control room, compressor house for Conveying & Instrument Air System, silo blower room, silo utility building, MCC room etc.) and shall communicate to the AHP PLC located in the control room, through dual redundant fibre optic cable links. The exact locations for RIO shall be decided during detail engineering.

PLC shall be networked with the Plant DCS by dual redundant communication link – based on Ethernet TCP/IP using bidirectional OPC connectivity, on fibre optic cable. The data network shall be extended using redundant link on fibre optic cable up to central control room for installation of one operator workstation at the central control room.

6.3 Input/output Sub system

1. I/O subsystem shall be suitable for accepting discrete inputs, BCD inputs and analog inputs. The I/O modules shall be mounted in the I/O racks.
2. Each I/O shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 500 V DC.
3. Each module shall have LED for each digital I/O channel to indicate the status of each input / output. Redundancy in I/O level shall be maintained as per the process requirement.
4. PLC inputs shall be used with potential free dry contacts. All the inputs shall be double ended i.e., two wires per input and not common return for all inputs. The contact interrogation voltage for input contacts shall be 24V DC minimum. Each input channel shall be protected by separate fuse.

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5. Output contacts from the PLC shall be potential free dry contacts. Each output shall be short-circuit proof and protected by fuse.
6. Visual indication of fuse blown must be provided for each input and output channel.
7. There shall be at least 20% spare capacity available on input & output modules, over and above the system requirement.
8. All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply.
9. PLC shall have the following monitoring features:
 - Power supply monitoring.
 - Contact Bounce filtering.
 - Optical isolation between input and output signals with the internal circuits.
 - In case of power supply failure or hardware fault, the critical outputs shall be automatically switched to the fail-safe mode.
 - Further, keying-in of individual wire connectors shall be used to ensure that only the correct card is plugged on the I/O module. It shall be possible to remove I/O module without disconnecting wiring from field inputs or outputs.

6.4 Processor Sub system

1. The processor sub system shall include CPU, memory, power supply, communication interface etc.
2. Dedicated PLC's shall be envisaged for each Auxiliary system. The processor shall have capability to implement all the control functions required. The processor shall have sufficient memory for storage of the program instructions as applicable to the logic requirements. CPU shall be of 32/64 bit or upgraded version of microprocessor.
3. Memory shall be non-volatile, preferably EEPROM type. However, in case volatile memory is provided, battery backup shall be used for a minimum of three months to keep the stored program intact. A battery drain indication shall be used at least one week before the battery gets drained. Memory shall be used with adequate capacity with 40% spare capacity under worst loading condition.
4. The healthiness of processor hardware and software shall be continuously monitored by watchdog timer.
5. PLC's shall be used as a minimum with dual redundant processor subsystem including CPU, memory and power supply. Redundancy shall be used such that, in case of failure of the main processor, the standby processor shall

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take over automatically and vice - versa. The changeover shall be bumpless and shall not result any process or system upset.

6. In case of failure of complete processor system i.e., both processors, outputs shall take fail safe state automatically.
7. The scan time of programmable controller shall be of the order of 100 milliseconds or better. Scan time of PLC is defined as the cycle time taken by the system to read input, process input executing logic and update control output for all the logics configured within the system. Other activities like diagnostic routines, output / dump of data to peripherals, or any other activity which consume processor time shall also be accounted while computing scan time.

6.5 Communication Sub system

1. The communication subsystem shall provide reliable and high speed data transfer between the processor subsystem, I/O subsystem, PLC console and other devices connected to the system.
2. Redundancy in communication subsystem shall be used, such that on the failure of the active device, communication link or bus, the redundant device communication link or bus shall take-over automatically without interrupting the system operation. The communication bus shall be of coaxial / Fiber optic type.
3. Information about the failed device shall be displayed locally as well as on the PLC console. It shall be possible to manually switch-over the communication from main bus device to redundant bus device without interrupting the PLC functions.
4. The PLC shall have provisions of communication interface facility with Plant DCS system in order to make the entire system operational from CCR. Bi-directional, Redundant soft links shall be used in the PLC for the connectivity with the Plant DCS.
5. Following are also included in the system:
 - Cables required for interfacing with DCS.
 - Implementation of Tags and establishing the Link.
 - Any other software/hardware required.

6.6 System Power Supply

1. For PLC system, redundant 24 V DC power supply shall be used. The required power supply cable shall be used from the UPS DCDB & ACDB for Ash Handling control system
2. For separately mounted I/O racks, separate power supplies shall be used. Power supply module shall be of ample capacity to supply all modules. In addition 20% spare capacity for future shall be used. All the drives shall be

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switched ON/OFF through 24V DC coupling relays to be provided in HT/LT SWGR panels.

3. For the Operator Stations and Engineering Station the power supply shall be from the 230 VAC UPS system.

6.7 PLC Console

1. PLC Console or operating panel/display panel shall be used as operator Interface station for control and monitoring of the plant. This shall be done through dynamic mimic displays and control displays.
2. PLC console shall also be used for program storage, display, fault diagnostic and alarm monitoring. It shall be possible to modify, add or delete the application program on-line without affecting the outputs. It should be possible to modify or create new displays from PLC Console.
3. Isolation shall be used between programming terminal and related subsystems, if there is any possibility of high voltage from TFT being transmitted to other subsystems.
4. The PLC system shall have provision to shift the Operator Station/ Engineering Station to the CCR in future with third party interactive communication facility.

6.8 Displays

The system shall be capable of reading the status of equipments, acquiring the analog signals, displaying the status in the form of mimic diagram, video trend, bar graph, periodic display, alarm display, alarm overview display, logs such as hourly/shift/daily logs, alarm logs etc.

Displays include plant mimic diagrams, which shall include the complete auxiliary plant system indicating each major components of the system and the operating status of individual equipment and devices

6.9 Alarms

1. The system shall display history of alarms in chronological order of occurrence on the Operator Station TFT. At least three (3) levels of alarm priority shall be available which shall be displayed in different color. It should be possible to display and print alarms. System shall have all alarm related functional keys like acknowledge, reset etc. Other design features like set point / dead band adjustment, alarm priority, manual and automatic inhibition based on predefined logic etc. shall be used, which shall be as finalized during detail engineering.
2. The alarm display shall be built bottom up with the most recent alarm at the top of the list. When a point returns to normal, the associated alarm line shall change color suitably and on acknowledgement, the line shall be blanked out.

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3. The alarms below the blank lines shall move upward to fill the empty lines. If the capacity of the OWS display page is exceeded, alarm history shall be stored in memory to accept the over- flow. This alarm history shall be displayed upon operator demand. The format and details of alarm displays shall be finalized during detail engineering.
4. When a point goes into an alarm state and appears on the alarm screen, the time of alarm shall flash until acknowledged by the operator. Acknowledgement by the operator shall cause the time to stop flashing. All alarm initiations and return to normal, shall be logged on a printer.

6.10 System Software

1. Complete licensed software for PLC based system including the communication software system shall be supplied and implemented to meet completely the specification requirements.
2. Application software shall be built based on approved logic diagram, graphics etc and shall include controls, graphics, logs, trends, history, report generation etc.
3. The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics.
4. Diagnostic software shall have the capability to provide information about the failed module / system either in the form of a system configuration display or provide information in the form of a statement.
5. The software's shall not be machine specific. All software licenses shall be valid for the continuous service life of the plant and equipment.
6. Password security shall be used in order to ensure security level to the plant operation.

6.11 Peripherals

Following Peripherals shall be used for ESP PLC only:

1. VDU/ TFT shall be multi-sync, 21" color monitor with intelligent terminal and key board. TFT shall be used with graphic and mimic capabilities with minimum 64 distinct colors. The graphic resolution shall be 600x 1280 dots minimum with 0.25 mm dot pixel and refresh rate shall be 85 Hz or better
2. Suitable optical filter for minimum secondary glare shall be used.
3. One number black & white laser printer shall be used for printing A4 size paper. Printing speed shall be minimum 24 ppm. The printer shall be heavy-duty type with minimum 50,000 pages/month printing capability, 600 dpi resolution, 128 MB memory and 3000 sheet input capability.

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7 UNINTERRUPTED POWER SUPPLY (UPS)

Redundant, 230 VAC Uninterrupted Power Supply (UPS) System for AHP control system consisting of 2x 100% capacity static inverters, 2 x 100% capacity static switches, Manual by-pass switch, 1x 100% capacity float-cum-boost chargers, Battery with accessories, Step-down transformer, Voltage Stabilizer, AC Power Distribution Boards etc. shall be provided. UPS shall be provided with all interconnecting cable between UPS equipment and battery, UPS system cabinets and enclosures etc.

UPS shall be provided with all equipment and accessories required for completeness of the system including any feeder distribution as required for protecting UPS equipment and connected inputs and outputs shall be furnished in line with the specification.

7.1 Technical requirements

1. The equipment furnished under this subsection of the specification shall meet the requirements of all applicable codes and standards including ANSI, NEMA, IEEE, NEC and IS.
2. The UPS equipment and the complete system shall have Surge Withstanding Capability (SWC) to meet the requirements of ANSI C 37.90a - IEEE Standard 472-1974.
3. The UPS shall be provided to cater to all the loads for systems, equipment and instruments requiring UPS supply. Spare feeders of at least 10% of the total number of feeders shall be built in.
4. The selection and selective co ordination of all the protecting devices including fuse free circuit breakers/ fuses shall conform to the requirements of National Electric Code NEC –1984 and other applicable codes and standards. The selectivity ratios of the fuses shall be such that there is a sufficient margin between the total electric energy of the upstream fuse. The selectivity ratio shall be finalised during the detailed engineering stage but the same shall not be less than 2:1 in any case.
5. The following general requirements shall be met for ensuring proper branch and circuit protection.
6. The feeder fuse ampere rating and feeder conductor ampacity must be at least 100% of the non continuous load plus 125% of the continuous load as calculated per Article 220 (220-10 G) of NEC Code- 1984. The feeder conductor must be protected by a fuse not greater than the conductor ampacity.
7. Each ungrounded service entrance conductor shall have a fuse in series with a rating not higher than the ampacity of the conductor.

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8. If secondary fuses are sized not greater than 125% of transformer secondary current, individual transformer fuses are not required in the primary, provided, the primary feeder fuses are not larger than 250% of the transformer rate primary current.
9. The UPS system shall be suitable for operation at ambient conditions indicated in the specification.

7.2 Functional requirements

1. The Uninterrupted Power Supply (UPS) system of continuous duty shall supply regulated, filtered and uninterrupted 230V, 50 Hz, single-phase power, within specified tolerances. Each of the UPS loads shall receive one feeder each from the AC Distribution Board of Inverter A& B. However, each inverter shall supply only 50% loads under normal conditions.
2. Each UPS System component shall be compatible for satisfactory and well coordinated operation with other related components as well as with the input and output systems.
3. The KVA rating of the UPS shall be guaranteed at 230VAC, 50 Hz, single phase output at 50 deg C ambient temperature and load factor of 0.8 lagging.

7.3 Normal Operation

1. During normal operation, UPS loads shall be supplied by both 100% capacity inverters each working at 50% load. The inverters shall receive power from DC source (Charger/Battery) and their static switches shall be in the respective "Inverter" position. In this mode the two inverters shall act as hot standby for each other.
2. Necessary paralleling networks shall be included to ensure equal load sharing by both inverters. The rating of the paralleling device / circuit shall be such that it does not act as a limiting factor on the fault clearing capability of the inverters individually and when working in parallel. Load sharing network details shall be provided to establish all functionalities including fuse clearance.
3. One inverter shall act as "Master", working on its internal oscillator and the other inverter shall follow by using the synchronising signal from master inverter for automatic control of its output frequency.

7.4 Emergency operation

In case of failure of any inverter, the static switch shall automatically transfer the UPS loads of faulty inverter (say Inverter-"A") to the healthy Inverter-"B" which shall start working at 100% capacity. Thus the feeding of UPS power is continued automatically to all loads connected to both inverters despite the failure of one inverter and the quality power supply to

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all UPS loads connected to both inverters shall be maintained without interruption. Isolation of faulty inverter shall be automatic and achieved in less than 4 mille seconds.

On inverter failure, the plant AC source is automatically brought in as the standby source to healthy Inverter working at 100% capacity. In this mode, the healthy Inverter shall get the synchronizing signal from the standby AC source.

Operation on internal oscillator and transfer/retransfer to standby source shall be as follows :

1. The output frequency of the healthy inverter shall be automatically synchronised with the plant stand-by AC source supplied through step down transformer and voltage stabliser using synchronising signal from the standby source. If the frequency of the standby source is beyond these limits, the inverter frequency control shall be automatically disconnected from stand-by synchronising signal and the inverter shall maintain the output frequency at 50 Hz within + 0.1 percent under all conditions of load and input voltage by working on its own internal oscillators.
2. During operation on its own internal oscillator, the inverters shall continuously monitor the frequency of standby source. Upon restoration of proper frequency conditions of stand-by source, the inverter shall automatically start using stand-by source frequency as the synchronising signal for inverter output frequency control.
3. During the operation of any inverter on its internal oscillator due to synchronising frequency being beyond the specified limits, the transfer of static switch from "Inverter" to "Standby source" shall be inhibited.
4. While one of the inverters (healthy) is feeding 100% load and the AC source is acting as standby, and in case this invertor also fails, the 100% load shall be automatically transferred from invertor to standby AC source through static switch, provided the standby source is synchronised to the invertor (synchronous transfer). However, such transfers shall be inhibited during operation of invertor on its internal oscillator due to standby AC source frequency being beyond the synchronisation limits. Asynchronous transfer of invertor loads to standby AC source with a beak, on invertor failure shall be provided.
5. Retransfer of loads from standby AC source to invertor shall be automatic or manual as pre selected by the operator and shall be accomplished only after synchronism of the invertor output with the standby source has been automatically accomplished.
6. The manual bypass switch shall have the provision for fully by-passing the UPS system and connecting all UPS loads to the standby AC source.

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7.5 Static inverters and auxiliary equipment

The static inverters shall be solid state type employing silicon controlled rectifiers or power transistors and other solid state devices to convert direct current power to essentially sinusoidal alternating current power as per this guidelines. Ferro resonant type inverters shall not be acceptable. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, surge suppression network, automatic synchronisation etc. as specified herein. Inverter shall be of continuous duty. Natural convection or forced cooling using redundant fans shall be used. Equipment shall be designed for operation with full load even with cooling fans failure / non-availability.

7.5.1 Inverter Capacity

Each static inverter shall have the following minimum capabilities.

Continuous full load rating: meeting specification stipulations

Over load capacity: 125% of full load rating for 10 minutes and 200% for 10 seconds minimum and 300% for 4ms minimum for all specified input voltages.

The inverter shall have sufficient I²t capability to clear a slow acting HRC fuse having a continuous current rating equal to at least 20% of the continuous full load current rating of the inverter, while feeding 100% rated loads of the inverter.

Voltage regulation: $\pm 1\%$ for 0-100% load at all input voltage and all power factors.

Step load pick up: Upon transfer of full load, the inverter output voltage shall not drop below 85% of nominal voltage during the first half cycle after transfer and 90% of nominal voltage in the next half cycle. The recovery to within $\pm 1\%$ of voltage shall be in less than 50 milliseconds.

7.5.2 Input / Output Voltage

The inverters shall be fed from Battery and chargers which do not feed any other loads. Input voltage shall be nominal DC output voltage of battery and charger of range from final voltage after discharge of battery to maximum DC bus voltage during equalize charging of battery. The inverter shall also be capable of working satisfactorily meeting all specification requirements with only the chargers connected to its input without battery in circuit. Filtering on the input of the inverters shall be furnished as required to operate with the output ripple of the chargers. Each inverter shall include equipment necessary to protect itself from damage resulting from excursions, loss or restoration of DC input voltage and synchronizing voltage. The inverter output voltage shall

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be 230V AC, 50 hz, single phase. Total harmonic content shall be 4% (max) and harmonic content of any single harmonic shall not exceed 3%. The inverter efficiency at 100% load and 0.8 pf shall be minimum 85% and at 50% load and 0.8 pf shall be minimum 80%.

7.5.3 Over loads, Short Circuits and Load loss

1. The inverters shall be provided with suitable fuses at the input and output which shall permit proper co-ordination with other protective devices and at the same time protect the inverter against damage due to internal faults. All necessary equipment shall be provided to protect the inverters against over loads, short circuits and 100% loss of load. The inverter shall be self protecting against damage if energized with full load connected. All the fuses used in inverter power & control circuits shall be fast acting type, operating in less than 5 ms.
2. The inverter shall be provided with current limiting circuitry which shall limit the output current to a value which shall not damage the inverter or blow its fuses.
3. The inverter shall have sufficient I²t capability to prevent damage to itself until short circuit conditions on the output are cleared.
4. Each inverter shall be capable of operation with non linear loads. Details of non linearity for the loads shall be furnished. Output waveform of the inverters) shall remain within specified limits when operating with non linear loads at 100 percent rated load.
5. The inverters shall be self protecting against all AC and DC transients, voltage surges and steady state abnormal voltages and current likely to be encountered in utility power station.

7.5.4 Automatic Synchronization

1. Inverter equipment shall include stable solid state oscillator devices designed to automatically maintain the inverter output in phase and in synchronism with the standby AC source. The frequency regulation shall be automatic within +/- 0.1% for all conditions of inputs, loads and temperature occurring simultaneously or in any combination.
2. Facility shall be provided for automatic transfer to internal oscillator operation when the standby source frequency is not within the synchronisation limits.
3. Provision shall be made for step less adjustment of synch disconnect frequency range from 50 Hz +/- 0.5 Hz to 50 Hz +/- 2 Hz.
4. Automatic adjustment of phase relationship between inverter output and standby AC source shall be gradual, at a controlled slew rate which shall not exceed one Hz per second.

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5. The inverter shall normally work on the internal oscillator with either of the two inverters as master synchronizer and the other following it. Suitable selector facility shall be provided to select the master. When any one inverter fails the healthy inverter gets the synchronizing signal from the standby A.C. source.

The DC input current shall never exceed the full load current except for a short circuit within the inverter. This limitation applies to transient as well as steady state currents and includes inrush currents upon initial energisation of the UPS, load energisation, short circuits external to the inverter etc. For any value of the load and load power factor drawn by the equipment served, the inverter shall not impose on DC source any voltage oscillations in excess of 5 volts (RMS total, all frequencies) or any current oscillations in excess of 3 percent (RMS total, all frequencies) of the DC current at full load.

7.5.5 Static inverter auxiliary equipment

In addition to the inverter equipment specified above, auxiliary equipment shall be furnished with each static inverter as follows:

1. Output ammeter, Output voltmeter, Output KVA meter, Input voltmeter, Frequency meter, Power factor meter, Inverter ON-OFF switch, Alarm Reset Push Button etc. of one number each shall be provided on the front panel of the inverter enclosures.
2. Indicating lights shall be furnished on front of the UPS panels. For those abnormal conditions which could be of a momentary nature, the indicating lights shall remain energized and the contact remain closed until cleared by a reset push button on the panel.
3. The following indications shall be provided as a minimum i.e. DC voltage to the Inverter Low/ High, Loss of DC input to the inverter, Inverter output voltage High/ low, Inverter failure, Standby AC source failure, Inverter synchronized with standby AC source in case of failure of the other inverter, Inverter feeding 100% UPS load, Standby AC source feeding 100% UPS loads, Fan failure and temperature high etc.
4. In addition to the above indications, electrically independent, potential free contacts for each of the above conditions shall be furnished. These contacts shall be rated for 0.5 Amps, 220 Volts DC and shall be wired to the terminal blocks.
5. The signals such as 4-20 mA signals for Inverter A & B output voltages, output currents, output frequency etc. shall be available.

7.1 Static transfer switches and auxiliary equipment

The static transfer switches shall be provided to perform the following functions

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1. To transfer the load automatically between the Inverter to the standby inverter as described under automatic synchronisation.
2. To transfer UPS load under manual control from standby AC source to inverter when placing the UPS System in service and from inverter to standby AC source when taking the UPS out of service.
3. The static transfer switches shall have two modes of operation namely automatic and manual.
4. The static transfer switches shall use silicon controlled rectifiers and other static devices required for automatic transfer of load from Inverter" to Standby" source and vice versa.
5. The static switches shall be provided with the requirements specified herein including the following:

- | | | |
|----|-----------------------------|---|
| a) | Capacity(continuous) | Continuous full load capacity of the inverter. |
| b) | Capacity (overload) | As per overload capacity of inverter indicated in the specification |
| c) | Capacity (Peak) | 1000% of continuous rating for 5 cycles. |
| d) | Transfer Time | 1/4 cycle maximum. (The transition shall be "make before break". Voltage failure shall be sensed at the output of static switch |
| e) | Voltage Rating (Nominal) | 230 Volts, 50 Hz, single phase. |
| f) | Transient Voltage Tolerance | 340 Volts peak above the normal line voltage. |
| g) | Ambient temperature | 50 deg C max. |
| h) | Cooling | Natural or forced circulation, using redundant fans. |
| i) | Duty | Continuous |

6. The transfer of static switch from normal "Inverter" position to "Stand-by" position shall be initiated by Inverter failure and UPS system trouble, Static switch output voltage failure, over current or manual push button operation.

The UPS bus shall be monitored by two voltage detectors. One fast acting circuit shall be used for detecting a complete and instantaneous voltage loss while the other slower acting averaging circuit with adjustable trip level shall be employed to detect voltage deviation beyond selected limits. Both voltage detector circuits shall automatically initiate operation of static transfer switch.

UPS bus current shall be continuously monitored by a current monitoring

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detector. This detector shall operate the static transfer switch when the load current exceeds the overload rating of any inverter. The detector shall rest when the load current falls below the rated current of the inverter resulting in retransfer of static switch with inverter position.

The static switch shall automatically transfer the load from inverter to stand-by AC source when the maximum I_{2t} capability of the inverter is reached or when the inverter output voltage drops below 90%.

Over current transfer limit shall be continuously adjustable from inverter continuous rating to inverter current limit rating.

7. Transfer Inhibit of static switch shall be under the following conditions:

Automatic or manual synchronous transfer of load from inverter to stand-by AC source or vice versa, shall be inhibited when the inverter frequency is not synchronized to the alternate source. However, asynchronous transfer facility under such condition shall be provided.

Transfer resulting from overload shall be inhibited when the standby AC source is not available. In this case the load fed by the inverter shall be automatically disconnected.

8. Static transfer switches shall be provided with necessary protective devices (circuit breakers) both in "Normal" as well as "Stand by" position.
9. The static switches shall be furnished with contacts to alarm failure of the alternate source or opening of any fuse protecting the static switches.
10. Auxiliary equipment for static transfer switch
11. Following auxiliary equipment shall be furnished with each static transfer switch a minimum:

- Red indicating Light to indicate switch in "Normal" position, Green indicating Light to indicate switch in "Standby" position, White indicating Light to indicate "Normal" and "Standby", power sources in synchronism, Push-button to simulate normal AC UPS power failure (sensed at static switch output) to test the satisfactory working of static switch, transfer labeled "Transfer Test", Push-button for manual retransfer of static switch to "Normal" position, Push-button for manual transfer from normal to alternate source, Light to indicate standby AC source voltage deviation high, Light to indicate voltage transfer enabled, Light to indicate voltage transfer disabled etc shall be provided on the front of the enclosure.
- Two (2) number each of NO contact for static switch transfer to "Standby" position and standby source voltage deviation > +/- 2 % from normal shall be provided within the static transfer switch enclosure.

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A. Manual by-pass switch

- a) The manual by-pass switch shall be used to isolate any static switch from its load and stand-by power supply and to take the static switch out of service without power interruption to the load. In doing so, the manual by-pass switch shall connect both load buses to a single inverter. The manual bypass switch shall provide the facility for by passing the entire UPS system during the operation of the UPS in the option of the operator.
- b) The manual bypass switch shall have "make before break" contacts to ensure continuous supply to UPS loads during the operation of the same.
- c) The manual bypass switch shall be rated for 600 Volts, 50 Hz, single phase operation. It shall have continuous load carrying capacity equal to full load inverter current and necessary short term load carrying and interrupting capacity to meet the requirements of the UPS system.
- d) Another bypass and disconnect devices shall be provided as required for orderly start up, shut down and maintenance of UPS system and system components-
- e) The manual by-pass switch and required disconnect devices shall be available with duly mounted and wired in enclosure.

B. Float-cum-boost chargers and auxiliary equipment

- a) Two 100% capacity chargers shall be furnished for the UPS system. Each charger shall confirm to the following requirements.
- b) Each charger furnished for UPS system shall be adequately rated to ensure that any one shall meet full DC load of UPS system operating at 100 % rating plus recharge the fully discharged UPS batteries within 8 hours.
- c) The chargers shall be served from a 415 volt, 50 Hz, 3 phase system. The chargers shall maintain the output voltage within plus and minus 0.5 % from no load to full load, with an input power supply deviation in voltage level of +/- 10 % and input power supply deviation in frequency of +/- 5 % and with both deviations present in any combination.
- d) In addition to supplying DC power for inverters, the chargers shall be designed to charge a fully discharged battery without over loading or causing over voltage or without causing interrupting operation of AC or DC circuit breakers for the entire range of intended operating regimes. Suitable solid state electronic circuits shall be provided to ensure that the charging current is voltage regulated and current limited. After the battery is recharged the charger shall maintain the battery at full charge until the next emergency operation when the UPS battery is again required to provide DC power.
- e) In addition to supplying DC power for inverters, the chargers shall be designed to charge a fully discharged battery without over loading or causing over voltage or without causing interrupting operation of AC or DC circuit breakers

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for the entire range of intended operating regimes. Suitable solid state electronic circuits shall be provided to ensure that the charging current is voltage regulated and current limited. After the battery is recharged the charger shall maintain the battery at full charge until the next emergency operation when the UPS battery is again required to provide DC power..

- f) Float and equalising controls shall have an adjustment range of +/- 5% continuous (without steps).
- g) The chargers shall be self-regulating, solid state, silicon controlled, full-wave rectifier type designed for single and parallel operation with the battery specified. The chargers shall be designed for automatic load sharing during parallel operation.
- h) The charger shall be current limited at 125% of full load to reduce output voltage for charger circuit protection and for protection of battery from overcharge. The current limit shall be continuously adjustable from 80% to 125%.
- i) All necessary equipment and devices shall be provided to protect the charger from short circuits, transient voltages, surges, load and supply fluctuations including sudden loss of input or load.
- j) The charger shall have a slow walk-in circuit which shall prevent application of full load DC current in less than 10 seconds after AC power is energised.
- k) The minimum full load efficiency at nominal input and float output shall be 90% or better. The output regulation, ripple content and power factor shall meet the requirements of UPS system offered.

7.5.6 Battery Charger Auxiliary Equipment

Following auxiliary equipment shall be furnished for battery charger a minimum:

AC Voltmeter, DC Voltmeter, AC Ammeter, DC Ammeter, Charger On-Off push buttons, Potentiometers (one "Float Voltage Adjust" and one "Equalising Voltage Adjust", both with manual adjustment knobs, the settings of these knobs, shall be independent of each other), Selector Switch for float charge / Equalising charge, Charging rate setter, Selector switch and lights for ground fault detector, Indicating lights with proper actuating devices, Circuitry and legend etc shall be furnished on the front of the panel of the charger enclosure.

Indications such as Failure of input AC supply, Charger failure, System on battery operation, Battery equalise timer 'on', Low battery voltage, DC ground fault, Redundant fan failure and temperature high (if provided), Charger fuse failure, Low DC output voltage, High DC output voltage etc.

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One set of independent potential free contacts rated for 0.5 amps, 220 volt DC shall be furnished for the alarms above and wired to terminal block for use of alarm annunciation system.

7.5.7 Ground Detector System

Each charger shall be furnished with a ground detector system consisting of a relay and a centre tapped resistor. The resistor shall be connected between the positive bus and the negative bus. The relay coil shall be connected to resistor and ground. The relay shall be furnished with one normally open and one normally closed contact wired to terminal blocks for connection to external circuits.

Two indicating lights and one three position spring return to centre selector switch mounted on front of charger cabinet shall be provided for each ground detector system.

7.5.8 UPS Battery

1. The battery shall be heavy duty Nickel-cadmium type and shall have sufficient Amp-hour capacity to supply 100% full load current of UPS for 30 min. The Ni-cd battery shall conform to IS: 10918 and shall be sized according to IEEE Std. 1115.
2. The battery shall be high discharge performance type to withstand discharge/charge cycles throughout life without loss of capacity. In battery sizing calculation, take into account a minimum voltage drop of 2.5 volts from battery room to the inverter input.
3. Bidder shall furnish battery sizing calculations, supporting curves/data etc. with the proposal to demonstrate that the proposed battery capacity meets the above specification. Various correction factors such as capacity factor, temperature derating factor (at a minimum electrolyte temperature of 4°C), design margin as per data given below:
 - a. Temperature derating factor (At : (Td)
an electrolyte temperature of :
40C)
 - b. Design margin : 20% = 1.2
 - c. Capacity factor (KT) (For : AH capacity of chosen cell
discharge duration of 1 hr. & : /(discharge current in amp for
end cell voltage of 1.1 volts) chosen cell Corresponding to
1 hour) x Float correction
factor.
 - d. The UPS battery shall be :
furnished as specified herein
and shall meet following
requirements.
 - i) iNominal Voltage : As per the requirement of

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		nominal DC voltage level at the input of the inverters.
ii)	Ambient temperature	: 50 ° C max.
iii)	Specific gravity, full charge	: 1.19 ± 0.01
iv)	Voltage per cell	
	Nominal	: 1.2 V
	Floating	: 1.40 V to 1.42V
	Boost	: 1.53 V to 1.67V
	End cell voltage	: 1.1 Volts

7.5.9 Battery Accessories:

2 nos of Hydrometer along with syringes suitable for vent holes in different cells, Thermometers, Specific gravity correction chart, Wall mounted type holder made of teak wood for hydrometer & thermometer, Cell testing voltmeter (3-0-3V), Acid/Alkali mixing jar 2 nos, Rubber apron, Rubber gloves, Set of spanners, Goggles (industrial) Instruction Card, Variable metallic resistor & shunt, Inter cell connectors, Suitable terminal lugs for cables, Two tier teakwood battery rack, Jack for lifting the cells etc shall be provided as accessories and fittings of the Batteries and auxiliaries.

7.5.10 Step-down transformer & voltage stabiliser

One 415 Volt, 3 phase to 240 Volt, single phase transformer along with associated voltage stabilizer shall be furnished.

This transformer and stabilizer combination shall convert 415 Volt +/- 10% plant auxiliary AC supply to 230V, +/- 2% single phase standby AC Power, which shall serve as UPS system back up supply source.

The transformer and stabilizer shall be sized for 100 % UPS load and shall co-ordinate with the largest branch circuit protection device for feeder short circuit current without sacrificing voltage regulation. The voltage stabilizer shall employ silicon solid state circuitry and shall maintain a stabilized voltage for 0 -100% load with input voltage variations as indicated above.

The stabilizer shall meet the following characteristics as a minimum. Fast rate of correction - within 5 cycle; Output distortion - less than 5% under worst conditions; Efficiency shall be better than 94%; No load losses less than 5%.

7.5.11 AC Distribution Boards

Panel boards for distribution of continuous AC power to essential loads shall be dead-front type panel boards rated for 600 V, AC service. Sheet steel thickness shall be 3 mm for load bearing member and 1.6 mm for other members. The hinged panel board front shall cover the fuses and wiring gutter but not the switch handles. The hinged front and switch handles shall be covered by the enclosure-door.

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Each panel board shall be constructed for 2 wire, single phase distribution with solid neutral bar. Phase and neutral bars shall be of copper. Rating of the main lugs shall be equal to the rated continuous full load current of each inverter. Type of enclosure shall be IP 42 as a minimum.

Each panel board shall have one fused disconnect switch of adequate rating for incoming feeder for AC Bus and requisite single pole, suitably rated disconnect switch branch circuit devices. Fused switches shall be equipped with arc quenchers, visible blades and quick-make quick-break operating mechanisms.

However, 25% spare feeders with fuses of each rating shall be provided.

Wiring and interconnections

All interconnections required from input to output terminals or outgoing inverter, transfer switches and distribution board equipment shall be provided within the enclosures, applicable international standards and good engineering practice. Internal wiring in factory pre-wired electronic systems cabinets may be installed according to the standard as to wire size, insulation and method of termination on internal equipment. Wiring for external circuits including all alarm contacts shall be brought to grouped terminal blocks located for convenient connection for external circuits entering from top or bottom.

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8 FIELD INSTRUMENTS & FINAL CONTROL ELEMENTS**8.1 Pressure / Differential Pressure / Level Transmitter**

Table 8.1
Specifications for Pressure / Differential Pressure / Level Transmitter

S.N	Features	Minimum Requirements
1	Type	Microprocessor based 2 wire type, HART protocol compatible
2	Sensor Type	Capacitive/ Piezo-electric
3	Output Signal	4-20 mA signals superimposed with HART signal.
4	Signal Processing Unit	Microprocessor based
5	Overpressure	150% of max. operating pressure. For vacuum service, the element shall have under – range protection to full vacuum
6	Turn-down Ratio	10:1 for vacuum / very low pressure applications. 100:1 for other applications.
7	Stability	± 0.1% of calibrated span for six months up to 70 Kg/cm ² and ± 0.25% for range more than 70 Kg/cm ² (g).
8	Span and Zero drift	± 0.015% per deg. C at max span & 0.11% per deg. C at min. span.
9	Enclosure Class	Weather proof as per IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500
10	Zero & span adjustability	Continuous, tamper proof, remote as well as manual from instrument with zero suppression and elevation facility.
11	Local Indicator	To be provided
12	Display	Digital LCD Integral Display (minimum 5 digit) Engineering Unit
13	Process connection	½ " NPT (F)
14	Electrical Connection	½ " NPT
15	MOC of Electrical Housing	Aluminum Alloy or better
16	Ambient Temperature	65 Deg. C
17	Operating Voltage	16 – 48 Volts DC
18	Load	600 Ohms (minimum) at 24 Volts DC
19	Accuracy	± 0.075% of span or better
20	Response Time	100 millisecond or better
21	Adjustment/ calibration/ maintenance	Port/provision for Centralised PC based system maintenance.

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S.N	Features	Minimum Requirements
22	Diagnostic	Self Indicating feature
23	Accessories	Diaphragm seal, pulsation damper, siphon, 3-valve or 5valve manifolds.

- All transmitters shall be equipped with all necessary accessories like valve manifolds, mounting bracket etc. Pulsation dampeners shall be used where the process media is unstable for measurement such as at the discharge of a pump. For absolute pressure transmitter, 2 valve manifold; for gauge / vacuum pressure transmitter, 3 valve manifolds and for DP / level / flow transmitter, 5-valve manifold shall be provided. In case if it becomes necessary to use a DP transmitter for pressure measurement then a 3 valve manifold shall be used in place of 2 valve manifold.
- Pressure transmitter shall have easily accessible span, zero and time constant adjustments. A range suppression / elevation device shall be used wherever required.
- For pressure / differential pressure transmitter, proof pressure shall be 200% of maximum static process pressure.
- All transmitter cases shall be dust – tight and rugged. Weather – proof and explosion – proof cases shall be used in outdoor and hazardous areas respectively. Protection clause shall be of IP 67 or better.
- Transmitters for pressure / DP measurements of liquid shall always be installed below the sampling point, preferably with the connection at the top.
- Transmitters for pressure / DP measurements for gases and air shall always be installed above the sampling point, preferably with the connection at the bottom.
- Transmitters with diaphragm seal system shall be considered when
 - The process temperature is outside of the normal operating ranges of the transmitter and cannot be brought into those limits with impulse piping.
 - The process is corrosive and would require frequent transmitter replacement or unusual materials of construction or
 - The process contains suspended solids or is viscous and may plug the impulse piping or
 - There is a need to make density or interface measurements or
 - The process medium may freeze or solidify in transmitter or impulse piping.
- Diaphragm seal shall be either capillary type or direct mounted type depending upon the application. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.

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9. Differential pressure type level transmitters shall be used for range above 1219 mm, for services requiring purge or where liquid might boil in external portions.
10. Differential pressure type level transmitters for use on corrosive service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type DP transmitter shall be considered for special application. Diaphragm material shall normally be stainless steel or any other special alloy.
11. Differential pressure type flow transmitters shall have in-built square-root extractors.

8.2 Temperature Transmitter

Table 8.2
Specifications for Temperature Transmitter

S.N	Features	Minimum Requirements
1	Type	2-Wire, Smart (HART)
2	Output Signal	4-20 mA signals superimposed with HART signal.
3	Signal Processing Unit	Microprocessor based
4	Accuracy	± 0.075 % of span or better
5	Local Indicator	To be provided
6	Display	Digital LCD Integral Display (minimum 5 digit) Engineering Unit
7	Input	Ohm input from Pt-100 RTD
8	Stability	± 0.1 % of reading or 0.1° C, whichever is greater, for 24 months for RTDs.
9	Output	4-20 mA DC, linear
10	Load	600 Ohms (minimum) at 24 Volts DC
11	Power Supply	24 VDC, 2- Wire Loop Power
12	MOC of Electrical Housing	Aluminum Alloy or better
13	Enclosure Class	IP 67 with corrosion resistance coating. For hazardous area explosion proof enclosure as described in NEC article 500

1. The temperature transmitter of following types (2-wire Loop Powered temperature transmitter) compatible with RTDs shall be used.

Single Input DIN-rail mounted Temperature Transmitter

These shall be suitable for mounting on DIN-rails in Panels/JBs in air conditioned room. This temperature transmitter shall be the ones which are especially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted

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on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category.

Dual-input Temperature Transmitter with Indicator

These shall be suitable for mounting on pipes/ supports. Indicator shall be used with these transmitters. These transmitters shall have bump-less change over facility to second sensor in case first sensor fails. This changeover is to be alarmed. Protection class shall be IP67 minimum.

The exact applications for which this type of transmitter is to be provided shall be finalized during detailed engineering.

2. Transmitters shall be used with following features:

- Sensor drifts alarm for sensor failure prediction
- Differential & average temperature measurement if required.
- Automatic switch-over to back-up sensor on primary sensor failure.
- Accepts any combination of two sensor types (RTDs, T/Cs, mV or ohms)
- Ambient temperature compensation
- Fault detection for electronics & sensors with fail-safe alarming.
- Provision of built-in CJC

3. Transmitters to be used for RTD sensors shall be used with RTD EMF correction features so that it shall detect and eliminate EMF errors which are the result of small voltage produced by RTD sensing elements.

4. The product and make shall be selected so that with one make of transmitter all applications with respect to measuring range, temperature sensor (resistance thermometer) and connection type (2/3/4) wire connection of resistance thermometers) shall be covered.

5. Transmitters shall be capable of communication with HART (Highway Addressable Remote Transducer) communicator. HART communicator shall be used with transmitters for tuning / configuring / diagnosing / maintenance of the transmitters. It shall meet the intrinsic safety requirement if required depending upon the application.

6. All transmitters' cases shall be dust-tight and rugged. Weather-proof and explosion-proof cases shall be used in outer and hazardous areas respectively.

8.3 Resistance Temperature Detector (RTD)

Table 8.3
Specifications for RTD

S.N	Features	Minimum Requirements
1	Type	3 / 4 wire , Pt-100 (100 ohm at 0 deg C) (as per DIN 43760)

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S.N	Features	Minimum Requirements
2	No. of Element	Duplex
3	Housing/Head	IP-65/Diecast Aluminium. Plug in connectors are to be provided for external signal cable connection
4	Sheathing of RTD	Metal sheathed , mineral insulated, ceramic packed
5	Calibration and accuracy	As per DIN-43670 Class-A for RTD
6	Stability	Zero & span drift within 0.1% of span for a 6 month period.
7	Characteristic	Linear with respect to temp, within $\pm 1/2$ percent of top range value
8	Standard	As per DIN-43670 for RTD & ASME PTC-19.3 for Thermowell
9	Accessories	a) Adjustable Nipple-Union-Nipple with thermo well connection / plug in connectors
		b) Compression fittings / unions
		c) Flanges etc.
		d) Thermowell as per requirement

- RTDs shall be of duplex, platinum three / four wire type with a nominal resistance of 100 ohms at 0°C and conform to DIN 43760 / BS 1904.
- Stability of RTD over full range shall be better than 0.05 ohms and the repeatability figure shall be better than 0.02 ohms. Accuracy shall be of the order of 0.15% or better and response time shall be less than 20 seconds with thermo well.
- The protective-sheath material shall be SS 316, seamless tubes using compacted magnesium oxide packing for insulation. The insulation resistance at 540°C shall not be less than 5 mega-ohms.

8.4 Thermowell for Temperature Elements

- The design of the thermo well shall take into consideration the temperature, pressure, medium and fluid velocity specified in the process in accordance with ASME Standard PTC 19.3, 1974.
- Welded type thermo wells with 38 mm O.D. for welding & ½" NPT internal threads shall be used for pressure above 100 kg / sq cm or temperature above 400 deg C. Socket weld type thermo well with 34 mm O.D. for welding & ½" NPT internal thread, shall be used for pressure between 40-100 kg/cm² and temperature up to 400°C. Screwed type thermo wells with ½" NPT internal threads & M33X2 (M) outer threads shall be used for pressure below 40 kg/cm² and temperature below 400°C. For pipes having

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probability of prolonged vibration, seal welding may be done all around after tightening the thermo well within the base.

3. RTD used in air path shall be supported by suitable protection tube of adequate strength with welded cap at the end. The connection size of the temperature detector with the protection pipe shall be adjustable flange type. The length of the protection pipe shall be such that it supports at a distance nearly 2/3rd length of the immersed temperature detector inside the duct using a heat insulated ring support in between.
4. Thermo wells used in Mill classifier Outlet area shall be made of suitable material of sufficient abrasion resistance such as alloy cast iron / 'Ni-hard' / Tungsten Carbide of hardness approx. 400 BHN. Protection rod in front of thermo wells for mill classifier if required shall be used.
5. Thermo well manufacturing drawing covering material specification, dimensional details, details of special treatment, finish etc. as well as test procedure. Material certificate shall have to be furnished for each thermo well.
6. The thermo well immersion depth (U) shall be sufficient to eliminate conduction error. A general rule which may be followed is to use an immersion length equaling a minimum of 10 times the diameter of the protective tube or well. In general, immersion length of thermo wells for different line sizes shall be as follows:

Table 8.4
Thermowell Immersion Length

S.N	Line Size	Immersion Length
1	From 4" to 6"	65 mm
2	From 8" & onwards	140 mm
3	Vessels	400 mm

8.5

Pressure Gauge/ Differential Pressure Gauge

Table 8.5
Specification for Pressure Gauge/ DP Gauge

S.N	Feature	Minimum Requirement
1	Type	Bourdon / Bellows / Diaphragm
2	Sensing Element Material	AISI 316 SS
3	Movement Material	AISI 304 SS
4	Case Material / Protection Class	SS / IP 65
5	Dial Size	150 mm
6	Scale	Black lettering on white background in 270 °C arc

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S.N	Feature	Minimum Requirement
7	Range Selection	Normally operate at 75% of its maximum pressure range. Instruments measuring varying pressures shall operate in a band of 60% of its maximum pressure range.
8	Over range Protection	150% of maximum range by internal stop. External stop below zero.
9	Adjustment	External Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
10	Stop at Max. Reading	Shall be used
11	Element Connection	Argon welding
12	Process Connection	½" NPT(M) bottom connection for local mounting, back connection for panel mounting
13	Accuracy	+/- 1.0 % of full scale or better
14	Operating Ambient Temperature	50 °C (Max. continuous)
15	Safety Feature	Neoprene Safety Diaphragm (Blowout disc) at the back
16	Window	Shatter-proof glass
17	Chemical Seal Unit	SS 316 Flange and Diaphragm, PTFE coated / block, Silicon Oil filling fluid
18	Accessories	Snubber for pulsating fluid applications / 3-way gauge cock / 2-valve manifold / Pigtail / Gauge Saver, if maximum or Design Pressure is very high than the Operating Pressure / Counter Flanges / Bolts, Nuts, Gaskets / SS Tag Plate

1. Directly connected pressure measuring instruments shall be diaphragm, bourdon or bellow type elements depending upon the services conditions. In general, diaphragm elements shall be used in the range of 0 to 1000 mm water column pressure, bellow type element for ranges of 0 to 1 Kg/cm² and bourdon type element for ranges greater than 1 Kg/cm².
2. Primary element material shall be corrosion resistant to process fluid or diaphragm seals shall be used for protection.
3. Snubber shall be floating pin type, externally mounted and externally adjustable. It shall be used for all pulsating services.
4. Diaphragm seals, filled type or mechanical type shall be furnished where plugging of the element may occur or where suitable material is not available in highly corrosive services. When chemical seals are required, they shall be the clean out type with flushing connection.

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5. Over-range protection shall be used to at least 150 % of range. For vacuum service, the element shall have under-range protection to full vacuum
6. Ranges of the gauges shall be so selected that the gauge normally operates in the middle third of the scale and conform to IS 3624 standard dials, wherever necessary.
7. The sensing elements for all gauges shall be properly aged and factory tested to remove all residual stresses and shall be SS 316 with forged socket and tip of the same material. Elements above 70 Kg/sq. cm range shall be bored instead of drawn.

8.6

Temperature Gauge

Table 8.6
Specification for Temperature Gauge

S.N	Feature	Minimum Requirement
1	Type	Mercury filled
2	Sensing Element material	Bourdon AISI 316 SS
3	Movement Materials	AISI 304 SS
4	Case Material/Protection class	SS / IP65
5	Capillary Armouring	SS Flexible
6	Capillary	SS 316 (5 mtr. Length for Local & 15 metre for panel Mounting)
7	Bulb/Stem Diameter	12 mm
8	Dial Size	150 mm
9	Window	Shatterproof glass
10	Scale	Black lettering on white background in 270 °C arc
11	Adjustment	Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
12	Pointer	Externally Adjustable
13	Range Selection	Normal Process Temperature – approximately two third of Temperature range.
14	Stop at Max. Reading	Shall be used
15	Over range Protection	150% of FSD
16	Instrument Connection	Bottom connection for local mounting, back connection for panel mounting.
17	Process Connection	½ " NPT with Thermowell
18	Performance :-	
a	Accuracy	+/-1.0% of full scale or better
b	Repeatability	Less than 0.5% of full range

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S.N	Feature	Minimum Requirement
c	Response Time	30 seconds (max.) with Thermowell and 15 seconds Bare.
15	Operating Ambient Temperature	50 °C (Max. continuous)
16	Accessories	Mounting brackets, Bolts, Nuts, Gaskets / SS Tag plate, SS Thermowell etc.

1. Temperature gauges shall be dial thermometers (liquid spring / metal expansion thermometer), either rigid stem or capillary tube depending upon application; if this is not possible for design reasons, industry type liquid – in – glass thermometers shall be used.
2. Case shall have back or bottom connection with adjustable gland to permit adjustment of thermometer into the thermo well.
3. Thermometer stem adjustable gland with union connection and bushing shall be suitable for ½ inch NPT connection.
4. Bi-metallic type dial thermometer, if used, shall be hermetically sealed, back or bottom connection type, with 150 mm dial.
5. The gauges shall be used with automatic ambient temperature compensation.
6. Scale ranges shall be selected so that normal process temperature in middle two – third of full scale range

8.7

Level Gauge

Table 8.7
Specification for Level Gauge

S.N	Feature	Minimum Requirement
1	Sensing Element & material	Tempered toughened Borosilicate gauge glass steel Armored reflex or transparent type
2	Body Material	Forged carbon steel / 304 SS
3	End Connection	Process connection as per ASME PTC and drain / vent 15 NB
4	Accuracy	+ 2 %
5	Scale	Linear vertical
6	Range Selection	Cover 125 % of max. of scale
7	Over Range Test	Test pressure for the assembly shall be 1.5 to the Maximum design pressure at 38 degree C
8	Housing	CS / 304 SS leak - proof
9	Identification	Engraved with service legend or or laminated phenolic Name plate

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S.N	Feature	Minimum Requirement
10	Packing	PTFE Teflon
11	Illumination	220 V, 50 Hz, 25 / 40 Watts either with deflector or diffuser (for transparent type level gauge) / 220V , 50 Hz, 25 /40 Watts with red and green filter for bicolor gauge
12	Accessories	Gasket for all KEL – F shield for transparent type vent and drain valves of CS / SS as per requirement
13	Others	Anti – Frost extension for low temperature service. Heating / cooling arrangement

- Level gauges shall be steel armoured reflex or transparent or bi –colour type, top and bottom connection as per pressure vessel standard of ASME PTC code and 15 mm NB (1/2 inch NPT) Drain and Vent connection.
- Body material and cover material shall normally be forged carbon steel, 304 stainlesssteel or other superior material.
- Reflex type gauges shall be used for clean and colorless liquids and transparent type for other liquids. For treated water, the transparent type with KEL – F shields shall be used to avoid their attack on the glands.
- The gauge glass must have a rating equal to or more than the vessel design pressure and temperature.
- The maximum length of a single gauge glass shall not exceed 1400 mm. Where large range is required, multiple gauges of preferably equal lengths shall be used with 50 mm over – lapping in visibility.
- Stand – pipes shall be used for multi – gauge glass and level controller installation and on horizontal vessel with top and bottom connections to have visibility of the complete span. The stand pipe shall not be used with block valves.
- Primary isolation valves shall be used In addition to the gauge glass valves unless otherwise specified. When the process fluid may create lugging or leakage problem, gauge valves may be omitted. For low temperature liquid having high vapor pressure at ambient temperature, isolation and gauge valves shall not be permissible. Safety valve shall be used at the vent connection of the gauge glass where isolation is required.
- Bi – colour level gauges shall have following features:
 - Temperature equalizing column expansion bend and chain patterned hand – wheel

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8.8 Pressure/ Differential Pressure Switch

Table 8.8
Specification for Pressure/DP Switch

S.N	Feature	Minimum Requirement
1	Type	Piston for high pressure application Bellow/Diaphragm for low pressure application
2	Sensing Element material	AISI 316 SS
3	Wetted Parts material	AISI 316 SS
4	Case Material	Epoxy coated Die Cast Aluminium
5	Setter Scale	Black graduation on white linear scale. Graduation 0 – 100% with red pointer for set points.
6	Over range for Pressure / Vacuum Switch	150% of maximum pressure
7	Set Point	Adjustable throughout switch operating range.
8	Static Pressure for Differential Pressure Switch	Maximum Line Pressure or Static Pressure on either side without permanent deformation or loss of accuracy.
9	Adjustments	Internal – set point Differential adjustable feature
10	Process Connection	½ " NPT(M) bottom connected
11	Switch Configuration	2 SPDT / 1 DPDT
12	Switch Rating	230 V, 5A AC / 220 V, 0.25 A DC/24 V, 2A DC
13	Switch Type	Snap acting, shock and vibration-proof
14	Cable Connection	½ " ET conduit connections or compression gland
15	Enclosure Class	Weather proof as per IP 65 with corrosion resistance coating.
16	Accuracy	1% of span up to 3Kg/cm2 0.5% of span for more than 3 Kg/cm2.
17	Repeatability	0.5% of span
18	Accessories	
a)		Snubber for pulsating fluid application.
b)		Tag Number, service engraved in SS tag plate
c)		Teflon back-up sheath protection, as required.
d)		i) Remote diaphragm seal with SS 316 armored capillary for typical application. MOC of seal material shall be as per process fluid requirement.

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S.N	Feature	Minimum Requirement
		ii) Silver coated diaphragm for corrosive services like chlorinated water.
e)		Retention ring and screws for surface mounting.
f)		3-way Gauge Cock (SS 316) for PS / 5-Valve Manifold (SS 316) for DPS.
g)		mp for 2 " pipe, bolt & nut.

- The pressure switches shall have sensing elements made of copper alloy or stainless steel sealed diaphragm and piston actuated for high pressure service and bellows for low pressure / vacuum service.
- Low differential pressure switches for low static pressure ranges shall be diaphragm type with snap action switch elements.
- Low differential pressure switches for high static pressure shall be elbows and torque tube type and snap – action switch elements and metric scale dial indicators.
- For corrosive, viscous process fluids diaphragm sealed with completely filled inert liquid shall be used. Material of diaphragm and wetted parts shall be selected considering the nature of process fluid.
- The sensing elements shall be properly aged and factory tested to remove all residual stresses. They shall be able to withstand at least 150 % the full scale pressure without any damage or permanent deformation.
- Actuation set point, dead band shall be internally adjustable throughout the range with tamper proof facilities.
- Electrical connection for the switch devices shall be suitable for plug in type connection.
- Process connection shall be ½ inch NPT. Process piping connections shall include necessary union, nut, nipple, tail pipe, isolation valve and test connection to permit servicing, testing, calibration and removal of the instrument device.
- Pressure switches shall be tested as per BS – 6134.

8.9 Ultrasonic Level Transmitter

Table 8.9
Specification for Ultrasonic Transmitter

S.N	Feature	Minimum Requirement
1	Application	Level measurement in silos, sump water level etc.
2	Medium	Coarse, hard solid materials like ash etc. Materials may be slowly falling through the

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S.N	Feature	Minimum Requirement
		detection range.
3	Type	Non contact Microprocessor based 2 wire type, HART protocol compatible Ultrasonic Transmitter
4	Principle	Time of flight
4	Sensor Material	Corrosion resistant material to suit individual application requirement.
5	False signal tolerance	Transmitter shall be capable of ignoring false echoes from internal tank / sumps obstructions such as pipes, heating coils or agitator blades. Also transmitters shall have adjustable damping circuitry.
7	Range	Capable of covering the complete level span of tank/vessel taking care of blocking distance, frequency, attenuation due to surface, obstructions, vapours etc.
8	Output	4 – 20 mA DC with 600 ohms load with HART compatibility.
9	Display	minimum 4 characters display with Integral keypad, access protected by user code.
10	Diagnostics	Loss of echo alarm etc.
11	Resolution	+/- 0.1 % of range or better
12	Accuracy	+/- 2 mm or 0.2% of span
13	Repeatability	3 mm or better
14	Operating temperature	0 to 60° C
15	Power supply	24 V DC + / - 10 %
16	Mounting	Flanged connection at top of covers / side walls as per requirement.
17	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

1. The power and frequency of transmission for the transmitter shall be selected to assure a sufficient signal / noise ratio.
2. The transmitter shall be designed with an electronic circuit having the features such as temperature compensation, rejection of unnecessary echoes

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and noises and adjusting 'zero' and 'span'. It shall consist of sensors, electronic unit and accessories.

8.10

Guided Wave Radar Type Level Transmitter

Table 8.10
Specification for Guided Wave Radar Type Transmitter

S.N	Feature	Minimum Requirement
1	Application	Level measurement of vessel under vacuum or low pressure application
3	Type	Guided wave radar
4	Principle	TDR (Time domain reflectometry)
5	Probe Material	SS 316
6	Accuracy	5 mm or better
7	Resolution	+/- 0.1 % of range or better
8	Signal Output	4 – 20 mA DC with 600 ohms load with HART compatibility
9	Power Supply	24 V DC + / - 10 %
10	Display	Integral
11	Mounting	External cage type
12	Transmitter housing Protection Class	IP-65 with corrosion resistance coating
13	Accessories	a) All weather canopies for protection from direct sunlight and direct rain.
		b) For hazardous areas, explosion proof enclosure as per NEC article 500 shall be used.
		c) All mounting hardware and accessories required for erection and commissioning. Mounting fittings material shall be SS 316.

8.11

RF Type Level Switch

Table 8.11
Specification for RF Type Level Switch

S.N	Feature	Minimum Requirement
1	Application	Solids
2	Particle size	Fine dust to 400 mm
3	Process Temperature	0 – 100°C
4	Vessel pressure	up to 60 bar
5	Insertion length	As required
7	Mounting	Side or top or top vertical at $\pm 15^\circ$
8	Process connection	40 NB thread or flanged

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S.N	Feature	Minimum Requirement
9	Protection Class	IP 67
10	Electronics	Remote
11	Cable connection	½ "NPT cable gland Plug-in cable connector

8.12 Sight Glass Indicator (Flow Glass)

Table 8.12
Specification for Flow Glass

S.N	Feature	Minimum Requirement
1	Application	Online observation of fluid flow in Pipeline
2	Type	Double window for pressurized pipe with rotary wheel for installation in horizontal or vertical pipeline. Full view for non-pressurized pipeline.
3	Size	Double window up to 12" and 600 lbs rating. Full view up to 6" and 150 lbs rating.
3	Body Material	SS 316
4	Glass	Pyrex tempered glass
	Others	Rotor & wetted parts shall be bronze All accessories shall be SS316
5	Protection class	IP-65
6	Connection	Screwed up to 50 NB size Flanged ANSI 150 RF – above 50 NB size
7	Accessories	Name plates, mating flanges with gasket, bolts & nuts etc.

8.13 Control Valves

8.13.1 Introduction

The control valves and accessories equipment furnished by the Supplier shall be designed, constructed and tested in accordance with the latest applicable requirements of code for pressure piping ANSI B 31.1, the ASME Boiler & Pressure Vessel code, Indian Boiler Regulation (IBR) & ISA or acceptable equal standards.

8.13.2 Control Valve Design & Sizing

- The design of all valve bodies shall meet the specification requirements and shall conform to the requirements of ANSI for dimensions, material thickness and material specification for their respective pressure classes.
- The valve sizing shall be suitable for obtaining maximum flow conditions with valve opening at approximately 80% of total valve stem travel and minimum flow conditions with valve stem travel not less than 10% of total

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valve travel. All the valves shall be capable of handling at least 120% of the required maximum flow. Further, the valve stem travel range from minimum flow condition to maximum flow condition shall not be less than 50% of the total valve stem travel. The sizing shall be in accordance with the latest edition of ISA Handbook on control valves. While deciding the size of valves, Supplier shall ensure that valves outlet velocity does not exceed 8 m / sec. for liquid services, 150 m/sec. Manufacturer shall furnish the sizing calculations clearly indicating the outlet velocity achieved with the valve size selected by him as well as noise calculations.

3. Control valves for water applications shall be designed to prevent cavitations, wire drawing, flashing on the downstream side of valve and downstream piping. Thus for cavitations / flashing service, only valve with anti-cavitations trim shall be used. Detailed calculations to establish whether cavitations shall occur or not for any given application shall be furnished.
4. Trim shall be multistage type having sufficient number of discrete pressure drop turns (stages) to ensure elimination of vibration, erosive – action, cavitations. Identity the number of pressure drop turns in the given equipment and shall also provide calculation demonstrating compliance to the trim exit velocity.
5. To prevent flow induced vibration and to protect the valve internals from foreign particles such as weld slag flow, direction shall be a flow to close (over the plug) configuration for liquid applications. To maximize noise attenuating benefits and to allow for constant fluid expansion, flow direction shall be under the plug for gas applications.
6. Control valves for application such as SH spray control, RH spray control, Heavy oil pressuring & control system shall have permissible leakage rate as per leakage class V. All other control valves such as low and high range feed control valves etc shall have leakage rate as per leakage class IV.
7. The control valve induced noise shall be limited to 85 dBA at 1 meter from the valve surface under actual operating conditions. The noise abatement shall be achieved by valve body and trim design and not by use of silencers.
8. The characteristic of the control valves shall be determined based on the application / service.
9. On supply air or electrical failure for pneumatic / electrical drive, the valve shall remain full closed, open or stay – put position as per process safety requirement.

8.13.3 Valve Construction

1. Proper selection of valve type and material of construction to meet operating requirement.

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2. All valves shall be of globe body design and straightaway pattern with single or double port unless otherwise recommended by the manufacturer to be of angle body type. Rotary valve may alternatively be offered when pressure or pressure drops permit.
3. Valves with high lift cage guided plugs & quick charge trims shall be supplied.
4. Cast iron valves are not acceptable.
5. Bonnet joints for all control valves shall be of the flanged and bolted type for easy dis – assembly. Bonnet joints of internal threaded or union type shall not be acceptable.
6. Plug shall be of one – piece construction either cast, forged or machined from solid bar stock. Plug shall be screwed and pinned to valve stems or shall be integral with the valve stems.
7. All valves connected to vacuum on down stream side shall be used with packing suitable for vacuum applications (e.g. double vee type chevron packing).
8. Valve characteristic shall match with the process characteristics.
9. Extension bonnets shall be used when the maximum temperature of flowing fluid is greater than 2800c.
10. Flanged valves shall be rated at not less than ANSI pressure class of 300 lbs.
11. Teflon shall be used for valve gland packing to suit process requirement.
12. The valve body shall be marked to show direction of flow.

8.13.4 Valve Materials

1. The control valve body material shall be
 - Carbon steel as per ASTM – A216 GR WCB for non – corrosive, non – flashing and non – cavitations services below 275 deg c temperature.
 - Alloy steel as per ASTM A – 217 GR WC 6 for low flashing / cavitations services like drain cooler normal level control etc.
2. The control valve trim material shall be
 - 17 – 4 PH SS for severe services listed under item D.1, 2nd point & 3rd point above
 - 316 SS for services listed at D.1, 4th point above and
 - 316 SS with stellite faced guide parts and bushings for remaining applications.

8.13.5 End Preparation

Valve body ends shall be either butt welded / socket welded, flanged or screwed. The welded ends wherever required shall be butt welded type as

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per ANSI B 16.25 for control valves of sizes 65 mm and above. For valves sizes 50 mm and below welded ends shall be socket welded as per ANSI B 16.11. Flanged ends wherever required shall be of ANSI pressure – temperature class equal to or greater than that of the control valve body.

8.13.6 Valve Actuator

1. The regulating control valves shall be furnished with pneumatic actuators. The supplier shall be responsible for proper selection and sizing of valve actuators in accordance with the pressure drop and maximum shut off pressure and leakage class requirements. The valve actuators shall be capable of operating at 60 °C continuously.
2. Valve actuators and stems shall be adequate to handle the unbalanced forces occurring under the specified flow conditions or the maximum differential pressure specified. An adequate allowance for stem force, at least 0.15 kg / cm² per linear millimeter of seating surface, shall be used in the selection of the actuator to ensure tight seating unless otherwise specified.
3. The travel time of the pneumatic actuators shall not exceed 10 seconds.
4. For quick opening / closing services (such as fuel oil shut – off valve), the actuator shall be pilot solenoid operated pneumatic drive; the rating of solenoid shall be 24 V DC.
5. Selection of actuator shall be such that it meets the requirements of thrust / torque, stroke length, angular movement, full scale travel time, repeatability & accurate positioning for successful operation of final control element.
6. All the actuators shall have also provision for manual operation during emergency / maintenance along with graduated local position indicator.

8.13.7 Control Valve Accessory Devices

All control valve accessories such as air locks, hand wheels / hand-jacks, limit switches, SMART positioners, diffusers, external volume chambers, reversible pilot for positioners, tubing and air sets, solenoid valves and junction boxes etc. shall be used as per the requirements.

Table 8.13
Specification for E-to-P converter

S.N	Feature	Minimum Requirement
1	Air Supply	1.5 Kg/Sq. cm
2	Input Signal	4-20 mA DC
3	Output Signal	0.2 to 1.0 Kg/ Sq. cm
4	Linearity	0.5 % of span or better
5	Hysteresis	0.1 % of span or better
6	Ambient Temperature Effect (-20 to +60 °C)	<0.2 % of span per Degree centigrade

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S.N	Feature	Minimum Requirement
7	Mounting	Close to Actuator
8	Protection class	IP-65
9	Enclosure	Die cast Aluminium
10	Drift	+/- 2% of set point per hour

Table 8.14
Specification for Smart Positioners

S.N	Feature	Minimum Requirement
1	Input	4-20 mA DC
2	Power Supply	24 V DC Loop powered
3	Type of Electronics	Microprocessor based with self diagnostic facility & digital communication by means of HART Protocol
4	Valve position sensing	Non-Contact type with 4-20 mA DC Output
5	Enclosure Type/Material	Weather & Dust proof to IP-65/ Die cast Aluminium
6	Ambient conditions	Suitable for - 30 to +80 *C temperature & 0-95% Humidity
7	Operating Range	Suitable for Full range & Split Range operation
8	Modes of operation	Suitable for Direct & reverse valve action
9	Flow characteristics	Suitable for Linear & Equal percentage Characteristics
10	Fail safe/Freeze feature	Required
11	Air Capacity	Sufficient to handle the Valves Selected/Boosters to be supplied if required.
12	Air supply pressure	To suite the Air Supply Pressure / Quality available
13	Process Connection	1/4" NPT
14	Characteristic Deviation	< =0.5% of span
15	Ambient Temperature effect	< =0.01%/Deg C or better
16	Configuration	Remote Calibration, Auto & Manual Calibration shall be possible
17	Cable Entry	½" NPT, Side or Bottom Entry to avoid water ingress
18	Accessories	a) Display with push buttons for configuration and Display on the positioner itself (Password Protected / Hardware Lock).
		b) For Supply & Output Pressure, Filter Regulator and other accessories shall be used as on required basis for making system complete

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S.N	Feature	Minimum Requirement
		c) Valves Mounting Assembly For Sliding Stem / Rotary / Single Acting / Double Acting on required basis

1. SMART positioner shall be a Double stage positioner. The first stage of the positioner shall be typically a flapper-nozzle that serves as a high-gain pre-amplifier. This sensitivity shall be maintained over a wide range of dynamic conditions. Second stage shall be a power amplifier that provides power to drive the actuator. Preferably this shall be a pneumatic relay. Spool Driven type SMART positioners are not preferred due to Higher Dead Band and Poor responsiveness. The SMART positioner shall have pressure sensors to measure the pneumatic outputs to the actuator.
2. The control algorithm for the positioner shall use feedback signal from the motion of the pneumatic relay beam instead of pressure feedback to minimize pneumatic related effects and for stable and smooth response of the control valve. The SMART positioner shall have user adjustable tuning sets to identify the optimum tuning for the total valve assembly. SMART Positioner with HART Communication facility shall communicate all the valve diagnostics to Plant DCS.

Table 8.15
Specification for Air Filter Regulator (AFR)

S.N	Feature	Minimum Requirement
1	Type	Constant Bleed type
2	Inlet Pressure	10 Kg/Sq. cm (maximum)
3	Output	Adjustable from 0-2 Kg/Sq. cm or 0-7 Kg/Sq. cm (Continuous) as required
4	Filter Element	5 microns
5	Filter Element Material	Phosphor Bronze
6	Bowl Material	Metallic
7	Drain	Automatic
8	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
9	Process connection	¼ " NPT
10	Accessories	All mounting accessories. 2" dial size Pressure gauge.

Table 8.16
Specification for Position Transmitter

S.N	Feature	Minimum Requirement
1	Power Supply	24 V DC Loop powered
2	Type	Non-Contact/ LVDT type

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S.N	Feature	Minimum Requirement
3	Output	4-20 mA DC/ Linear
4	Accuracy	+/- 1 %
5	Enclosure Protection class/ Material	IP-65/ Die cast Aluminium
6	Cable Entry	½" NPT, Side or Bottom Entry to avoid water ingress.
7	Accessories	All mounting accessories

Table 8.17
Specification for Limit Switch (Non Contact Type)

S.N	Feature	Minimum Requirement
1	Type	Non-contact type inductive Proximity/Namur type
2	Sensing distance	10 mm minimum
3	Hysteresis	Maximum 10% of sensing distance
4	Indicator	LED indication
5	Protection class	IP 67
6	Integral Cable	1 mtr.
7	Power supply	24 V DC/ 8 V DC
8	Mounting	Flush mounting with check nut
9	Other Feature	Explosion proof enclosures shall be used wherever required by the application. Shock & Vibration proof.

8.13.8 Test & Examination

- All valves shall be tested in accordance with the quality assurance programme agreed which shall meet the requirement of IBR and other applicable codes.
- The tests shall include but not but limited to the following:
 - Non-destructive test as per ANSI B – 16.34.
 - Hydrostatic shell test in accordance with ANSI B16.34 prior to seal leakage test.
 - Valve closure test and seal leakage test in accordance with ANSI B16.34 and as per the leakage class indicated under clause no. B.6.
 - Functional test: The fully assembled valves including actuators control devices and accessories shall be functionally tested to demonstrate times from open to close position.
 - All control valves shall be tested with the positioners for accuracy of positioning and reproducibility over the full range of travel.

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- CV Test: CV test shall be carried out as type test on each size, type and design of the valves as per AISA 75.02 standard.
- Magnetic particle inspection shall be performed on all machined surfaces of valves having ASA rating of 1500 lbs ASA or greater. All carbon steel valves with 1500 lbs ASA or greater shall receive 100% radio graphic examination in accordance with ASTM – E71.

8.14

Pneumatic Power Cylinder

Table 8.18
Specification for Pneumatic Power Cylinder

S.N	Feature		Minimum Requirement
1	Applicable standard		ISO 6431
2	Mounting Type		Fixed Position mounting/ Trunion mounting
3	Material	Cylinder	Seamless Steel Tube
		Piston rod	Hard Chrome Plated Steel
		Tie rod	Stainless steel
		End Cover	Cast Iron
		Sealing	Polyurathane
4	Control Signal		4-20 mA DC signal to Smart positioner with HART protocol for modulating purpose. Solenoid valve operating on pneumatic line for open & closing purpose of ON-OFF Damper.
5	Supply Air		0-7 Kg/cm ²
6	Accuracy		Better than +/- 1 %
7	Repeatability		Better than 0.5 % of full travel
8	Hysteresis		Less than +/- 0.2% of full travel
9	Dead Band		+/- 0.1 %
10	Selection		Based upon thrust/torque, stroke length, angular movement, full scale travel time, repeatability, space factor etc. Provision for air-to-open or air-to-close operation
11	Accessories		Air lock relay, hand wheel, AFR, Volume booster, Limit switch, Positioner, Solenoid valve, position transmitter & all required mounting accessories etc.
12	Fail safe operation		Stay put for regulating duty

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8.15 Solenoid Valves

Table 8.19
Specification for Solenoid Valves

S.N	Feature	Minimum Requirement
1	Operating Principle	Electromagnetic (noiseless), Pilot operated
2	Coil Voltage Rating	24 V DC (in general)/220 V DC/230 V AC/110 V AC as required
3	Ways	3 ways in general others as required
4	Port size	¼ " NPT all ports
5	Body	SS Bar stock/Brass
6	Trim	AISI 316 SS
7	Manual Operation	In built
8	Duty	Suitable for continuous Energisation
9	Sealing	Airtight & leak proof
10	Coil Enclosure	SS 316/Moulded type
11	Insulation class	Class H
12	Coil Casing	IP-67
13	Mounting	Suitable for mounting On pipe or in panel
14	Cable connection	½ " NPT Cable gland
15	Accessories	Mounting Bracket, nuts, bolts etc.
16	Other Features	LED Indication

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9 PROCESS CONNECTION PIPING

Installation and testing of all required material for completeness of impulse piping system, sample piping system and air piping system as per the requirements of this clause on as required basis for the connection of instruments and control equipment to the process and make the system complete.

Control and instrument piping & connections shall generally be designed in accordance with the following criteria and these criteria shall be closely co-ordinated with Mechanical Piping / Erector to fulfill the Mechanical Design Criteria also. This is a guideline for Piping design & selection.

1. Pressure connections and piping up to the root valves for all pressure indicators, pressure switches, pressure transmitters, etc., shall be as indicated for miscellaneous piping.
2. Temperature indicators, temperature controllers, temperature switches, temperature detectors, and test well connections shall be used.
3. Flow transmitter connections and piping up to the root valves shall be 25 mm for all piping except orifice flanges, where 15 mm piping and valves shall be used.
4. Level switch connections and piping up to root valves shall be 25mm.
5. Level controllers and level transmitters of the displacement type shall have connections and piping up to root valves of 50 mm.
6. Level controllers and level transmitters of the differential pressure type shall have connections and piping up to root valves of 25 mm.
7. Instrument columns at tanks and pressure vessels shall generally be 65 mm minimum.

a) Design Pressure and Temperature

Instrument primary piping design pressure and temperature shall be selected consistent with the requirements discussed in Mechanical Design Criteria of this specification, for the process pipe to which the instrument primary piping is connected. The following general criteria shall also apply:

Instrument primary piping for other systems shall be designed for 1-½ times the maximum sustained process pressure and temperature (plus 20°C).

b) Materials for Instrument Primary Piping

Material for instrument primary piping connecting to the root valve shall preferably be the same as that used in the process system to which it is connected. Higher strength materials may be substituted in the interest of standardization; however, welding procedures at the point of joining the instrument primary piping to the process piping must be appropriate to the

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combination of materials involved. Copper may be used only for compressed air services that use copper process piping.

c) Insulation of Instrument Primary Piping

Instrument primary piping connecting to high temperature systems, which might become hot enough to injure personnel during blow down of the instrument line, shall be insulated where such hazard exists. Insulation materials, exterior finish, and metal lagging shall conform to the standards adopted for the process piping.

All materials supplied shall be suitable for intended service, process operating conditions and type of instruments used and shall fully conform to the requirements of this specification.

9.1 Impulse Piping, Tubing, Fittings, Valves & Valve Manifolds

All impulse pipes shall be of seamless type conforming to ANSI B36.10 for schedule numbers, sizes and dimensions etc. The material of the impulse pipe shall be same as that of main process pipe. For various applications specification of impulse pipe materials and associated fittings and valves shall be as given in Table –9.1 (Process Connection Piping).

Table 9.1
Process Connection piping

S. N	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
						3000LBS	400LBS
1	Water system	SCH.80 21.34m m OD	12.7 mm ODX 1.65mm THK	SS316	ASTM-A-106-Gr-B (carbon steel)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
						3000LBS	400LBS
						3000LBS	150LBS
2	Instrument air system	SCH.40 21.34m m	12.7 mm ODX	SS316	IS 1239 Heavy Class	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II

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S. N	Service	Size		Impulse tube material	Impulse tube material	Impulse line fitting material	valves material
		Pipe	Tube			ANSI rating	ANSI Rating
		OD(pipe through out)	1.65mm THK		(Galvanized)	3000LBS	150LBS
3	Service air system	SCH.40 21.34m m OD	12.7 mm ODX 1.65mm THK	SS 316	IS 1239 Heavy Class (Black)	ASTM-A-105-Gr-II	ASTM-A-105-Gr-II
						3000LBS	150LBS
						3000LBS	150LBS

Notes:-

1. Impulse pipe thickness shall be selected as per ANSI B 36.10. based on the schedule indicated against each service.
2. Wherever impulse tubes are provided, all the fittings required for these shall be SS316.

The following guidelines shall also be considered along with the Table 9.2 for size, material and rating for impulse line/tube fittings and accessories:

a) Impulse line / tube fittings and accessories

1. Nipple shall be used for root valve size more than ½ inch and the nipple size shall be same as the root valve size. Reducer / adapter shall be used to suit instrument connection, where nipple, root valve size is more than ½ inch.
2. Bulk head fitting socket welded type to be provided at instrument rack / enclosure.

b) Fittings

1. All fittings except the last fitting connecting to the instrument shall be socket welded. The size of the fittings shall be same as the impulse line size.
2. The fitting connecting to the instrument shall have a size and thread to suit the instrument connection.

c) Instrument Valves

1. Type of the valve shall be needle valve with built in drain valve.

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2. Sizing of the valve shall be ½”.

d) Right / left threaded fittings

1. This shall be used for installation / removal of instruments without disturbing the tubing / piping.
2. A suitable adapter shall be used to install the instruments on ½” right-left threaded fittings.

e) A ½” vent line with a ½” isolation valve shall be used in the instrument rack for air and compressible fluids or other wise if the installation call for eg., for liquid service where the transmitter is located at a higher elevation than the tapping point.

f) Stainless steel tube shall be used inside enclosures and racks from tee connection to valve manifold and then to instrument. For high pressure/temperature applications the material shall be ASTM A 213 TP 316H and for other applications material shall be ASTM A 213 TP 316L. The wall thickness of the tube shall be in accordance with the ANSI B31.1 standard.

All fittings shall be forged steel and shall conform to ANSI B16.11. The material of forged tube fittings for shaped application (e.g. tee, elbow etc.) shall be ASTM A182 Gr. 316 H for high pressure/ temperature applications (as defined above) and ASTM A182 Gr. 316L for other applications. The material for bar stock tube fitting (for straight application) shall be 316 SS. Metal thickness in the fittings shall be adequate to provide actual bursting strength equal to or greater than those of the impulse pipe or SS tube, with which they are to be used.

The disc and seat ring materials of carbon steel and alloy steel valves shall be ASTM A-105 and ASTM A-182, Gr. F22, hard faced with stellite (minimum hardness - 350 BHN.) The surface finish of 16 RMS or greater is required in the area of stem packing. The valve design shall be such that the seats can be re-conditioned and stem and disc may be replaced without removing the valve body from the line.

The valve manifolds shall be of 316 s Furnishing Recommended protection interlock logics stainless steel with pressure rating suitable for intended application. 2-valve manifold and 3 valve manifold shall be used for pressure measurements using pressure transmitters/ pressure switches and differential pressure transmitters/ switches respectively. 5-valve manifold shall be used for remaining applications like DP, flow and level measurements.

For Pressure/D.P gauges in fluid application two-way globe valve on each impulse line to the instrument and in air application two way gate valve on each impulse line to the instrument shall be used near the instrument. These

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shall be in addition to the three way gauge cock provided along with the pressure/D.P gauges.

Table 9.2
Specification for Seamless SS Pipe

S.N	Property	Requirement
1	Reference	ASTM A-312 TP-316
2	Material Grade	TP-316
3	Type	Seamless/Plain end
4	Size	½ " NB
5	Schedule	40/60/80
6	Standard Length	5 metre

Table 9.3
Specification for Seamless SS Pipe Fittings

S.N	Property	Requirement
1	Reference	ASTM A-182 F-316
2	End Connection	Socket welded
3	Type	Forged conforming to ANSI B16.11
4	Size	½ " NB
5	Rating	3000/6000/9000 lbs
6	Type of Fittings	Reducing coupling, Male-Female reducer, Straight coupling, Equal Tee, Three Piece Union, Elbow, Cap etc.

Table 9.4A
Specification for Seamless SS Tube (1/2")

S.N	Property	Requirement
1	Reference	ASTM A-213 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	½ " OD X 2.1 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness

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S.N	Property	Requirement
8	Test	Flare, Hardness, Ball & Bubble test
9	Standard Length	5 metre

Table 9.4B
Specification for Seamless SS Tube (1/4")

S.N	Property	Requirement
1	Reference	ASTM A-269 TP-316
2	Material Grade	TP-316
3	Type	Cold Drawn annealed, pickled, passivated, descaled, hydraulically cleaned seamless tube.
4	Size	1/4" OD X 1.2 mm thick
5	Properties	Tube shall be free from scratches & suitable for bending & capable of being flared by hardened & tapered steel pin. The expanded tube shall show no crack or rupture. Hardness shall be RB 80
6	Test Pressure	400 Kg/Sq mm minimum
7	Tolerance	+/- 0.13 mm for outside dia. +/- 15% for wall thickness
8	Test	Flare, Hardness, Ball & Bubble test
9	Standard Length	5 metre

Table 9.5
Specification for Seamless SS Tube Fittings

S.N	Property	Requirement
1	Reference	ASTM A-182
2	Material Grade	SS 316 forged
3	Type	Double ferrule double compression
4	Ferrule	SS 316
5	Size	To suit SS tubing & NPT end connection
6	Type of fittings	Male/Female connectors, elbow, Equal & Unequal Tee, Cross, Straight connector, bulk head unions, etc. as required to suit the installation.

Table 9.6
Specification for Instrument Valve Manifolds

S.N	Property	Requirement
1	Type	Two valve manifold/Three Valve Manifold

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S.N	Property	Requirement
		Five valve manifold
2	Mounting	Remote 2" pipe mounting
3	Construction	Single Block (Bar Stock)
4	Material	Forged body & bonnet AISI 316 SS
5	Ports	½ " NPT
6	Rating	420 Kg/ cm2 at ambient
7	Packing	PTFE Wafer
8	Seat & Stem	AISI 316 SS
9	Plug	AISI 316 SS free to turn on stem/ 17-4 PH
10	Handle	AISI 316 SS
11	Connection	Straight
12	Accessories	Plug for all ports Mounting Bracket, nut, bolts etc.

Table 9.7
Specification for Seamless Copper Tube

	Property	Requirement
1	Reference	ASTM B-68/1975
2	Material	The copper tube shall be of following chemical compositions - copper content 99.90% (minimum) phosphorus content 0.04% (maximum).
3	Type	Cold drawn soft annealed PVC coated 1mm thick
4	Size	6 mm OD /4 mm ID
5	Properties	The tube shall be suitable for bending and capable of being flared by hardened and tapered steel pin. The expanded tube shall show no cracking or rupture.
6	Test Pressure	Burst pressure 100 Kg/Sq. Cm
7	Tolerance	± 0.5 mm for outside diameter ± 0.1 mm for wall thickness
8	Test	Ball and Bubble Test

Table 9.8
Specification for Seamless Copper Tube Fittings

	Property	Requirement
1	Material	Leaded brass (58% Cu, 2% Pb) forging, Nickel plated.
2	Type	Double ferrule double compression
3	Ferrule	Brass, Nickel plated

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	Property	Requirement
4	Pressure Rating	40 Kg/Sq. cm
5	Temperature Rating	-100 to +200 Deg C
6	Size	To suit copper tubing and end connection
7	Type of fittings	Male/Female connectors, elbow, Equal & Unequal Tee, Cross, Straight connector, bulk head unions, etc. as required to suit the installation.

9.2 Air Supply Piping

1. All pneumatic piping, fittings, valves, air filter cum regulator and other accessories required for instrument air for the various pneumatic devices/ instruments shall be used.
2. This shall include as a minimum air supply to pneumatically operated control valves, actuators, instruments, continuous and intermittent purging requirements of Local Instrument Enclosures (LIE) etc.
3. For individual supply line and control signal line to control valve, 1/4 inch size light drawn tempered copper tubing conforming to ASTM B75 shall be used. The thickness of copper tubing shall not be less than 0.065 inch and shall be PVC coated. The fittings to be used with copper tubes shall be of cast brass, screwed type.
4. All other air supply lines of 1/2 inch to 2 inch shall be of carbon steel hot dipped galvanized inside and outside as per IS-1239, heavy duty with threaded ends. The threads shall be as per ASA B.2.1. Fittings material shall be of forged carbon steel A234 Gr. WPB galvanized inside and outside, screwed as per ASA B2.1. Dimensions of fittings shall be as per ASA B16.11 of rating 3000 lbs.
5. Instrument air filter cum regulator set with mounting accessories shall be used for each pneumatic device requiring air supply. The filter regulators shall be suitable for 10 kg/ sq.cm max. inlet pressure. The filter shall be of size 5 microns and of material sintered bronze. The air set shall have 2 inch size pressure gauge and built in filter housing blow down valve. The end connection shall be as per the requirement to be finalised during detailed engineering.
6. All the isolation valves in the air supply line shall be gate valves as per ASTM B62 inside screw rising stem, screwed female ends as per ASA B2.1. Valve bonnet shall be union type & trim material shall be stainless steel, body rating 150 pounds ASA. The valve sizes shall be 1/2 inch to 2 inch.

Table 9.9
Specification for Instrument Air Header

S.N	Property	Requirement
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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

		For Panel	For Field
1	Material	SS 316	SS 316
2	Inter Connection	2" NPT (M)	1" NPT (M)
3	Header Take-Off	SS 316	SS 316
4	Take-Off Connection	½" NPT (M)	½" NPT (M)
5	Take-Off Valve	½" Ball Valve SS 316	½" Ball Valve SS 316
6	Drain	½" Ball Valve SS 316 at the lowest point	½" Ball Valve SS 316 at the lowest point

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10 INSTRUMENTATION CABLES & ACCESSORIES

10.1 Specifications of Instrumentation Cables

a) Common Requirements

Table 10.1
Specification of Instrumentation Cables- Common Requirement

S.N	Property	Requirement
1	Voltage grade	600 V (Peak Value)
2	Codes and Standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6 , VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification
3	Continuous operation suitability	At 70 deg. C for all types of cables, while 205 deg C for Type-C cables
4	Progressive automatic on-line sequential marking of length in meters.	To be provided at every one meter on outer sheath.
5	Marking to read 'FRLS'	To be provided at every 5 meters on outer sheath except for type-C cable.
6	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet.
7	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
8	Ovality at any cross-section	Not more than 1.0 mm
9	Others	<p>a) Durable marking at intervals not exceeding 625 mm shall include manufacturer's name , insulation material, conductor's size, number of pairs, voltage rating, type of cable, year of manufacture to be provided.</p> <p>Cables shall be suitable for laying in conduits, duct, trenches, racks and underground-buried installation</p> <p>Repaired cables shall not be</p>

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S.N	Property	Requirement
		b) acceptable

b) Specific Requirements

Table 10.2
Specification of Instrumentation Cables- Specific Requirement

S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
A.	Conductors				
i.	Cross section area				
ii.	Conductor material	ANSI type KX	ANSI type SX	High conductivity annealed tin coated copper	ANSI type KX
iii.	Colour code	Yellow-red	Black-Red	As per VDE-0815	Yellow-red
iv.	Conductor Grade	As per ANSI MC 96.1		Electrolytic	As per ANSI MC 96.1
v.	No. & dia. of strands	n (nom)			
vi.	No. of Pairs	2, 6	2	4, 8, 12, 16, 24, 48,	2
vii.	Max. conductor resistance per Km (in ohm) at 20 deg. C	As per ANSI MC 96.1		73.4 (loop)	As per ANSI MC 96.1
viii.	Reference Standard	As per ANSI MC 96.1		VDE 0815	As per ANSI MC 96.1
B.	Insulation				
i.	Material	PVC type YI 3 with FRLS properties			Teflon (i.e. extruded FEP)
ii.	Thickness in mm (Min/Nom/Max)	0.25 / 0.3 / 0.35			0.4 / 0.50
iii.	Volume Receptivity (Min) in ohm-cm	1x10 ¹⁴ at 20 deg. C & 1x 10 ¹¹ at 70 deg.			---
iv.	Voltage rating	600 V peak operating voltage			
v.	Reference Standard	VDE 0207 Part 4			VDE 0207 part 6 & ASTM D 2116.
vi.	Core diameter above insulation	Suitable for cage clamp connector			

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
C.	Pairing & Twisting				
i.	Max. lay of pairs (mm)	50			
ii.	Single layer of numbered binder tape on each pair provided	Yes			
iii.	Unit formation of four pairs with printing of no. of Unit provided	NA		Yes	NA
iv.	Conductor / pair identification as per VDE0815	NA		To be provided	NA
D.	Shielding				
i.	Type of shielding	Al-Mylar tape			
ii.	Individual pair shielding	No		To be provided for Type-F cable	No
iii.	Minimum thickness of individual pair shielding	No		28 micron	No
iv.	Overall cable assembly shielding	To be provided			
v.	Minimum thickness of overall cable assembly shielding	55 micron			
vi.	Shielding coverage	100% with at least 20% overlap			
vii.	Drain wire provided for individual shield	NA		Yes (for F-type) 7 -strand 20 AWG (0.51 mm2) annealed Tin coated copper	NA
viii.	Drain wire provided for overall shield	Yes (for F-type) 7 -strand 20 AWG (0.51 mm2) annealed Tin coated copper			
E.	Fillers				
i.	Non-hygroscopic, flame retardant	To be provided			
F.	Outer Sheath				
i.	Material	Extruded PVC compound YM1 with FRLS properties			Teflon (i.e. extruded FRP)

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
ii.	Minimum thickness at any point	1.8mm			0.4 mm
iii.	Nominal Thickness at any point	> 1.8mm			0.5mm
iv.	Color	Blue			
v.	Resistant to water, fungus, termite & rodent attack	Required			
vi.	Oxygen index as per ASTM D-2863	Not less than 29%			NA
vii.	Temperature index as per ASTM D-2863	Not less than 250 deg. C			NA
viii.	Acid gas generation by weight as per IEC-60754-1	Maximum 20 %			NA
ix.	Smoke Density rating as per ASTM D-2843	Maximum 60% (defined as the average area under the curve when the results of smoke density test plotted on a curve indicating light absorption vs. time as ASTM D-2843)			NA
x.	Reference Standard	VDE 207 part 5			VDE 207 Part 6 & ASTM D 2116
xi	Armour	Galvanised steel wire armoured type conforming to IS-3975			
G.	Electrical Parameters				
i.	Mutual capacitance between Conductors. At 0.8KHz (Max.)	200 nF / Km		120 nF / Km for F type 1000 nF / Km for G-type	200 nF / Km
ii.	Insulation resistance (Min.)	100 M ohm / Km			
iii.	Cross talk Figure (min.) at 0.8 KHz	60 dB		60 dB	NA
iv.	Characteristics impedance (Max) At 1 KHz	NA		320 ohm for F type 340 ohm for G type	NA
v.	Attenuation Figure at 1 KHz	NA		1.2 dB / Km	NA

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S.N	Specification Requirement	Type-A	Type-B	Type- F&G	Type-C
H.	Complete Cable				
i.	Complete Cable assembly	Shall pass Swedish chimney test as per SEN-SS 4241475 class F3.			NA
ii.	Flammability	Shall pass flammability test as per IEEE-383 read in conjunction to this specification			NA
I.	Accessories				
i.	Cable accessories of flame retardant quality	Yes. (Accessories such as harnessing components, markers, bedding, cable jointer, binding tape etc.)			
J.	Cable Drum				
i.	Type	Non-returnable wooden drum (wooden drum to be constructed from seasoned wood free from defects with wood preservative applied to the entire drum) or steel drum.			
ii.	Outermost layer covered with waterproof paper	Yes			
iii.	Painting	Entire surface to be painted			
iv.	Length	1000m + 5% for up to & including 12 pairs 500m + 5% for above 12 pairs			

c) Type Test

Table 10.3
Type Test Requirement for Cables

S.N	Item	Test Requirement	Standard
1	Conductor	Resistance Test Diameter test Tin coating test (drain wire)	VDE – 0815 IS – 10801
2	Insulation	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
3	Inner sheath	Loss of mass	VDE – 0472

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S.N	Item	Test Requirement	Standard
		Heat shock Hot deformation Shrinkage Cold bend / Cold impact test	VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831
4	Outer sheath	Loss of mass Ageing in air ovens Tensile strength & elongation test before & after ageing Heat shock Hot deformation Shrinkage Bleeding & Blooming Colour fastness to water Cold bend / Cold impact test Oxygen Index test Smoke Density test Acid gas generation test	VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 VDE – 0472 IS – 5831 IS – 5831 IS – 5831 ASTM D – 2863 ASTM D – 2843 IEC – 754 – I
5	Filters	Oxygen Index test Smoke Density test Acid gas generation test	ASTM D – 2863 ASTM D – 2843 IEC – 754 – 1
6	AL-MYLAR Shield	Continuity test Shield thickness Overlap test Noise interference	
7	Overall cable	Flammability	IEEE 383 & IEC – 332
8		Noise interference Dimensional checks Cross talk Mutual capacitance HV test Drain wire continuity	IS – 10810 VDE – 0472 VDE – 0472

d) Routine Test

To be carried out by supplier during various stages of manufacture.

1. Insulation & jackets: All tests as per IS – 5831 except insulation resistance, voltage & spark test shall be as per BS – 5308, Part II (1986)

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2. Armor test as per IS – 3975
3. Conductor resistance
4. Cable capacitance and L/R ratio.

e) Acceptance Test

These following tests shall be carried out as acceptance test:

1. Continuity test
2. Voltage test as per BS – 5308 Part II (1986)
3. Conductor resistance and drain wire resistance
4. Cable capacitance and L/R ratio test.
5. Tests for uniformity of galvanization of armor as per IS – 2633
6. Oxygen and temperature index test as per ASTM D – 2863
7. Dimensional checks for overall diameter and under armour / over armour diameter.
8. Checking of drum length & overall length tolerances.

Immediately after completion of electrical tests, the ends of the cable shall be sealed to prevent ingress of moisture with suitable PVC / Rubber caps

10.2 Specifications of Optical Fibre Cables (OFC)

1. OFC shall be installed on cable tray, duct bank, cable trench installation as necessary. For outdoor applications the cable shall be armoured with Poly Ethylene sheathing. In all cases cable shall be routed through suitable grade HDPE permanently lubricated protection pipe as per IS-4984, IS-12235 & TEC.G/CDS-08/01 of suitable size @ 53% fill factor.
2. The optical fibre core shall be of ultrapure fused silica glass coated with UV cured acrylate suitable to withstand temperature of about 80 deg. Centigrade continuously.
3. OFC shall be 4 / 8 / 12 core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor / indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multi-mode fibres on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties & to be identified with the manufacturer's name, year of manufacture, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
4. The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. steel central member, Loose buffer tube design, 4 fibres per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly or better material etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once

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installed, a tensile 1000 N minimum. The compressive strength of cable shall be 3000N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 DegC to 70 DegC.

5. The splicing loss of any two fibres in any case shall not exceed 0.10 db/splice.
6. The total additional attenuation above the nominal attenuation due to regular splices, repair splices, connectors, temperature variation, ageing etc. shall be indicated.
7. Fibre coloring shall conform to EIA/TIA-598. The color-coding shall be permanent thus withstanding normal handling; e.g., during termination, testing, or cable relocation. Refer to EIA – 359 for color identification and coding.
8. Cables shall be designed & tested in accordance with ISO 11801, TIA-568 & ICEA 596 and Performance specifications shall be measured in accordance with the Fibre Optic test procedures(EIA/TIA -455 documents) test procedures of IEC-60793 & IEC-60794
9. The OFC shall generally conform to the following specifications

Table 10.4A
Specifications for Single Mode Optical Fibre

S.N	Feature		Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@1310 nm	0.4 dB/km
		@1550 nm	0.3 dB/km
2	Mode field Diameter	@1310 nm	9.2 ± 0.4 µm
		@1550 nm	10.4 ± 0.8 µm
3	Maximum Cable Cut-off Wavelength		1260 nm
4	Maximum Zero Dispersion Wavelength		1321.5 nm
5	Minimum Zero Dispersion Wavelength		1301.5 nm
6	Maximum Zero Dispersion Slope		0.092 ps/nm ² ·km
7	Maximum Polarization Mode Dispersion		0.2 ps/√km
8	Gigabit Ethernet Length 1000BASE-LX		2-5000 mtrs.
9	Ten Gigabit Ethernet Length	10GBASE-LX	2-10000 mtrs.
		10GBASE-LX4	2-10000 mtrs.
10	Maximum Core/cladding Concentricity Error		0.5 µm
11	Cladding Diameter		125.0 ± 1.0 µm
12	Cladding Non-circularity		1 %

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S.N	Feature	Minimum Requirement
13	Coating Diameter	245 ± 5 µm
14	Maximum Coating Concentricity Error	12.5 µm
15	Temperature Dependence (-60 to +85C)	0.05 dB/km
16	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)	0.05 dB/km
17	Minimum Proof Test	100 kpsi
18	Bending Induced Attenuation (100 turns, 75mm diameter)	0.5 dB

Table 10.4B
Specifications for Multi Mode Optical Fibre

S.N	Feature	Minimum Requirement
1	Maximum Uncabled Attenuation Coefficient	@850 nm 3 dB/km
		@1300 nm 0.7 dB/km
2	Overfilled Launch Bandwidth	@850 nm 200 MHz·km
		@1300 nm 500 MHz·km
3	Gigabit Ethernet Length	1000BASE-SX 2-300 mtrs.
		1000BASE-LX 2-550 mtrs.
4	Ten Gigabit Ethernet Length	10GBASE-SR 2-33 mtrs.
		10GBASE-LX4 2-300 mtrs.
5	Numerical Aperture	0.275 ± 0.015
6	Core Diameter	62.5 ± 3.0 µm
7	Maximum Core Non-circularity	6 %
8	Maximum Core/cladding Concentricity Error	3 µm
9	Cladding Diameter	125.0 ± 2.0 µm
10	Cladding Non-circularity	2 %
11	Coating Diameter	245 ± 10 µm
12	Maximum Coating Concentricity Error	12.5 µm
13	Temperature Dependence (-60 to +85C)	0.2 dB/km
14	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)	0.2 dB/km
15	Minimum Proof Test	100 kpsi

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S.N	Feature	Minimum Requirement
16	Bending Induced Attenuation (100 turns, 75mm diameter)	0.5 dB

10. The cables shall be supplied in non-returnable strong wooden (or alternatively steel) drums provided with lagging of adequate strength, constructed to protect the cable against any damage and displacement during transit, storage and subsequent handling and stringing operations in the field.

11. Test on Fibre optic cable:

Table 10.4C
Type Test Requirement for Fibre Optic Cables

S.N	Test Requirement	Standard
A	Optical Characteristics of Fibres	
1	Attenuation	IEEE Std. 1138 IEEE STD. P1222 (EIA/TIA – 455-61,78A) (IEC 793-1-C1A,B,C)
2	Cut off wavelength	IEEE STD. 1138 IEEE STD P1222 (EIA-455-80, 170) (IEC-793-1-C7A,B)
3	Fibre Dispersion	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-168A,169A,175A) (IEC-793-1-C5A,B,C)
4	Frequency Response	IEC-793-1-C2B
5	Mode Field Diameter	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-164A,165A,167A) (EIA-455-174) (IEC 793-1-C9A,B,C,D)
6	Temperature Cycling	IEEE STD. 1138 IEEE STD. P1222 (EIA/TIA-455-69A) (IEC 793-1-D1)
B	Mechanical Characteristics of Fibres	
1	Abrasion	IEC 793-1-B4
2	Core Concentricity	IEC 793-1-A3
3	Macro Bending	EIA/TIA-455-62A (IEC 793-1-C11)
4	Micro Bending	IEC-793-1-C3
C	Proof Test	IEC-793-1-B1

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S.N	Test Requirement	Standard
D	Strippability	IEC 793-1-B6
E	Visual Examination	EIA/TIA-455-13 (IEC 793-1-B5)

10.3

Instrumentation Cable Interconnection & Termination Philosophy

The cable interconnection philosophy to be adopted shall be such that expensive grouping of signals by large scale use of field mounted Group Junction Boxes (JBs) at strategic locations. (Where large concentrations of signals are available, e.g. valves limit and torque switches, switchgear) is done and consequently cable with higher number of pairs are extensively used. The details of termination to be followed are mentioned in the following Table:

Table 10.5
Instrumentation Cable Interconnection & Termination Philosophy

S.N	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
1.	Limit, Torque switches of valves / dampers / drives (integral junction box)	Marshalling cubicle / Marshalling cum Termination Cubicle / Local group JB	Plug-in connector	Posts mount cage clamp type	G
2.	Transmitters, E/P converters, process actuated switches mounted in LIE / LIR	Integral junction box of LIE / LIR	Plug-in connector	Cage clamp (rail mount)	F, G
3.	RTD heads	Local junction Box	Plug-in connector	Cage clamp (Rail mount) type	F
4.	Other Field Mounted Instrument	Local JB / Group JB	Plug in connector	Screwed, Cage clamp (Rail mount) type	F (For analog signals) G (For Binary Signals)
5.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Group JB	Cage clamp (Rail mount) type	Cage clamp (Rail mount) type	F, G
6.	Local junction box, Instrument Junction box of LIE / LIR / Group JB / MCC / SWGR	Marshalling Cubical / Marshalling cum termination Cabinet	Cage clamp (Rail mount) type	Posts mount cage clamp type	F, G
7.	Marshalling	Electronic	Cage clamp post	Plug-in connector / Other System	Internal

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S.N	Application		Type of Termination		Type of Cables
	From (A)	To (B)	End A	End B	
	Cubical / Termination Cabinet	system cabinet	mounted type	as per manufacturer's Standard	Wiring

Notes:

1. Normally 10% spare cores shall be used when the numbers of pairs of cables are more than four pairs.
2. For analog signals, individual pair shielding & overall shielding & for binary signals only overall shielding of instrumentation cables shall be used.
3. * For high temperature applications only.
4. Instrument Cabling for instruments / equipment of specialized / proprietary Control System shall be as per manufacturer's standard.

10.4

Terminal Blocks

1. All terminal blocks shall be rail mounted/post mounted, cage clamp type with high quality non-flammable insulating material of melamine suitable for working temperature of 105 deg. C. The terminal blocks in field mounted junction boxes, temperature transmitters, instrument enclosures/racks, etc. shall be suitable for cage clamp connections. The terminal blocks in Control Equipment Room logic / termination / marshalling cubicles shall be suitable for the post mounted cage clamp connection at the field input end. The terminal blocks for Ash Handling control system Input/ Output connections from/to SWGR/MCC, shall be used with built in test and disconnect facilities complete with plug, slide clamp, test socket etc.
2. All the terminal blocks shall be used complete with all required accessories including assembly rail, locking pin and section, end brackets, partitions, small partitions, test plug bolts and test plug (as specified above for SWGR connections), transparent covers, support brackets, distance sleeves, warning label, marking , etc.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams. At least 20% spare unused terminals shall be used everywhere including local junction boxes, instrument racks/enclosures, termination/marshalling cabinets, etc. All terminal blocks shall be numbered for identification and grouped according to the function. Engraved labels shall be used on the terminal blocks.
4. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.

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5. Internal wiring in factory pre-wired electronic equipment cabinets may be installed according to the applicable standards as to wire size and method of termination or internal equipment. Terminal blocks for connection of external circuits into factory pre-wired electronic equipment cabinets shall meet all the requirements as specified above.

10.5 Internal Panels, Cabinets, System Cabinet Wiring Philosophy

1. Internal panel/cabinet wiring shall be of multi-stranded copper conductor with FRLS PVC insulation without shield and outer sheath meeting the requirements of VDE 0815.
2. Wiring to door mounted devices shall be done by 19 strand copper wire provided with adequate loop lengths of hinge wire so that multiple door opening shall not cause fatigue breaking of the conductor.
3. All internal wires shall be used with Tag identification of printed type (partex labels) at both ends. All wire directly connected to trip devices shall be distinguished by one additional red color.
4. All external connection shall be made with one wire per termination point. Wires shall not be tapped or spliced between terminal points.
5. All floor slots of desk/Panels/cabinets used for cable entrance shall be used with removable gasketed gland plates and sealing material. Split type grommets shall be used for prefabricated cables.
6. All the special tools as may be required for solder less connection.
7. Tag identification for internal wires shall be printed (partex labels)
8. Wire sizes to be utilized for internal wiring shall be as per following table.

Table 10.6
Wire Size for Internal Wiring

S.N	Application	Wire Size
1	Current (4-20mA), low voltage signals (48 V)	0.5 Sq. mm
2	Ammeter/ Voltmeter circuit, control switches etc. for electrical system.	1.5 Sq. mm
3	Power supply and internal illumination.	2.5 Sq. mm minimum (shall be as per load requirement)

10.6 Cable Installation & Routing

1. All cable assigned to a particular duct/conduit shall be grouped and pulled in simultaneously using cable grips and suitable lubricants. Cables removed from one duct/conduit shall not be reused.
2. Cables shall be segregated as per IEEE Std. 422. In vertically stacked trays, the higher voltage cable shall not be in higher position and instrumentation

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cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other system shall be as follows:

- From 11KV/6.6KV/3.3KV tray system - 900 mm
 - From 415KV tray system - 600 mm
 - From control cable tray system - 300 mm
3. Cables shall terminate in the enclosures through cables glands. All cable glands shall be properly gasketed. Fire proof sealing (to prevent ingress of dust entry and propagation of fire) shall be used for all floor slots used for cable entrance. Compression cable glands (double for armored and single for other cables) shall be used.
 4. All cables shall be identified by Tag. Nos. provided in approved format at both the ends as well as at an interval of 5 meters.
 5. Line voltage drop due to high resistance splices, terminal contacts, insulation resistance at terminal block, very long transmission line etc. shall be reduced as far as practicable.
 6. The cables emanating from redundant equipment/devices shall be routed through different paths. The above segregation of cables & wiring for redundant equipment / devices shall be in accordance with IEEE-Std-422

10.7 Cable Laying

1. Cable shall be laid strictly in line with cable schedule. In general, the cable routing from the local instrument to JB shall be such that the cable go away from the hot zone.
2. Identification tags for cables.
Indelible tags to be provided at all terminations, on both sides of wall or floor crossing, on each conduit/duct/pipe entry/exit, and every 20 m in cable trench / tray.
3. Cable tray numbering and marking.
To be provided at every 10m and at each end of cables way & branch connection.
4. Joints for less than 250 Meters runs of cable shall not be permitted.
5. Buried cable protection
With concrete slabs; Route markers at every 20 meters along the route & at every bend.
6. Road Crossings
Cables to pass through buried high density PE pipes encased in PCC. At least 300 mm clearance shall be used between.
 - HT power & LT power cables,
 - LT power & LT control cables,

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- LT control & instrumentation cables,
Spacing between cables of same voltage grade shall be in accordance with the derating criteria adopted for cable sizing.
7. Segregation (physical isolation to prevent fire jumping)
 - a) All cable associated with the unit shall be segregated from cables of other Units.
 - b) Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire.
 8. Cable clamping
All cables laid on trays shall be neatly dressed up & suitably clamped/tied to the tray. For cables in trefoil formation, trefoil clamps shall be used.
 9. Optical fibre cables inside conduits shall be laid on cable trays wherever available and feasible. In areas where the same are required to be buried, the same shall be buried in separate trench approx. 1.6 meter depth, to be laid in 2" GI/rodent proof HDPE conduits covered with sand, brick and soil along the pipe line route.
 10. While crossing roads- to be laid in GI/rodent proof HDPE conduits with sand filling at bottom and sand, soil filling at top with cement concrete;
While crossing canals/river- to be laid in GI/rodent proof HDPE conduits within Hume pipe.

10.8

Cable Accessories

1. Cables, which terminate in cabinets or draw out sections, shall have sufficient cable coils in the bottom of the cabinet to permit full withdrawal of draw out sections without disconnecting the cables. When prefabricated cables with factory connectors on both ends are longer than required, the excess cable shall be coiled in the bottom of one or both termination cabinets.
2. No splices shall be made in conductors for instrument and control circuits except where required at connections to devices equipped with factory installed pigtails. Such splices shall be made only in approved splicing boxes of fitting with removable cover. The splices shall be made with sufficient slack left in the wire to permit withdrawal of the splice from the splicing boxes for ease of future disconnection of the splices. All exposed conductor or connector surfaces shall be covered with a minimum of three half-lapped layers of all weather vinyl plastic electrical tape. Taping shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the other insulation or connections requiring insulation.

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3. Proper grounding of all equipments shall be done. Further, proper termination of cable shield shall be verified and the grounding of the same shall be coordinated so as to achieve grounding of all instrumentation cable shields at same potential. This shall be completed prior to system tests.
4. Take full care while laying/installing cables as recommended by cable manufacturers regarding pulling tensions and cable bends.

10.9 Cable Conduits

1. Conduits shall be generally used for interconnecting cables from field instruments to Local JB's. All unarmoured cables shall be installed in conduit. All rigid conduits, couplings and elbows shall be hot dipped galvanized rigid mild steel in accordance with IS: 9537 Part-I (1980) and Part-II (1981). The conduit interior and exterior surfaces shall have continuous zinc coating with an overcoat of transparent enamel lacquer or zinc chromate. Flexible metal conduit shall be heat resistant lead coated steel, water leak, fire and rust proof. The temperature rating of flexible conduit shall be suitable for actual applications. The flexible metal conduit shall be constructed with interlocked corrosion resistant steel & manufactured in accordance with UL1 & NEC Article 348.
2. All grounding bushings within all enclosures shall be wired together and connected internally to the enclosure grounding lug or grounding bus with 8 AWG bare copper conductors. Conduit runs to individually mounted equipment shall be grounded to the cable tray grounding conductor with 12 AWG bare copper conductors.
3. All rigid conduit fittings shall conform to the requirements of IS: 2667, 1976. Galvanized steel fitting shall be used with steel conduit. All flexible conduit fittings shall be liquid tight, galvanized steel. The end fittings shall be compatible with the flexible conduit supplied.
4. All individually mounted equipment and devices shall be connected to the supply conduit, using not more than one meter of flexible conduit adjacent to the equipment or device. Flexible conduit shall be installed in all conduit runs, which are supported by both building steel and structures subject to vibration or thermal expansion.
5. Special areas, such as Control Rooms in which external noise is to be minimized, shall have flexible conduit in conduit runs where the runs cross from the main building framing to the Control Room framing.
6. Conduit supports shall be furnished and installed in accordance with these specifications. Support material shall comply with the requirements.
 - a) Hanger rods shall be 12 mm diameter galvanized threaded steel rods.

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- b) Single conduit support shall be one-hole cast straps and clamp backs. Multiple conduit bank supports shall be constructed of special galvanized support channels with associated conduit clips.
7. Conduit sealing, explosion proof, dust proof and other types of special fittings shall be used as required by these specifications and shall be consistent with the area and equipment with which they are installed. Fittings installed outdoors and in damp locations shall be sealed and gasketed. Hazardous area fittings and conduits sealing shall conform to NEC requirements for the area classification.
8. Double locknuts on all conduit terminations shall be used. Water tight conduit unions and rain tight conduit hubs shall be utilized for all the application which shall be exposed to weather. Moistures pockets shall be eliminated from conduits.
9. Conduits shall be securely fastened to all boxes and cabinets.

10.10 Cable Sub Trays & Support

1. The cable sub-trays and the supporting system, to be generally used between Local/Group JB's and the main cable trays. It is the assembly of section and associated fitting forming a rigid structural system used to support the cable from the equipment or instruction enclosure up to the main cable trays (trunk route). The material of cable tray shall be GI.
2. The covers on the cable sub-trays shall be used for protection of cables in areas where damage may occur from falling objects, welding spark, corrosive environment, etc. & shall be electrically continuous and solidly grounded. The cable trays shall not have sharp edges, burrs or projections injurious to the insulation or outer sheath of the cables.
3. The supporting arrangement of cable tray system shall be able to withstand the weight of the cable and cable tray system. The supporting interval shall not be more than the recommended span for the above loading for the type of cable tray selected. The tray shall not overhang by more than one meter from the support at the dead end. As far as practicable the cable sub-tray system shall be supported from one side only, in order to facilitate installation and maintenance of cables.
4. Install the estimated quantities and size of sub trays / troughs including all required fittings and adaptors on as required basis

Table 10.7
Specifications for Cable Tray

S.N	Feature	Minimum Requirement
1	Material	Mild Steel as per IS-2062
2	Thickness	Not Less than 2 mm
3	Finish	Hot Dip galvanised as per IS-2629, 2633

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S.N	Feature	Minimum Requirement
		& Zinc Coating as per IS-4579
4	Length	2.5 Mtr. +/- 10 mm
5	Width	W +/- 3mm
6	Inward Bend	25 mm
7	Coupler Plate	Thickness 2 mm, length 100 mm, Width 50 mm
8	Coupler plate material	MS with Hot dip galvanised
9	Nuts, Bolts, washer etc.	As required/ Hot dip galvanised
10	Cover	Dome Fixed type, Thickness 1.2 mm (Minimum)
11	Cover Material	Hot dip galvanised MS sheet

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11 SYSTEM CABINETS, PANELS & JUNCTION BOX

11.1 General Requirements

1. All control panels, system cabinets, local panels and local instrument enclosures, racks shall be furnished fully wired with necessary provision for convenience outlets, internal lighting, grounding, ventilation, space heating, anti-vibration pads and accessories as per IS:5039-1969 as required for completeness of the system.
2. All panels & cabinets shall be free standing type and have bottom entry for cables unless otherwise specified. The bottom of panels, cabinets, enclosures shall be sealed with bottom plate, compression cable glands and fire proof sealing material to prevent ingress of dust and propagation of fire. The Cabinets shall be designed for front & back access to components, terminals and wiring.
3. The cabinets shall be used with bottom glanding plate which shall be removable from inside and shall be used with sufficient no. of knockouts. The details of knockouts shall be used during detail engineering. All knockouts shall be used with pluggable grommets.
4. The cabinets shall be of max. 2200mm height including base channel. The base channel shall be of 100 ISMC. All cabinets shall be of same height. Construction shall be modular.
5. System & non-system cabinets shall have "look alike" appearance.
6. All electronic system cabinets shall be designed for 50 deg C operating under maximum ambient temperature without air conditioning system in service. Further cabinets, panels shall be so designed that temperature rise due to heat load does not exceed 10 deg. C above ambient temperature under all operating conditions. Necessary louvers, fans, limited packing density, adequate spacing between instruments, devices etc. shall be used to maintain temperature rise within permissible limits.
7. Panels, cabinets enclosures wiring shall be arranged to enable the removal of modules/instruments and devices without unduly disturbing them.
8. All panels, cabinets, enclosures interiors shall be illuminated with rapid start fluorescent strip fixtures with door actuated switches. Door switch terminals shall be shrouded. All illuminated lights shall be used with isolation switch in addition to door switch for maintenance & switching off when not required. Illumination light shall be used on both front & back sides if both sides are provided with equipments/instruments/terminal blocks requiring maintenance.
9. Sufficient number of power receptacles with disconnect switches shall be installed within panels, enclosure and racks.
10. The local instrument enclosures/racks shall be used locally for mounting of electronic transmitters and switches, etc.

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11. Exterior steel surface shall be sand blasted, ground smooth, filed, primed, sanded and smooth enamel painted to give a good finish subject to minimum paint thickness of 65-75 microns for sheet thickness of 3 mm and 50 microns for sheet thickness of 2mm. Minimum 2 coats of primer and two sprays of final finish colour shall be applied to all surfaces.
12. The colour of the panel's interior shall be brilliant white. External colour of the panels shall be as RAL 7032 for LIE/ LIR and RAL 7035 for control room system cabinets.
13. All panels, enclosures, system cabinets, marshalling cabinets shall be used with a minimum of 20% spare terminations and system cabinets shall be used with spare space for 20% additional modules fully wired with connectors etc. in excess of the total requirement of the system design when the cabinets are delivered. The spare space capacity shall be distributed evenly throughout the cabinets.

11.2

System Cabinets

Table 11.1
Specifications for System Cabinets

S.N	Features	Minimum Requirements
1	Application	For housing Signal conditioning cards, input/output cards, processor cards, power supply units etc.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Anti vibration pad	Required, 15mm
9	Painting	Interior- Brilliant White Exterior- RAL 7035
10	Cabinet Dimension	To be decided during detail engineering
11	Grounding	M6 earthing stud shall be used
12	Ventilation	Fans & louvers with brass mesh required
13	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
14	Lifting arrangement	Removable lifting eyebolts shall be used

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1. Beacon Lamps shall be used in each cabinet to indicate panel having fault condition.
2. The racks in system cabinets shall have provision along with plug in sockets/back plane to house accommodate the spare slots/modules as specified elsewhere.
3. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots & details of the card type/service shall be inscribed on this metal tag.
4. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
5. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
6. All cabinets shall have common key for locks.
7. Door shall have concealed type of hinges with 120 degree swing.
8. Door latches shall be of the three-point type to ensure tight closing.
9. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material.

11.3 Marshalling Cabinets

Table 11.2
Specifications for Marshalling Cabinets

S.N	Features	Minimum Requirements
1	Application	For termination of all cables originating from field.
2	Location	Indoor
3	Type	Free standing Vertical type
4	Protection class	IP-44
5	Material & Thickness	CRCA steel/ min. 2mm for panel sides & 3mm for gland plates
6	Doors	Double door with neoprene gasket, Lockable,
7	Cable entry	Bottom with fire proof compound thickness 50 mm for sealing
8	Terminal Blocks	Rail mounted cage-clamp suitable for conductor size up to 2.5 mm ² & fused type with LED indication for power supply (24 VDC, 230 V AC, 110 V AC etc.) for instruments & equipments.
9	Anti vibration pad	Required, 15mm

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S.N	Features	Minimum Requirements
10	Painting	Interior- Brilliant White Exterior- RAL 7035
11	Cabinet Dimension	To be decided during detail engineering
12	Grounding	M6 earthing stud shall be used
13	Ventilation	Fans & louvers with brass mesh required
14	Lighting	rapid start fluorescent strip fixtures with door actuated switches required
15	Lifting arrangement	Removable lifting eyebolts shall be used

1. Separate Marshalling cabinets for the system shall be supplied for terminating all cables originating from the field and for distributing the signals to different functional panels and cubicles.
2. The terminal blocks shall be cage clamp type. Fused terminal blocks hinged at one end to facilitate easy isolation shall be used wherever necessary. All cabinets shall be used with spare terminals for the spare inputs/outputs as specified elsewhere in the specification. The type of terminals for terminations from cabinets/panels shall match with the pre fabricated cables and pins supplied.
3. The terminals for field cables shall be arranged in a logical order of equipment/system wise.
4. The marshalling cabinets, the terminal blocks, the terminals and the electronic hardware if any, shall have identification numbers.
5. Each cabinet shall be used with one each 3 pin receptacles for 230 V, 1P, 50 Hz and receptacles for 24V DC.
6. One of the doors shall be used with folder to keep the relevant engineering document of the cabinet.
7. All cabinets shall have common key for locks.
8. Door shall have concealed type of hinges with 120 degree swing.
9. Door latches shall be of the three-point type to ensure tight closing.
10. Separate Power & shield earthing bus shall be used at the front & rear side of the cabinets. The earthing bus shall be isolated from panel body by suitable insulation material

11.4 Local Instrument Enclosure & Racks

1. Transmitters and switches, devices, etc. mounted in the field shall be suitably grouped together and mounted in local instruments enclosures in case of open areas of the plant and in local instrument racks in case of covered areas. These local instrument enclosures and racks shall be furnished as per the project requirements.

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2. The local instrument enclosures shall be constructed of 2 mm sheet plate and shall be of modular construction with one or more modules and two end assemblies bolted together to form an enclosure. Vibration dampeners shall be installed for supporting each enclosure. The internal layout shall be such that the impulse piping/ blow down lines are accessible from back doors of the enclosure and the transmitters etc. are accessible from front side for easy maintenance. Gaskets shall be used between all mating sections to achieve protection class of IP-65.
3. The local instrument racks shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be used with a canopy to protect the equipment mounted in racks from falling objects, water etc. The canopy shall not be less than 3 mm thick steel, and extended beyond the ends of the rack. Bulk heads, especially designed to provide isolation from process line vibration shall be used. Exact fabrication details shall be as finalized during detailed engineering stage. The junction box for racks also shall conform to IP 65 protection class.
4. The junction box of Local Instrument Enclosure & Racks shall be used with hinged type door, latch for locking & gland plates for cable entry. All terminals in junction box shall be of rail mounted cage clamp type suitable for conductor size up to 2.5 Sq. mm.

11.5

Local Junction Box

Table 11.3
Specifications for Junction Box

S.N	Features	Minimum Requirements
1	No. of Ways	32 (2X16) with 20% spares terminals
2	Material & Thickness	3 mm thick Stainless steel
3	Protection class	IP-65 for outdoor/ IP 55 for Indoor
4	Cable entry	Bottom
5	Mounting	Suitable for Wall/column/structures mounting
6	Terminal Blocks	Rail mounted cage-clamp type suitable for conductor size up to 2.5 mm ²
7	Grounding	M6 earthing stud shall be used
8	Gland plate	Removable type
9	Door	Single Lockable door with gasket, able to open sideways, turnable hinge based, latch type lock without handle with common key.
10	Accessories	Tag plate, clamps, fixtures, bolts (SS), nuts (SS), Gasket (Neoprene), cable glands (SS), Lugs (Brass), Fire proof compound for sealing.

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1. All JB's for outdoor application shall be used with individual canopies to prevent ingress of water.
2. All JB' shall have provision to add 10% additional TB's.
3. The marking on terminal strips shall correspond to the terminal numbering on wiring diagrams.
4. Separate Terminal blocks shall be used for Analog & Digital Signals & also for signals with different voltage levels.
5. The terminal blocks shall be arranged with at least 100 mm clearance between two sets of terminal blocks and between terminal blocks and junction box walls.
6. Separate shield bus shall be used with screw connection for terminating cable shields.
7. All spare cable entries shall be used with plugs.
8. All wires in JB shall be neatly dressed & ferruled.
9. Double deck type terminal block shall not be used.

Table 11.4
Specifications for Cable Glands

S.N	Features	Minimum Requirements
1	Type	Double compression
2	Entry Thread	½ " NPT
3	Material	Brass
4	Finish	Cadmium Plated
5	Protection	IP-54 or better
6	Accessories	Neoprene gasket, Locknut, Reducer etc.

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-II
SECTION-II, PART-D
DETAILED TECHNICAL SPECIFICATION-CIVIL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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1. CIVIL, STRUCTURAL & ARCHITECTURAL WORKS- DESIGN & EXECUTION CRITERIA

1.1 Introduction

This specification covers the design, preparation of general arrangement, construction as well as fabrication drawings, supply of all labour as well as materials and construction of all civil, structural as well as architectural work on EPC basis for Renovation and Modernisation of Ash Handling system and associated structures. Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope shall be as per Volume-II, Section-I, CIVIL SCOPE OF WORK.

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2. *[BUILDINGS & STRUCTURES]*

Design and construction of new buildings, structures, foundations etc. as well as repairing / retrofitting of existing buildings, structures, foundations shall take into account requirement for operation and maintenance of all equipments and its users. The buildings will have good architectural features. The surrounding areas shall be properly micro levelled and graded. The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials fittings and finishes.

- *Due consideration shall be given for adequate natural lighting and ventilation for both plant and non-plant buildings.*
- *Retrofitting / repair works / new constructions shall not cause damage to the existing structures. The temporary supports shall not be allowed on the existing structures for any of these works unless the loads are minor and may not cause any damage to any existing structure. However in such a case Bidder shall take approval from the Owner/Consultant prior to initiating the work.*
- *Internal finishes shall be provided with latest available materials approved by Owner/Consultant with due consideration of the functional aspect of the area.*
- *External finishes shall be provided with latest materials approved by Owner/Consultant for improving the aesthetics.*
- *The orientation of the important buildings shall be in line with the existing site condition and function as such.*
- *Each building shall have its own identity. However, a total homogeneity shall be maintained in the design of all buildings.*
- *Adequate frontage shall be provided to all important buildings to create a better visual impact.*
- *All other civil and structural buildings shall be developed in conjunction with the above aspects.*

All Civil, Structural and Architectural works of the following systems shall be covered under this package.

- a) *Vacuum Pump House including Switchgear Room*
- b) *Ash water pump house including ash water tank, with switchgear and Control room*
- c) *Ash slurry pump house including make-up water sump, ash slurry sump, switch gear and control room*

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- d) Bottom Ash Disposal System Structures including Storage hopper*
- e) Fly Ash Disposal System Structures including intermediate surge hoppers*
- f) Fly ash equipment building*
- g) Fly ash silos*
- h) Silo utility building*
- i) Pipe racks & Cable racks*
- j) Pedestal for lean slurry disposal system*
- k) Ash Pond*
- l) AHP Clarifier, Clear Water Tank, Recirculation Pump House and Chemical House for Ash WTP*
- m) Any building inadvertently left out in the above list, however required for proper functioning of the power plant as per system requirement stipulated under Mechanical & Electrical section of this specification shall also be included.]*

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3. DESIGN REQUIREMENTS

3.1 Location

Geographical location of the plant site is approximately between [...]°[...]′[...]″ N] to [...]°[...]′[...]″ N], Latitude and [...]°[...]′[...]″ E] to [...]°[...]′[...]″ E], Longitude.

3.2 Ground Condition

Subsurface condition: The natural ground surface level approximately varies from [...] m to [...] m] from MSL.

[The soil profile in the plant area can be broadly classified into 3 layers namely laterite, cemented sand and cemented silt in general as per detail soil investigation report. Top soil upto a depth ranging from 0.4 m to 0.75 m is entirely non-uniform. The underlying layer is laterite whose depth varies from 4.0 m to 5.5 m followed by deep layers of cemented silt and cemented sand].

The ground water table (GWT) at finished ground level shall be considered for foundation design purposes.

The detailed soil investigation report conducted for plant shall be made available to Bidder for required replacement / refurbishment / retrofitting of Foundations, if any.

Bidder is advised to carefully study the content of detailed Soil investigation report for the existing type of foundations and design of new ones.

The type, size, depth of the foundation shall be based on the detail soil investigation report provided by OWNER.

3.3 Climatic Condition

a) Temperature

Maximum : [...] °C

Minimum : [...] °C

For design purpose, maximum temperature to be considered: [...] °C

minimum temperature to be considered: [...] °C.

b) Rain fall

Minimum : [...] mm in May]

Maximum : [...] mm in October]

Peak hourly rain fall: [...]mm] (corresponding to 50 years return period)

[Note: Maximum per day rainfall as per weather report has been considered conservatively as peak hourly rain fall which will be used for drainage system design etc.]

Annual average: [...] mm to [...] mm & average [...] mm]

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3.4 Seismic Zone

The site is located in [Zone III] as per IS: 1893-2002. Zone factor shall be [0.10]. Importance factor shall be considered as [1.75].

3.5 Wind Zone

The site is located in wind speed zone [...] m/s] as per IS: 875 (Part 3)-1987.

3.6 Loads and Load Combinations

All new structures shall be designed and old structures requiring modification shall be checked for the most critical combinations of dead loads, imposed loads, equipment loads, wind loads, seismic loads, temperature loads, forces developed due to differential settlement and any other loading conditions which can occur during the design life of the facility.

(a) Dead Loads

Dead loads consist of the weights of the complete structure with finishes, fixtures, partitions, wall panels and all existing / modified / replaced equipments of semi-permanent nature including storage structures (Tanks, bins, silo etc) partitions, roofing, piping, cable trays, bus ducts etc. The content of storage structures etc. shall be measured at full capacity for this purpose.

The piping loads (for empty, operating and test conditions), cable tray loads and the contents of the storage structures shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing load for uplift.

The following unit weight of material shall be considered for computation of loads. Loads given in IS: 875 (part-I) shall be made use of for material not listed below.

Table 2.1
Weights of Material

Material	Unit weight (kN/m ³)
Plain cement concrete	24.0
Reinforced cement concrete	25.0
Structural steel	78.5
Brick work	19.0
Cement plaster	21.0
Floor Finish	24.0
[Coal]	11

(b) Superimposed Live Load (SILL)

Listed below is the minimum SILL for the areas involved. Floors and supporting members subjected to heavy equipment live loads shall be designed on the basis

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of the equipment loads specified by vendor or specifically defined SILL whichever is greater.

The specific minimum floor SILL is listed below:

**Table 2.2
Superimposed Live Load (SILL).**

S.No	Description	SILL Value
a)	Roof	
	Flat accessible roof	1.5 kN/m ²
	Flat accessible roof with HVAC equipments, etc.	5 kN/m ²
	Flat inaccessible roof	0.75 kN/m ²
	Sloped Roof	As per code IS: 875 (Part-2)
b)	All building floors & Stairs	5 kN/m ²
c)	Walkways of Conveyor Galleries	5 kN/m ² or Concentrated Load of 3 kN at centre which ever is critical
d)	M.C.C. Floor	10 kN/m ²
e)	Equipment Load	As applicable
f)	Culverts & its allied structures including Concrete pipes	Class "A" / Class "70R" as per IRC standard whichever is higher / load due to bull dozers
g)	Underground basement,	Surcharge of 10 kN/m ²
h)	Vehicular traffic	Surcharge of 20 kN/m ²
i)	Covers for Channels	Surcharge of 10 kN/m ²
j)	Pump Houses	
	Operating Floor Slab	15 kN/sqm or as required by equipment supplier whichever higher
	Workshop	10 kN/m ²
k)	Other areas:	
	• RCC floors (Offices, laboratories, conference rooms and general floors)	5 kN/m ²
	• Balconies	5 kN/m ²
	• Chequered plate / gratings	5 kN/m ²
	• Walkways	3 kN/m ²
	• Toilets	2 kN/m ²

- In addition to LL, Hung loads for electrical, ventilation & air conditioning minimum of 0.5 kN/m² shall be considered.

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- Load of 1 kN/m² shall be considered as hung load for piping unless otherwise mentioned. However, the actual loads will be as furnished by the supplier. The stringent most will be followed.
- For other areas LL shall be considered as per IS: 875 (Part-2).

(c) Seismic Load

The proposed plant is located in Seismic *[Zone-I]* as per IS: 1893, Seismic force on the structures will be considered accordingly.

(d) Wind Load

The proposed plant is located in Wind Speed Zone of *[...m/s]* as per IS: 875 (Part 3). The wind force on the structures will be considered as follows:

**Table 2.3
Wind Speeds**

Description	Wind Speed
Basic Wind Speed V _b (at 10m above mean ground level)	<i>[50 m/sec]</i>
Risk coefficient K ₁ (for 100 years)	<i>[1.07]</i>
Category of terrain	<i>[Category 1]</i>
Factor K ₂	As per IS: 875
Topography factor K ₃	As per IS: 875

For the design of structures, wind force on Equipment, supported on frame including all fixtures, piping, staircase, ladder, etc, shall be considered.

Design of structures shall be checked for the condition of wind load with gust factor.

(e) Earth Pressure Loads

For earth pressure the worst condition with dry / submerged and active, passive or at rest shall be considered. The pressure coefficient shall be adopted as recommended in Soil Report or for the backfill material used.

(f) Temperature Loads

The total temperature variation shall be considered as 2/3rd of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the average between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50 % of the total considered temperature variation with temperature load applied with positive and negative sense.

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For design purpose average maximum annual variation shall be taken as *[+50°C]* to +5°C.

Coefficient of thermal expansion of steel shall be taken as per IS: 800 where the value is given as $12 \times 10^{-6}/^{\circ}\text{C}$. Coefficient for thermal expansion for concrete shall be taken as per IS: 456.

(g) Thermal Loads (during operating condition)

When thermal loads (such as produced by temperature changes in piping, equipment and structures) results in friction between equipment and supports (exchangers) or piping and supports, the friction force will be taken as the operating load on the support multiplied by the applicable friction coefficient given below:

**Table 2.4
Thermal Loads**

Description	Value
Surfaces	Friction coefficient
Rolling supports	0.05
Steel to steel	0.30 (longitudinal) and 0.10 (lateral)
Concrete to steel	0.30

(h) Equipment Loads

Static and dynamic loads of major existing / modified / replaced equipments shall be based on the manufacturer's data of the specified equipments and shall be considered in design in addition to the live load.

Equipments to be tested for hydraulic test, tanks and piping design loading shall include hydraulic test loading. Weight of equipments, ducts, tanks, pipes, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads applicable.

(i) Cranes, Hoists, Monorail and Elevator loads

All lifting beams and monorails shall have their design loads increased for impact factor. Loads for overhead cranes, hoists, monorails and elevators shall be taken as per IS: 875.

100 % of the lifted load including elevator live load plus the cab weight shall be considered for the elevator support beam design. Pedestals in elevator pits shall be designed assuming impact factor as per IS codes.

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(j) Vibration and Noise

The design shall ensure that vibrations from any moving machinery transmitted from its immediate foundations to adjacent buildings or areas of the same building shall be suppressed in accordance with the recommendations of relevant codes of practice.

(k) Other Loads

- Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance loads, creep and shrinkage shall also be considered in design of all structures.

- Dust loads

All buildings / structures shall be designed for a dust load of 1 kN/m² for flat roof and 0.5 kN/m² for sloped roof.

- Construction /Erection/Maintenance Loads

The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing as far as possible. However, construction or access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

- Future Loads

Loads from future expansion shall be considered when so directed by the Owner/Consultant. Future loads may include any of the loads listed above.

- Surge Loads

Surge loads may occur in some vessels or equipment. In such cases, the magnitude and direction of the load shall be given by the equipment supplier.

(l) Basic Load Cases

Following basic loads shall be considered for analysis and design:

Dead load	:	DL
Superimposed dead load	:	SIDL
Self weight of permanent equipment	:	EL
Steam piping (Static & Dynamic) & other piping loads	:	PL
Cable loads	:	CL
Live load on floor / walkway	:	LL
Superimposed live load	:	SILL
Live load on roof	:	LLR

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Seismic load	:	SL
Wind load	:	WL
Load due to soil pressure	:	SP
Load due to surcharge	:	SCL
Load due to hydrostatic pressure	:	HP
Load due to temperature	:	TL
Hoist, monorail loads	:	MR1
Crane Load	:	CRL
Special loads	:	SPL

(m) Load Combinations

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load combinations shall be taken as per IS: 456, IS: 800 & IS: 875 (all parts) and other relevant IS codes.

Wind and seismic forces shall not be considered to act simultaneously.

Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loading.

(n) Load Combinations for underground structures

- For the design of sub structure only liquid pressure from inside and no earth pressure and ground water Pressure and surcharge pressure from outside (applicable only to the Structures which are liable to be filled with water or any other liquid) shall be checked.
- For the design of sub structure combination of earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside shall be applied.

(o) Ash Silos

The following densities of ash shall be considered for the design or renovation & modernisation of concrete ash silos:

For volume calculation of bottom ash silo	:	6.5 KN/cum
For volume calculation of fly ash silo	:	7.5 KN/cum
For load calculation of both types of silos	:	16 KN/cum

The concrete ash silo shall be designed generally as per the criteria laid down in IS: 4995 (Part I & II). The static pressure calculated at rest shall be multiplied by an over pressure factor of 1.35 for the top 1/3 rd portion and by a factor of 1.75 for the bottom 2/3rd portion. Special attention shall be given in assessing

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the effect of hot temperature of ash on the concrete wall. Temperature of ash shall be taken as 150° C.

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4. EARTHWORK AND ROCKWORK

4.1 General

This section applies to all earth and rockwork required for the replacement / refurbishment / retrofitting of existing foundations or construction of new buildings foundations (if any), any types of structure and burying service lines in the ground.

The Bidder shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the detailed soil investigation and of the available information and instruction given in writing by the Owner/Consultant.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Owner/Consultant. All necessary precautions shall be taken to cause the minimum possible alteration or disturbance to the other existing foundations, material lying under and adjacent to the excavation final lines.

4.2 Fill Materials

The fill materials used and source are to be examined and approved. Excavation materials can be used if they fulfil the requirements.

a) Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials, which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas etc.

b) Ordinary fill shall have the following properties:

- Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.
- The intention is to use ordinary fill for non-built areas.

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c) Special fill:

- Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks.

4.3 Excavation

The works shall be excavated either by hand or by use of excavating plant and tools acceptable to the Owner/Consultant. Last 300 mm shall be excavated by hand tools only to ensure that natural conditions of soil at foundation level should not be disturbed. In case if over excavation has been done, the depth of soil over excavated shall be filled with M10 Grade concrete and no earth filling shall be allowed to fill over excavated earth.

Also excavation by hand may be required close to existing installations, existing foundations and/or underground services, but subject to special instruction of the Owner/Consultant.

The Bidder shall carry out all kind of earth and rockwork for the following particular works as defined hereafter (where applicable):-

- i) Clearing and grubbing
- ii) Excavation of topsoil
- iii) Open cut excavation
- iv) Backfilling
- v) Safety precaution during earthwork
- vi) Mining or underground excavation (if required)
- vii) Grading
- viii) Replacement of material
- ix) Trench excavation for service lines
- x) Embankments
- xi) Archaeological findings

4.4 Safety Precautions

The Bidder shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc shall be to the Bidder's debit. The additional moving of soil resulting from such damages will not be paid for.

4.5 Over Excavation

Bidder shall ensure that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

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4.6 Stockpiles and Disposal

Excavated material from the works selected by the Owner/Consultant for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on site as directed by the Owner/Consultant

The Bidder shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Owner and shall not be permanently deposited elsewhere. The Bidder shall trim and form the edges of spoil to profiles and levels as directed by the Owner/Consultant. . Distance of stockpiling of excavated material from the pit edge shall be minimum 1.5 meters or half of the depth of the pit whichever is higher.

The placing of materials within the waste disposal areas shall be made in layers not exceeding 0.50 m in thickness in order to obtain an appreciable degree of compaction by means of transportation equipment and/or if required by appropriate compaction equipment.

All traffic to or from the waste disposal areas shall run over the surface of such areas in order to achieve compaction.

4.7 Preparation of Foundation

All earth surfaces against which concrete is to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Owner/Consultant and then protected by means of a lean concrete layer, 7.5 cm or PCC thickness as shown in the design drawings, whichever is greater. No concrete is to be poured until formation is inspected and approved by the Owner/Consultant. No structural concrete shall be poured against earth surface. Shuttering shall be used at sides and PCC shall be provided below foundations.

4.8 Backfilling

Foundations and structures shall be backfilled with approved material compacted in layers not exceeding 150 mm by suitable equipment upto the required designed levels. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Owner/Consultant.

Density requirements as per standard Proctor Test shall be in accordance with relevant parts of IS: 2720 and all tests shall be made by/on under the supervision of Owner/Consultant at Bidder's own expenses, at optimum moisture content:

- a) Backfilling of foundations and under grade slabs - 98%
- b) Under roadways and parking areas - 98%
- c) Embankment - 95%

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The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Owner/Consultant after compaction tests have been made.

Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the sub-grade.

Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Owner/Consultant.

4.9 Soil Replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange. The suitability of soil for its use for filling shall be as per provisions of Indian Standards.

Prior to the commencement of work, three samples shall be taken from the anticipated borrow area and tested in respect of IS: 2720 or Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

These three samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of not more than 15 cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for watering of soils.

The fill material shall be compacted by vibratory roller (min. weight 20T.). However for small compaction works such as small patches etc., comparatively low weight compactors or other compaction methods may be used after taking approval from Owner / Consultant. The minimum required degree of compaction should be as defined under "Tests and Properties". One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Owner/Consultant. Bidder shall make suitable arrangements for carrying out all the necessary quality tests or he shall co-operate with an experienced soil testing laboratory, subject to the approval of the Owner/Consultant

Filling work may be continued in case all tests performed show satisfactory results.

4.10 Pipe Bed Preparation

Pipe beds shall be constructed to guarantee the uniform transmission of loads. The bearing section for supported profiles shall cover at least an arc of 90°.

Pipes shall be bedded in an earth foundation of uniform density and carefully shaped by means of a template supported at the desired grade, to fit the lower part of the pipe exterior.

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Where rock in either ledge or boulder formation is encountered, it shall be removed below grade and replaced with suitable materials in such a manner as to provide a compacted earth cushion having a thickness under the pipe of not less than one quarter of outside pipe diameter with a minimum allowable thickness of 20 cm if not otherwise specified.

Where a firm foundation is not possible at the grade established due to soft, spongy or other unstable soil, all such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed and replaced with suitable selected materials as approved by the Owner/Consultant, properly compacted to provide adequate support for the pipe.

4.11 Protection of Existing Utilities and Services

During modification/rehabilitation of existing structures or construction of new structures, the Bidder shall provide all protection for existing utilities and services as may be required by his modification and construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Owner/Consultant.

In addition to the requirements as specified, herein the Bidder shall comply with the following requirements:

- a) Use all necessary precautionary and protective measures required to maintain existing structures, utilities, services and appurtenances that must be kept in operation. In particular, the Bidder shall take adequate measures to prevent undermining of existing structures and utilities/services presently in service.
- b) Protect existing or new utilities and services where required by the Bidder's operations and/or as directed by the Owner/Consultant. The Bidder shall be responsible for bracing and supporting existing structures, utilities and services to prevent settlement, displacement or damage.

4.12 Dust Control

The Bidder shall use all means necessary to control dust on roads, dismantling/demolition and modification areas, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

4.13 Dewatering during Construction

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the detail soil investigation and/or information given in writing by the Owner/Consultant.

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Ground water control for keeping the construction pits dry shall be included in the Bidder's scope of work.

The method and technique shall be based on the IS: 3764.

The scope of supply includes removal of all equipment, plants, pipes, machinery, etc for modification /rehabilitation of existing foundations and re-installation of all equipment, plants, pipes, machinery, etc and its removal after completion including operation & maintenance of the equipment during the construction period.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that alterations and extensions can be made at any time throughout the operating time, if necessary. Reserve units shall be kept ready for service when failure of any of the installed units occurs.

The Bidder has to consider the possibility of a temporary failure of any pump, diesel engine and/or the electric power service and shall install emergency power units with sufficient capacity to feed the necessary power to the installed unit at the moment of failure. The Bidder shall submit to the Owner/Consultant, the detailed method of the envisaged pumping system for dewatering, the pump capacity and the standby reserve units. The Bidder shall adjust the system if required by the Owner/Consultant.

The Bidder must ensure that any dewatering works will not cause any interference to his own work and to those of other Bidders working elsewhere on site. Any damage occurring during the above mentioned period should then be made good by the Bidder at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least *[0.50]* m below the foundation level.

4.14 Equipments

All equipments, instruments, machineries, tools, pipelines, etc required for execution of the water control shall be kept in good working condition throughout the operation period.

4.15 Execution

The Bidder shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to the Owner/Consultant for information and checking every working day. For that purpose, the lowering of the water table shall be controlled by piezometers. The numbers and position of them shall be submitted to the Owner/Consultant's approval. The Bidder shall provide and maintain these piezometers at his own

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expenses during the dewatering works or as long as the Owner/Consultant requires it.

Pump operations shall not be stopped nor pipes, channels and equipment for dewatering and water control removed or altered in any way, except with the express permission of the Owner/Consultant. The Owner/Consultant will stipulate the time of removal. Until then, the pumps and water drainage facilities shall be kept in proper working order without extra payment being granted.

Pump sumps and channels:

Provision of pump sumps and channels of the dimensions required for each particular case shall include all necessary excavation of any kind of soil above and under water, backfill and consolidation, sheeting, bracing, stiffening, sealing, scaffolding accesses, as well as the disposal of water and all auxiliary works.

Routing of channels or pipes for discharge water shall be such as not to impede or obstruct any of the other works and/or operations.

The same shall be applicable for pump sumps. Prior to the determination of any arrangement of pump sumps, the Owner/Consultant's approval shall be obtained.

Routing and location of water discharge lines shall be submitted to the relevant authorities and to the Owner/Consultant's approval.

Difficulties during dewatering:

The Bidder shall consider all difficulties and additional work due to the presence of unexpected ground water during subsequent construction work. Where it is possible to keep off or divert such water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from Owner/Consultant has been obtained.

Ready for service condition:

The Bidder shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by the Owner/Consultant in this matter shall be carried out immediately.

Leakage:

Blockouts and pipe connections through structures and their closure, proper grouting of joints, etc or repairs in the event of leakage shall be the responsibility of the Bidder.

Piezometers:

The ground water lowering effect is to be checked by piezometers in unfavourable positions (e.g. in the middle of the building pit) before starting the excavation. The piezometers are to be installed at unfavourable positions or in

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more permeable layers (in stratified sub-soil) below the bottom of the excavation. They serve to check whether or not the water pressure (head) has been sufficiently reduced in those layers below the bottom of the excavation, which are more permeable. Security against hydrostatic uplift is to be demonstrated by calculation.

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5. REINFORCED CONCRETE STRUCTURES AND FOUNDATIONS

5.1 General

All structures, building foundations, machines / equipment foundation, water retaining structures, trenches, pits, etc. shall be checked / designed as per latest relevant IS codes in general. Construction in general shall follow provisions of IS: 456 and IS: 3370 for normal and water retaining structures respectively.

5.2 Design Methodology

a) General

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456.

IS: 11384 shall be followed for design of steel concrete composite beam.

For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

b) Foundation and Underground Structures

Type of foundation system, i.e. isolated, strip, raft shall be decided based on the loading arrangement, load intensity and soil strata. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

Foundation system adopted shall ensure that settlement / relative settlement is as per provision of IS: 1904 and other Indian Standards. However, the settlement shall be restricted to a lower value, if necessary as per the system requirement.

All foundation including machine / equipment foundations shall be of RCC construction. All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian standards IS: 2974 and IS: 456. Raft foundations shall be designed as per IS: 2950.

All foundations shall be treated as per the guidelines prescribed in IS 456: 2000 against sulphate/other aggressive chemicals if found present in soil or as per the requirements of detail Geotechnical Investigation Report.

For design of underground structures, subsoil water level shall be assumed at Finished Ground level. All underground pits, tunnels, basements, cable and pipe trenches, etc. shall be designed as leak proof RCC structure, where depth of ground water table so warrants. In case of leakage in the above structures injection grouting method shall be applied to repair the structure according to

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the requirement of IS: 6494. Effects of uplift and reduction in bearing capacity due to underground water table shall also be considered.

For Subsoil conditions, Average ground water table, Foundation system, Earth Pressure Coefficient, refer to detail geo-technical investigation report of the site.

The soil conditions met during the foundation works especially in the foundation level are to be checked by the Bidder's soil Engineer, recorded and compared with previous known or investigated results. If essential differences occur, which could be detrimental to the structures, the Bidder has to inform the Owner/Consultant and to propose further measures. Foundation works in such areas are to be continued only after approval of such measures by the Owner/Consultant

If there is any doubt about the soil quality or if discrepancies appear with regard to the previous decisions or investigations stated by the Owner/Consultant, then additional measures are to be taken after consulting the Owner/Consultant (e.g. additional excavation and lean concrete fill)

Allowable settlements, elastic plus consolidation, shall be limited as follows: -

- i) Total settlement : 38 mm
- ii) Differential settlement : 6 mm

Foundations for equipment shall be designed to meet the total and differential settlement established by the equipment manufacturer if they are more stringent than the allowable settlements listed above. Foundations for buildings shall be designed to meet the total and differential settlement as required for the building function if they are more stringent than the allowable settlements listed above.

c) Movement and Expansion Joints

Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS: 8009 – "Code of Practice for calculation of settlement of foundation".

d) Foundations at Different Depths

Foundations at different levels should be based beyond a load-spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure) of the higher-level structures on the lower ones must be taken into consideration.

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e) Replacement

If unsuitable soils are encountered below the grade slabs or basement floor, they are to be replaced by suitable layer wise compacted material down to the good bearing soil.

Materials and compaction method as well as quality control are described in clause 'Earth and Rockworks' of this section. Selected fill is to be employed below all grade paving and basement floors.

f) Liquid Retaining Structures

RCC water retaining structure like storage tanks shall be leak proof and designed as un-cracked section in accordance with IS: 3370 (Part 1 to IV) by working stress method. However the parts of such structures not coming in contact with liquid may be designed according to IS: 456.

Water channels and substructure of pump houses shall be designed as cracked section with steel stresses as per IS: 3370 (Part 1 to IV) by working stress method and limiting crack width to 0.2 mm.

All water retaining / storage structures shall be designed assuming liquid upto the height of wall irrespective of provision of any over flow arrangement. No pressure relieving devices shall be permitted in underground structures.

In all liquid retaining structures, PVC water bar shall be provided at each construction / expansion joint. The sequence of construction shall also be specified on drawings showing construction joints.

The walls shall be designed for a surcharge load of 2000 Kg/m² or actual whichever is higher.

Liquid Retaining Structure shall be checked for two loading conditions. With water inside up to operating level and no earth fill outside or water in one compartment and no water in the other compartment (where two compartments are provided).

Base slab / raft of all liquid retaining structure shall be designed to withstand the uplift pressure.

g) Modification of the existing foundation (as required) for the new equipment supplied

The new equipment shall be supported on an RCC deck which in turn shall be supported over steel helical springs and viscous dampers. The steel helical springs and viscous dampers shall be supported over structural steel beams which in turn shall rest over columns. The columns shall be supported over foundation. The modification of existing foundation may involve partial to full dismantling and reconstruction of new foundation as per design & constraints of space.

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Precautions shall be taken not to disturb the basic building structure & other foundation and it shall be ensured that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

The contractor shall be responsible for maintaining all safety norms including the stability of existing structures. Any propping, shoring and under pinning required to this effect shall be put in place before the dismantling work is undertaken.

Wherever any existing concrete member is required to be partially dismantled, a coat of epoxy paint shall be applied to the exposed reinforcement and the cut surface of concrete shall be built up by providing 40 mm thick concrete with wire mesh.

h) Machine Foundations

General

Design of equipment foundation for block type machine foundation (if any) shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in mind the existing structural arrangement and space limitation.

The design of machine / equipment foundation shall be as per IS: 456 and IS: 2974. The provisions of DIN 4024 shall also be followed for machine foundations. All machine / equipment foundations and structures subject to vibrations shall be suitably proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

For the foundations supporting minor equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining part of building and other foundations. Joints at floor/ slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitable to ensure integral action.

The extent of foundation shall be based on the general arrangement of the equipment and the design requirement. However minimum width of any foundation shall not be less than one meter. Water table has to be considered at finished ground level for design of all foundations.

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Suitable arrangement shall be made for prevention of transmission of vibration from the proposed foundation to the nearby structure/ foundation/ paving slab.

All design calculations and drawings shall be submitted to Owner for approval.

In case any modification to any existing nearby structural steel bracing/support system/ concrete work is required, the contractor shall check the adequacy of the design of the existing structures for the new loads. Suitable modification to the existing structure as required shall be carried out by the contractor.

Loose pockets if any found below the foundation shall be removed and filled up with PCC of grade M10.

Loads

All static and dynamic forces / loads which equipment supplier considers applicable shall be considered for analysis and design of machine foundations.

Foundation Sizing

The outline plan dimensions of foundations as given by the machine supplier will be adopted. The height of foundation will be selected after taking into consideration soil strata and operating level of the machine. The eccentricity of common CG of machine and foundation with respect to the centroid of base area should not exceed 5 % of the corresponding base dimensions of foundation. Partial contact between the foundation and soil strata shall be considered wherever applicable. The footing will be checked for minimum contact area of 80 % and maximum bearing pressure will be calculated for the actual contact area only.

Analysis and Design

The minimum grade of reinforced cement concrete shall be M25, unless specified otherwise.

The analysis and design of machine foundations will be carried out to ensure the following:

- Compliance with the manufacturer's requirements and relevant standards
- No resonance phenomenon of a disturbing nature to machine operation should exist at the normal running speed
- Calculations to be performed for dynamic as well as static cases for reinforced concrete block type pedestal
- Soil bearing capacities
- Deep foundation capacities
- Lateral earth pressures
- Allowable settlements
- Structure, equipment and environmental loadings
- Equipment performance criteria
- Access and maintenance requirements

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- Temporary construction loadings

The foundation will be designed for the most critical combinations of forces and moments, resulting from all possible combinations of the various loading from the equipment system. The foundation sections will be sized and reinforced adequately for bending moments and shear stresses and uplift.

The foundation shall be checked for overturning, sliding and uplift as per relevant IS Codes. The foundation will be checked for overturning with minimum and maximum vertical loads.

For analysis of machine foundation following data will be furnished by the equipment manufacturer:

- Loading diagram showing static and dynamic loads and points of application of loads
- Operating speed of machine
- Weight of rotating parts, maximum eccentricity of rotating mass from the geometric axis of rotation
- Location of C.G. of machines in all three axis
- Mass moment of inertia
- Allowable amplitude / velocity of vibration at machine bearing points
- Temperatures at various areas during operation

While designing following aspects shall also be taken care of:

- All dynamic foundations shall be isolated from building foundations. The isolation gap shall be of minimum 25 mm.
- Natural frequencies of structures and components shall be away from running speed of equipment by at least 20 % generally but for important ones it shall be away by at least 30 %.
- For design of foundation of large fans etc., provision shall be kept in the foundation for addition of mass / area for retaining of the foundations if required at a later date

However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral loads shall be 1.5
- Factor of safety against sliding shall be 1.5
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5. Uplift check shall be carried out during construction stage also.

For miscellaneous machines, most suitable type of foundation shall be provided. Foundation for pumps, and minor rotating equipment etc., are usually in the form of solid block foundations, resting on the ground or on a floor of the building. At such machine supports, floor may be thickened and extra reinforcement may be provided. Also the machines, which are almost vibration free, light to moderately heavy, may be supported in the above manner. Rubber

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or neoprene pads under some of these machines to reduce transmission of vibrations to the supporting floor will be provided if required.

All block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456. Suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining foundations.

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25°C when placed. For maintaining the temperature of 25°C in the top decks of machine foundations, crushed ice shall be used in mixing water.

Non-Shrink Grout for Equipment Foundations

Special non-shrinking grout of approved make shall be provided in strict accordance with the manufacturer's instructions / specifications. Ready mix non-shrink grout of GP2 brand or equivalent, of approved make shall be used for base grouting of major rotating equipments.

i) Increase in Stresses

Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

Bearing capacity of the soil shall be allowed to be increased by 25 % under seismic/ wind load condition.

j) Elevated Foundations

Design of all equipment foundations shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in view the existing structural arrangement and space limitation. Adequacy of the design of the existing structures, for the new loads shall be, checked by the contractor. Suitable modification as required shall be carried out by the Contractor and complete design for the same shall be furnished to owner for approval. Where ever new columns/foundation is required the same shall be designed and constructed by the contractor as per relevant Indian Standard Code.

For the foundations of the all equipments details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic forces as per 18:1893. The dynamic analysis shall consist of free vibration

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analysis and forced vibration analysis. Design of RCC foundations/as well as structures, checking of design of existing structure shall be carried out by working stress method. A fatigue factor of 2.0 shall be considered for dynamic forces.

The foundation general arrangement shall be such that the spring units are placed over the structural steel beams. The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The vibration amplitudes at the bearing locations shall not exceed the limits as per VDI 2060 or limits specified by the machine supplier whichever is more stringent. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

The grade of concrete for the top deck shall be M35.

k) Steel Helical Springs and Viscous Dampers

The supporting structural beam and columns shall be designed for the loads transferred through springs and all other loads such as piping loads, seismic loads as per IS:1893. The stiffness of the beams supporting the springs shall be at least 10 times the stiffness of the springs supported over it along both vertical and horizontal direction.

The scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implied for the successful completion of the work for which these specifications are intended.

Scope of work of the bidder shall include manufacturing, testing, supply, transport to site, pre-stressing, erection, supervision of erection, release of pre-stress, alignment, commissioning etc of Steel helical springs and viscous dampers:

- Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
- Frames for pre-stressing of spring elements.
- Suitable hydraulic jack system including electric pumps, high- pressure tubes etc. required for the installation, alignment etc, of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.
- Any other items which may be required for the complete installation and satisfactory commissioning of the spring system.

Supervision of complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

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The steel helical springs and viscous dampers supplied should be of proven make. The bidder or his sub-contractor should have designed spring supported machine foundations, manufactured, supplied and installed steel helical springs and viscous dampers (conforming to DIN 2096 & DIN2089) and viscous dampers (providing damping resistance in all three planes) for not less than 2 (two) machine foundations of heavy rotating machine systems.

The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of units.

All design calculations and drawings shall be submitted to Owner for approval.

5.3 Stability of Structures

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like underground storage tanks, pits, trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For the purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area of the base slab shall be taken in to consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS: 456 and other latest relevant IS codes. However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum
- Factor of safety against sliding shall be 1.5 minimum
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In cases where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

5.4 Minimum Thickness of Concrete Structural Elements

The following minimum thickness shall be followed:

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Table 2.5
Minimum Thickness of Concrete

S.No	Description	Thickness, mm
a)	Suspended floor / slab / walkways /canopy slabs, etc.	125
b)	Ground floor slab (non-suspended)	150
c)	Water Retaining slabs / walls	200
d)	Cable/pipe trenches/underground pits/Laundry walls and base slab	125
e)	All footings (including raft foundations)	300
f)	Parapets	125
g)	Sunshades	75 at edge
h)	Precast louvers / fins	50
i)	Precast trench cover slabs / floor slabs / louvers	75
j)	Paving	100
k)	Basement walls and base slab	200
l)	Bin Walls	150
m)	Underground tank:	
	Below ground water table	200
	Above ground water table	150

From fire resistance point of view minimum cover to reinforced concrete members shall be as per Table 16A of IS: 456.

5.5 Minimum Heights for Pedestal of Steel Columns

Pedestals to Steel Columns for building structures:

Top of RCC foundations (pedestals) shall normally be kept at a minimum [250 mm] above finished floor level (FFL) unless specified otherwise. Foundation levels for columns shall be decided to accommodate underground services, pits, trenches, etc.

Stair and ladder pedestal shall be kept [200 mm] above the finished floor level.

Pedestals to Steel Columns for Equipment structures:

- a) Equipment in open area : as required [(300 mm min)]
- b) Equipment in covered area : as required [(150 mm min)]
- c) Structures and equipment
Supplied by vendor : as per vendor's data subject to minimum as specified above.

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5.6 Minimum heights for encasement of steel columns

In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following:

- a) Open area : [300 mm] above paved level
- b) Covered area : [150 mm] above FFL

5.7 Concrete Works

i) General Description, Proportions and Mixing

Mix Design

At the commencement of the contract the Bidder shall make preliminary tests to determine the proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling and placing and when concrete hardens, it shall have the required strength, durability and surface finish. The Bidder shall get approval of Owner/Consultant to such proportions before he starts concreting. However, such approval shall not relieve the Bidder of his responsibility to produce concrete having compressive strengths as laid down in the foregoing Table.

No departure from the approved proportions will be permitted during the works unless and until the Owner/Consultant gives written authorisation for any change in proportion. The Owner/Consultant shall have authority at any time to check whether the mixing of concrete is being carried out according to the approved proportions.

For the all major and important R.C. works and for all special works, the design of mixes shall be made by the Bidder at his own cost, for each grade of concrete as well as for various workability. The design of mixes shall be made according to I.S. 10262 or any other approved standard methods.

The concrete made by designing the mix is termed hereinafter as "Design Mix Concrete".

The cement content for various grades of concrete shall be based on design mix. However, irrespective of requirement of cement found out from design mix, cement content of concrete shall not be reduced below the quantities specified as under.

Grade of concrete	Minimum cement content per Cu.m finished concrete
M-15	290 kg
M-20	320 kg

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M-25	380 kg
M-30	not less than 400 kg
M-35	not less than 400 kg

Water Cement Ratio

Where a particular water cement ratio is stipulated in the design or drawing along with the characteristic grade of concrete the design of mix shall be carried out by adjusting the other variable factors to obtain the characteristic strength of concrete with stipulated water cement ratio.

In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, such as water retaining structures, basements, underground premises, tunnels, pump houses, pre-stressed structure, thin precast members etc. the water cement ratio shall be kept low and preferably not exceeding 0.45.

The water cement ratio, as achieved in the Mix Design, or as specified in the drawings shall be adhered to strictly and shall not be varied without the permission of the Owner/Consultant.

Workability

The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling & placing so that after compaction it becomes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

The workability of fresh concrete at the place of batching/mixing shall be measured by compacting factor test and at the place of disposition by means of slump test. During the finalisation of Trial Mixes, the relationship between compacting factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS:1199.

Normally, in the condition of low water cement ratio as well as for medium/high workability, the workability shall be achieved by increasing the cement content, in consistent with added water.

In cases where the cement content is to be limited to reduce the heat of hydration, and the water/cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of plasticiser or air entraining agent. In such cases the method of mixing and dosage of the plasticiser/air entraining agent shall be according to the manufacturer's specification and with the approval of the Owner/Consultant.

The usual limits of consistency for various types of structures are given below:

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Limits of consistency

Degree of Workability	Slump in mm with Standard - Cone		Use for which concrete is suitable as per IS : 1199
	Minimum	Maximum	
Very low	0.0	25.0	Large mass concrete structure with heavy compaction equipment, roads and the like.
Low	25.0	50.0	Uncongested wide and shallow R.C.C structures
Medium	25.0	75.0	Deep but wide R.C.C structures with congestion of reinforcement and inserts
High	75.0	125.0	Very narrow and deep R.C.C structures with congestion due to reinforcement and Inserts

Durability

The durability of concrete, depending on the exposure condition, is to be taken into account while designing the mix. For given aggregates, the cement content should be sufficient to make sufficiently low water cement ratio and Appendix A of IS: 456 shall be taken as guideline for durability considerations.

Minimum fire rating of 2 hours shall be considered where fire hazard is expected and accordingly minimum cover shall be taken as per Table 16 A of IS: 456. For structures below ground level which are exposed to sulphate attack, requirement of cement shall be as per Table 5 of IS: 456. Intermixing of different grades of concrete in the same structure shall not be allowed in a particular element.

Mix design concrete shall be used for all areas other than plain concrete work used for lean concrete, screeds and backfill.

The following minimum grades of concrete as per IS: 456 shall generally be used for the type of structures noted against each grade.

Table 2.6
Grades of Concrete

Concrete mix/Grade	Type of structure
1:5:10	Fill concrete
1:4:8	Blinding layer below foundations, trenches and underground structures, foundation below brick wall, etc. Minimum thickness of layer shall be 75 mm

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Concrete mix/Grade	Type of structure
M15	Plinth protection work around buildings
M25	Base plate encasement, encasement of structural steel work, all RCC paving work, ground floor slabs, cable and pipe trenches, precast concrete work etc.
M30	All RCC structures and equipment foundations, super structure, grade beams, columns, roof slabs and all underground RCC structures, cable and pipe rack foundation, pedestals etc.

Inter mixing of different grade of concrete in the same structure shall not be allowed normally.

ii) Trial Mixes

- Before concreting commences, the Bidder shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation. Only materials which the Bidder intends to use for concreting (including all admixtures) shall be used in the trial mixes.
- Test cubes from trial mixes shall be made and tested in accordance with IS: 516.
- As per IS: 456 and IS: 516, three separate batches of concrete should be made, workability of each batch determined and three test cubes shall be made from each batch for each age (e.g. for 7 and 28 days) at which tests are required. The strength shall conform to target mean strength as per IS: 456 – Requirements for design mixes.
- The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength and if the average strength of the nine cubes is not less than recommended by IS: 456 and IS: 516, trial mixes.

iii) Quality and Testing

Not more than 5% of the test results may fall below the 28 days specified strength. Making and curing of test specimens shall be in accordance with relevant IS: 456, IS: 516 and IS: 1199.

All mixes can only be placed following approval by the Owner/Consultant. The mean strength shall exceed the characteristic strength by a margin of 1.65 times the standards deviation expected from the batching plant. However, no standard deviation less than 3.5 N/mm² shall be used as a basis for designing a mix.

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iv) Trial Mixes and Field Tests

Sufficient laboratory trial mixes shall be prepared to show that concrete complies fully with the specified performance criteria. The following tests are to be included:

- Air content < 1%
- Slump: Piles 170 + 25 mm, regular work 80 + 20 mm as per IS: 1199
- Fresh and hardened concrete densities
- Field trial mixes shall be carried out under full-scale site conditions as per IS: 4925 (for structural concrete only).
- Where directed by the Owner/Consultant, concrete incorporating reinforcement details shall be cored to assess stratification of mixes. Cores of 150 x 200 mm (diameter and length) shall be used.
- Each trial mix shall have 9 x (150 x 150 x 150 mm) cubes taken to measure 24 hours/7 days and 28 day compressive strengths. These trials shall be run for three consecutive days (for structural concrete only).
- At least 3 x sets of field trials shall be tested according to the provisions laid down in laboratory testing.
- The average 28 day characteristic strength for trial mixes shall be as per IS: 456. Failure to comply shall result in the mix having to be re-designed.
- All test results shall have to be complied before approval can be given.

v) Consistency of Concrete

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests measured in accordance with IS: 1199 and shall not exceed the values given in clause 7.1 of IS: 456-2000.

vi) Mixing of Concrete

- The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way and shall comply with the requirements of IS: 456, IS: 1791 and IS: 12119.
- The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than 2 (two) minutes after all the materials and water are in the drum.

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- Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

Bidder shall make suitable arrangements for carrying out all the necessary quality tests and ensure that testing work shall be carried out in compliance with the standards..

5.8 Strength of Concrete

i) Testing of fresh concrete by means of test cubes

- All test cubes shall be made and tested for compressive strength in accordance with IS: 456, IS: 516 and IS: 1199.
- The minimum required strength for different classes of concrete shall be as shown in clause "General description and proportions and mixing" here above.
- The grade of concrete required will depend partly on the particular use and the characteristic strength needed to provide the structure with adequate ultimate strength and partly on the exposure conditions and the cover provided to any reinforcement.
- A minimum of four test samples (of six test cubes each) shall be taken on each concreting day (from the same mix) and for at least each 40 m3 of concrete mixed. At least one sample shall be taken for each shift.
- For columns, beams and cantilevers seven (7) cubes for every 15 m3 of concrete poured shall be taken. The concrete for test samples shall be taken directly from the concrete mixer and shall be handled (vibrated etc) under similar conditions to those prevailing during the construction. The moulds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.
- The strength level of each type and each strength concrete will be evaluated separately and the concrete strength will be considered satisfactory if:
 - Compressive strength: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-
 - The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column 2 of table 11 of IS: 456.
 - Any individual test result complies with the appropriate limits in column 3 of table 11 of IS: 456.
 - Flexural strength: When both the following conditions are met, the concrete complies with the specified flexural strength:-
 - The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm².
 - The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm²..

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- g) If the results are less than those specified, the Owner must suspend all concreting work and order further tests. Any concrete found not to comply with the specification shall be broken out and replaced to the satisfaction of the owner.
- h) The Bidder shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

ii) Testing of concrete in structures

- a) The types of tests described hereinafter are applicable to the finished parts of the structures. They may be used in routine inspection and for quality control.
- b) Type of tests:
- Cutting cores: The procedure used shall comply with the requirements of IS: 516 or an approved equivalent standard.
 - Gamma radiography: The testing shall be carried out in accordance with the requirement of IS: 13311, part 1 or equivalent.
 - Ultrasonic test: Such tests may be used to obtain approximate indications of the strength of the concrete in the structures (IS: 13311, part 1).
 - Electromagnetic cover measuring devices: Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design (IS: 13311, part 1).
 - Rebound hammer test: Such tests may be used to obtain approximate indications of the strength of the concrete (Ref. IS: 13311, part 2).
 - Load tests of structures or parts of structures: If the results of the above mentioned check tests show that the quality of the materials is inadequate or if other defects are revealed, the owner may require a loading test to be made.
- c) For the purpose of testing floors, roofs and similar structures and their supports, the test load shall be equivalent to the sum of the characteristic dead load and one-and-a quarter times (1.25 times) the characteristic imposed load for a period of 24 hours which the works or part thereof to be tested have been designed.
- d) Wherever certain procedures for testing of parts in structures are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Owner/Consultant.
- e) If within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under superimposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.
- f) If the result of the test is not satisfactory, the Owner/Consultant shall instruct that the part of the works concerned be taken down or cut and

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reconstructed to comply with this specification. The Bidder shall at his own cost take down or cut out and reconstruct the defective work.

- g) The Owner/Consultant may require other tests to be made. Number of samples, tests and types will be as per Owner requirements.
- h) All the costs for the above mentioned tests shall be borne by the Bidder.

5.9 Materials

a) Storage of materials

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Storage of materials shall conform to IS-4082 "Recommendation on stacking and storage of construction materials and components at site". Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Bidder.

b) Cement

OPC/PPC Cement of reputed make conforming to relevant codes, shall be used for all Concreting works and the certificate of manufacturer shall be furnished with each batch. Cement used shall be ordinary Portland cement unless the chemical nature of the soil warrants special cement for structures below ground level.

Sampling and Testing of Cement

- All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties as required by relevant IS: 8112 for grade 43 and IS-12330 for sulphate resistant cement.
- The manufacturer's test certificate will normally be accepted as proof of compliance with the specification, but the Owner may order further tests of a character specified in the appropriate Indian standards. The confirmatory tests are to be conducted by a recognized quality control organization. The Bidder shall bear all expenses required for the preparation, dispatch, and tests of the samples. In case the results of such tests show any sample to be inferior to specifications, the whole consignment from which the sample was taken shall not be used and shall be immediately removed from the site.

Delivery and Storage of Cement

- The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture, date of original loading, destinations en-route, date of unloading, intended date of delivery to site.
- The Bidder shall obtain and provide to the owner the manufacturer's average test certificate for each consignment of cement to the works.

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- The certificates shall be provided before the consignments are required for use and shall show the chemical composition and physical properties determined in accordance with the relevant standard.
- Samples shall be taken from each consignment of cement and tested as directed by the owner in an approved independent laboratory.
- Consignments shall be used in the order in which they were delivered.
- Bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the owner before any cement is delivered to site.
- Each consignment of cement shall be separately stored for ease of access, identification, inspection and sampling. Sufficient stocks shall be maintained on site to ensure the proper progress of the works and the stock holdings shall be to the approval of the owner.
- No cement from any consignment shall be used in permanent works without the approval of the owner.
- Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter or which has been contaminated or is otherwise unsatisfactory in the opinion of the Owner/Consultant will be rejected and shall be removed from site without delay.
- The Bidder shall be responsible for satisfying himself that the performance characteristics of cement are not such as to necessitate excessive cement content or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete notwithstanding apparent compliance with this specification.

c) Reinforcing steel

General

Reinforcing steel used in reinforced concrete shall comply with the following standards:-

Deformed bars shall be of grade Fe500 and conform to IS: 1786.

Mild steel shall conform to IS: 432.

Mesh reinforcement shall conform to IS: 1566.

Binding wire

Binding wire for general use shall be annealed wire 16/18/20 BWG conforming to IS 280. The number of strands shall be as per IS specification.

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Reinforcement supports

- Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing; supporting, and fastening the reinforcement.
- Spacers shall be cast from concrete of the same quality as that in which they will be embedded.
- Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.
- Binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the Bidder shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

Certificates

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analyzed and the date of such tests and analyses and that such tests and analyses comply in all respects with the standards. The following tests shall be carried out on reinforcement:-

- Cast analysis
- Carbon equivalent value
- Tensile strength, yield stress, elongation
- Bend test
- Bond classification
- Chemical analysis

Stock of reinforcing steel

In order to ensure due progress of the works, the Bidder shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted as satisfactory by the Owner/Consultant.

Rejection

The owner at his discretion may order random testing of the reinforcement steel and in the event of any failed test reject the entire lot notwithstanding the manufacturer's or coating applicator's certificates.

The Bidder shall remove all rejected reinforcing steel from the site without delay at his own expense.

Storage

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All bars for reinforcement and steel fabric reinforcement shall be stored on the site under cover on timber or concrete supports suitably spaced and of sufficient height to keep the steel not less than 150 mm clear of the ground.

Bar-bending Schedules

The Bidder shall prepare bar bending schedules based on the detailed reinforcement drawings. These shall be presented to the Owner/Consultant for review. The Bidder is fully responsible for their completeness and correctness in every way nor shall any claim for extra cost or time be allowed on the grounds of errors or discrepancies which may arise between drawings and schedules.

d) Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. pH value of water shall not be less than 6.

Only potable water shall be used. Tests and quality of water shall be in accordance with IS: 456 or equivalent.

e) Aggregates

General

The aggregates for concrete shall be crushed natural rock subject to Owner's approval.

The aggregate to be used in the work shall be supplied from an established pit or quarry.

The concrete supplier shall obtain from the aggregate producer, or otherwise provide current test, examination, and inspection reports performed and certified by an approved laboratory for submittal to the Owner/Consultant.

As a minimum, this information shall include the following items:-

- **Item 1**

A comprehensive description, with current photographs of the pit or quarry, including but not limited to, identification by name and location, type of deposit, age, potential reserves, primary products by size including average gradation based on previous six (6) months production and the range for each sieve size; mining methods, process equipment, quality control organization and laboratory; the primary and alternate means of product transportation; listing of primary and secondary users of the product.

- **Item 2**

Petrographic examination in accordance with IS: 2386 (Part-8) and ASTM C-295 performed by a qualified concrete aggregate petrographer. This

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report shall be based on material produced and examined within the previous six (6) months and must be representative of the current production.

- **Item 3**

Coarse aggregate shall be sampled from current production in accordance with IS: 2386 (Part 1 to 8). Three [20 mm, 10 mm & 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:

IS 2386(Part 1):	Methods of test for aggregates for cement: Part 1 Particle size and shape (Amendments 3)
IS 2386(Part 2):	Methods of test for aggregates for concrete: Part 2 Estimation of deleterious materials and organic impurities (Amendment 1)
IS 2386(Part 3):	Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking
IS 2386(Part 4):	Methods of test for aggregates for concrete: Part 4 Mechanical properties (Amendments 3)
IS 2386(Part 5):	Methods of test for aggregates for concrete: Part 5 Soundness
IS 2386(Part 6):	Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregates (Amendments 2)
IS 2386(Part 7):	Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity
IS 2386(Part 8):	Methods of test for aggregates for concrete: Part 8 Petrographic examination
ASTM C-295	Standard guide for petrographic examination of aggregates for concrete

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the Owner/Consultant shall meet the requirements of IS: 383 and IS: 456.

Testing is to be carried out at the following intervals:

Table 2.7
Grades of Concrete

Type	Coarse Agg.	Fine Agg.
Grading	Daily	Daily
Specific Gravity	7 days	7 days
Magn Sulphate soundness	30 days	-

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Type	Coarse Agg.	Fine Agg.
Clay, Silt and dust content	Daily	Daily
Shape (elongation and flakiness)	3.5 days	-
Los Angeles Abrasion	Initial stage only	Initial stage only
Moisture content	2 days	Daily
Drying shrinkage	Initial only	Initial only
Organic impurities	30 days	30 days
10% fines value for concrete	7 days	-

Combined grading shall also be done on a daily basis.

Storage and handling of aggregates

- Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent wind blown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.
- Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect against wind blown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.
- Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.
- Rescreening Coarse Aggregate: Rescreening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If rescreening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.
- Natural or manufactured sand shall be allowed to drain until it has reached somewhat uniform moisture content before it is used.

Fine Aggregate

Fine aggregate source shall be manufactured crushed stone or river sand, excluding fines, which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone nor 4% for natural sand.

The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

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Crushed Stone Sand

- i) Concrete subject to abrasion 1 % by weight
- ii) All other concrete 3% by weight

There shall be no clay or fine silt present.

The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on an IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS: 383.

The grading of the aggregates should be such as to produce a concrete of the specified proportions, which will work readily into position without segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of silt adhering to the aggregate is found to be unacceptably high.

Coarse Aggregate

Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The unit weight of the coarse aggregate shall not be less than 2.5 t/m³. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm² when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

Samples of aggregates shall be submitted to the Owner/Consultant, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the Owner/Consultant have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

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f) Concrete additives

Use of Concrete Additives

Concrete additives approved by the Owner/Consultant shall be used to improve consistency, workability, quality and strength of the concrete.

Chemical admixtures manufacturer shall provide certified test reports from qualified independent laboratories showing actual test results indicating material that complies in all respects with the applicable specification.

Admixtures used in concrete shall conform to the appropriate specification and requirements as indicated below:-

- Air entraining admixtures shall conform to IS: 9103.
- Water reducing and retarding admixtures shall conform to IS: 9103. Accelerating admixtures shall not be used.
- High range water reducers shall be naphthalene-sulfonated polymer based material. No admixtures containing chlorides shall be used.
- Chemical admixture suppliers shall provide certified test reports with each shipment indicating compliance with the appropriate specification. The test reports shall include the chloride content of the admixture, specific gravity and solids content.
- Fibers: Polypropylene fibers shall be collated, fibrillated polypropylene fiber of approved manufacture.
- Admixtures used in production of concrete shall be the same as used in establishing the required concrete mix and shall be used in accordance with the manufacturer's directions.
- Liquid admixtures shall be stored in such a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations

Accelerating and Retarding Additives

Such additives shall only be used in case of necessity and after obtaining the written approval of the Owner/Consultant.

Plasticizers and Air entraining Additives

Plasticizers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Owner/Consultant and in accordance with the manufacturer's instructions.

5.10 Dismantling/Demolishing and Modification in PCC&RCC

- The dismantling implies, carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of a structure. This includes chipping work, cutting of reinforcement, making holes/opening

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etc. in concrete members, according to the required shape, size and profile at all elevations.

- The term demolition implies, taking up or down or breaking up of a structure/member, in part or full, as specified or shown in the drawings or as directed by Engineer.
- In a structural member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as directed by the Engineer.
- All material obtained from the demolition/dismantling work shall be property of the Owner, unless otherwise specified.
- All serviceable materials obtained, shall be separated out and stacked properly upto a lead of *[500 meter]* or shall be returned to OWNER's stores and all unserviceable materials, rubbish etc., shall be disposed off as directed by the Engineer, upto a lead of *[2kms]*.
- The dismantling / demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process or work.
- Necessary propping, shoring and under pinning shall be provided for safety of adjoining work or property which is to be left intact, before dismantling/demolishing work.
- All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall be taken to keep the dust nuisance down. Safety requirements stipulated in IS: 4130 shall also be followed.
- As and where necessary, the dismantled/demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Engineer. Wherever required, temporary enclosures shall be erected to minimize the dust or moisture infiltration.
- Wherever fresh concrete is laid over old concrete, to ensure proper bond between old concrete and fresh concrete, the surface of old concrete shall be thoroughly cleared by removing all loose particles and coat of epoxy paint shall be applied.

5.11 Minimum Cover to Foundation Bolts

Minimum distance from the centre line of foundation / anchor bolt to edge of pedestal shall be the maximum of the following:

Clear distance from the edge of base plate / base frames to the outer edge of the pedestal shall be minimum 50 mm

Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm

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Clear distance from the edge of sleeve or anchor plate to the edge of pedestal shall be 75 mm

5.12 Miscellaneous Requirements

Fillets at the junction of roof and vertical walls shall be provided with cast in-situ cement concrete 1:2:4 (nominal mix) followed by 12 mm thick 1:4 cement mortar.

A screed layer not less than 100 mm thick of cast in-situ concrete of nominal mix 1:3:6 shall be provided below all water retaining structures. A sliding layer of craft paper or bitumen paper shall be provided over the screed layer to destroy the bond between screed and base slab.

Plywood formwork shall be used for all water retaining / conveying structures and for all over ground concrete works. For other areas steel/ plywood formwork shall be used.

Unless specified 20 mm and down graded aggregates shall be used for all structural concrete works. However 40 mm and down graded aggregates may also be used under special conditions for foundation.

Tolerance for formed and concrete dimension shall be as per IS: 456.

5.13 Major Equipment Foundation

Special requirements for concreting of major equipment foundations shall be as given below:

Coarse Aggregates

Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali aggregate reaction. Materials, which contain high percentage of reactive silica, shall not be used. In exceptional cases of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations, which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundations).

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25° C when placed. For maintaining the temperature of 25° C in the top deck of machine foundations, crushed ice shall be used in mixing water.

Admixture

Plasticizer cum retarder/accelerating type admixture shall generally be added to the concrete for promoting workability in addition to retarding / accelerating setting time for mass concreting work. The Bidder shall submit the mixing proportion/report after conducting the design mix as per the relevant codes and standards. The slump of concrete shall generally be in the range given below:

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Block foundation : 100mm to 150mm
Column : 100mm to 150mm

Formwork

Plywood formwork shall be used for the top deck of all machine foundations. Any other type of formwork required to be used may be permitted subject to prior approval of the OWNER/CONSULTANT after submission of the required data.

Scheme for Concreting

Batching plants shall be mobilized for all RCC works. Concrete pump shall be mobilized for foundations. Arrangements for stand-by Plant and Equipments shall also be made.

Placing of Concrete

Base mat as well as top deck of machine Foundations shall be cast in a single pour. However the BIDDER shall submit method statements for various structures and shall get the prior approval from the OWNER/CONSULTANT before placing the concrete.

Ultrasonic Testing

Ultrasonic pulse velocity test shall be carried out for the top deck of all machine foundations to ascertain the homogeneity and integrity of concrete. In addition, additional cubes (at the rate of one cube per 150 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values. Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the BIDDER shall rectify the defects suitably using cement / epoxy grout etc.

5.14 Transport of Concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods, which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The Concrete shall be transported by transit mixers of adequate capacity. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Owner/Consultant.

The Bidder shall obtain permission well in advance of any concrete pour.

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5.15 Concreting Operations

Inspection prior to Concreting

All concreting methods shall be subject to the approval of the Owner/Consultant.

Concrete placing shall not be started until the Owner/Consultant has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

Placing of Concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The Bidder shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

The temperature of concrete shall not exceed 40°C measured at discharge into the works.

The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable differential temperature between any two points in the same element is 15°C. Additional temperature control measures during construction (such as the use of insulated formwork) will be required. Bidder to prepare a process control chart and method statement verifying measures to achieve these requirements.

Temperature monitoring of concrete work is required where:

The minimum dimension of any casting is 0.8 metres or more, or otherwise instructed by the Owner/Consultant.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours time shall be subject to the same treatment as the construction joints.

Concrete shall not be dropped into place from a height exceeding 1.5 metres. Trunking and chutes to Owner/Consultant's approval shall be used for any concrete to be deposited from a height exceeding 1.5 m.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured

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continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

5.16 Compaction and mechanical vibration of concrete

As concrete is being placed it shall be compacted by mechanical vibrators complying with IS: 2505, IS: 2506, IS: 2514 & IS: 4656, to obtain a dense material free from honeycombing, free from water and air holes.

The Bidder shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation/bleeding caused, but complete compaction of the concrete is achieved.

5.17 Finish of concrete

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

5.18 Construction, expansion and contraction joints

Construction joints

The number of construction joints should be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subject to agreement between the Owner/Consultant and the Bidder before any work commences. Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Concrete should not be allowed to run to a featheredge and vertical joints should be formed against a stop board.

The top surface of a layer of concrete should be level and reasonably flat unless design considerations make this undesirable. Joint lines should be so arranged that they coincide with features of the finished work.

If a kicker (i.e. a starter stub) is used it should be at least 70 mm high and carefully constructed. The kicker must be incorporated with the previous concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

The maximum horizontal length of wall to be poured in one operation in any one direction is 7.5 metres. A period of 7 days to be allowed between adjacent

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pours except where water stops are provided when this can be reduced with Owner/Consultant's approval. Alternatively a gap of 600 mm width shall be left between adjacent pours and filled after 7 days from the date of formation subject to Owner/Consultant's approval.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible a vibrator should be used.

Where the Owner/Consultant considers that special preparation is necessary, i.e. for an in-situ structural connection, preparation should be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush, which is sufficient to remove the outer mortar skin and expose the larger aggregate. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking of hardened surfaces should be avoided.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.

Joints shall be straight and vertical, except where otherwise specified, and concrete surfaces on both sides of the joint shall be flush. Where necessary, water stoppers of a type approved by the Owner/Consultant shall be embedded in the concrete. The water stopper should be made of high quality material, which must obtain its resilience through the service life of the structure for the double function of movement and sealing. The surface of water stoppers should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints the water stopper should be provided with anchor parts. The cross-section of the water stoppers should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

All joints between structural steel and concrete parts shall be sealed by a suitable permanent flexible compound.

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5.19 Concreting at night

When approval is given to carry out concreting operations (under control of the Owner/Consultant) at night or in places where daylight is excluded, the Bidder has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

5.20 Protective measures for concrete

In general, the cover of rebars shall be as per IS: 456 taking into account the site conditions. However, the minimum concrete cover shall not be less than:

Concrete parts above ground (external surface)	: 40 mm
Concrete exposed to underground & groundwater	: 50 mm
Isolated footings	: 50 mm
Raft	: 75 mm
Slabs	: 25 mm
Beams	: 25 mm
Columns	: 40 mm

Immediately after the compaction of the concrete has been finished, the Bidder shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constant moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Owner/Consultant. Where formwork cannot be removed within 24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Owner/Consultant's approval to the use of a particular curing compound and to the method of application will only be given after the Bidder has completed satisfactory site trials and a sample panel has stood for at least 28 days.

Where large sections of concrete are poured, special precautions to the approval of the Owner/Consultant shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete.

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind, however light, shall be allowed on concrete which has not properly set and the Bidder shall prevent any load to be imposed on the concrete structures until it has been declared by the Owner/Consultant to be ready to carry loads.

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5.21 Concrete with Special Properties

General requirements

The pre-condition for obtaining concrete with special properties is that it should be made with the appropriate composition, that it is placed in such a way that segregation does not occur and further that it is fully compacted and given appropriate curing.

Waterproof concrete

This concrete must meet the provisions of IS: 3370. Waterproof concrete must be sufficiently dense (impermeable).

Waterproofing and protection of underground concrete structures

Water aggressive to concrete should be kept away from the fresh concrete.

Concrete, which is exposed for a prolonged period to “very severe” chemical attack, must be protected against direct access of the aggressive substances.

The protection, which is to be laid as protection to all concrete surfaces in contact with the ground, shall consist of an approved waterproofing membrane. The membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane.

Such membranes shall be PVC sheets of minimum 0.35 mm thickness with knobs of Maxlock.

The waterproof membranes shall be installed in strict accordance with manufacturer’s instructions.

The membranes shall extend 15 cm above ground level.

When setting forms and reinforcing steel caution shall be exercised to avoid damage to the impervious membrane. The surface of the impervious membrane extending outside the forms shall be protected during subsequent operations.

Any puncture or damaged areas shall be cleaned and patched according to manufacturer’s instructions.

Concrete with high wearing resistance

Concrete which is exposed to severe mechanical action, e.g., due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, should possess high wearing resistance and correspond at least to grade M30.

The aggregate upto 4 mm size should consist predominantly of quartz or materials of at least equal hardness; the coarser particles should consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action, it will be necessary to use special hard

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materials. The particles of all types of aggregate should have a moderately rough surface and be of compact shape. The combined aggregate should be as coarsely graded as possible.

Furthermore, the concrete should be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete should be kept moist for at least 7 days after placing.

Finishing of formed surfaces

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that shall be covered with earth backfill. Exterior surfaces that shall be exposed above grade and all interior surfaces, except those not usually exposed to view shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed. The resulting recesses shall be cleaned, wetted, and filled with patching mortar. Patches on rubbed surfaces shall match the texture of the adjacent concrete.

Finishing of unformed surfaces

No surface treatment shall be required for buried or permanently submerged concrete. As a minimum, unformed surfaces shall be finished by screeding and floating. Surfaces requiring a trowelled finish shall be finished by screeding, floating, and trowelling.

Float finished and screeded surfaces shall be finished to provide a flat profile within a 6 mm deviation as measured from a 3 m straightedge. Trowel finished surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 3 mm when measured from a 3 m straightedge.

Screeding

Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

Floating

The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

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Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and colour.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

Trowelling

The exposed portions of the tops of equipment bases, tops of interior curbs, and the surfaces of interior slabs not receiving a separate finish shall receive a steel trowel finish. Trowelling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Trowelling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

Surfaces to be covered with neoprene-hypalon coatings shall be lightly trowelled but not burnished.

Brooming

Brooming shall follow the float finish for exterior surfaces where a nonslip surface is required. Brooming shall be done with an acceptable steel or fiber broom not less than 450 mm wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1.5 mm and 3 mm deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

Aggregate Exposure

Surface mortar shall be removed and the aggregate exposed from surfaces that shall be covered with mortar, concrete, or grout at a later time.

Edging

Unless specified otherwise, exposed edges of floated or troweled surfaces shall be edged with a tool having a 6 mm corner radius.

Finishing mortar

Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 102 kilograms of concrete sand to one sack of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 50 mm.

Separate finishes

Certain slabs surfaces shall be finished with a separate concrete finish or floor covering.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances. Low areas shall be filled. High spots shall be ground

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slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 3 mm from a 3 m straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the drawings or a float finished surface set 3 mm low and levelled with trowel finished fill material.

Surfaces that receive a mortar set quarry tile, ceramic tile, or vitrified finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 6 mm as measured from a 3 m straightedge.

5.22 Formwork

Design and construction

For stability and type of formwork and support framing used, IS: 14687 is to be observed.

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section) "Dimensional Tolerances".

The Bidder shall submit in sufficient time in advance for the approval of the Owner/Consultant the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Particular attention must be paid to the formwork supports and braces to avoid any slip when the concrete is poured.

Materials for formwork

Forms shall be constructed from steel or from sound timber well seasoned and free from shakes. Plywood lining for forms shall be of timber, which is resin-bonded and water repellent.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete. Where a slope exceeds 1 V: 2 ½ H, formwork shall be provided for the top of the concrete faces and anchored to prevent flotation.

The details of fair-faced concrete facades have to be to the satisfaction of the Owner/Consultant. The concrete surface for facades has to be absolutely

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stainless and all efforts have to be taken to achieve this. All the proposed formwork shall be properly designed before its usage.

Grading of formwork and of finished concrete surfaces

Quality of formwork, materials to be used and treatments of surface are graded according to the finish of the concrete surface as given in IS: 14687.

The type and treatment of the formwork lining (plywood, metal, plastics, etc) should be appropriate to the grade of concrete finish required.

Preparation and inspection of formwork

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces, which are not oiled, shall be wetted thoroughly to prevent warping.

Erection and placing of formwork

All formwork shall be erected and placed in accordance with the construction drawings approved by the Owner/Consultant. Shuttering shall be true to line and braced and strutted to prevent deformation under weight and pressure of the wet concrete, live loads, wind and other forces. The deflections shall not exceed 3 mm.

The formwork for beams and slabs shall be erected so that the form on the sides of the beams and of the soffits of slabs can be removed without disturbing the beam soffit.

If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Wherever necessary, panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc shall be fixed to the formwork carefully.

Panels shall be put together to ensure a perfect fit at the joint and fixed in both directions.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on the drawings as "Fair-faced Formwork".

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Where concrete surfaces are covered (non-exposed surfaces), the formwork shall be referred to and marked as "Sawn Formwork".

Internal spacers and ties, if any, shall be so arranged that after removing of the forms no holes shall extend through the concrete, in the case of watertight concrete or to be closed by plastic plugs and epoxy mortar in all other cases.

All formwork will be inspected and approved by the Owner/Consultant before concrete placing commences but this shall not relieve the Bidder of any of his responsibilities under the contract.

Striking of formwork

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

In accordance with IS: 456 clause 11.3.1, the striking period for cast in-situ concrete under certain conditions may be taken as follows: -

Table 2.8
Formwork

Type of Formwork	Minimum period before striking formwork
Vertical formwork to columns, walls, beams	16 to 24 hours
Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs:	
1) Spanning upto 4.5 m	7 days
2) Spanning over 4.5 m	14 days
Props to beams and arches:	
1) Spanning upto 6 m	14 days
2) Spanning over 6 m	21 days

Special care is necessary in the case of components, which have to carry nearly the full-calculated load as soon as the formwork is struck.

Columns, piers and walls are to be struck before the beams and slabs supported by them. Scaffolds, formwork supports and self-supporting floor formwork are to be carefully lowered by releasing the devices.

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Extreme care shall be taken to avoid chipping of corners during removal of formwork.

To keep deflections through creep and shrinkage to a small amount, auxiliary supports should be left in place or immediately repositioned after striking.

5.23 Water stoppers

Water stoppers shall be of PVC or equivalent and shall be eye-letted with a minimum 25 cm width. Type and manufacturer shall be submitted to the Owner/Consultant's approval.

All intersection pieces shall be prefabricated by the manufacturer and only welding of butt-joints in running lengths will be allowed to be carried out on the site.

The site welding of butt-joints shall be executed by using the manufacturer's purpose-made electrically heated jig and work shall be done by competent and trained personnel only. The manufacturer's instructions shall be carefully observed.

The wings of the water stoppers shall be formed with corrugations or bulbs to achieve a good bond. Moreover, the water stoppers shall conform to the following requirements:-

- The tensile strength not less than 10 N/sq.mm when tested.
- The ultimate elongation shall not be less than 22% when tested.
- The tear resistance shall not be less than 2 N/sq.mm when tested.
- The material shall not crack when tested.
- Under accelerated elongation, the tensile strength shall not be less than 8 N/sq.mm and the ultimate elongation shall not be less than 200%.

The water stoppers shall be installed so that they are securely held in position during the placing of concrete, which shall be fully and properly compacted around the water stoppers to prevent voids or porous areas. Adequate clearance between the reinforcement and all the water stoppers shall be kept to permit proper compaction of concrete.

No holes or nailing shall be made through any water stopper for fixing purposes. Jointing by lapping two pieces of water stoppers shall not be permitted.

The free edges of water stoppers shall at all times be protected from direct sunlight.

5.24 Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed and if required the concrete may be protected for few more days as per the design mix / approved methodology.

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Trowelled surfaces except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane-curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

Water curing

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The application of water may be interrupted for surface rubbing. The concrete surface shall not be permitted to dry.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap and kept saturated for the remainder of the curing period.

Membrane curing

Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at coverage of not more than 7.4 sqm/litre. Membrane curing shall not be used on surfaces that shall be covered at a later date with mortar, concrete, damp proofing, tile, or any coating. Membrane curing shall not be used on cast-in-place concrete bases for field-erected tanks. Membrane curing will be permitted only after prior approval of the OWNER/CONSULTANT.

Floor sealer

All concrete floors shall be given two coats of clear floor sealer in addition to that applied as membrane curing compound. The first coat shall be applied at the end of the curing period before any traffic is permitted on the floor. The second coat shall be applied after the floor has been cleaned in preparation for the final inspection. Floor sealer shall be applied in strict accordance with the manufacturer's recommendations.

5.25 Waterproofing/Damp proofing

A waterproofing seal shall be provided for all below grade structures where applicable by external tanking with PVC sheets of 1.0 mm thickness with knobs for membrane type waterproofing. In addition, joints in deep underground structures shall be provided with structural waterproofing.

Damp-proof course 40 mm thick, consisting of cement concrete 1:2:4, with admixture of approved water-proofing compound shall be laid at plinth level for walls of all buildings for protection of super-structure against moisture and dampness.

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5.26 Repair of damaged and defective concrete

Concrete after its final setting shall be inspected by the Owner/Consultant and any cracks, honeycomb areas, segregations, etc shall be marked. No repairs shall be carried out until directed by the Owner/Consultant.

Surface defects in formed concrete shall be repaired to the satisfaction of the Construction Manager within 24 hours. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 25 mm shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the concrete is placed.

Defective concrete shall be replaced within 48 hours after the forms have been removed.

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6. PRESSURE GROUTING

The work shall consist of drilling grout holes, exploratory holes and check holes, pressure testing, pressure washing, and injecting suspension grout under pressure, and shall include furnishing of all materials, labor, and equipment as described and specified.

6.1 Materials

a) Cement

Portland cement shall be containing less than 0.6 percent alkali.

b) Aggregate

Aggregate shall be non reactive and shall be washed before use. When sources of aggregate are changed, test reports shall be provided for the material from the new source prior to commencing grout work. Fine aggregate shall be sand or crushed stone.

c) Admixtures

Admixtures shall be compatible with the grout and shall comply with the manufacturer's recommendations. Admixtures shall be added to the grout mix separately.

Water Reducing Retarder: Water reducing retarder shall comply with relevant Indian standard or as approved by Owner.

Lubricant: Lubricant additive for cement pressure grouting shall be Intrusion Prepakt Intrusion Aid, Sika Intraplast N, or as approved by Owner.

d) Water

Water for washing aggregate, for mixing and for curing shall be potable, shall not contain more than 1000 mg/l of chlorides as Cl, nor more than 1300 mg/l of sulfates as SO₄, and shall not contain impurities which may change the setting time by more than 25 percent or a reduction of more than 5 percent of the compressive strength of the grout at 14 days when compared to the results for grout made with distilled water.

e) Grout

Drypack Grout

Drypack grout shall be a mixture of approximately one part cement, 1.5 parts sand, water reducing retarder and sufficient water to make a stiff workable mix, branded Dry Pack or approved equal.

Cement Grout

Cement grout shall be a mixture of one part cement, two parts sand proportioned by volume admixtures for pressure grouting and sufficient water to form a workable mix.

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Nonshrink Grout:

- Non-shrink expansive flowable grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticiser admixture shall be added in the grout. For grouting of base of machine foundation high strength ready mixed non-shrink flowable grout shall be used.
- Type and grade of grouting for structural columns and equipment bases shall be as indicated. Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M 30.
- Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipment. For secondary posts, stair and ladder base, etc. grouting shall not be less than 25 mm thick.

Special grout, where specified on the drawings, shall be provided in strict accordance with the manufacturer's instructions/specifications. Pre-mixed Grout Conbextra GP-2 of 'FOSROC' make or equivalent of crushing strength 650 kg/cm² for major equipment foundations and Conbextra GP-1 or equivalent having crushing strength of 450 kg/cm² for other foundations where concrete grade M30 or higher is provided

- Forms and shims used to obtain adequate clearance shall not be removed and the anchor bolts shall not be tightened for at least three days after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and edge of the foundation shall be finished smooth to allow drainage away from the base. Attachment of interconnecting piping of machinery and complete load transfer of machinery shall not be done before the bolts are tightened. During this period, grouting work shall be properly cured using rags/gunny bags.

In view of extremely small proportion (about 0.01% by weight of cement) of the aluminium powder required, it is necessary to take all precautions to ensure thorough mixing. It is advisable to mix the blend of aluminium powder thoroughly with sand and cement before water is added because aluminium powder has a tendency to float on water.

- Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement: 1 admixture: 1 sand), or as per manufacturer's instructions.

Pre-mixed non-shrinking grout shall be used as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

Epoxy Grout for Crack Repair and Dowel Anchorage

Except for applications involving pressure grouting or crack injection, epoxy shall be a high modulus, moisture insensitive, two components, 100 percent solids,

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thermosetting modified polyamid epoxy compound. The material shall equal which is capable of not sagging in horizontal or overhead anchoring applications.

Epoxy for applications involving pressure grouting or crack injection, shall be a high modulus, moisture insensitive, two components, injection grade, 100 percent solids blend of epoxy resin compounds. The material shall equal which is capable of achieving complete penetration of hairline and larger cracks.

Polymer Concrete for Resurfacing and Patching

Polymer concrete shall consist of a liquid binder and dry aggregate mixed together to make a flowable mortar. The liquid binder shall be a chemical and oil resistant, stress relieved, low modulus, moisture insensitive, two component epoxy resin compound. The binder material shall equal with a consistency similar to light weight oil for proper mixing with the aggregate. The aggregate shall be oven dry, kept in sealed packages until the time of mixing and be of size and consistency compatible with recommendations of the manufacturer of the liquid binder for the intended application.

Adhesive Resin for Dowel Anchorage:

Pneumatically operated caulk gun and automatically mixed at nozzle. Subject to compliance with one of the following: HIT RE500-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-2322), HIT-HY 150 MAX-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-3013), SET-XP Adhesive Anchoring Systems, Simpson Strong-Tie Co. (ICC ESR-2508).

6.2 Pressure Grouting Equipment

Pressure grouting equipment shall include a mixer and holdover agitator tanks designed to place grout at pressures up to 0.345N/mm² (50 psi). Gauges indicating grouting pressure shall be provided and the mixer shall be equipped with a meter capable of indicating to within 0.003 m³ the volume of grout placed.

6.3 Execution

Bonding compounds for use with grout is to be provided and installed per the manufacturer's recommendations.

a) Drypack Grout

Drypack grout is to be used for built-up surfaces, setting miscellaneous metal items and minor repairs.

Surfaces required to be built-up with drypack grout are to be roughened by brushing, cleaned and coated with the bonding compound before application of grout. The grout is to be applied to the required thickness.

b) Cement Grout

Cement grout is to be used for filling nonbearing portions of equipment pads and pressure grouting.

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Except for the specialized requirements for pressure grouting, grout is to be mixed and placed in the same manner as cast-in-place concrete. Grout is to be mixed for at least one minute and diluted grout is to agitated until placed.

c) Non-shrink Grout

Nonshrink, nonmetallic aggregate grout is to be used under equipment, bearing plates and column base plates. Nonshrink, metallic aggregate grout is to be used under rotating equipment where high strength and fatigue are of concern, to grout anchor bolts and to grout reinforcing steel. Grout is to be placed and cured in accordance with the manufacturer's recommendations.

Holes required for grouting shall be blown clean with compressed air and are to be free of dust or standing water. Horizontal holes for grouting are to be drilled at a slight downward angle and with the inserted dowel or bolt bent to match.

d) Epoxy Grout

Epoxy grout shall be used for repairing cracks by pressure grouting or gravity, repairing structural concrete and may be used for setting dowels or bolts in holes. Concrete is to be primed in accordance with the grout manufacturer's recommendations.

The use of epoxy grout must comply with the following restrictions:

- Limited to areas where exposure, on an intermittent or continuous basis, to acid, chlorine gas or to machine or diesel oils, is extremely unlikely.
- Limited to applications where exposure to fire or to concrete temperatures above the product heat deflection temperature or 120 deg F (40 deg C)(whichever is less) is extremely unlikely. Overhead applications are not allowed.
- Holes for the anchors shall be drilled (not cored), shall be blown clean with compressed air and shall be free of dust or standing water.
- The anchor type, size and embedment depth shall be as shown on the drawings and the anchor must be installed in accordance with the manufacturer's recommendations.
- The anchor must not be loaded until after the full curing period has elapsed.

e) Pressure Grouting

Prior to grouting, cracks and holes to be grouted shall be washed clean. Washing is not required for grouting soil voids. Once started, grouting shall be continuous until completed. In case of a mechanical failure or other stoppage of the work, the grout equipment shall be washed out sufficiently to ensure that fresh only grout is pumped when the work is restarted.

After grouting is completed, the Contractor shall remove the grouting plant and all related parts, equipment, and supplies from the site, including unused materials and waste.

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6.4 Field Quality Control

- Bidder shall make suitable arrangements for carrying out all the necessary quality tests and ensure that testing work shall be carried out in compliance with the standards.
- Testing of grout mixes for conformance to manufacturer's specified strength: The independent testing laboratory shall take four test samples of each day's grout mix and test grout mix samples at 7 and 28 days. Test reports shall be submitted to the Owner for review.
- Test 25 % of reinforcing steel dowels installed with adhesive resin on a given day in tension using pullout procedure. Test to 80% of specified yield strength of the dowel with special inspection. Dowels specifically noted on the drawings as "No test required" do not require tension testing.
- If the failure rate of dowels exceeds 10 percent, testing will be increased to 100 percent of that day's installation of similar anchors or dowels. Testing will be reduced to 25 % of that day's installation when the failure rate is reduced to 10 percent or less. Failed dowels will be replaced at no additional cost to the Owner. The Contractor will produce daily reports of all testing activities; copies of daily reports will be submitted to the Owner in a timely manner.

6.5 Submittal

- Manufacturer's data shall be provided for bonding compounds, dry pack, non-shrink, pressure grout, retardants, epoxy grout, polymer concrete.
- Test reports, accompanied by a manufacturer's statement that previously tested material is of similar type, quality, and manufacture as that which is proposed for use on this projects, shall be submitted for Cement, Aggregates, Retardants, Bonding compounds and Epoxy resin
- The Contractor's testing laboratory shall provide evidence of correction of deficiencies noted in the inspection report before materials specified in this section are delivered to the job site.

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7. RETROFITTING WORKS

7.1 General

- a) The Work shall, in general, conform to other works/items specified in this Specification.
 - If the specifications for any item are not available in in this Specification cited above, relevant BIS Specifications should be followed.
 - In case BIS Specifications are also not available, the decision of Engineer-in-Charge given in writing based on acceptable sound engineering practice and local usage shall be final and binding on the contractor.
- b) The work will be carried out in accordance with the architectural and structural drawings to be approved by Owner. The structural and architectural drawings shall have to be properly correlated before executing the work.
- c) For items where so desired, samples shall be prepared before starting the particular items of work for prior approval of the Owner and nothing extra shall be payable on this account.
- d) Materials brought at site of work shall not be used in the work before getting satisfactory Mandatory test results.
 - Equivalents for the various materials and the materials of approved make shall be got approved from the Owner in writing before using them on the work.
- e) The contractor shall submit the required documents regarding the genuineness of materials used such as manufacturer's certification that the firm has manufactured the supplied materials.
- f) The contractor shall get approved from the Owner the storage space for epoxy/polymer/patented/other manufacture of materials to ensure that the storage temperature is maintained between 5° C and 38° C unless recommended otherwise by the manufacturer.
- g) Contractor shall comply with manufacturer recommendations so as to comply with environmental conditions under which the repair materials may be applied.
- h) The contractor shall employ Principal Technical Representative & skilled site workers who shall have adequate qualifications and experience for the proper execution of such works and already performed works of this kind with success.
- i) Contractor shall advise all workers working with epoxies to avoid contact with eyes and skin, inhalation of vapours, and ingestion. Necessary protective and safety equipments in the form of hand gloves, welders' goggles, shall be provided by the contractor and used on site.

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- j) Care shall be taken to ensure that vibrations are well within acceptable limits for structural safety and users of the building.
- k) For the execution of protection and repair works, properly maintained plant and equipment permitting adequate treatment of the concrete substrate, proper execution of the work and determination of the required properties of the construction materials and construction measures must be present on the construction site.
- l) To ensure efficient and effective functioning, all plant and equipment must be checked on-site and at field material testing laboratory prior to first use and at appropriate intervals thereafter.

7.2 Chipping of Unsound/Weak Concrete Material

a) Purpose

To remove weak, loose or carbonated concrete over an area from its surface with pneumatically operated or power driven tools by chiselling, chipping etc.

b) Materials and Tools & Plants (T&P)

Power or pneumatically driven chisel, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator (0.2% phenolphthalein solution) with pH range at least up to 10.5 and clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

Procedure

Step-1: Prop and support to relieve the structural member of stress and strains.

Step-2: Scaffolding, if necessary for the exterior members, shall be done for working upon the area.

Step-3: Working Platforms for interior members, if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if necessary.

Step-5: Mark off the area to be repaired using straight lines between corners. The marked area shall have 90° corners with the sides parallel or normal to the direction of the reinforcement. The marked boundaries for the repair area should be a minimum of 50 mm outside the perimeter of the spall. For a single spall, the repair area should have a minimum width of 100mm in any direction. If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair.

Step-6: Cut shall be made along the marked boundary, normal-to-the surface. It should be made with a diamond cutter blade. However, when diamond cutting is not practical, the normal cut can be made with a power driven chisel. Minimum depth of cut shall be 10 mm. In situations where the diamond saw could cut

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into the reinforcing steel due to inadequate concrete cover, the boundary edge should be formed manually by means of chisel and impact hammers. A cover meter could be used to estimate the depth of cover.

Step-7: Chipping to remove all the unsound and weak concrete material shall be done carefully from the damaged portions of structural members by adopting mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

d) Tolerance

The chipping tolerances shall be $\pm 5\text{mm}$.

e) Chiselling

Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer. Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm Mechanical Milling (single drum, rotary cutter head with Tungsten-carbide bits) is applicable for large areas where the concrete cover is to be removed. Care must be taken to avoid contact with the reinforcing steel as both the reinforcement and the cutter drum could be damaged. Rounded And Feathered Edges should be hand cut to form normal-to-the-surface boundaries. All the edges and cavities shall be square shouldered.

Step-8: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on concrete in contact and in the immediate vicinity of reinforcement soon after its chipping. As otherwise, chipped concrete surface in contact with air is likely to get carbonated soon after its coming in contact with atmospheric carbon dioxide.

Step-9: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, in case the concrete in contact and in immediate vicinity of the reinforcement is carbonated.

Step-10: Inspection and soundness testing, after concrete removal & cleaning, for weaknesses and delamination of exposed surfaces shall be visually carried out. If required, additional removal will be done.

Step-11: Cleaning of debris and dust shall be carried out from within the chiselled/ chipped area and its disposal as per direction of the Engineer-in-Charge.

7.3 Removing concrete all around reinforcement including from its behind

a) Purpose

To create an average clear air gap equal to nominal size of coarse aggregate plus 5 mm all around embedded reinforcement, in contact with carbonated concrete for rust removal & passivating its surface with fresh alkaline passivating coat and concrete/ mortar.

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b) Materials and T&P

Power or pneumatically driven chiselling, abrading, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator i.e. 0.2% solution of phenolphthalein indicator for pH range preferably up to 11.5 or at least up to 10.5, clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support, if not done already, to relieve the structural member of stress and strains.

Step-2: Scaffolding & working platforms for the exterior members, if not already done and if necessary, shall be erected for working upon the area.

Step-3: Working Platforms for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if not already done and if necessary.

Step-5: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on freshly chipped concrete in contact and in the immediate vicinity of reinforcement.

Step-6: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, if the concrete in contact and in immediate vicinity of the reinforcement is carbonated. The concrete around reinforcement shall be removed so as to have a near uniform air gap of about 5 mm plus the nominal size of coarse aggregate to be used in repair concrete/mortar. However, the air gap shall not be less than 15 mm in any case. Power/pneumatic driven tools/chisels shall be used for such portions of carbonated concrete around reinforcement, which could not be removed manually, to achieve a near uniform required air gap all around including behind the reinforcement. Power Driven Chisels/Hammers are normally applicable for chiselling smaller depths up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger depth in excess of 50 mm.

Step-7: Cleaning of debris and dust shall be carried out from within the chiselled /chipped area and its disposal as per direction of the Engineer-in-Charge.

7.4 Rust Cleaning from reinforcement steel

a) Materials and T&P

Chiselling, abrading, chipping, hammering, wire brushes, paint brush, abrading cloth, etc hand tools complete with accessories, tested and approved chemical rust remover.

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b) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

c) Procedure

Step-1: Cleaning by manual method-

Remove the rust manually from all round the surface along the length of reinforcement, using hand tools like chisels, hammers, wire brushes, abrading cloth/paper, etc. This shall be continued manually along the length of the rusted reinforcement till such time that the steel surface is cleared of all rust that could be removed manually.

Step-2: Cleaning by chemicals –

Remove the Rust by using tested chemicals, if directed by Engineer-in-Charge, due to unsatisfactory results of manual rust removal. Chemical rust remover shall be brush applied over the reinforcement surface thoroughly all around the circumference and along the full length of rusted reinforcement. After 24 hours (or as prescribed by manufacturer) of its application, the surface shall be cleaned with wire brush and all loose particles removed. It shall be washed with water thoroughly and allowed to dry.

7.5 Cleaning Reinforcement and exposed concrete surface of loose and foreign material by means of sand blasting

a) Purpose

Clean the prepared concrete surface of all-loose, lightly sticking materials including the foreign materials, loose concrete, aggregates etc to provide a good bond with the applied repair material and clean the reinforcement surface of any minor rust remaining after manual and chemical cleaning to achieve shining bright metal.

b) Materials and T&P

Coarse sand conforming to Zone I or II as per IS: 383, Air compressor of a minimum 35 Kilowatt capacity, spray gun for sand, all related accessories for sand blasting, hand tools like wire brushes, chisels, etc

c) Testing of Materials and T&P

The sand shall be tested to conform to the specification.

The air compressor shall be tested to perform to the required standards as laid down in specifications of shotcreting.

d) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

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e) Procedure

Step-1: Specified tested coarse sand shall be collected at site in required quantity for sand blasting.

Step-2: Make available mechanical power driven air compressor in working condition at site with all required accessories for carrying out sand blasting as well as air blasting operations.

Step-3: Coarse sand shall be sprayed under pressure over the exposed surface so as remove all loose and foreign material and to cause an intense abrading of the reinforcement and removal of rust from entire surface of reinforcement to achieve shining bright surface. The sand blasted surface shall be subsequently cleaned with oil free air blast.

7.6 Providing drilling and inserting nipples along crack lines

a) Purpose

To fix injection nipples and seal the remaining portion of honey combed or cracked concrete /masonry for grout injection.

b) Materials and T&P

12 mm diameter approved PVC/aluminium /Galvanised Iron nipples, Chisel, hammer, power driven tool for chase cutting & drilling, hand operated blow out pump, sealing putty of polyester/epoxy/polymer modified mortar etc. and all related accessories and materials.

c) Testing

The sealing putty and the nipples shall be tested to conform to the manufacturers specifications. The power driven tools shall be test driven and their drill/cutting bits shall be tested for effectiveness before taking up the repair operation.

d) Procedure

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Personnel, Supervision, Product delivery, Storage and Handling etc.

Step-2: Identify the Cracks and mark the area for injection grouting.

Step-3: Prop & support the structural member, if required, to relieve it of stress and strains.

Step-4: Open up cracked surface by making 'V' notch or groove of size 12 mm x 12mm.

Step-5: Remove plaster, if required, to identify and mark the honey combed area.

Step-6: Drill holes at least 25 mm diameter and 40mm deep along crack lines at spacing of 300 mm or thickness of the structural member, whichever is less. In

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honey combed area @ 9 nos per sqm. as directed by Engineer-in-Charge and up to 30 mm to 40 mm depth.

Step-7: Remove coarse debris and dust in opened up cracks and drilled holes by blowing oil free compressed air, if available with air compressor, otherwise with hand operated blow out pump. Concrete surfaces required to be grouted shall be free from all loose and unsound materials by means of mechanical abrasion using stiff wire brushes, after removing all loose areas with chisel and hammer. Area shall be made free from any deleterious materials, such as oil dust dirt etc. by means of oil free jet of compressed air. All prepared concrete surfaces shall be thoroughly inspected and got approved by the contractor.

Step-8: Insert 12mm dia specified injection nipples in holes drilled along crack lines and fix them by sealing only its sides with epoxy or polymer modified mortar.

Step-9: Seal the crack or the honey combed surface between the nipples by polymer modified mortar as may be approved by Engineer-in charge. The polymer used shall be of approved grade and applied as per specifications mentioned separately elsewhere. The polymer-modified mortar shall be moist cured for 1-3 days and allowed to gain strength before actual grouting commences.

7.7 Sealing of cracks by injection of advance grout

a) Purpose

To inject the specified grout into honeycombed or cracked concrete/ masonry

b) Materials and T&P:

Cement, sand. Water and admixture for cementitious grout shall be as per clause 5 of this specification.

Polymer: It shall be as specified and shall conform to ASTM-C-1059.

Hand/power operated grouting pressure pump/gun with pressure gauge. The grouting equipment shall be capable of supplying, mixing, stirring and pumping grout to the satisfaction of the Owner. The equipment shall have the capacity to inject grout at a pressure upto 7 kg per square centimeter measured at the grout connections. It shall be capable of mixing and pumping of cement sand grout 1:2 with water cement ratio ranging from 0.5 to 1.

Air compressor with all related accessories for carrying compressed air to the required location. Hand operated blow out pump may be allowed by Owner for small crack depths/areas.

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing, Spray equipment/brush for application of polymer modified/ bonding cement slurry

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c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured material (e.g. specified resin, hardener, polymer, cement, etc as may be required) shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: If directed by Owner, collect random samples of materials for test and send to approved laboratories so as to ensure that they satisfy the physical and mechanical properties. The grout pump and the pressure gauge shall be tested before taking up the repair operation.

Step-4: Identify the Cracks and mark the area for injection grouting.

Step-5: Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

- Prop & support the structural member to relieve it of stress and strains.
- Provide grouting nipples.

Step-6: Blow the compressed air followed by washing with water through nipples located at the highest level and downwards to ensure removal of even fine dust particles from the cracked surface, which could obstruct the free flow of grout material and impede its bonding with cracked surface (and drying with air blast wherever epoxy injection grout is to be used).

Step-7: Saturate the cracked surface in the vicinity of crack/honeycombed concrete/ masonry with water (but without excess water), only if the cementitious grout is to be injected. Otherwise, this step may be skipped.

Step-8: Prepare the injection grout as specified under clause 5 of this specification.

Step-9: Inject the approved & specified grout into the cracks by means of suitable gun or pump at a pressure of 1- 2 kg./cm² for epoxy grout and 4-7 kg./cm² for cementitious grout. In case of vertical cracks injection shall be started at the lowest nipple and continued until the injected grout begins to flow out at the next higher nipple. Whereas in other cases of horizontal locations, the injection shall be started from one nipple and continued until the injected grout begins to flow out at the other nipple.

The first nipple shall then be closed off and injection continued at the second until the grout flows out at the third. The process shall be repeated until the whole of the crack has been sealed. As soon as the system is cured, the nipples shall be cut.

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In case of Honeycombed Area, each grout hole shall be grouted individually. Grouting pressures to be used in the work will vary with the conditions encountered and different areas and the pressure used shall be between 1 to 4 kg/cm². The sequence of injection shall be as per the direction of Engineer-in-Charge.

7.8 Providing and inserting shear key bars

a) Purpose

Shear key bars are used for providing a structural connection of the applied repair material with the substrate/parent surface for transfer of forces occurring at the interface.

b) Materials and T&P:

Epoxy cartridges and specified lengths and diameter of steel reinforcement.

Standard Power driven drilling/hammering equipment, Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

c) Procedure

Step 1: Mark the locations of shear keys and get the same approved for structural connection from the Owner.

Step 2: Drill holes to specified depth and diameter in concrete at marked locations for the specified dia of shear key bars.

Step 3: The drilled hole in dry state shall be cleaned with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump.

Step 4: Inject epoxy from the foil pack with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards.

Step 5: Insert the reinforcing bar and allow the epoxy adhesive to cure.

7.9 Reinforcement for RCC works etc.

a) Purpose

To provide reinforcement in repair concrete for structural purposes, controlling effects of thermal variation or holding shotcrete/gunite material in position. The reinforcement material may comprise specified grade and quality with or without zinc coating.

b) Material & T&P:

Specified reinforcing material, necessary hand or power driven tools for cutting, bending, binding, transportation, handling and placement etc. Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

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c) Procedure

The general requirements, placing in position, measurement etc. shall be generally followed as in clause 4 of this specifications excepting those specifications provided in the following clauses.

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Testing of Material: The requisite number of test specimens of specified reinforcing material shall be collected from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements before use on the work.

Step-3: Execution:

The required reinforcement as per approved detailed drawings in the form of round bars or welded wire fabric in such a way so as to cause the least interference with placement of repair material.

d) Overlaps:

Lapped reinforcing bars shall not be tied together. They shall be separated by at least 50 mm wherever possible. Wire mesh shall be lapped by 1-1/2 squares in all direction. Minimum requirement of lap length of bars shall be as specified in I.S. 456.

e) Clearance around reinforcement:

Sufficient clearance shall be provided around the existing exposed and additional reinforcement to permit complete encasement with sound repair material.

f) Cover:

Minimum cover to reinforcement shall be as specified under clause 4 or as per I.S. 456. As far as possible the bars shall be arranged so as to permit shooting from opposite side.

g) Fixing:

Reinforcement shall be fixed to existing shear key bars and depth gauges driven into the concrete with wires and secured rigidly so that the vibration resulting from the deposition of repair material shall not impair or displace them.

h) Where Guniting /shotcrete to be done in more than one layer

In such cases, the additional reinforcement should be so fixed that it is encased in succeeding layer. No additional reinforcement is required to be fixed in first layer of guniting.

Mesh reinforcement shall be fixed in the manner so that it is firmly held at least 12 mm away from the parent concrete surface as well as from the final finished surface. It shall be ensured that it is stiffened enough and cannot belly out during the guniting / jacketing / concrete overlays with consequent lack of cover. It shall be done by tying with parent concrete surface through shear key

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bars or depth gauges. GI-wire mesh fabric will add sacrificial "Zinc" coating & shall reduce corrosion process in the reinforcement. The wire mesh spacing shall be as specified in the drawings.

7.10 Alkaline Passivating bond coat over Reinforcement

a) Purpose

To protect steel reinforcement with a passivating alkaline layer provided all around its circumference along the length with strong adhesive to bond with applied repair concrete or mortar.

b) Materials and T&P:

Specified alkaline passivating & bonding materials e.g. CPCC material, epoxy, epoxy phenolic IPN-RB or specified polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, mechanical mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882.

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

Patented materials e.g. CPCC or epoxy-phenolic IPN-RB as per licensee's specifications

c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: Prepare the surface for treatment.

Step-4: Thoroughly inspect all the concrete surfaces prior to applications of passivating/ bond coat and get approved from the Engineer-in-Charge.

Step-5: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-6: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),

Mechanical blender for mixing

Brush for application of specified and approved passivating/bond coat.

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Step-7: Material Mixing: Components of the passivating/ bond coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-8: Material Application: The alkaline passivating & bonding material shall be applied to prepared reinforcement substrate after tying in new reinforcement wherever specified in the form of bars or welded wire fabric. It shall be applied to reinforcement surfaces by stiff nylon bristle brush. The coating material shall be worked well all round the periphery and along its exposed length using a stiff brush ensuring that no pinholes are remaining. The second coat, if required, the same shall be applied as per manufacturer's recommendation after the first coat is touch dry.

7.11 Bonding coat for hardened concrete with repair concrete/shotcrete/cement mortar

a) Purpose

To provide adequately strong adhesion of parent concrete with applied repair concrete or mortar.

b) Materials and T&P

Specified bonding materials e.g. epoxy or polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, spray gun, mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

c) Execution

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer- in-Charge Full quantity shall be worked out as theoretically required for consumption in the whole work

Step-3: Prepare the surface for treatment.

Step-4: Saturate the surface with water but shall be free of excess surface water, debris and dust, where cementitious bond coat is to be applied. Otherwise, surface to remain dry and clean of debris and dust.

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Step-5: Thoroughly inspect all the concrete surfaces prior to applications of adhesive and get approved from the Engineer-in-Charge.

Step-6: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-7: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing Spray equipment, brush for application of epoxy, polymer modified, bonding cement slurry.

Step-8 Bond Coat Mixing: Components of the bonding coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-9 Bond coat application for jacket concrete/ shotcrete/ Mortar placement: The specified adhesive shall be applied to concrete surface at atmospheric temperatures below 40°C for epoxy adhesive and below 30°C for polymer modified cement or cement-sand slurry adhesive. Bonding coat shall be applied by spray equipment or stiff nylon bristle brush as approved by Engineer-in-Charge. The bonding material shall be worked well into the surface of the parent body ensuring that no pinholes are visible.

Polymer modified bonding cement slurry shall be applied to a thickness not in excess of 2 mm.

If necessary, a second coat shall be applied at right angles to the first to ensure complete coverage and absence of pin holes.

All concrete surface shall be well protected beyond limits of surface receiving adhesive against spillage.

Step-10 Repair Material Application: Fresh plastic concrete/ shotcrete/ mortar shall be applied while adhesive is still tacky and well within the pot-life/ setting period. If adhesive cures to the extent of losing its tack or has set before plastic concrete/shotcrete/mortar is placed, the same shall be removed or slightly abraded and second coat of adhesive applied. Freshly placed plastic concrete shall be thoroughly consolidated to ensure full bonding of new concrete with the substrate.

d) Bond of repair with parent concrete:

Evaluate bonding of fresh concrete/ shotcrete/ mortar to existing concrete after the fresh material has cured for not less than 7 days by sounding and tapping fresh concrete with a blunt metal instrument to the satisfaction of Engineer-in-charge. Suspect inadequate bonding, if a hollow sound is detected in any area.

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In case of conflicted location contractor shall extract one core from the repaired surface area at the end of 28 days.

Conduct one core test at random for checking the bond, for every 100 square metre or part thereof. The contractor shall core each area after 28 days of application of concreting/ shotcreting/ repair mortar application for determination of bonding adequacy.

Core drilling shall be done through applied repair material and into the existing concrete. Core diameter shall be not less than three times the nominal size of the coarse aggregate used in repair material or as required by the Engineer-in-Charge. Length of cylindrical cores shall preferably be twice the core diameter or twice the thickness of applied repair material or as instructed by Engineer-in-Charge but in any case not less than the dia of the core.

Cores shall be visually inspected by Engineer-in-Charge for evidence of poor workmanship.

Cores shall be tested in tension to evaluate the quality of bond between new concrete/shotcrete/mortar and the parent concrete. If the failure is in the parent concrete the bond of new repair material shall be deemed to be satisfactory.

Failure at the bond line or in the repair material shall be concluded as lack of proper bond or inadequate strength of repair mortar

Dismantle such areas of work failed in bond or repair material and re-prepare the surface after chipping off new concrete/mortar work and abrading the epoxy/polymer/cement slurry interface. Nothing for testing concrete for bond between old and new concrete shall be paid separately.

7.12 Curing of RCC Surfaces etc

a) Purpose

To ensure satisfactory hydration of cement by retaining or replenishing the mixing water lost due to natural drying and evaporation process for a specified period through exposed cementitious surfaces of the freshly placed cement mortar/ concrete.

b) General

Importance of wet curing to all items of work involving use of cement can not be over emphasised. Any surface experiencing discontinuity of dampness of surface with any patch having dried out during the specified period of curing, it shall be prominently marked with lime or other suitable prominent colour.

c) Materials and T&P:

Curing compound, brush or hand operated spraying gun and all other related accessories for application on Concrete/Plastered Surface.

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d) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified manufactured material shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out theoretically for consumption in the whole work.

Step-3

- **Moist Curing:**

Cover all exposed surface of concrete, when the concrete begins to harden i.e. two to three hours after compaction with moist gunny bags or any other material approved by the Owner.

Keep the exposed surfaces continuously damp after its final setting (i.e. after a maximum of 8 hours of concreting) by ponding with a sheet of water or by covering with a layer of sacks, canvass, hessian or similar water absorbent materials constantly kept wet by water sprinkling for at least 7 days, where ordinary portland cement is used and 10 days, where portland pozzolana cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as per manufacturer's recommendations or as directed by the Owner.

- **Using Curing compound:**

Testing of Materials:

It must be ensured that curing compound should neither affect the strength nor the surface of concrete. It shall not leave any undesirable stains on surface to affect the bond of plaster or other finishes to be applied later. It should be soluble in water, so that it can be removed by splashing or washing with water without scrubbing the surface.

Test for Efficacy:

The testing of curing compounds shall be done from each lot of curing compound received at site by casting two sets of 15 cm cubes with each set having 6 cubes. One set shall be moist cured by covering with damp gunny bags and subsequently by immersing under water and the other set by applying curing compound on top after 2 to 3 hours of casting and subsequently on de-moulding apply on the remaining faces all around. The cubes shall be kept in an environment similar to which the actual structure is exposed for a period of 7 days after its casting. Three concrete cubes each from both sets shall be tested after 7 days for their crushing strength as per standard test procedure. The average crushing strength of cubes cured with curing compound shall be not less than 95% of the crushing strength of cubes cured under damp or immersion curing.

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Test for Staining:

The set of three sample cubes applied with curing compound, remaining after 7-day cube crushing strength test, shall be washed with water with soft brush scrubbing with nylon bristles and allowed to dry for a period of seven days in an atmosphere with relative humidity not exceeding 40% at ambient temperature. The other set of three cubes cured for seven days under damp or immersion conditions shall also be kept for another seven days under identical humidity and temperature conditions. The surface of the two sets of such cubes shall be compared by closely observing for any visible stain and texture that may detrimentally affect its bond with subsequently applied plain plaster or aesthetic appearance. Such observations shall be recorded in three categories as no effect, slight effect and moderate effect. The curing compound shall be considered as acceptable in the 'no effect' category and unacceptable in the 'moderate' category. The decision of Engineer-in-Charge, which shall be final and binding, based on the likely use of finished surface of concrete/plaster shall determine the acceptability of the 'slight effect' category.

Concrete curing compounds, after testing satisfactorily for efficacy, may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing within two to three hours of casting and well within an hour of removal of formwork.

7.13 Engineered Steel Tubular double Scaffolding System

a) Purpose

To provide a scaffolding system with adjustable working platforms on the exterior of the building for the workmen to work upon any part of the area to be accessed safely and with ease for surface preparation, application of repairs and construction activity.

b) Materials

The standard proprietary tubular double scaffolding system of repute with all accessories, working platforms etc.

c) Design

It shall be designed for all the incidental dead, live and wind loads as per IS: 875 in steel tubular sections as per general design considerations governed by IS:800. The design of the scaffolding system shall cater to the safety features for the workmen.

d) Fabrication and Erection

Fabrication and erection shall be done as per the design brief and installation instructions of the proprietary firm. It shall be maintained in functional condition for the work duration.

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7.14 Temporary barricading using angle iron verticals and sheet panels

a) Purpose

To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work.

b) Materials

Available Corrugated G.I. Sheet minimum 24 G thick; Framing structural material at least MS Angle iron of size [40x40x5mm] or equivalent.

c) Fabrication & Erection

Size of framing panel shall be decided depending upon site conditions and these could be approximately 2.0 metres long with height as 1.8 metre.

It shall be made up at least of two verticals, each with additional length of about 600 mm for fixing in to ground firmly and two horizontals equal to the length of panel.

It shall be made up by cutting the structural sections to size, shear punching holes in verticals and horizontals for nuts and bolts or making other suitable provision for receiving CGI sheet or other specified panelling material and connection of panel with adjoining panels.

Fabrication of frame of an individual panel shall be by welding at corners, welding MS plate at base of verticals or any other acceptable practice approved by Engineer-in-charge.

G. I sheet or other specified panelling material shall be suitably fixed. It shall preferably be done by means of nuts and bolts at its ends spaced at about 300 mm c/c transversely and at about 600 c/c longitudinally along corrugations. The corrugations of CGI sheet shall run along the shorter span of the panel.

In case of newly fabricated panels, these shall be painted with red oxide zinc chromate primer on steel work and approved primer on other material and at least one coat of paint of approved shade. In case of used panels, one coat of paint of approved shade shall be applied over the existing paint. The portion of verticals to be embedded in ground shall be suitably protected against rusting by painting it with bitumen or other suitable paint.

The fabricated panels shall be suitably fixed vertically and firmly in to the ground to the satisfaction of Engineer-in charge by maintaining a uniform height of about 1.8 metres above GL and connecting each panel with the adjoining panels with nut and bolts or other suitable means.

Suitable provision of frame/posts in the openings provided in barricading shall be made for receiving door shutter at locations as approved by Engineer-in-Charge.

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7.15 Temporary protective fabric screens

a) **Purpose**

To protect passersby from falling debris and also to protect the workmen and structure being repaired against direct exposure to sun.

b) **Materials:**

For screening purpose jute cloth, woven PVC cloth, geo-textile or wire-mesh as specified and approved by Engineer-in-Charge shall be used, which shall conform to their relevant BIS Code. Screen materials shall be fixed by suitable means comprising of M.S.Flats/ J-bolts /nails/clamps, etc with washer or any other suitable means on frames of existing scaffolding etc.

c) **Procedure**

Scaffolding, if required, comprising of verticals, horizontals and diagonal bracings of steel tubes shall be fixed over ground which is payable separately.

One end of the screening material, brought to site in looms/rolls, shall be properly fixed over top horizontal member with suitable means and suspended so as to cover the required area.

The vertical fall of screen shall be suitably fixed/firmed up at intermediate levels so as to keep it in position during the work duration.

Next strip of the screening material shall be fixed with its sides stitched or suitably jointed or lapped with the previous ones as approved by Engineer-in-charge.

Spacing of frame member of scaffolding shall be so selected that the sagging of screen shall not hinder the repair process.

The contractor shall maintain the protective screens in acceptable conditions for the entire work duration as required by the Owner.

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8. CONCRETE RETROFITTING METHODS

In selecting the retrofitting method, the current status of the existing concrete structure as determined through inspection, the performance of the structure, the performance required of the structure after retrofitting, the conditions for retrofitting construction work, the ease of maintenance, economy and other factors shall be considered.

At the stage of selecting the retrofitting method, the current status of the existing structure and its performance shall be obtained, and the performance required for the structure after retrofitting and the conditions for retrofitting work shall be determined. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors.

Various retrofitting methods listed below shall be used for retrofitting objective:

8.1 Retrofitting of concrete members

a) **Continuous fiber reinforced plate bonding construction method:**

Bonding continuous fiber reinforced plates to the surface of the existing structure to restore or improve load-carrying capacity

b) **Continuous fiber reinforced plate jacketing construction method:**

Jacketing with continuous fiber reinforced plates around the periphery of the existing structure to restore or improve load-carrying capacity and deformation characteristics

c) **Prestressed concrete jacketing construction method:**

Placing pre-stressing wires and pre-stressing stranded steel wires in place of lateral ties around the periphery of existing member sections and using mortar and concrete to bond them in order to reinforce the structure. To increase the restraining effect of the inner concrete, the pre-stressing steel is generally stressed during placement.

d) **Pre-stressing introduction (internal cable) construction method:**

Using internal cables for the existing concrete members to provide pre-stressing and restore or improve the load-carrying capacity of the members.

e) **Repaving method:**

Replacing some or all of the existing concrete members with new members through the use of precast members or concreting on site to restore or improve load-carrying capacity.

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8.2 Retrofitting as a structural body

a) Beam (girder) addition method:

Adding beams between the main girders of the existing reinforced concrete deck to reduce the deck span and restore or improve the load-carrying capacity of the reinforced concrete deck.

b) Seismic wall addition method:

Placing new reinforced concrete walls between existing reinforced concrete rigid-frame bridge piers and bonding them to form a continuous unit in order to restore or improve the load-carrying capacity as a structural body.

c) Support point addition method:

Supporting the intermediate sections of the beams and other existing concrete members with new members to reduce the span of the members in order to restore or improve the load-carrying capacity as a structure.

d) Seismic isolation method:

Using seismic isolation bearings and the like to reduce the seismic energy applied to the structure in order to improve its various performance values during an earthquake.

8.3 Foundation retrofitting

a) Underground wall (beam) addition method:

Connecting the foundations with cast-in-site diaphragm walls and underground connecting beams to distribute stress and ensure the stability of the entire system.

b) Pile/footing addition construction method:

When pile foundations are damaged or there is residual displacement, adding piles or footings to increase the load-carrying capacity of the foundation.

c) Foundation improvement method:

Improving the ground around the foundation with cement improvement materials to improve the ground bearing capacity and horizontal foundation resistance. Also prevents excessive pore water pressure and liquefaction.

d) Steel sheet-pile coffering construction method:

Placing sheet-piles around the periphery of the footings and bonding them to the footings to improve bearing capacity and horizontal resistance.

e) Foundation compacting method:

When insufficient foundation bearing capacity is a concern due to scouring or the like, using concrete or the like to compact the ground around the foundation in order to restore bearing capacity.

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8.4 Repair of cracks and missing sections

a) **Cracks fill method:**

Forcing low viscosity resin and ultra-fine cement into the cracks in existing concrete members to seal the cracks.

b) **Fill method:**

Filling cracks, rock pockets, cavities, peeling and other small-scale missing sections in existing concrete members with resin and mortar to repair sections.

c) **Section repair method:**

Removing deteriorated or damaged portions of existing concrete members and then restoring these members to their original sectional status using materials with excellent bonding to existing concrete.

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9. SHORING AND UNDERPINNING

9.1 Material and Equipment

- a) The contractor shall furnish all materials, tools, equipment, facilities and services as required for providing the necessary shoring and underpinning work and facilities. Jack and jacking equipment shall be more than adequate for the imposed loads and shall be provided with calibrated gauges.
- b) Shoring and bracing materials
Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles, and accessories as required.
- c) Lagging and sheeting material
Provide heavy timber boards, planking or sheeting as required. Lagging board shall be secured in place by steel H-piles, with boards inserted between the H-flanges.
- d) Underpinning Pier
An excavation pit, provided generally by manual excavation, which is carried to a pre-selected bearing surface and then filled with concrete to provide supplementary foundation support for the underpinning structure.
- e) Concrete
Refer clause 4 of this specification for concrete requirements.
- f) Grout
Refer to Clause 5 of this specification for Non-Shrink Grout requirements.
- g) Structural Steel
Refer to Clause 9 of this specification for Structural steel requirements

9.2 Execution

- a) Detection of Movement
 - For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding improvements to be monitored. Settlement markers shall be capable of being read to an accuracy of 1.52mm.
 - Take and record readings not less than once per week during performance of the work until the permanent structures is complete to the ground level.
 - Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.

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- Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks or longer if movement persists, and report the results to the Engineer.
- The detection of movement shall be performed by a qualified licensed land surveyor or civil engineer.

9.3 Shoring and Underpinning

- Existing footings, foundations, pile caps, grade beams, retaining walls, or pavement which may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement.
- Provide soldier piling, lagging and sheeting, tie-backs, slurry diaphragm wall, and cementitious grouting, as required, to hold back earth at excavations and as required to prevent cave-ins and earth sloughs.
- Footings, foundations, pile caps, grade beams, retaining walls, or pavements which have been undermined by earthwork and pile-driving operations shall be filled and supported with concrete extended to undisturbed bearing earth or bedrock.
- Concrete may be placed as a stiff mix of minimum slump (dry pack), or concrete may be pneumatically placed (shotcrete), or concrete may be placed by conventional methods with concrete formed to hold it in proper position.

9.4 Concrete Piers, Walls and Pile caps

- Install concrete underpinning piers, walls, and pile caps as indicated, with the bottom at the indicated or bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed.
- Where earth forms are indicated, install waterproof building paper or board between the earth and concrete to prevent water loss from the fresh concrete.
- Do not remove support of existing structure until concrete piers, walls, or pile caps have attained design strength.

9.5 Piles and Caissons

- Install pipe pile shells or drilled shafts at locations indicated, and extend from underside of existing footings to indicated elevations, plus additional penetration if required to develop the design working load of the pile or caisson.
- Distribute jacking reactions over the existing structure in a manner that will not overstress or deflect the existing structure.

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- Weld splices where indicated. Provide watertight welds capable of developing the full strength of the pile or caisson. Align splices to ensure the straightness of the pile from top to tip. Use outside sleeves and backup rings as necessary.
- Where the pile tip is below the ground-water table, maintain the elevation of the water inside the shell at approximately the elevation of the ground-water table during installation of the shell.
- After installation of the shell, apply the full design-working load to the empty pile shell and maintain until there is no measurable settlement over a one hour period.
- Maintain the excavation within the pile shell approximately 12 inches above the tip during driving, and dewater pile shells prior to filling with concrete in a manner which will prevent loss of earth or soil at the tip. An earth plug may be left in the pile tip or a concrete plug may be placed and cured prior to dewatering pile shells.
- After load testing to the design load, dewatering, and inspection of the shell by the Engineer, fill accepted pile shells with concrete in the presence of the Engineer. Keep an accurate record of the volume of concrete deposited in each pile. Deficiencies revealed by comparing the volume of the inside of the pile with the volume of placed concrete will be cause for rejection of the pile or correction of the deficiency.
- Securely wedge in place with steel wedges those piles that have satisfied the load-testing requirements. Weld and encase in concrete all wedges, plates, wedging struts and piles, as indicated or required.
- Following completion of load transfer of underpinned structures, fill the underpinning pits with concrete as indicated. Provide reinforcement, shear keys, dowels, and water stops as indicated or required. Place concrete to within 3 inches of the underside of the existing foundation. After three days, dry pack the space between the foundation and concrete.

9.6 Load testing of piles and acceptance criteria

- After the concrete within the pile or shaft has set for at least 24 hours, test each pile or pier by jacking to a load equal to 150 percent of the design-working load of the pile. Maintain the load until there is no measurable settlement of the pile over a one-hour period.
- Load-test piles in sequences and groupings that will minimize or eliminate eccentric loadings on the existing foundation and piles.
- Piles will be rejected and shall be retested if, in the opinion of the Engineer, there is a danger of unequal loading.
- Should the existing structure fail to furnish sufficient reaction to installed underpinning piles to the test loads specified, provide additional reaction to prevent damage to, and movement of, the structure during installation of

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piles, and to obtain specified underpinning test loads. The additional reaction shall not detrimentally affect the structure.

- Maximum out-of-plumb tolerance for installed piles: two percent.
- Maximum offset of top of pile from the design center: 3 inches.

9.7 Fill and backfill

Provide engineered fill and backfill in accordance with Clause 3 of this specification, after acceptance of the underpinning by the Owner.

9.8 Temporary Supports

Install temporary supports where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work.

9.9 Restoration

Restore existing structures to conditions equivalent to those existing prior to the start of shoring and underpinning work, including repair of any settlement-related damage.

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10. STRUCTURAL STEEL WORK

Design of structural steel work shall include generally but not be limited to the steel constructions listed below:

- Steel building structure and open structures including beams, columns, bracings, supporting structures for floors, roof slabs, cladding etc.
- Hoist & monorail supporting beams etc.
- Platforms and walkways
- Ladders, staircases, handrails, etc.

10.1 Design

(a) General

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However where large cut outs are to be provided in the floor slabs horizontal floor bracing shall be provided. Grating / Chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support and horizontal bracing shall be provided as required in such cases.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimize vibration, avoid resonance and maintain alignment and level.

(b) Design of structure

The Design of steel structures shall be done by Working stress or Limit state method, in accordance with the provisions of IS: 800 and other relevant IS codes as applicable to specific structures. Basic consideration for structural framing shall be stability, rigidity, building usage, ease of fabrication / erection and overall economy. Additional bracings / moment connections shall be used to assure stability of structures. Structure shall be designed such that the surfaces of all parts shall be accessible for inspection, cleaning, painting and maintenance. Most of steel superstructure shall be designed as simple space frame structures. Simple space frame design utilizes single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Large span built-up girders shall be single web plate girders of welded construction with bearing and intermediate stiffeners. For lifting / monorails beams ISMB sections shall be preferred and the bottom flange of all beams shall be checked separately for distortion and reinforced suitably if required.

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Columns shall be designed to support the load combination which results in maximum interaction ratio. Exterior columns shall be designed to resist moments due to wind & seismic. Columns shall also be designed to resist moments caused by discontinuous vertical bracing or non-concentric bracing work points. Column base can be fixed or pinned. Lateral forces shall be resisted by rigid jointed moment connections in rigid frame design. For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension, etc.) use 90 % of the column dead load and no live load. Uplift forces from vertical bracing and Wind uplift on the roof shall be included where applicable.

Permissible stresses for different members shall not be allowed to exceed by 33.33 % under wind and seismic conditions. However, members who shall be designed primarily to resist wind load such as bracing members, no increase in permissible stresses will be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. All anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself. No anchor pockets in foundation shall be allowed. Design of base plates shall be based on design pressure on foundation which shall not exceed the following:

Pedestal in concrete grade M30 7.50 N/mm²

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A coefficient of friction of 0.30 shall be used in conjunction with the minimum column load. If the horizontal shear force exceeds the frictional resistance force or if the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Anchor bolts are not assumed to resist any horizontal shear force. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Static analysis of overhead conveyor galleries upto a span of 24 m is allowed. However dynamic analysis shall be carried out for overhead conveyor galleries exceeding 24 m span.

For equipments, the bolt shall be either embedded or placed inside the pedestal and grouted with non-shrink grout.

The following criteria shall be followed for posting loads on the design drawings. For vertical beam reactions, the load shall be posted whenever the value exceeds the maximum allowable uniform distributed load. For axial loads in floor beams, the actual horizontal load which the beam end connection must resist shall be posted for each end of the beam. Note that this value may be different for opposite end of the same beam. For truss members, only one member force shall be noted for each member.

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(c) Permissible deflections

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

• **Vertical deflection**

a) For beams supporting dynamic equipment	Span / 500
b) For beams supporting floors / masonry	Span / 325
c) For beams supporting pipes (pipe racks)	Span / 400
d) For roofing and cladding components	Span / 250
e) For gratings and chequered plates	Span / 200 subject to a maximum of 6 mm

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

For manually operated cranes and monorails : Span / 500

For electric overhead cranes

i) Up to 50 t capacity : Span / 750

ii) Over 50 t capacity : Span / 1000

• **Horizontal deflections**

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	Height / 325
b)	Multistoried building (without crane load)	Height / 500
c)	Pipe rack columns	Height / 200
d)	Open Structures	Height / 200
e)	Crane gantry girder due to surge	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail due to action of crane surge load only	Height / 2500 limited to level maximum of 10 mm
g)	Open gantry columns at crane rail level due to action of crane surge load only	Height / 4000 limited to maximum of 10 mm

Provisions of IS: 800 and relevant latest IS Codes shall be followed for limiting deflections of structural elements not listed above.

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(d) Minimum thickness and size of steel elements

• **Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgement in each instance.

Trusses, purlins, girts and bracing	6 mm
Columns and beams	8 mm
Gussets	8 mm
Stiffeners	8 mm
Base plate	10 mm
Chequered plates	6 mm o/p
Grating flats	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc shall be 6 mm.

• **Minimum Sizes**

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

(e) Slenderness and depth ratios

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

Truss	1 / 10
Rolled beams and girders for Ordinary floors and rafters	1 / 24
Supporting floor beams for vibrating Machines / equipments	1 / 15
Roof purlins and girts	1 / 45
Gable columns	1 / 30

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(f) Design of Connections

Welding will be done in accordance with the recommendations of IS: 816 and IS: 9595.

Shear connections will be designed for 75 % of section strength for rolled sections and 80 % of section strength for built up section or rolled section with cover plates. Designed shear force shall be more than actual shear. Moment connections between beam and column will be designed for 100 % of moment capacity of the beam section.

All butt welds will be full penetration butt welds.

Size of fillet weld for flange to web connection for built up section will be as follows:

- i) Able to take full shear capacity or actual shear whichever is more for box section
- ii) Able to take 80 % of full shear capacity or actual shear (if indicated in drawings) or shall be 0.5 times of the web thickness whichever is more. For I-section Weld will be double fillet
- iii) All welds will be continuous. The minimum size of the fillet weld will be 6 mm as per relevant IS code

Connection of vertical bracings with connecting members will be designed for full tensile capacity of the bracings. The connection between top flange & web of built-up girder will be full penetration butt weld & for bottom flange, connection may be fillet weld.

Connection of base plate & gusset members with the columns will be done considering that total load gets transferred through weld.

Splicing

All splicing work will be full strength. Field splicing will be done with web / flange cover plates. For, exceptional cases the field splicing will be designed for 50 % of load carried by the cover plates and remaining 50 % load through full penetration butt weld. Shop splicing for all sections other than rolled will be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections will be carried out using web and flange cover plate. For design efficiency of site weld shall be considered as 80 %.

Insert plates

Insert plates shall be designed / checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall also be checked. Lugs using steel bars shall preferably be fillet welded to the plate to transfer full strength of the lug.

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10.2 Fabrication

(a) General

Fabrication drawings shall be prepared according to the provision of IS: 800, IS: 813, IS: 816, IS: 9595, IS: 1367 and IS: 9178.

The work to be provided by the Bidder, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following:

- i) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on design drawings submitted by the Bidder and approved by the Owner/Consultant.
- ii) To submit revised design with calculations and detailed fabrication (drawings in case any substitution of the designed sections are to be made.
- iii) To submit design calculations for joints and connections developed by the Bidder along with detailed fabrication drawings.
- iv) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding \ electrodes for field connections. The field connection materials supplied by the Bidder shall be to the extent of actual requirement plus 10 % (ten percent).
- v) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- vi) Suitably mark, bundle and pack for transport all fabricated materials.
- vii) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

(b) Conformity with Design

Except where the standard connection details are furnished, the Bidder shall design all connections, supply and fabricate all steelwork and furnish all connection materials, Shear connectors / shear lugs on the beams in accordance with the approved drawings and / or as instructed by the Owner/Consultant Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and / or as approved by the Owner/Consultant. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

(c) Quality control

The Bidder shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work shall be performed in accordance with this specification. In addition to the

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Bidder's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Owner/Consultant. As far as possible, all inspection by the Owner/Consultant shall be made at the Bidder's fabrication shop whether located at Site or elsewhere. The Bidder shall co-operate with the Owner/Consultant in permitting access for inspection to all places where work shall be done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Bidder.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

- a) Steel Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
- b) Bolts, Nuts Manufacturer's certificate, dimension & Washers checks, material testing.
- c) Electrodes Manufacturer's certificate, thickness and quality of flux coating.
- d) Welders .Qualifying Tests
- e) Welding sets Performance Tests
- f) Welds Inspection, X-ray, Ultrasonic tests
- g) Paints Manufacturer's certificate, physical Inspection reports
- h) Galvanizing Tests in accordance with IS: 2633 and IS: 4759.

(d) Materials

If desired by the Owner/Consultant, Test Certificates of materials supplied by the Bidder in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Owner/Consultant, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

Materials for main and secondary members shall be selected in line with good engineering practice and shall be arranged within any structure with due regard for maintenance of the structure and Plant and Equipment supported or sheltered by the Structure and also with regard to corrosion.

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pitting, rusts, etc. that may impair their strength, durability and appearance.

All rolled steel shall conform to the requirements of the Indian Standards.

- i) Structural Steel will conform to IS: 2062 Grade-A for rolled steel members or plates up to 20 mm thickness.

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- ii) For plates above 20 mm thickness and welded construction, steel conforming to IS: 2062 Grade-B will be used.

(e) Workmanship

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of IS: 800 and other relevant Indian Standards or equivalent.

Straightening Material

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed as per IS:1852. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

Cutting

Cutting shall be affected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Owner/Consultant.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

Planning of Edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Owner/Consultant.

Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end,

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but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

Bolted construction

All bolts and nuts shall conform to the requirements of IS: 1367.

Field connections shall preferably be bolted connections unless specified otherwise. Weld connections at site shall be avoided.

High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter unless designated otherwise. High strength bolts shall be installed as bearing type joint except where loads are reversible. Bearing Type connection (H.T. bolts Grade 8.8) shall be used for all removable type connections. Bolts will be tightened to develop the required pre-tension during their installation.

All erection bolts shall be of minimum 16 mm diameter of property class 4.6 conforming to IS: 1367 unless specified otherwise.

Holes for bolts shall not be more than 1.5 mm for bolt of diameter equal or lesser than 25 mm and shall not be more than 2 mm for bolt of diameter greater than 25 mm.

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

Assembly

Drifting to enlarge un-matching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted nor damaged and shall be so prepared that the specified cambers, if any, are maintained.

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Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Owner/Consultant.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or locknut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

Welded Construction

Welding shall be in accordance with relevant Indian Standards. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817. All shop connections shall be welded type.

Preparation of Material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears, Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than 20C.

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

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When required by the Owner/Consultant, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Consultant.

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding shall be started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

No welding shall normally be done on parent material at a temperature below (-) 50C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 50C and 00C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 200C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

Submerged arc welding process shall be used for welding longitudinal fillet welds (connecting flanges with web) and longitudinal / transverse butt joints for fabrication of columns, framing beams and all other built up members unless manual arc welding is specifically required. All electrodes, flux, bare wire etc will be procured from approved manufacturers. All butt welds in beams, girders & columns will be of full penetration. All butt welds will be radio-graphically or ultrasonically tested as per relevant IS codes and standard practice. The base wire electrodes for submerged arc welding will conform to IS: 7280. The combination of wire and flux will satisfy requirements of IS: 3613.

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Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the Owner/Consultant.

Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-buttressed over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2 mm.

Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

Miscellaneous

- Lacing bars

The ends of lacing bars shall be neat and free from burrs.

- Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

- Bearing Plates

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

- Architectural Clearances

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Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

- Shop Connections
 - i) All shop connections shall be welded as specified on the Drawings.
 - ii) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Owner/Consultant for convenience of erection and the Bidder will have to make the desired changes at no extra cost to the Owner.
- Shop Erection

The steelwork shall be temporarily shop-erected complete or as directed by the Owner/Consultant so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

(f) Shop Painting

All fabricated steel material, except those galvanized or to be embedded in concrete, shall receive paint coatings as specified below. All paints shall be of approved brand and shade as per the Owner's requirement.

Steel surface, which is to paint, shall thoroughly be cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by wire brush & if required by sand blasting prior to actual surface preparation. The surface shall be cleaned to grade ST-2.5 as per SIS05-5900 or as per IS: 1477 (Part -I).

All steel structures shall receive two primer coats and two finish coats of painting. After fabrication the first coat of primer shall be immediately given over the prepared steel surface. The second coat of primer shall be applied over the dried first primer coat. Two finish coats shall be applied over the primer coats before dispatch of structure at site.

Primer paint shall be red oxide zinc chromate conforming to IS: 2074. Dry film thickness of each coat shall be 50 microns. Adequate care should be taken such that the surface does not possess a slick finish to which paint may not adhere properly. Top coat shall consist of two coats of HB Synthetic enamel of approved shade and colour with glossy finish and DFT as 75 microns (total). Thus the total DFT of painting including that of primer coats shall not be less than 175 microns.

Following care shall be taken while painting:

- i) Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.

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- ii) Surfaces inaccessible after assembly shall receive two coats of primer prior to assembling.
- iii) Surfaces inaccessible after erection, including top surfaces of floor beams supporting gratings or chequered plate, shall receive one additional coat of finish paint over and above number of coats specified above before erection.
- iv) Portion of steel member embedded / to be encased in concrete shall not be painted.
- v) Areas / Surfaces subjected to chemical attacks shall be painted with acid resistant paint.
- vi) Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

(g) Inspection, testing and acceptance criteria

Unless specified otherwise, inspection to all work shall be made by the Owner/Consultant at the place of manufacture prior to delivery. The Owner / Consultant shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification. The Bidder shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Owner/Consultant to carry out inspection and / or tests in accordance with the Contract.

The Bidder shall guarantee compliance with the provisions of this Specification.

The Bidder shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Bidder shall get the specimens tested in a laboratory approved by the Owner/Consultant and submit to the Owner/Consultant the test results in triplicate within 3 (three) days after completion of the test.

Steel

All steel supplied by the Bidder shall conform to the relevant Indian Standards, except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Owner/Consultant, random samples of materials will be taken from each unidentified lot of 50 ton or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be borne by the Bidder.

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All material shall be free from all imperfections like mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

All raw steel plate of thickness more than 20 mm supplied by the Bidder shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Owner/Consultant:

- i) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.
- ii) If the results of the tests in (i) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (i) or as directed by the Owner/Consultant.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Owner/Consultant requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Bidder. If the plates in the fabricated item are found to be laminated, the component will be rejected.

Welding

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Owner may ask for at least one test-destructive or non-destructive including X-ray, ultrasonic test or similar, the cost of which shall be borne by the Bidder. In the event of further tests as may be desired by the Owner. The cost of such test shall be borne by the Bidder if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Owner / Consultant shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

Bolts, nuts and washers

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Owner/Consultant and shall conform to the relevant Indian Standards. If desired by the Owner/Consultant, representative samples of these materials may have

- i) Name of the Bidder
- ii) Number and date of the Contract
- iii) Name of the office placing the contract

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- iv) Nomenclature of stores
- v) A schedule of parts or pieces, giving the parts or piece number with
- vi) Tolerance

The tolerance on the dimension of the individual rolled steel components shall be as specified in IS: 1852. The tolerances on straightness, length etc. of various fabricated components (such as beams, girders, columns, etc) of the steel structures (other than steel railway and road bridges structure) subjected to dynamic loading (like wind, seismic etc.) and thin walled constructions (like box girders) shall be as specified in IS: 7215.

10.3 Erection

(a) General

The work to be provided for by the Bidder, unless otherwise specified in the Bid, shall include but not be limited to the following:

- i) The Bidder shall provide all transport equipment, lifting equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- ii) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Bidder shall pay all demurrage and / or wharfage charges etc. on account of default on his part.
- iii) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the Owner/Consultant. If necessary, suitable temporary approach roads to be built for transportation of fabricated steel structures.
- iv) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Owner/Consultant. The Bidder shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- v) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Owner/Consultant.
- vi) Touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Bidder free of cost to the Owner.
- vii) All minor modifications of the fabricated steel structures as directed by the Owner/Consultant including but not limited to the following:

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- Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
- Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
- Reaming of holes for use of higher size bolt if required.
- Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Owner/Consultant.
- Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
- Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
- Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
- Carry out tests in accordance with this Specification if directed.

(b) Conformity with design

The Bidder will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and / or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and / or the instructions of the Owner/Consultant. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and / or the instructions of the Owner/Consultant.

(c) Storage of materials

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site.

(d) Yard

The Bidder will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access, trailers and other heavy equipments. The yard shall be fenced all round with security / arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

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The Bidder should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. All of which shall be carried out by the Bidder at his own cost as directed by the Owner.

(e) Covered Store

All field connection materials, paints, etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Bidder.

(f) Workmanship

Erection Plant and equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Owner/Consultant.

Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Owner/Consultant. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

Temporary bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure Installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Bidder in respect of temporary bracings and guys shall cease when the structural steel is once located plumbed levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Owner/Consultant.

The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Bidder to take out the materials from 'the project site. The Owner may remove and return the materials in good condition to the Bidder without any charge if they have been left in place under other agreed arrangement.

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Temporary floors for buildings

It shall be the responsibility of the Bidder to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and / or by-laws of state, Municipal or other local authorities.

Setting out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Owner/Consultant. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Bidder shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations.

He shall remain responsible for correct positioning. For heavy columns, etc. the Bidder shall set proper screed bars if desired by the Owner/Consultant, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

Drifting

Correction of minor misfits of bolts will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

(g) Testing and Acceptance Criteria

General

Loading tests shall be carried out on erected structures, if required by the Owner/Consultant, to check adequacy of fabrication and / or erection. Any

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structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract of either fabrication or erection of steelwork whoever is responsible for it and no payment towards the cost of the dismantled portion and any connected work shall be made to the Bidder, unless it is proved that the deficiency is due to reasons beyond the Bidder's scope. If any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Bidder responsible, to the satisfaction of the Owner/Consultant. The cost of the tests specified hereinafter shall be borne by the Owner. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed. The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated below. The method of testing and application of loading shall be as approved by the Owner/Consultant.

Stiffness Test

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 % of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 % of the maximum increase in strain or deflection recorded during the second test.

Strength Test

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours. In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

Structure of same design

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or

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deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure when a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Owner/Consultant. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20 % of the maximum strain or deflection recorded at similar load in the test on the prototype.

Repair after inspection tests

An actual structure which has passed the "Strength Test" as specified above herein before and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' above.

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11. ARCHITECTURAL WORKS

The architectural design concept of buildings shall be evolved considering the functional, technical and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes. To achieve above objective Bidder shall employ a qualified architect / architectural firm to carry out all designs and hold all other architectural responsibilities for the project.

The Bidder shall obtain and be conversant with all laws, by-laws and regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The Bidder shall provide the drawings and documents for such statutory approvals.

11.1 General

The architectural services shall cover finishing work of new buildings and modernised existing buildings/structures, included under the specification starting from masonry work, partition walls, cladding walls, roof protection, finishing of walls, floors and ceilings, false ceiling as required potable water system, sanitation etc.

During execution of the contract, the Bidder shall take approval from the Owner, for all building materials and finish items (e.g. floor tiles, doors, and windows, paints etc.) to be used for the contract by submitting samples and/or product literature as appropriate.

Finishing works including material used for renovation/modernisation work shall be matched with the finishing of existing structures to make similarity in architectural view of new and existing structures.

11.2 Finishes

All exposed surfaces shall be clean and smooth and members shall be sized to give a pleasing appearance. The Finishes for all Structures and Buildings shall meet the functional requirements and shall be as per the approved Finishing Schedule. However, the finishing schedule shall be pre-approved by the Owner/Consultant.

11.3 Design Requirements

(a) Architectural Concepts

- All buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to all

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buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

- Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipments, exposed structural elements, piping, trestles, bus ducts and other service elements.
- Overall emphasis shall be on developing an eco-friendly architecture, merging with the nature with its own sustainable energy management systems.
- The scheme shall be conceptually finalized in totality including that of equipments so that the proper co-ordination with other agencies can be taken up at appropriate time.

(b) Architectural Design

- Natural light shall be used to the maximum extent. For adequate light and ventilation, National Building Code recommendation shall be followed.
- Entrance canopies, chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.
- All the buildings shall be architecturally designed to meet the National Building Code.
- Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect Statutory requirement and any clearances from local authority may be required to be met with, wherever essential. The Architect Consultant shall be of national - International repute having experience in similar kind of works. The consultant shall evolve the design philosophy and shall present it in the form of presentation drawings, prospective views, 3-D Models & detail drawings.
- A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving plant technology and architectural & civil engineering for a smooth control hierarchy and man machine interface.

The Bidder shall develop the architectural layout of all the buildings listed in this document as per the final approved equipment disposition and other layout considerations indicated elsewhere in this specification. These drawings shall need the approval of the Owner/Consultant before construction. The Bidder shall also have to submit perspective views if so desired by the Owner/Consultant at no expenditure to the Owner. Approval from statutory authorities, e.g. Factories Inspector, Explosives Inspector, Loss Prevention Association of India / Tariff

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Advisory Committee etc. shall be the responsibility of the Bidder without any obligation of the Owner.

The entire complex shall have an architectural character and style of its own and shall be visually and functionally integrated with the existing landscape. The Bidder must visit the site and have a feel of the overall environment, so that a harmonious as well as integrated architectural concept of the proposed phase of development is achieved. Special care must be taken to enhance the visual and technological quality of development by adopting updated technology, materials, finish etc.

11.4 Guideline for Architectural Works

11.4.1 Roof Insulation and Ventilation

Wherever required the roof of buildings shall be insulated with foam concrete. For ventilation requirements relevant section of the specification shall be referred.

11.4.2 Roof Waterproofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size 230x230x18 mm laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

11.4.3 Brick/stone masonry and parapet wall

All masonry works shall be designed in accordance with IS: 1597, IS: 1905, IS: 2212, IS: 4326 and other relevant IS codes as applicable. Structural design of load bearing and non-load bearing walls constructed with solid or perforated burnt clay bricks or concrete blocks shall be in accordance with criteria specified by National Building Code of India.

All walls shall be non-load bearing infill panel walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change rooms, first aid rooms and toilets, which may be half brick thick.

Minimum 50 kg/sq.cm compressive strength brick shall be used for non-load bearing super structure brickwork. Cement sand mortar 1:6 for one brick thick wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided to reinforce the wall where required.

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All brickwork shall be plastered as per specification.

Even where metal cladding is specified, for initial *[3 m]* height from the ground level, minimum one brick thick masonry wall shall be provided.

All up stands and parapet walls on roof shall be of RCC construction, minimum height of parapet walls shall be *[1050 mm]* and a minimum thickness of *[125 mm]*.

11.4.4 Cement based polymer modified mortar

a) Purpose

To carry out structural repairs to prepared patches of spalled concrete with an alkaline impervious repair material comprised of polymer admixed cement-sand mortar.

b) Materials and T&P

Polymers in emulsion or powder forms as may be specified conforming to ASTM C1059, Ordinary Portland Cement of 43 grade conforming to relevant BIS code, Sand conforming to Zone-II or Zone-III grade of IS: 383, Mixing water conforming to IS: 456-2000, mortar mixer with mechanical water dozer, spatulas, trowels, etc.

c) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified polymers shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 Testing of Material: The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less). These are to be tested for conformance to the specified requirements before use on the work. Polymer modified cement mortar with cement: sand proportion by weight as (1:3) shall have the following properties

Minimum compressive strength -20N/sq.mm after 28 days at 27oC

Step-4: Identify and mark the area for Polymer modified mortar repair.

Step-5 Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

Prop & support the structural member to relieve it of stress and strains.

Removal of existing surface plaster/treatment shall be done.

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Chipping unsound/weak concrete material shall be done.

Removing concrete all around embedded rusted reinforcement shall be done.

Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done.

Sealing the cracked or honeycombed concrete with injection grouting shall be done.

Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate, which may also be used as depth measuring gauge.

Additional fresh reinforcement, if required, shall be tied with required overlaps or welded.

The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically.

Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done.

Step-6: Clean the dust and saturate the prepared surface of concrete and reinforcement with a clean oil free air blast and water fit for construction.

Step-7: Inspection of concrete surface prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-8: Alignment & thickness Control- Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-9: Apply Passivating & bonding coat over the cleaned existing and new reinforcement.

Step-10: Apply bond coat on the cleaned concrete substrate.

Step-11: Mix and Prepare Polymer Modified Mortar to have a uniform consistency and texture by adding cement sand and polymer as weigh batched ingredients of the design mix, a specified proportion of water through water dozer.

Use of prepacked ready to use components supplied by manufacturers in containers may be allowed subject to approval of Owner. In case where prepacked ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

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Plastering with cement based polymer modified mortar shall be done immediately after applying the bonding slurry to the prepared surfaces, preferably in coats of approximately 10mm thickness as greater thickness may lead to delamination/collapse. However, coats shall be applied in fairly rapid successions within 15 to 30 minutes. After applications of mortar the surface shall be finished using a wooden float.

Step-12: Moist cure the polymer modified mortar surface for 1-3 days followed by air curing at ambient temperature or as per manufacturer's specification, if specified otherwise. Use of flowing water or ponding of water shall not be done for curing. Steam curing shall not be permitted.

Step-13: Test the Surface of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

d) Inspection & Quality control

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing stoppage of work during low temperatures (minimum working temperature being 8°C in most of the polymer modified mortar or as per manufacturer direction) and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 28 days of mortar application. The cores shall be examined for evidence of poor workmanship by the Owner, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall dismantle such areas of work as required by the Owner and re-do the same after re-preparing the surface by chipping off mortar work and abrading the bonding slurry interface.

11.4.5 Partition Wall

All intermediate walls shall be full brick thick wall in 1:6 cement sand mortar. Half brick thick wall in 1:4 cement: sand mortar with [2 nos. 6 mm] diameter rod in every fourth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area.

11.4.6 Metal cladding

a) Permanent colour coated sandwiched insulated metal cladding system

Trough zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 180 gm / sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film

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Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanised M.S. sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanising shall not be less than 180 gm / sq. m.

The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanised steel sheet of grade 375 as per IS: 277. Inner sheet shall be fixed at the rate not more than 0.75 m centre to centre to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS: 8183, having a density of 32 kg / cu. m for glass wool & 48 kg / cu. m for rock wool.

b) Permanent colour coated (non-insulated) metal cladding system

Trough zinc-aluminium alloy coated not less than 180 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability.

c) Flashings, Cap, Trim Closures etc.

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

11.4.7 Plastering

On the exterior wall & rough side of interior brick wall *[18 mm]* thick minimum with cement-sand mortar in two layers shall be applied. Where external finish will require rich plastering for special finish plaster shall be of 1:4/1:3.

Interior wall: *[12 mm]* thick with 1:4 cement-sand mortars

Ceiling: *[6 mm]* thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

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11.4.8 Removal of plaster manually from masonry or concrete surface using chisel and hammer and disposal of debris etc

a) Purpose

For removal of all type of loose /delaminated /damaged/weak cement plaster from surface of masonry or concrete.

b) Procedure

Step-1: Safety shall be ensured in accordance with contract conditions and specifications.

Step-2: Provide double scaffolding, protective screens etc.

Step-3: Existing plaster to be identified for removal by tapping all areas and its boundary shall be marked with a colour marking (in an optimal rectangular shape), which shall be approved by Engineer-in-Charge.

Step-4: Make a cut normal to the surface all along the boundaries with power driven cutters. The depth of cut shall not exceed the thickness of plaster.

Step-5: Remove the plaster manually with the help of chisel and hammers to completely expose the parent masonry or concrete surface, so as not to have any traces of such plaster left behind.

11.4.9 False ceiling and under deck insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the under side of the roof / floor slab of the air-conditioned areas based on the functional requirement. Aluminium false ceiling system shall comprise of [84 mm] wide [12.5 mm] deep closed type plain panels of approved colour, roll formed out of [0.5 mm] thick corrosion resistant aluminium alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, AC ducts etc. Suitable M.S channel (minimum ISMC100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc.

Bidder shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire detectors, fire protection sprinklers etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the Owner approves the layout. Under deck insulation shall comprise of [50 mm] thick resin bonded mineral wool insulation mat conforming to IS:8183. This mat shall be backed with [0.05 mm] thick aluminium foil and [24 Gx25 mm] wire mesh netting. These shall be fixed to ceiling or wall as the case may be with [100x50x6 mm] slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at [600 mm c/c and 14 G] steel wire drawn through slots and fixed to wire netting.

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11.4.10 Doors

- Generally hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas.
- Solid core factory made wooden flush doors in hard wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.
- Special areas like control rooms and other special area shall be provided with minimum 15 micron pre-coated Le. colour anodised aluminium glazed partitions with air lock facilities having two sets of doors.
- Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard and also to all fire exists as per TAC requirement.
- Doors shall be provided at appropriate location to prevent dust ingress from outside.
- FRP Doors with FRP Frames shall be provided for all the toilet doors.
- Weather stripping shall be provided to all outside doors as well as air-conditioned areas and all other doors where dust-free environment is required.

11.4.11 Rolling shutters

Rolling steel shutters conforming to IS: 6248 will be used for large openings where frequent use is not envisaged. Unless noted otherwise, main entry doors of width and height to suit the requirements. Rolling shutters with area up to 8 m² shall be pull and push type hand operated, while above 8 m² shall be pull and push type with ball bearings (Electrically operated) as per IS specification.

11.4.12 Windows & Ventilators

In all buildings, full glazed windows and ventilators in minimum *[15 micron]* colour anodized aluminium window frame shall be provided with *[4 to 6 mm]* thick (depending on the size of panel) clear float glass and *[6 mm]* thick clear wired/laminated glass where required from safety point of view. Structural glazing may be considered as an important facade element.

The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Glass thickness and member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Bidder before execution.

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11.4.13 Plywood Covering Panels to Cover Windows etc. During repairs

a) Purpose

To protect the finished items against their spoiling/damage to finishes during the process of carrying out repairs in a building. The items could include finished windows, doors, glass curtain wall or other such items.

b) Materials:

Wooden Battens of size 50mm X 50mm (approximately) or as approved by Engineer-in-charge, free from warping, cracks etc. made from locally available timber.

Plywood of suitable thickness, preferably 6 mm thick, as approved by Engineer-in-Charge.

Nails, screws etc. as per requirement.

c) Fabrication:

Size of covering panels shall be more than the size of windows etc. to be shielded/ protected, enough to be fixed to the walls without damaging the windows etc.

Wooden battens shall be cut approximately to the size of panels of windows etc. to be protected. The joints of the wooden framework shall be lap joint or as approved by Engineer-in-Charge.

Where the panel size is more than 2 square metres or as specified by the Engineer-in-Charge, the stiffening shall be done with batten backing to impart stiffness enough to provide rigidity against undue deflection due to impact of falling debris, self load, etc.

Plywood shall be fixed with nails/screws over the batten frames. The spacing of nails/screws shall be about 300mm c/c or as may be required at site.

d) Fixing:

The plywood covering panel shall be suitably fixed without damaging the windows etc. being protected by such panels with nails/screws fixed in walls strong enough to resist the forces likely to be imparted during repair work. It shall be done in such a manner that it can be removed with ease without damaging the covered windows etc. after completion of repairs.

e) Removal:

After completion of work, the covering panels shall be removed carefully, so as not to cause any damage to windows etc. covered. The damages, if any, shall be made good.

11.4.14 Facilities in Buildings

Adequate toilet and drinking water facilities shall be provided for personnel working in each building. Each building shall have toilet facilities both for Gents

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and Ladies. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.

However minimum 1 Water Closet, 1 washbasin, 1 urinal shall be provided in each toilet.

Each floor shall have drinking water facility connected through water purification system like Aquaguard or similar approved make.

11.4.15 Glazing & Glazed Partition

- Glazing in Control room between AC. and non-AC. areas shall be insulating glass consisting of *[two 6 mm]* thick toughened float glass sheet hermetically sealed and separated by *[12 mm]* gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.
- *[4 mm]* thick ground glass shall be provided for toilets.
- Glazing between two AC. areas shall be with 6 mm thick clear float glass.
- All glazing shall be in aluminium frame.
- *[6mm]* thick Wired / laminated glass shall be used for windows / ventilators at higher level for safety.
- *[24mm]* thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with *[12mm]* air gap & hermetically sealed shall be mounted on *[15 micron]* coloured anodised aluminium frame suitable for structural glazing system.

11.4.16 Sealant

Silicon sealant or polyurethane sealant shall be used in all expansion joints exposed to weather. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water-lightness.

11.4.17 Damp Proof Course

[40 mm thick 1:1.5:3] concrete with waterproofing admixture. Water proofing compound shall be of Zydex, SIKA, or similar approved.

11.4.18 Plinth Protection

Minimum *[1000 mm]* wide and minimum *[100 mm]* thick M 15-grade concrete plinth protection along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be provided. The plinth protection shall be laid over prepared sub-grade and base formed with locally available broken laterite stone to thickness of *[150 mm]*.

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11.4.19 Painting

- Exterior Masonry Surface : Buildings shall be finished with [Acrylic Emulsion pain] as per IS specification with approved colour and scheme.
- Exterior Steel Work : Anti-corrosive synthetic enamel paint over [anti corrosive primer].
- All Woodwork: [Synthetic paint over a coat of primer].
- All Internal Steel Work : [Synthetic enamel over a coat of primer].
- Interior Office Spaces Rooms, All AC Areas : Acrylic emulsion paint over [2 mm] control thick plaster of paris punning.
- Balance areas: As indicated in finish schedule in this document.
- Fire Door: Post Office red shade shall be provided.

11.4.20 Flooring

Unless and otherwise specified, the nominal total thickness of floor finish shall be [50 mm] including under bed and topping. The flooring shall be laid on already matured concrete base. The under bed for floors shall consist of minimum grade of M 15 with stone chips [12.5 mm] downgraded as coarse aggregates. The under bed shall be provided appropriate slope towards catch pit for floor drainage.

- **False Flooring System**

Removable type false flooring system shall be provided wherever required (computer rooms etc.). RCC floor slab will be sunk to a depth [800 mm], which shall be height of the false floor system. The flooring shall consist of fire resistant phenol formaldehyde bonded particle board panels [600x600x35 mm] size, mounted on steel pedestals of adjustable height and supporting steel grid system to provide under floor space. [2 mm] thick flexible anti-static PVC topping on top and PVC strip edging on sides of each panel shall be provided.

- **PVC Floor Finish**

Two mm thick PVC as per IS: 3462 and laid as per IS: 5318 over concrete under bed of [48 mm] shall be provided in electronic cubicle rooms, conference room, etc. PVC tiles shall ensure anti static surface.

- **Vitrified ceramic Tiles**

Heavy duty vitrified ceramic tiles of appropriate thickness and of minimum size [600 mm x 600 mm] of approved shade & colour shall be provided for control room as per relevant code and manufacturer's specification over concrete bedding to result in an overall thickness of [50 mm].

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- **IPS Flooring**

IPS (cement concrete flooring) with metallic floor hardener topping [12 mm] thick with a total thickness of [50 mm] shall be provided in maintenance and unloading area, ground floors, floor of pump house, permanent stores and other plant building areas where heavy duty flooring is required.

IPS flooring with non-metallic floor hardener shall be provided in all MCC and switchgear rooms, which are not air-conditioned.

IPS flooring shall also be provided in areas, which are not provided with any special finish. Areas which are likely to be subjected to oil spillage shall be provided with two coats of oil resistant painting over IPS floor finish. If required, Bidder has to use floor hardeners at appropriate locations.

- **Heavy Duty Ceramic Tiles**

Heavy duty vitrified ceramic tiles with suitable finish shall be used in toilets, pantry, dining hall of canteen, locker rooms etc. The tiles shall be minimum of [300 x 300 x 7 mm] of approved shade, brand and colour.

- **Acid / Alkali Resisting Tiles**

Battery rooms and other areas coming into contact with acid / alkali vapours or fumes shall be given acid / alkali resistant tiles [25 mm] thick, jointed with acid / alkali resistant cement slurry. Bedding shall comprise of potassium silicate mortar conforming to IS: 4832 (Part-I) and resin based mortar like epoxy for jointing. Total thickness of flooring shall be [50 mm]. Ceramic unglazed vitreous tiles conforming to IS: 4457 with minimum thickness of 20 mm may also be used as acid / alkali resistant tile.

- **Integral Floor Finish**

For cable vaults floor finish integral to the concrete base shall be provided as per IS: 2571.

- **Cast-in-situ Terrazzo**

Risers and treads of staircases shall be provided with cast in-situ terrazzo. This shall be laid as per IS: 2114, using white cement or cement with colouring pigment. Chequered finish shall be provided for treads. Total thickness of the finish shall be 25 mm.

11.4.21 Miscellaneous

PVC nosing shall be provided for edge protection of R.C.C. stair treads.

Angles [50x50x6 mm] (minimum) with lugs shall be provided for edge protection of cutouts / openings in floor slabs, edge of drains covering gratings, edge of R.C.C cable / pipe trenches of any other place where breakage of edges / corners is expected.

Floors of switchgear rooms shall have embedded steel channel suitable for easy movement of breaker panel.

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11.4.22 Skirting/DADO

- [150 mm] skirting matching with floor finish shall be provided in all areas unless specified otherwise elsewhere.
- Toilets and locker rooms shall be provided with dado of [2100 mm] high with glazed tiles of minimum 5 mm thickness generally as per IS: 777.
- For battery room and other areas coming in contact with acid / alkali spillage / fume, dado of acid / alkali resistant tiling as per IS: 4457 shall be provided to a height of [2100 mm] set in potassium silicate mortar and joints pointed with resin bonded mortar
- Staircase wall shall be given dado of vitrified tiles of approved colour and shade to a height of [2100 mm] or as per approved drawings.

11.4.23 Roof access

All roofs shall be provided with access thorough a staircase / cage ladder. Minimum [1000 mm] wide access path shall be provided with suitable tiles to approach equipment on roof.

11.4.24 Roof Drains

Roof drains design criteria

Minimum diameter of the pipe shall be [150 mm]. The roof drains shall be sized for the roof area runoff for a maximum rainfall per hour at site.

Detailed specification is mentioned elsewhere in this specification.

Roof Drainage and Water Proofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size [230x230x18 mm] laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

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12. GENERAL REQUIREMENTS

12.1 Roof

All the buildings having R.C.C slabs over structural steel framing are provided with troughed metal sheet decking which acts as permanent shuttering. These sheets shall meet the general requirements of IS: 14246 and shall conform to class 3 for durability. The sheeting shall be permanently colour coated galvanised M.S. troughed metal sheet decking of approved profile with minimum base metal thickness of 0.8 mm and minimum trough depth of 38 mm. Silicon modified polyester painting shall be used for permanent coating over galvanised surface with minimum rate of galvanising of 180 gm of zinc per sq. m. Dry film thickness of colour coating shall be at least 20 micron.

Roof of all buildings having R.C.C. framework shall have cast in-situ R.C.C. slab with conventional shuttering.

Structural steel roofing wherever required shall be of permanently colour coated galvanised M.S troughed metal sheet of approved profile. Minimum base metal thickness shall be 0.8 mm. The rate of zinc consumption for galvanising shall be 275 gm/sq. m. The external face shall have permanent colour coating of PVF 2 paint of minimum DFT of 20 microns and inner surface shall be coated with silicon modified polyester paint with DFT of 20 microns.

12.2 Platforms and walkways

Platforms shall be provided to all major equipment, not directly accessible from the floors, for maintenance. Platforms and connecting walkways shall have a minimum width of 750 mm. Platforms in front of the entry shall be at least 900 mm wide. Platforms located close to each other shall be connected with walkways.

All steel platforms above grade level shall be constructed with kick plates at edge of the platform to prevent tools or materials from falling off. It shall consist of 8 mm thick steel plate projecting 100 mm above the platform surface. Kick plate shall be painted with the same type of coating as the material to which it is attached. Approach to EOT crane shall be ensured by Cage ladder or staircase.

12.3 Stairs and ladders

Steel Stairs

All steel staircases shall normally have minimum clear width (back to back of stringer) of 1000 mm and maximum inclination with horizontal of 35.75°. However, in case of space restriction, minimum clear width up to 750 mm and slope up to 45° may be provided. The vertical height between successive landings shall not exceed 5 m. Channels (minimum MC 200) shall be provided as stair stringers. Treads shall be minimum 250 mm wide of chequered

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plate/grating, with suitable nosing, and spaced equally so as to restrict the rise to maximum 180 mm (200 mm in exceptional cases).

Steel Ladders

Ladders shall be provided to platforms, walkways, instruments and equipments, which do not require frequent access. Ladders shall preferably be vertical and its angle with vertical shall not exceed 50. Ladders shall be of minimum 450 mm clear width with 20 mm diameter MS rungs spaced at 300 mm (maximum).

Ladders shall be provided with a safety cage of minimum 750 mm diameter clear when the top of ladder is more than 4.5 m above the landing level. However safety cages shall start at 2.5 m above the lower landing level.

RCC Stairs

All stairs shall have maximum riser of 180 mm and a minimum tread of 250 mm. However, for public buildings riser shall be limited to 150 mm and tread width of 300 mm. Minimum width of stairs shall be 1200 mm generally. All stairs normally shall not have more than 15 risers in one flight. Aluminium angle nosing with minimum 50X25X3 angle or PVC nosing shall be provided for edge protection of RCC stairs.

12.4 Handrails

Handrails shall be provided at appropriate places to ensure safety e.g. around all floors/roof openings, projections / balconies, walkways, platforms, steel stairs etc.

All handrails shall be of 32 mm nominal bore MS pipes (medium class) as per IS: 1161 galvanised using 900 gm/sq. m of zinc. Handrails for platforms, walkways and projections shall be a two-rail system with the top rail 1000 mm above the walkway surface and the intermediate rail 450 mm below the top rail. Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the protected horizontal opening. In such a case spacing shall not exceed 1850 mm centre to centre of posts. Handrails shall be shop fabricated for specific locations and field welded or bolted to the erected structural steel. For platforms at elevation more than 30 m, three rail system with top rail at 1500 mm shall be adopted.

For RCC stairs, handrails with 20 mm square MS bar balustrade with suitable MS flat & aluminium / Teakwood handrail shall be provided, unless specifically mentioned otherwise. All hand rails except stairways shall be provided with toe guard plate of 100x8mm thick.

12.5 Edge protection

Wherever possible around floor openings an RCC kerb of 100 mm wide 150 mm high shall be provided. All concrete edges, where breakage of concrete corner is expected, shall be provided with angles at least L 50x50x6 with lugs for edge protection e.g. all round the cut-outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers,

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edges of manholes supporting covers and supporting edges of precast covers etc.

12.6 Vertical Headroom

All accessible areas shall be provided with minimum clear headroom as follows, unless otherwise specified:

Table 2.9

Headroom

Description	Headroom, mm
Finished floors to ceiling (buildings)	3000
Doors, Walkways, Platforms, Stairs etc.	2100
False ceiling of office areas	3000
False ceiling walkway	1000
Safety cage for ladders	2500
Access for forklift trucks	2800
Main roads/Railway crossings & crane access	7000
Other plant roads and truck access	5000
Cable & Pipe rack (except road/rail crossings)	3000

12.7 Waterproofing of underground structures

All underground structures like basements, pump houses, water retaining structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sq.m (minimum) for water/ damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that waterproofing grouting can be injected later in case of leakage.

12.8 Anti-termite treatment/Anti-weed treatment

Pre-constructional anti termite treatment shall be given to all buildings as per IS: 6313 and other relevant Indian Standards.

Reservoirs shall be given an anti-weed treatment of approved quality and quantity as per the manufacturer's specification. Anti weed treatment shall be carried out before carrying out the lining work.

12.9 Plinth Level

The finished floor levels shall be 800 mm higher than the external finished ground level. Finished ground floor level (plinth level) of all buildings and pump houses shall be minimum 500 mm above the formation level/grade level.

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All cable vaults shall be located above ground level i.e. cable vaults shall not be provided as basements in the buildings.

12.10 Statutory Requirements

All the applicable statutory rules pertaining to Indian Factories act, Factory rules of state government, Fire safety rules of Tariff Advisory Committee, Water act of Pollution Control Boards, Explosives act etc. and stipulations of other relevant statutory authorities shall be taken into consideration at the time of design.

Provisions of safety, health and welfare according to Factories act shall be complied with design stage. These shall include provision of continuous walkway (minimum 500 mm wide) along crane-girder at crane girder level on both sides of the building, comfortable approach to EOT crane cabin, railings, fire escape, locker room for workmen, pantry, toilets, rest room etc.

Adequate number of fire escapes shall be provided in a building. Fireproof doors, number of staircases, fire separation walls, lath plastering on structural steel member (in fire prone areas) shall be made according to the recommendation of TAC. For fire safety requirements of buildings IS: 1641 and IS: 1642 shall be followed in addition to TAC requirements. All masonry firewalls shall be minimum 345 mm thick and RCC firewall shall be minimum 200 mm thick.

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13. GENERAL CIVIL WORKS AND CONSTRUCTION TOLERANCES

13.1 Basic requirements for all civil works

Design requirements

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Owner/Consultant.

- Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers (whichever is less).
- The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable nor troublesome to personnel and will not cause damage to the machine or structure.
- The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating plant.
- The differences between frequencies and the dynamic analysis of the superstructures and foundations shall be in accordance with the relevant design standard.
- The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.
- Throughout the works all floor slabs above rooms containing electrical equipment shall be watertight. No drainpipes or water pipes are permitted to pass through these rooms.
- All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Owner/Consultant and shall comply strictly with the tests prescribed hereinafter or, where tests are not laid down in this specification, with the requirements of the latest issue of the relevant Indian, American, British, German Standards or other Standards approved by the Owner/Consultant.
- Samples of all materials proposed to be used in the works may be called for at any time by the Owner/Consultant.

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- The work shall be carried out by competent personnel skilled in their various trades.
- Before commencing the works, the Bidder shall ascertain the locations and nature of all existing underground services and shall take every possible precaution against any damage occurring to them or interference therewith, during the execution of the works.
- Suitable access to the roofs of the buildings by means of steel stairs shall be provided for maintenance and repair of any installation.
- All rooms with fire hazard shall be provided with suitable emergency exists.
- Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles, which will be used (cars, forklifts, trucks/trailers etc) to reach up to the point of unloading of the equipment.
- Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms, at all levels using suitable stair wells and suitable electric hoists. The dimensions of rooms, stairwells, doors, etc shall be designed to suit the a.m. transport concept.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.

13.2 Basic requirements during construction

Basic Cleaning

Basic cleaning includes all floors, walls, ceilings, built-in fittings and equipment, including the furnishings. The basic cleaning operation must result in a degree of cleanness, which permits the fully equipped buildings and rooms and associated outdoor installations and secured surfaces to be taken over without complaint.

Advertising boards and stickers, temporary protective coatings and claddings, remains and splashes of paint, must be removed with water or suitable solvents. Dust and other dirt must be completely removed from all wall and floor surfaces, as well as from all furniture.

Windows and mirrors must be cleaned so that they are completely clear and without streaks.

Perlator gauges, showerheads, odour traps and floor drains of the sanitary installations must be cleaned and the fittings and bright pipe work must be spotlessly polished.

Petrol and oil separators must be emptied, cleaned and refilled if necessary during basic cleaning.

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Lamps, including dishes, lighting units and tubes, switches and sockets as well as bases and skirting boards, doors with frames and glazing, windows, window seats and other furniture and fittings must be included in the basic cleaning operation.

Initial Equipment

The specification is drawn up on the assumption that the scope of the initial equipment and consumption materials is to be provided complete in every respect; everything required for the use and care of the installations must be supplied, even if this is not expressly specified in the documentation.

Bidder shall ensure that during excavation ground water level shall be lowered by at least 0.50 m below the founding level adopting appropriate method of dewatering. Lean concrete below foundation shall be laid soon after excavation with minimum loss of time.

13.3 Ash Pond

General

The Ash Bund shall be designed to be suitable under all conditions to which they may be subjected to, including self weight, vertical loads, lateral loads, water pressure, seepage and draw down, seismic effects etc. for the ultimate stage of raising of the bund. Raising of the bunds of the settling ponds shall be by upstream method of construction. The bunds shall be of homogenous earthen construction. Earth used shall conform to classification GC, CL or CI. Earth may be from inside of the pond or from approved borrow pits. It is the responsibility of the Contractor to identify suitable source of earth in adequate quantities. The source and type of earth shall be same for the full length and height of starter bund. The design of the bund shall in generally follow the provision of IS: 8826. Stability analysis shall in general follow IS: 7894.

Construction of the bund shall generally commence about 750 mm below the general ground level after the ground is clear of all roots, stumps, organic and vegetable matter. Loose pocket if any shall be removed and rectified to ensure fairly uniform bearing capacity. The bunds shall have a minimum top width of 6000 mm. Slope on the downstream side shall be a minimum 1 vertical to 2.5 horizontal. Slope on the upstream side shall be minimum 1 vertical to 2.5 Horizontal. Free board above full reservoir level shall be calculated as per IS:10635. However minimum free board shall be 1500 mm. The design of bund shall ensure that the phreatic line shall not meet downstream face of the embankment. To ensure this adequate internal drainage arrangement shall be provided as described below:

- i) Sand chimney a minimum of 500 mm thickness upto 1 m below the top of bund.
- ii) Continuous Sand blanket of a minimum 500 mm thick at ground level connecting chimney to rock toe.

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iii) Rock toe to a minimum height of 1000 above the outside ground level with a top width of 1 meter and side slope of 1 vertical to 1.5 horizontal. The rock toe shall extend to the full depth of bund below ground level

iv) 150 mm thick coarse sand filter and 150 mm thick fine sand filter between sand blanket and rock toe.

The embankment shall be safe against failure due to “piping”. The design shall ensure that the exit gradient is less than 1 m. The gradient shall be calculated by drawing flow net.

Downstream face shall be protected by turfing with turf. A peripheral drain of minimum internal width of 450 mm and minimum depth of 300 mm shall be provided at the side of the rock toe along the periphery of the bund to drain the seepage from rock toe and rain water from the surface drains. The toe drain shall be of brick in CM 1:4 with cement plaster 15 mm thick on the outside and inside. Base of the drain shall be 150 mm thick PCC of grade M15. The drain shall be constructed in a minimum slope of 1 in 750 and shall lead the water to the nearest water course. To lead out the rain water on the downstream side surface drains formed out of brick paving 75 mm thick minimum 600 mm wide and 150 mm deep shall be provided at about 100 Meters c/c along the length of the bund. The brick shall be pointed using cement mortar 1:3. The surface drain shall be connected to the toe drain through the filter and rock toe. The upstream slope for the bottom ash slurry side will be protected by providing LDPE Liner. The LDPE Liner shall be 200 micron thick and of black colour. The lining shall have a 150 mm sand cushion at the bottom. The liner shall be as per IS:2508. The liner shall be protected by providing one layer of brick 75 mm thick over a cement mortar layer of minimum 15 mm thick or 75 mm thick M10 PCC layer over a (1:4) cement mortar layer of minimum 15 mm thick spread over the LDPE Liner. The joints between the brick shall be filled with CM 1:4 after curing the brick paving for 3 days. The LDPE Liner shall be properly anchored at the top of the bund, at the berms and at the bottom of the bund with appropriate embedment with PCC in continuous trench. The bottom ash pond floor shall also be lined to prevent seepage of ash into ground water as per the requirements of environmental authority. The floor shall be based with LDPE Liner of 150 microns thickness as per IS:2508, black in colour with a bottom sand cushions of 150 mm and top earth cover of 300 mm. IS:8237 shall also be followed for guidance while designing slope protection. The subgrade for LDPE film shall be prepared from natural river sand / manufactured crusher sand as per IS codes / fly ash.

Water Escape Structure (Discharge Shaft):

The decanted water collected in stilling ponds shall be discharged through water escape structure, to the forebay of the pump house of the Ash water recovery system. Discharge shaft shall be circular in shape of suitable diameter with an internal diameter of a minimum of 4000 mm. On the two opposite sides of the shaft vents will be provided at different levels to drain out the decanted water as the level of ash in the ponds increase. Size of the vents shall be fixed in such a way that the inflow into the ponds equals the out flow. These vents will be

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blocked progressively as the ash level in the pond rises. The discharge shaft shall be sized to handle full out flow from the pond. The shaft will be designed as water retaining structure limiting crack width to 0.1 mm. Minimum grade of concrete shall be M25 for the shaft and foundation. The structure and foundation shall be designed to support the load of the ultimate height of the shaft. The contractor shall conduct necessary geotechnical investigation at the location of the water escape structure to decide on the type of foundation considering the ultimate load on the structure. From the discharge shaft water will be led out through a pipe with R.C.C encasement all round to protect the pipe from the super imposed earth load. The invert level of the pipe shall be kept 250 mm above the bottom of the shaft and will be given adequate slope to ensure discharge matching the inflow into the shaft. The shaft shall be provided with G.I rungs of 25 mm dia at 300 mm c/c for access during maintenance. Stop Log arrangement to block the vents during maintenance shall be designed and provided. At the top of the shaft removable platform with G.I gratings will be provided for operation and maintenance. The bunds shall be designed in spans not exceeding 20 m with R.C.C piers to support intermediate spans. Bridges shall be of structural steel with precast R.C.C deck slab for ease in dismantling and re erection. As the height of the bund is increased, these bridges will also be dismantled and re-erected.

The location of the discharge shaft shall be such that the edge of the foundation shall be 5000 mm clear of the upstream toe of ultimate stage of the bund.

Energy Dissipating Structures:

Along the upstream slope of the stilling ponds the ash slurry will be discharged through pipes at intervals. The pumped slurry will erode the lining and the bund proper if proper energy dissipating steps are not provided. The energy dissipating structure shall confine the flow from the pipe to an R.C.C. trough about 1500 mm wide projecting about 600 mm from the slope surface with R.C.C steps extending from the top of the bund to the toe where a water cushioning sump 1000 deep and 1500 x 1500 in plan will be provided for water overflow. Grade of concrete shall be a min of M25.

Weir with energy dissipating arrangement in all ash lagoons of dyke body at suitable points shall be provided to drain off the surface rain off.

Road way on top of bund:

4000 mm wide carriage way with WBM finish with 200 mm thick granular sub base and 200 mm thick WBM layer shall be provided at the top of the bund.

The carriage way shall be sloped in one direction toward downstream side where surface drains are provided. Guard stones shall be provided at 3000 mm c/c on either side of the bund.

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14. Standards, Codes and References

14.1 General

The Design of the Steel Structural Works shall be prepared and presented in accordance with IS codes. In absence of guidelines of specific items in the IS codes, International codes viz., American, BS, DIN or Australian code shall be used. All the Indian Standards referred to shall be the latest revision (including all amendments issued thereto) on the date of opening of the price bid. The Standards adopted shall be clearly stated in the calculations.

The Design shall comply with the current Local Authority Building Regulations (National Building Code) where appropriate. Subject to the agreement of the Owner, other International / Foreign National Standards, and, International / Foreign National Standard Codes of Practice, may be used.

To the extent that the Design shall include materials, methods or workmanship to be incorporated into the works, they shall be selected and incorporated into the design in accordance with the recommendations and requirements of the following (as appropriate in order of precedence but not mutually exclusive):

Statutory requirements

The Contract provisions

Bureau of Indian Standard Codes of Practice

International / Foreign National Standards

Agreement Certification for Materials

Manufacturer's recommendations for materials

Competent Trade Association recommendation

Engineering judgment

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

Where British / American / DIN or other codes and standards are referred to in this document, equivalent Indian Standards may be substituted if available.

Materials supplied from India shall follow the Indian Standard Specifications.

Field and laboratory testing procedures for materials follow Indian Standard Specifications.

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14.2 Codes for Loads

- IS: 875 : Code of Practice for design loads (other than earthquake) for Buildings and structures (All parts)
- IS: 1911 : Schedule of unit weights of building materials
- IS: 1893 (Part 1) : Criteria for earthquake resistant design of structure – General provisions and buildings
- IS: 1893 (Part 4) : Criteria for earthquake resistant design of structure – Industrial structures including stack-like structures

14.3 Codes for RCC

- IS: 456 : Plain and reinforced concrete - Code of Practice
- IS: 2974 : Code of Practice for design and construction of machine foundations
- IS: 2911 : Code of Practice for design and construction of pile foundation
- IS: 4326 : Code of Practice for earthquake resistant design and construction of buildings
- IS: 4995 : Criteria for design of reinforced concrete bins for storage of granular (all parts) and powdery materials
- IS: 5525 : Recommendation for detailing of reinforced concrete works
- IS: 1786 : Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS: 11384 : Code of Practice for composite construction in structural steel and concrete
- IS: 13920 : Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces

14.4 Codes for Structural Steel

- IS: 800 : Code of Practice for general construction in steel
- IS: 801 : Code of practice for use of cold-formed light gauge steel structural members in general building construction
- IS: 806 : Code of Practice for use of steel tubes in general building construction
- IS: 808 : Dimensions for hot rolled steel beam, column channel and angle section
- IS: 812 : Glossary of terms relating to welding & cutting of metals
- IS: 813 : Scheme of symbols for welding
- IS: 814 : Covered electrodes for manual metal arc welding of carbon and carbon manganese steel - Specification
- IS: 815 : Classification coding of covered electrodes for metal arc

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- welding of mild steel and low alloy high tensile steel
- IS: 816 : Code of Practice for use of metal arc welding for general construction in mild steel
- IS: 817 : Training of welders - Code of practice (Part 1 & 2)
- IS: 818 : Code of practice for safety and health requirements in electric and gas welding and cutting operation.
- IS: 819 : Code of practice for resistance spot welding for light assemblies in mild welding
- IS: 822 : Code of practice for inspection of welds.
- IS: 1182 : Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
- IS: 1200 : Method of measurement of building and civil engineering works
- IS: 1161 : Steel tubes for structural purpose
- IS: 1363 : Indian standard- Hexagonal head bolts, screws and nuts of product grade C
- IS: 1367 : Technical supply condition for threaded fasteners
- IS: 1477 : Code of practice for painting of ferrous metal in building
- IS: 1852 : Specification for rolling and cutting tolerance for hot-rolled steel products
- IS: 2062 : Structural steel (fusion welding quality)
- IS: 2074 : Ready mixed paint, air drying, red oxide zinc-chrome, priming
- IS: 2645 : Specification for integral cement waterproofing compound
- IS: 2932 : Specification for enamel, synthetic exterior type –I
- IS: 3613 : Acceptance tests for Wire flux combination of submerged arc welding
- IS: 3757 : Specification for high strength structural bolts
- IS: 4000 : Code of practice for High Strength bolts in steel structures
- IS: 7205 : Safety code for erection of structural steel work
- IS: 7215 : Specification for Tolerances for fabrication of steel structures
- IS: 7280 : Specification for Bare wire electrodes for submerged arc welding of structural steel
- IS: 8640 : Recommendations for dimensional parameters for industrial building
- IS: 9178 : Criteria for design of steel bins for storage of bulk material (All parts)
- IS: 9595 : For Metal arc welding of carbon and carbon manganese

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steel - Recommendation

IS: 11592 : Conveyor galleries

IS: 12843 : Tolerances for erection of steel structures

14.5 Miscellaneous Codes

IS: 919 : ISO system of limits and fits

IS: 1038 : Specification for steel doors, windows and ventilators

IS: 1172 : Code of basic requirements for water supply, drainage and sanitation

IS: 1346 : Code of Practice for water proofing of roofs with bitumen felts

IS: 1742 : Code of Practice for building drainage

IS: 1905 : Code of Practice for structural use of unreinforced masonry

IS: 2210 : Criteria for design of reinforced concrete shell structures and folded plates

IS: 2633 : Method for testing uniformity of coating on Zinc Coated Articles

IS: 3067 : Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings

IS: 4759 : Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products

IS: 10440 : Code of Practice for construction of reinforced brick and reinforced brick concrete floors and roofs

IS: 13592 : Un-plasticized polyvinyl chloride (UPVC) Injection molded fittings for soil & waste discharge system for inside and outside buildings including ventilation and rail water system specification

IS: 15658 : Precast concrete blocks for paving

SP: 6 : Handbook for structural engineers - All parts

SP: 7 : National Building Code of India

SP: 16 : Design Aids for reinforced concrete to IS: 456-1978

SP: 20 : Handbook on masonry design and construction

SP: 22 : Explanatory handbooks on codes for earthquake engineering (IS: 1893-1975 and IS: 4326-1976)

SP: 24 : Explanatory handbooks on Indian Standard code of Practice for plain and reinforced concrete

SP: 25 : Handbook on causes and prevention of cracks in buildings

SP: 32 : Handbook on functional requirements of industrial buildings

SP: 34 : Handbook of concrete reinforcement and detailing (SCIP)

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- TAC : Traffic Advisory Committee
- : Indian Explosive Act
- : Indian Factory Act and State Factory Act
- : Indian Electricity Act

Any statutory codes / standards / regulations other than listed above, as may be applicable, shall be followed.

Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in this document, the latest editions of the codes and standards given below shall also apply:

- a) Japanese Industrial Standards (JIS).
- b) American National Standards Institute (ANSI).
- c) American Society of Testing and Materials (ASTM).
- d) American Society of Mechanical Engineers (ASME).
- e) International Organization for Standardization (ISO).
- f) American Welding Society (AWS).
- g) National Electrical Manufacturers Association (NEMA).
- h) National Fire Protection Association (NFPA).
- i) International Electro-Technical Commission (IEC).
- j) German national codes (DIN)
- k) Expansion Joint Manufacturers Association (EJMA)

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-III
PART-A
TECHNICAL SCHEDULES-MECHANICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)**

**VOLUME-III, PART-A
TECHNICAL SCHEDULES-MECHANICAL
(TO BE FILLED BY BIDDER)**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

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TECHNICAL DATASHEETS – ASH HANDLING PLANT

1	ASH HANDLING PLANT		
1.1	Design Basis		
			<i>Design Coal Worst Coal</i>
	Maximum Coal consumption	: (TPH)	[...]
	Ash content	: (%)	[...]
	Ash generated		[...]
	a) Bottom ash generated	: (TPH)	[...]
	b) Coarse ash generated	: (TPH)	[...]
	c) Fly ash generated	: (TPH)	[...]
	Bottom ash removal time	:(minutes)	[...]
	Coarse ash & fly ash removal time	:(minutes)	[...]
	Guaranteed Capacity of Ash Handling System	:	[...]
	Bottom Ash System	:	
	Fly Ash System	:	
1.2	Bottom Ash (BA) System		
	BA Hopper – Type; Capacity; Material	:	
	a) Storage capacity of ash hopper 300 mm below operating water level	:	[...]
	b) Hours of storage of Boiler BA corresponding to maximum specified ash collection rate		
	c) Hopper material and Thickness	:	[...]
	d) Hydraulic Gate		[...]
	Material	:	
	Type	:	
	No.s per Hopper	:	
	Method of operation	:	

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	e) Clinker grinder – Quantity; Rated/ Design Capacity; Type; Manufacturer	:	[....]
	f) Standby quantity provided	:	[....]
	g) Speed of the grinder in RPM		[....]
	h) Guaranteed size to which clinker is grinding	mm	[....]
	i) Flushing Nozzles – No.s, Nozzle size, flow rate.		[....]
	Materials:		
	a) Grinder rolls & teeth	:	[....]
	b) Wear plate/liner & Grinder housing	:	[....]
	c) Shaft, shaft sleeve		[....]
	d) Motor rating	: (kW)	[....]
	Jet Pumps – Quantity Capacity Size (Inlet size X Throat Dia X outlet Size) Guaranteed Evacuation time of BA Hopper. Jet pumps new condition Jet Pumps worn out conditions Velocity in throat (m/sec) Material:- i. Inlet Piece ii. Nozzle Tip (Replaceable) iii. Discharge Piece iv. Nozzle Throat	:	[....]
	BA transport pipe – Quantity; Material; and type of pipe Joining	:	[....]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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	Air/Oil Converter tank		[...]
	a) Manufacturer	:	
	b) Numbers per hopper	:	
	c) Description of instrumentation and connections provided	:	
1.3	Clinker Grinder		
	Type (Single Roll/Double roll)	:	[...]
	Numbers provided	:	[...]
	Rated Capacity	: (TPH)	[...]
	Maximum Input size of clinker which can be handled by clinker grinder	:	[...]
	Guaranteed output size of clinker corres, to above mentioned input size	:	[...]
	Materials of Construction		[...]
	Grinder Chamber	:	
	Bearing	:	
	Rolls	:	
	Teeth	:	
	Wear Plate		
	Shaft		
	Shaft sleeves		
	Lantern rings		
	Speed (rpm) of clinker grinder	:	[...]
	Motor Power Consumption and KW rating of Motor at 50 deg C	:	[...]
1.4	Flushing Boxes		
	Numbers provided per unit	:	[...]
	Rated Capacity of each	: (TPH)	[...]
	No. s of nozzles provided per Hopper	:	[...]
	Water requirement per flushing box and required pressure	:	[...]

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	Material of Construction		[....]
	Nozzle body	:	
	Apparatus body	:	
	Nozzle tip	:	
	Gasket		
	Slurry outlet pipe		
1.5	Coarse Ash (CA) System		
	Feeder Ejectors – Quantity	:	[....]
	Guaranteed Removal rate	: (TPH)	[....]
	Material	:	[....]
	Material of nozzles, nozzle tips	:	[....]
	CA slurry piping – Size; Material; and type of joints	:	[....]
1.6	Fly Ash System		
	a. Capacity of Conveying System from Fly Ash Hoppers to the intermediate storage hopper (ISH)	Tph	[....]
	b. Phase Density (ratio of ash to mass of air)	:	
	c. Capacity of conveying system from ISH to FA silo	Tph	[....]
	d. Phase Density (ratio of ash to mass of air)	:	
	e. Operating time to completely evacuate Fly ash collected in one shift	min	[....]
	Fly ash extraction valves – Size; Body; Valve seals as valve slides/flaps	:	[....]
	Branch air intake valves – Size; material (body, disc/flap)	:	[....]
	Branch isolating valves & vacuum breakers – Material (body/gate)	:	[....]
	Collector tanks – Quantity & material	:	[....]

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	Wetting head – Quantity; material (Body & nozzles)	:	[...]
	Air washer – Material; type of nozzles; and nozzles	:	[...]
1.7	Mechanical exhausters (vacuum pumps)		
	a) Make; Quantity & type	:	[...]
	b) Design Standard	:	[...]
	c) Guaranteed Capacity	: (cfm)	[...]
	d) Pressure	:	[...]
	e) Volumetric efficiency	: %	[...]
	f) Motor rating and speed	: (kW)	[...]
	g) Material of construction:		[...]
	i) Casing	:	[...]
	ii) Shaft	:	[...]
	iii) Impeller/shaft sleeves	:	[...]
1.8	Fluidizing air blowers:		ESP Collector Tank
	a) Make; Quantity [working + standby]; type	:	[...]
	b) Design Standard	:	[...]
	c) Guaranteed Capacity	: (Nm ³ /hr)	[...]
	d) Discharge pressure	: (MWC)	[...]
	e) Motor rating	: (kW)	[...]
	f) Materials of construction:		[...]
	▪ Casing	:	[...]
	▪ Vanes (rotor)	:	[...]
	▪ Shaft & shaft sleeve		[...]

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	g) Inlet Air Filter Details Filter area Filter efficiency	:	[...]
	h) Accessories to be provided with the blower		[...]
1.9	Transport air compressors:		
	a) Make; Quantity; type	:	[...]
	b) Design Standard	:	[...]
	c) Guaranteed Capacity	: cum/hr)	[...]
	d) Discharge pressure	: (MWC)	[...]
	e) Motor rating	: (kW)	[...]
	i) Inlet Air Filter Details Filter area Filter efficiency		[...]
	f) Accessories to be provided with the Compressor		[...]
	g) Material of Construction: o Casing o Impeller o Shaft and shaft sleeves o Bearing		[...]
1.10	Instrument air compressors:		
	a) Make; Quantity; type	:	[...]
	b) Design Standard	:	[...]
	c) Guaranteed Capacity	: cum/hr)	[...]
	d) Discharge pressure	: (MWC)	[...]
	e) FAD of each compressor at design ambient	:	[...]
	f) Motor rating	: (kW)	[...]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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	j) Inlet Air Filter Details Filter area Filter efficiency		[....]
	g) Inter Cooler (if provided) Air cooled/ water cooled : If water cooled, state : pressure and capacity. :		[....]
	h) Accessories to be provided with the Compressor		[....]
	i) Material of Construction: o Casing o Impeller o Shaft and shaft sleeves o Bearing		[....]
	j) <u>Air Dryer:</u> o Make, Quantity , Type o Rated flow rate , Nm3/min. (condition of air to be indicated) o Working / Design / Test pressure, kg/cm2 (g) o Inlet Condition (Pa/deg C/dew point) o Outlet Condition (Pa/deg C/dew point) o Motor Rating at 50 deg C		[....]
	k) <u>Air Reciever:</u> o Design standard o Size and capacity o Material of construction Shell Dished Ends		[....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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1.11	Fly Ash Transport Pipe Work		Dry	Wet
	a) Size and thickness		[...]	
	b) Material	:	[...]	
	c) Type of joining pipes	:	[...]	
	d) Maximum Velocity (air-ash mixture / ash slurry)	:	[...]	
	e) Type of Joints Pipe to Pipe Pipe to fittings/ valves Fitting to Fitting/ valve	: : :	[...]	
	f) Type of Wear Back for Fittings		[...]	
	g) Min. Thickness of Wear back		[...]	
1.12	Fly Ash Silo:			
	a) Quantity		[...]	
	b) Capacity Effective Total	(Cu.M)	[...]	
	c) Type		[...]	
	d) Material of construction Body Liners (indicate hardness also)	: :	[...]	
	e) Method of Venting Conveying Air from Silo		[...]	
	f) Type of Bunker Level Measurement and numbers		[...]	
	g) Accessories and mountings		[...]	
	h) Number of outlet connections provided	:	[...]	

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	i) Clear head room from the ash discharge chute up to ground level for trucks to pass through		[...]
1.13	FA conditioner:		
	a) Quantity & type		[...]
	b) Removal rate	(TPH)	[...]
	c) Material – Body & Nozzles (water spray)		[...]
	d) Motor rating	(kW)	[...]
	e) Maximum moisture content	%	[...]
	f) Trough		[...]
	g) Shaft		[...]
	h) Paddles		[...]
1.14	Bag Filter:		
	a) Type and size		[...]
	b) Quantity and Capacity		[...]
	c) Guaranteed outlet dust emission (mg/Nm3)		[...]
	d) Efficiency		[...]
	e) Material of Construction <ul style="list-style-type: none"> • Body • Bag 		[...]
	f) Life of bag filter		[...]
	g) Type of Bag filter cleaning arrangement provided.		[...]
1.15	Rotary Feeder:		
	a) Quantity & Capacity		[...]
	b) Motor Rating		[...]

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	c) Material of construction <ul style="list-style-type: none"> • Shaft • Rotor • Rotor Blades • Bearings 		[....]
	d) Sealing arrangement at bearings		[....]
1.16	Telescopic Chutes:		
	a) Capacity		[....]
	b) Elevation during retracted/Expanded position		[....]
	c) Material of Construction		[....]
	Ash Disposal System		
1.17	Plug gates		
	a) Size & quantity [working + standby]		[....]
	b) Motor rating	(kW)	[....]
	c) Material of construction:		[....]
	i) Gate/stand		[....]
	ii) Plug gate		[....]
1.18	Ash slurry pumps:		
	a) Quantity [working + standby]		[....]
	b) Design Standard		[....]
	c) Guaranteed Capacity	(cum/hr)	[....]
	d) Head	(MWC)	[....]
	e) Type of Suction (suction lift/ flooded suction)	:	[....]
	f) Total dynamic head at rated capacity	: MLC	[....]
	g) Shut off head		[....]
	h) Motor rating	(kW)	[....]
	i) Material of construction:		[....]

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---	-------------------

	• Pump casing (inner & outer)		[...]
	• Impeller & impeller rings		[...]
	• Shaft & shaft sleeves		[...]
	j) Tip Speed	m/sec	[...]
	k) Slurry speed, Suction side	m/sec	[...]
	l) Slurry speed, Discharge side	m/sec	[...]
	m) Pump efficiency at rated capacity		[...]
	n) Specific gravity of slurry		[...]
	o) Power required at pump shut-off	: KW	[...]
	p) Slurry speed, suction side / Discharge side	m/sec	[...]
	q) Lubrication type		[...]
	r) Quantity and Quality of external water required		[...]
	s) Total weight		[...]
1.19	Gear Box		
	Type		[...]
	Reduction ratio and stages of reduction		[...]
	Transmission efficiency		[...]
1.20	Wet slide valves:		
	a) Make & size		[...]
	b) Mode of operation		[...]
	c) Material:		[...]
	• Body & seat		[...]
	• Gate		[...]
	• Stem		[...]

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---	-------------------

	• Deflection cone		[...]
1.21	Ash disposal pipeline:		
	a) Quantity; Size & material with type of lining		[...]
	b) Design Standard		[...]
	c) Disposal length		[...]
	d) Flow Velocity	: m/sec	[...]
	e) Pipe friction Factor	:	[...]
	f) Type of pipe jointing		[...]
	g) Guaranteed life of lining		[...]
	h) Material of fittings		[...]
	i) Material of Construction Body/Cover Gate Plug Stem Plate Gland Packing Sleeve/Yoke Seat		[...]
	j) Details of Basalt Lining: Specific gravity Hardness Abrasion resistance		[...]
1.22	Drain pumps:		BAH Area AWPB ADPH
	a) Make; Quantity [working + standby]	:	[...]
	b) Capacity	:cum/hr)	[...]
	c) Head at rated capacity	: MWC)	[...]
	d) Shut-off Head	: MWC)	[...]
	e) Motor rating	: (kW)	[...]
	f) Type of Lubrication		[...]

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---	-------------------

	g) Size (suction flange/ discharge flange)	:	[...]
1.23	Water System		
	Water Pump Sets:		HP Water LP Seal
	a) Make; Quantity (operating + standby)		[...]
	b) Design standard		[...]
	c) Guaranteed Capacity	cum/hr)	[...]
	d) Total Developed Head at rated capacity	(MWC)	[...]
	e) Shut-off Head		[...]
	f) Motor rating	(kW)	[...]
	g) Pump Speed	: rpm	[...]
	h) Efficiency of pump at design capacity	%	[...]
	i) Material of Construction:		[...]
	• Casing and Casing wear ring		[...]
	• Impeller& impeller rings		[...]
	• Shaft & shaft sleeves		[...]
	• Shaft bearing		[...]
	• Type of Lubrication		[...]
	BA Overflow Water Pump:		
	a) Type		[...]
	b) Material of Construction		[...]
	c) Capacity		[...]

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---	-------------------

1.24	Ash Water Requirement		
	LP Water Refractory Cooling BA Hopper cooling water BA Hopper fill Seal trough make-up Fly ash conditioning Others(please identify)		[...]
	HP Water Jet Pump BA Hopper flushing Seal trough flushing Gate housing flushing Others (please identify) Economiser water Slurry transportation		[...]
	Quantity of water required for fly ash handling	: m3/hr	[...]
1.25	Ash Water Recovery System		
	AHP Clarifier		[...]
	a) Type of clarifier		[...]
	b) Size of clarifier		[...]
	c) Material of Construction		[...]
	d) Guaranteed output suspended solids & pH value		[...]
	Recovery Water Pumps		
	a) Quantity of pumps (operating + standby)		[...]
	b) Type of pumps		[...]
	c) Guaranteed Capacity of each pump (flow/head)		[...]
	d) Head developed at rated capacity		[...]

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--	--------------------------

	e) Shut-off head		[...]
	f) Motor rating		[...]
	g) Pump input power at shut-off		[...]
	h) Lubrication type		[...]
	i) Material of Construction		[...]
	Casing		[...]
	Impellar		[...]
	Base Plate		[...]
	Shaft and Shaft sleeve		[...]
	Stuffing Box and glands		[...]
	j) Pipe line size and material		[...]
	Transfer Pumps		
	a) Quantity of pumps (operating + standby)		[...]
	b) Type of pumps		[...]
	c) Guaranteed Capacity of each pump (flow/head)		[...]
	d) Head developed at rated capacity		[...]
	e) Shut-off head		[...]
	f) Motor rating		[...]
	g) Pump input power at shut-off		[...]
	h) Lubrication type		[...]
	i) Material of Construction		[...]
	• Casing		[...]
	• Impellar		[...]
	• Base Plate		[...]
	• Shaft and Shaft sleeve		[...]
	• Stuffing Box and glands		[...]
	j) Pipe line size and material		[...]

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--	--------------------------

	Piping and Fitting		
	a) Size		[...]
	b) Material of construction		[...]
	c) Design pressure Pipes Fittings		[...]
	d) Type of Protective coating		[...]
	e) Motor operated Butterfly valves Design Code KW rating of actuator Material of Construction Body Disc/trim Stem		[...]
	f) Manually operated Butterfly valve Design Code Material of Construction Body Disc/trim Stem		[...]
	g) Non-return Valve Design Code Material of Construction Body Disc/trim Stem		[...]
	h) Gate Valve Design Code Material of Construction Body Disc/trim Stem		[...]

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Tender Document for R&M of Unit No. [../] Capacity [../] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Signature : _____

Name : _____

Designation : _____

Seal of Company

Date : _____

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-III
PART-B
TECHNICAL SCHEDULES-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
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	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
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6. Forms and Schedules

* * * * *

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1. Intent of Specification
2. Site & Project Specific Information
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SECTION-II: DETAILED TECHNICAL SPECIFICATION

1. Detailed Technical Specification-Mechanical
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* * * * *

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(TO BE FILLED BY BIDDER)**

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING PLANT
(PACKAGE NUMBER: R&M-SP-05)**

**VOLUME-III, PART-B
TECHNICAL SCHEDULES-ELECTRICAL
(TO BE FILLED BY BIDDER)**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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{Only the Applicable portion of the Data Sheet based on the scope of work as firmed up in Section-I, Volume-II should be retained and the remaining portion should be deleted. The scope of work in Section-I, Volume-II is based on Residual Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA) Report.}

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

1.0 MOTOR

SL. NO.	DESCRIPTION	UNIT	DATA
1.	Manufacturer		
2.	Type and frame size		
3.	Nos. required		
4.	Application		
5.	Specification & Codes		
6.	Capacity for specified climatic conditions [50°C]		
7.	Location for installation		
8.	Type of enclosure & ventilation		
9.	Degree of protection		
10.	Type of duty		
11.	No. of phases, frequency & voltage		
12.	Permissible variations in		
a)	Voltage		
b)	Frequency		
c)	Combined		
13.	At rated voltage & frequency		
a)	Full load current		
b)	Full load speed		
c)	No load current		
14.	Minimum permissible voltage during starting :		
15.	Maximum permissible time at minimum permissible voltage during running at full load.		
16.	Maximum permissible time at 75% of rated voltage during running at full load.		
17.	Whether motor stalls at 70% of rated voltage Efficiency & power factor.		
18.	Stator winding		
	Type & nos. of terminals Brought out		
	Resistance between terminals at 20°C		
	Resistance per phase at 20°C		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

SL. NO.	DESCRIPTION	UNIT	DATA
	Inductance per phase		
	Capacitance per phase		
	Starting current as % of full load current		
19.	Torque at full load in Kgm.		
a)	Break away torque in % of full load torque		
b)	Pull up torque in % of full load torque		
c)	Pull out torque in % of full load torque		
20.	Starting time in sec.		
a)	Without mechanism coupled		
b)	Mechanism coupled through hydraulic coupling when it may be presumed that load is transferred to motor shaft only after attaining almost full speed.		
	i. with rated voltage		
	ii. with 80% of rated voltage		
	iii. with 110% of rated voltage		
21.	Starting time in sec. With mechanism coupled through flexible coupling		
a)	with rated voltage		
b)	with 80% of rated voltage		
c)	with 110% of rated voltage		
22.	Safe stall time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
23.	Safe stall time (Cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
24.	Limiting motor temperature to determine safe stall time		
25.	Permissible maximum accelerating time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

SL. NO.	DESCRIPTION	UNIT	DATA
26.	Permissible maximum accelerating time (cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
27.	Class of Insulation And Material		
28.	Whether insulation is suitable for 415 V, 6.6kV system		
29.	Temperature rise under normal conditions over 50°C ambient temperature		
30.	By resistance method --- °C over cooling water temp. for CACW motors.		
31.	Degree centigrade over cooling air temp. for CACA motor.		
32.	By Thermometer method ---- Degree centigrade over cooling water temp. for CACW motor.		
33.	Degree centigrade over cooling air temp. for CACA motor.		
34.	Method of starting :		
35.	Permissible starting duty cycles :		
36.	Stator thermal time constant :		
37.	Method of cooling (If applicable)		
	Details of water cooling system		
a)	No. of cooler		
b)	Water requirement per cooler		
c)	Losses removed by cooler		
d)	Max. permissible temperature of cooling water at inlet		
e)	Max. permissible temperature of cooling water at outlet		
f)	Maximum permissible pressure at water outlet		
g)	Water pressure drop through the cooler		
h)	Temp. of cold air coming out & entering the machine For permissible cooling water temperature of [31°C]		
i)	Temp. rise of air passing through machine at full load.		
j)	Air pressure drop through The cooler		
k)	Temp. rise of water through cooler		
l)	Protection against leakage of water :		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

SL. NO.	DESCRIPTION	UNIT	DATA
m)	Arrangement to ensure the water flow		
38.	Bearings		
a)	Number :		
b)	Type :		
c)	Lubrication system :		
d)	Quantity of lubricant reqd. For both the bearings. Life in hours at rated speed :		
e)	Recommended lubricant :		
f)	Bearing end play :		
g)	Inlet oil pressure :		
h)	Temp. rise of oil :		
i)	Max. permissible temp. of bearing :		
j)	Max. Permissible temp. of Oil		
k)	Permissible running time without forced oil at full load & full speed :		
39.	Whether bearings are provided with 4 wire, platinum RTD having 100-ohm resistance at 0°C for remote temp. Indication.		
a)	Whether bearings are provided with local temperature indicator having two adjustable contacts rated for 5A at 240V AC or 0.5A at 220V DC. : Yes/No		
b)	If forced lube oil system provided :Yes / No		
c)	Qty of lubricant required for initial filling.		
d)	Recommended period after which lubricant should be replaced		
e)	Bearing cooling water requirement		
f)	Max. Permissible bearing cooling water inlet temp. (permissible)		
g)	Max. Permissible bearing cooling water outlet temp.		
h)	Terminal designation corresponds to direction of rotation (Facing driving end).		
i)	Terminal boxes with accessories separate terminal boxes provided.		
40.	Winding temp. detectors		
41.	Bearing temp. detectors		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

SL. NO.	DESCRIPTION	UNIT	DATA
42.	Moisture detectors		
43.	Neutral terminals		
44.	Main terminal box details		
a)	Type & Nos.		
b)	Fault level permissible for 0.25 sec.		
c)	Location		
d)	Cable gland size & no.		
e)	Direction of cable entry.		
45.	Space Heater		
a)	Number		
b)	Location		
c)	Capacity of each		
d)	Total power requirement		
e)	Voltage.		
46.	Details of 4 wire platinum RTD having 100 ohm resistance at 0°C for winding temp. detector.		
a)	Nos. provided		
b)	Location		
47.	Whether CTs for differential protection are provided : Yes / No		
a)	If Yes, no. of CTs supplied along with motors C.T. details		
	i. C.T. ratio		
	ii. Knee point voltage		
b)	S.C. withstand capacity		
c)	Type of mounting		
48.	Shaft orientation		
49.	Shaft extension		
50.	Grounding pads size nos. & location		
51.	Method of coupling to driven mechanism		
52.	Motor GD ² :		
53.	Lifting device		
54.	Weight		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

SL. NO.	DESCRIPTION	UNIT	DATA
a)	Weight of stator (wound)		
b)	Weight of rotor (wound)		
c)	Weight of base plate		
d)	Weight of cooler		
e)	Net weight of motor		
f)	Shipping dimensions & weight		
55.	Thermometer provided		
a)	In cold air path		
b)	In hot air path		
c)	For measurement of oil temp.		
56.	Characteristic curves furnished		
a)	Speed vs. current at rated voltage	Yes / No	
b)	Speed vs. torque at 110%, 100%, 90% and 80% of rated voltage:	Yes / No	
c)	Thermal withstand curve for hot & cold conditions.	Yes / No	
d)	Efficiency vs. load:	Yes / No	
e)	P.F. Vs. load:	Yes / No	
f)	Current vs. time:	Yes / No	
g)	Negative phase sequence curve:	Yes / No	
57.	Drawings furnished		
a)	General arrangement of motor	Yes / No	
b)	Main terminal box showing the method of terminating the incoming cables Yes/No	Yes / No	
c)	Instruction manuals	Yes / No	
	MOTOR (DC)		
1.	GENERAL		
a)	Manufacturer :		
b)	Equipment driven by Motor :		
c)	Motor type :		
d)	Country of origin :		
2.	DESIGN & PERFORMANCE		
a)	Frame Size :		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

SL. NO.	DESCRIPTION	UNIT	DATA
b)	Type of duty :		
c)	Type of enclosure & type of cooling :		
d)	Applicable standard to which motor generally confirms:		
e)	Type of mounting :		
f)	Direction of rotation :		
g)	KW rating at amb. Temp. 50 °C :		
h)	Rated power supply voltage		
	i. Armature circuit (V) :	V	
	ii. Field circuit (V) :	V	
i)	Permissible voltage variation :		
j)	Minimum permissible starting voltage :		
k)	Rated speed at rated voltage (RPM) :	RPM	
l)	At rated voltage		
	i. Full load current (A) :	A	
	ii. NO load current (A) :	A	
m)	Starting current (A) :		
	i. 100% voltage :		
	ii. 85 % voltage :		
n)	Starting time (with pump coupled) :		
	i. 100% voltage (Sec) :		
	ii. 85 % voltage :		
	iii. 80 % voltage :		
o)	Efficiency at rated voltage at :		
	i. 100% load :		
	ii. 75% load:		
	iii. 50% load:		
p)	Safe stall time (sec) at 110% :		
	i. Hot condition :		
	ii. Cold condition :		
q)	Torque (Kg-m) :		
	i. Starting at min. permissible voltage:		
	ii. Rated:		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

SL. NO.	DESCRIPTION	UNIT	DATA
r)	Fly wheel moment (GD2) motor (Kg-m)		
3.	CONSTRUCTIONAL FEATURES		
a)	Winding insulation :		
	i. Class & type :		
	ii. Tropicalised (Yes/No) :		
	iii. Temp. rise over specified ambient of 50 °C. :		
	iv. Method of temp. measurement :		
b)	Degree of protection of terminal box for :		
	i. Main terminal box :		
	ii. Space heaters (AUX. TB) :		
c)	For main terminal box :		
	i. No. and type of cable gland :		
	ii. Recommended cable size (Armature/field) :		
d)	Fault level (KA, sec) :		
e)	Bearings :		
	i. Type (at DE/NDE):		
	ii. Make :		
	iii. Recommended lubricant :		
	iv. Life :		
f)	Weight of motor (Kg.) :		
g)	Field current at rated speed (A)		
h)	Field resistance (Ohm) at rated speed at 30 °C		
i)	Field trimmer rating (Ohm) for getting basic speed at 30 °C.		
j)	Resistance (Ohm) between terminals at 30°C.		
	i. Armature :		
	ii. Series winding :		
	iii. Inter pole winding :		
	iv. Shunt winding resistance:		
k)	1 st and 2 nd critical speed :		
l)	Overload that can be carried by motor without changing overall performance and period for which it is applicable		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

SL. NO.	DESCRIPTION	UNIT	DATA
m)	Grounding device :		
n)	Space heater :		
	i. No. & location :		
	ii. Volt & KW rating :		
4.	RESISTORS		
a)	Starting (external) resistance :		
	i. Type of resistor :		
	ii. Ohmic, current & power rating of resistor elements		
	iii. Max. permissible temp. of resistor elements :		
	iv. Connection diag. Of resistor elements		
	v. No. of startup stages/steps :		
	vi. Resistance values of stages :		
	-at 30 deg. C (Ohm) :		
	-at running condition (Ohm) :		
	vii. Expected temp of resistor at running condition		
	viii. Expected temp of box at running condition		
	ix. Mounting/stacking of resistor elements and G.A. of resistor box		
b)	Schematic connection diag. Of motor with starting resistor and field trimmer resistor.		
5.	CHARACTERISTIC CURVES		
a)	Starting current/times :		
b)	Thermal withstand curve for hot and cold condition		
c)	Torque/speed		
d)	Load/Efficiency		
e)	Speed/Time		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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2.0 MOTOR ACTUATORS

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		
2.	Application		
3.	Motor type		
	Supply voltage	V	
4.	Phase, frequency	Hz	
5.	Motor rated voltage	V	
6.	Control Voltage	V	
7.	Voltage and its variation	V	
8.	Frequency and its variation	Hz	
9.	Combined V & f variation	%	
10.	Degree of Protection		
11.	Winding Insulation		
12.	Temperature Rise (over ambient temperature)	°C	
13.	Painting		
14.	Motor Starting		
a)	Method		
b)	Starting Current		

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3.0 LT TRANSFORMER (OIL TYPE/DRY TYPE)

6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Make		
2.	Application		
3.	Location		
4.	Type		
5.	Reference standard		
6.	Rated power (indicative)		
7.	Rated winding voltage ratio (line to line)		
8.	Number of phases		
9.	Winding		
10.	Rated frequency		
11.	Type of cooling		
12.	Insulation Class		
13.	Temperature rise Over ambient temperature of 50°C		
a	For Winding by resistance method		
b	For Oil by Thermometer method		
14.	Insulation level (LI/AC)		
a	HV- (LI/AC)		
b	LV- (LI/AC)	-Vp/3KVrms	-KVp/3KVrms
15.	Vector group		

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16.	Short-circuit impedance on principal tap				
17.	Parallel operation of transformer				
18.	Type of taps provided				
19.	Taps provided on				
20.	Range of taps				
21.	Method of Tap charge control-				
a	Manual local				
b	Electrical local				
c	Electrical remote				
d	Automatic				
22.	System earthing				
a	H.V.				
b	L.V.				
23.	Terminal arrangement				
a	H.V.				
b	L.V.				
24.	Neutral for earthing				
25.	Transformer bushing	HV	LV	LV - N	
26.	Voltage class KV(r.m.s.)				
27.	Creepage distance mm				
28.	Min. Ph-Ph/ Ph-E clearance mm				
29.	System fault Level				
a	HV Side				
b	LV Side				

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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30.	Max. Noise level		
31.	Auxiliary supply		
32.	LV neutral side current transformer for standby earth fault protection		
33.	Guaranteed no load loss (kW)		
34.	Guaranteed load loss (kW)		
35.	Efficiency		
a	At full load		
b	At 75% load		
c	At 50% load		
36.	Accessories		
	Each transformer furnished With fittings and accessories as per specification.		
37.	Approximate overall dimensions		
a	Length		
b	Breadth		
c	Height		
38.	Crane lift for un taking core and coil assembly Approximate Weights		
a	Core and coil		
b	Enclosure and fittings		
c	Oil		
d	Total weight		
39.	Shipping Details:		
a	Weight of the heaviest package		
b	Dimension of the largest package : (LxBxH)		
40.	Tests		
	Routine test as per IS and other tests as per specification		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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4.0 LT PCC/MCC/DISTRIBUTION BOARD

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material	Cu/Al	
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Colour finish shade	Interior exterior	

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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Starters		
3.1	Type	DOL Rev / Star-Delta	
3.2	Contactor rated duty		
3.3	Single phasing preventer required.	Yes / no	
3.4	Thermal overload relay reset	Manual / Auto	
4.0	Circuit breakers		
4.1	Maker's name		
4.2	Voltage, frequency & no.of phases , poles		
4.3	Rated operating duty		
4.4	Circuit breakers type		
4.5	Short circuit withstand current for 1 sec. Duration	kA	
4.6	Rated making current	kAp	
4.7	Rated current at site reference ambient temp	A °C	
4.8	Type of operating mechanism		
4.9	Minimum no. of auxiliary Contacts for purchaser's use		
4.10	Control voltage		
a	For Spring charging motor	V AC/DC	
b	For closing/tripping	V AC/DC	
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	
b	Closing at normal voltage	%	
c	Trip coil	%	
4.12	Power required for closing at normal voltage	W	
4.13	Power required for tripping at normal voltage	W	

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S. No.	DESCRIPTION	UNIT	DATA
4.14	Spring charging motor details:		
a	Rating	kW	
b	Rated voltage	V, AC/DC	
c	Spring charging	Sec.	
	Electrical and mechanical anti-pumping features been provided	Yes/No	
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		
5.2	Rated operating duty		
5.3	Rated breaking capacity	kA (rms)	
5.4	Rated making current	kA (Peak)	
5.5	On/Off operation		
5.6	Manual	Yes/No	
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	
5.8	Auxiliary contacts required	Yes/No	
6.0	Contactors		
6.1	Make		
6.2	Rated duty	AC3/AC4	
6.3	No of poles		
6.4	Utilization category		
6.5	Rated voltage of auxiliary contacts	V	
6.6	Rated voltage of coil	V	
6.7	Rated breaking capacity	Factor of rated current	
6.8	Rated making capacity	Factor of rated current	
6.9	Limits of operation		
a	Supply voltage variation		

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S. No.	DESCRIPTION	UNIT	DATA
b	Supply frequency variation for closing		
c	Drop out voltage		
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		
7.1	Voltage Ratio		
7.2	CT Ratio		
7.3	Measuring CTs		
7.4	Protection CTs		
7.5	Measuring VTs		
7.6	Protection VTs		
8.0	Control transformers		
8.1	Make		
8.2	Type		
8.3	Applicable standards		
8.4	Ratio		
8.5	Class of insulation		
8.6	Rated output	VA	
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		
10.2	Make		
10.3	Type designation		
10.4	Setting range		
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		
11.2	Make		
11.3	Type		
11.4	Current setting range		

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	
12.0	Under voltage relay		
12.1	Make		
12.2	Type		
12.3	Voltage rating	V	
12.4	Setting range	V	
13.0	Auxiliary relays and timers		
13.1	Make		
13.2	Type		
13.3	Coil voltage	V	
14.0	Control/selector switch		
14.1	Make		
14.2	Type designation		
15.0	Meters		
15.1	Applicable Standards		
15.3	Accuracy Class		
15.4	Make		
15.5	Type		
16.0	<u>Voltmeter</u>		
16.1	Make		
16.2	Type		
16.3	Applicable standards		
16.4	Accuracy class		
17.0	<u>Ammeter</u>		
17.1	Make		
17.2	Type		
17.3	Applicable standards		
17.4	Accuracy class		

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S. No.	DESCRIPTION	UNIT	DATA
18.0	<u>Indicating lamps</u>		
18.1	Make		
18.2	Type		
18.3	Voltage	V	
18.4	Wattage of lamp	W	
19.0	<u>Push buttons</u>		
19.1	Make		
19.2	Type designation		
19.3	Contact rating	A	
20.0	<u>Space heater</u>		
20.1	Make		
20.2	Type		
20.3	Rated voltage	V	
21.0	<u>Wiring and terminal blocks</u>		
21.1	Voltage grade		
21.2	Insulation		
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	
b	Control wiring	Sq.mm	
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		
	II) For Fixed Type		
21.5	Minimum current rating of terminal blocks	A	

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5.0 415V NON SEGREGATED PHASE BUS DUCT

S. No.	DESCRIPTION	UNIT	DATA
1.	Make/ Name of Manufacturer		
2.	Type of Busduct	Segregated /non segregated	
3.	Type of cooling	Natural/Forced	
4.	Reference Standard		
5.	Rated Voltage	V	
6.	No of phase and Frequency	Hz	
7.	Insulation level a) Min Power frequency Voltage b) Impulse withstand voltage	kVrms kVp	
8.	Rated Continuous current	Amp	
9.	Short time withstand capability a) Symmetrical for 1 sec b) Momentary	kA kAp	
10.	Maximum temperature rise over 50 degree design ambient temperature a) Bus bar b) Enclosure	Degree	
11.	Degree of protection of enclosure		
12.	Bus bar a) Material & Grade b) Conductivity c) Size		
13.	Enclosure a) Material & Grade b) Thickness c) Ph- ph spacing d) Over all dimension		
14.	Dc resistance in micro ohm/metre/phase a) At 20 degree		

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S. No.	DESCRIPTION	UNIT	DATA
	b) At 85 degree		
15.	Reactance in ohm/meter/phase		
16.	Capacitance to ground		
17.	Losses in watt/meter/phase		
18.	Insulators		
	a) Make		
	b) Material		
	c) No per support		
	d) Voltage Glass		
	e) Compression strength		
	f) Cantilever strength		
19.	Size and material of ground bus		
20.	Support steel structure		
21.	Whether the following has been provided		
	a) Thermostat controlled space heater		
	b) Silica gel breather		
	c) Drain plug		
	d) Neoprene rubber gaskets at joints		
	e) Disconnecting links		
22.	Painting shade		
	a) Interior		
	b) Exterior		

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6.0 220V DC SYSTEM

SL. NO.	DESCRIPTION	UNIT	DATA
A.	DC SYSTEM		
	BATTERY		
	General		
	• Make		
	• Catalogue No.		
	• Type		
	• Reference Standard		
	Rating		
	• Rated Voltage	Volt	
	• 10-hour rating at 27 Deg.C to end cell voltage	AH	
	• 2-hour discharge rate to end cell voltage	Amp	
	• 1 –hour discharge rate to end cell voltage	Amp	
	• 1 -minute discharge rate to end cell voltage	Amp	
	Performance		
	• Battery duty cycle curve furnished	Yes/No	
	• Cell voltage characteristics during duty cycle furnished	Yes/No	
	• Minimum cell voltage during duty cycle	Volt	
	• AH efficiency at 10-hour discharge rate	%	
	• Expected life of Battery	Yr	
	Battery Characteristics		
	• Recommended charging rate for		
	i) Float charging	Amp	
	ii) Equalising Charge	Amp	
	iii) Boost charging in 10 hrs.		
	• Start	Amp	
	• Finish	Amp	
	• Recommend specific gravity at 27 Deg.C		
	i) For first filling		

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SL. NO.	DESCRIPTION	UNIT	DATA
	ii) At full charge		
	iii) At end of 10-hour discharge		
	• Short-circuit current for a dead-short across battery terminals, when		
	i) Float charge at 2.15 V/Cell	kA	
	ii) Boost charge at 2.75 V/Cell	kA	
	• Battery internal resistance	Ohm	
1	Cells		
	• Number of cells per battery	Nos.	
	• Nominal Cell voltage	V	
	• Cell voltage at the end of duty cycle	V	
	• Cell voltage at the end of full discharge at 10-hour rate	V	
	• Type of the cell		
	• Cell designation as per relevant Standard		
	• Material of the container		
	• Overall dimension of each cell (LxDxH)	mm	
	• Weight of complete cell		
	i) Without electrolyte	kg	
	ii) With electrolyte	Kg	
	• Internal resistance of cell	Ohm	
2	Intercell Connector		
	• Intercell connector furnished	Yes/No	
	• Type of intercell connector	bolted/burned	
	• Material of intercell connector		
3	Plates		
	• Number of positive plates per cell	Nos.	
	• Type of positive plate		
	• Type of negative plate		
4	Separator		
	• Type		
	• Material		

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SL. NO.	DESCRIPTION	UNIT	DATA
	• Thickness	mm	
5	Electrolyte		
	• Amount of electrolyte for first filling		
	i) Per cell	litre	
	ii) Per set	litre	
	• First filling with 10% extra furnished	Yes/No	
	• Electrolyte conforms to		
6	Racks		
	• Number of racks per battery	Nos.	
	• Number of cells per rack	Nos.	
	• Type of racks	Rows/Tiers	
	• Material of rack		
	• Racks provided with		
	i) Numbering tags for cells	Yes/No	
	ii) Clamps for cables	Yes/No	
	• Insulator furnished for		
	i) Cell	Yes/No	
	ii) Stand	Yes/No	
	• Inter-row, Miter-tier connectors and end take-off furnished	Yes/No	
	• Connector hardwares furnished	Yes/No	
7	Dimension & Weight		
	• Overall dimension (LxDxH)	mm	
	• Approx. Weight	Kg	
	• Battery layout drawing furnished	Yes/No	
8	Ventilation requirement furnished	Yes/No	
9	List of accessories furnished	Yes/No	
10	Technical leaflets furnished	Yes/No	
	BATTERY CHARGER		
i)	GENERAL		

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SL. NO.	DESCRIPTION	UNIT	DATA
	a. Make		
	b. Catalogue No.		
	c. Type		
	d. Reference Standard		
ii)	A.C. Input		
	a. Voltage \pm % variation	Volt, %	
	b. Phase	No.	
	c. Frequency \pm % variation	Hz., %	
	d. Input current	Amp	
iii)	D.C. Output		
	a. Voltage	Volt/Cell	
	b. Current	Amp.	
	Type of Cooling		
iv)	Max. Temp rise within cubicle above site ambient		
	a. Rectifier transformer	°C	
	b. SCR	°C	
v)	Performance		
	a. Regulation for 0-100% rated load with \pm 10% Input voltage and \pm 5% input frequency variation	%	
	b. Ripple content in O.C. output		
	i) With battery	%	
	ii) Without battery	%	
	c. Guaranteed efficiency at rated load	%	
	d. Power factor at rated load	%	
vi)	Miscellaneous		
	a. Charger provided with following features		
	i) Automatic voltage regulation	Yes/No	
	ii) Current limiting circuitry	Yes/No	
	iii) Smoothing filter circuit	Yes/No	
	iv) Soft-start feature	Yes/No	
	v) Automatic load shahng during parallel operation	Yes/No	

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SL. NO.	DESCRIPTION	UNIT	DATA
	b. SCR elements provided with		
	i) Surge protection	Yes/No	
	ii) Fast acting HRC fuse	Yes/No	
vii)	A. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
viii)	A. C. Fuse / MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
ix)	A.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rated Current	Amp	
	e. Utilization category		
	f. Thermal overload with In-built single-phase preventer provided	Yes/No	
x)	Rectifier Transformer		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating		
	i) KVA	KVA	

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SL. NO.	DESCRIPTION	UNIT	DATA
	ii) Voltage	V	
	iii) % reactance	%	
	e. Class of insulation		
	f. Method of cooling		
xi)	Controlled Rectifier (SCR)		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. RMS Current rating	Amp	
	e. Surge Current		
	i) One-cycle	Amp	
	ii) Repetitive Cycle	Amp	
	f. Peak inverse voltage		
	i) Continuous	Volt	
	ii) Surge	Volt	
xii)	D.C. Fuse/MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating		
	i) Continuous	Amp	
	ii) Interrupting	KA	
xiii)	D.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating	Amp	
	e. Utilization category		
xiv)	Blocking Diodes		
	a. Make		
	b. Type/Cat. No.		

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SL. NO.	DESCRIPTION	UNIT	DATA
	c. Reference Standard		
	d. Current Rating		
	i) One – minute	Amp	
	ii) One-hour	Amp	
	e. Peak inverse voltage	Volt	
xv)	Indication Lamps		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Wattage	Watt	
	e. Series resistor	Ohm	
xvi)	Meters		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Size	mm	
	e. Accuracy		
xvii)	Alarm Facia		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. No. of window per facia	Nos.	
xviii)	D. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating	Amp	
	e. No. of poles	Nos.	
xix)	Charger Panel		
	a. Make		
	b. Type		

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SL. NO.	DESCRIPTION	UNIT	DATA
	c. Reference Standard		
	d. Enclosure		
	i) Degree of protection		
	ii) Sheet steel thickness	mm	
	e. Panel provided with		
	i) Internal lamp with door-switch	Yes/No	
	ii) Space heater with thermostat	Yes/No	
	iii) 5A, 3-pin receptacle with plug	Yes/No	
	f. Internal Wiring		
	i) Insulation		
	ii) Voltage grade	V	
	iii) Minimum conductor size	mm ²	
	g. Power Terminals		
	i) Make		
	ii) Size/Cat. No.		
	h. Control Terminals		
	i) Make		
	ii) Size/Cat. No.		
	iii) 20% spare terminal furnished	Yes/No	
	i. Ground Terminal furnished	Yes/No	
	j. Overall dimension (LxDxH)	mm	
	k. Weight	Kg	
	l. General Arrangement drawings furnished	Yes/No	

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7.0 HV CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.1.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
a)	In air	A	
b)	In ground	A	
c)	In duct	A	
d)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		

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S. No.	DESCRIPTION	UNIT	DATA
a)	Material reference standard for conductor		
b)	Grad and Shape of conductor		
c)	Nominal cross section area	mm ²	
d)	Number of wires		
e)	Diameter of wire	mm	
f)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	i. Between cores	mm	
	ii. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.20	Inner sheath		
a)	Material, confirming standard / type		
b)	Extruded	Yes/No	
c)	Calculated diameter over laid up cores		
d)	Thickness (min)	mm	
e)	Diameter of cable over inner sheath	mm	
f)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
g)	Filler Material details		
1.21	Armouring		
a)	Material		

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S. No.	DESCRIPTION	UNIT	DATA
b)	Type of armouring		
c)	No. and size of strip/wire		
d)	Whether galvanized	Yes/No	
e)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
a)	Material confirming standard/ type		
b)	Extruded	Yes/No	
c)	Minimum Thickness of sheath	mm	
d)	Tolerance on thickness of sheath	mm	
e)	Min. tensile strength	N/sq mm	
f)	Min. elongation percentage at rupture		
g)	Colour of Outer sheath		
h)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification and standards	Yes/No	
1.23	Overall diameter of cable and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous current		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/km	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated		

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S. No.	DESCRIPTION	UNIT	DATA
	temperature		
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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8.0 LT POWER & CONTROL CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.2.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
e)	In air	A	
f)	In ground	A	
g)	In duct	A	
h)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
g)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
h)	Grad and Shape of conductor		
i)	Nominal cross section area	mm ²	
j)	Number of wires		
k)	Diameter of wire	mm	
l)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
	iii. Between cores	mm	
	iv. Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.20	Inner sheath		
h)	Material, confirming standard / type		
i)	Extruded	Yes/No	
j)	Calculated diameter over laid up cores		
k)	Thickness (min)	mm	
l)	Diameter of cable over inner sheath	mm	
m)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
n)	Filler Material details		
1.21	Armouring		
f)	Material		
g)	Type of armouring		

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S. No.	DESCRIPTION	UNIT	DATA
h)	No. and size of strip/wire		
i)	Whether galvanized	Yes/No	
j)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
i)	Material confirming standard/ type		
j)	Extruded	Yes/No	
k)	Minimum Thickness of sheath	mm	
l)	Tolerance on thickness of sheath	mm	
m)	Min. tensile strength	N/sq mm	
n)	Min. elongation percentage at rupture		
o)	Colour of Outer sheath		
p)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification	Yes/No	
1.23	Overall diameter of cable and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous currents		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/km	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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9.0 ILLUMINATION SYSTEM

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC	
1.2	Variation in Supply		
	a) Voltage	%	
	b) Frequency	%	
	c) Combined voltage & frequency	%	
1.3	Design Ambient Air Temperature	°C	
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	
	b) At 220V DC (For DC LP)	kA(DC)	
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		
b	Conductor size	SWG	
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		
2.2	Rated Voltage, phase and Frequency	AC	
2.3	One Minute Withstand Voltage	V	
2.4	Mounting Type		
	a) LDBs		
	b) Single Phase LP		
2.5	Type and no of circuits & feeder rating		
2.6	Colour shade		
2.7	Lighting Transformer		
	a) Type		
	b) Voltage Ratio	V	
	c) Taps	%	
	d) Vector Group		
	e) Impedance	%	
	f) Rating	KVA	
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		
3.2	Luminaries		
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		

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	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		
	a) Luminaires		
	b) Accessories		
4.0	Schedule of fitting and Accessories		
5.0	Technical details of luminaries		
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumens	
	ii) After 1000 burning hours	Lumens	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		
a	Power factor		
5.4	Luminaires		
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		
	ii) Suitable upto conductor size	SWG	
c	Internal wiring size	Sq.mm	
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		

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6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		
8.1	Make		
8.2	Type		
8.3	Output	VA	
8.4	Accuracy Class		
8.5	Literature enclosed	Yes/No	
9.0	Meters		
9.1	Make		
9.2	Type		
9.3	Accuracy Class		
9.4	Literature enclosed	Yes/No	
10.0	Relays (if any provided)		
10.1	Make		
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a) Normally open		
	b) Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		
11.2	Suitable for use in hazardous area		
	a) Area classification		
	b) Gases/Vapor group		
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	
12.0	Lighting Control Switches		
12.1	Make		
12.2	Decorative		

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12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	
14.0	Lighting wires		
14.1	Make		
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	CONDUITS		
15.1	Make		
15.2	Rigid Steel		
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		
17.1	Make		
17.2	Type of Poles/Towers		
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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10.0 CABLE CARRIER SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		
2.	Size of Tray	mm	
3.	Material		
4.	Application		
5.	Type of Tray		
6.	Thickness of Tray	mm	
7.	Thickness of Galvanization	mm	
8.	Tray Cover Size	mm	
9.	Cable Tray Accessories		
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	

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11.0 EARTHING & LIGHTNING PROTECTION SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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12.0 6.6KV SWITCHGEAR

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage(Nom/Max), phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	Insulation Level <ul style="list-style-type: none"> One minute power frequency Voltage Impulse withstand Voltage 		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material		
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Color finish shade	Interior Exterior	

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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Circuit breakers		
3.1	Maker's name		
3.2	Voltage, frequency & no.of phases , poles		
3.3	Rated operating duty		
3.4	Circuit breakers type		
3.5	Short circuit withstand current for 1 sec. Duration	kA	
3.6	Rated making current	kAp	
3.7	Rated current at site reference ambient temp	A	
3.8	Type of operating mechanism		
3.9	Minimum no. of auxiliary Contacts for purchaser's use		
3.10	Control voltage		
	Spring charging motor	V AC/DC	
3.11	Closing Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.12	Opening Coil		
a	Voltage	V	
b	Permissible Voltage Variation	%	
c	Closing Current at rated Voltage	A	
3.13	Operating time		
	Opening time	ms	
	Breaking time	ms	
	Total tripping time	ms	
	Total Closing time	ms	
3.14	Number of breaks per pole		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Contactor		
	Voltage class	kV	
	Short time Rating		
	Duty		
5.0	Fuse		
	Voltage class	kV	
	Rupturing capacity	kAp	
6.0	Current Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Basic Insulation level	kV	
6.1	CT for differential protection		
	Class		
	Secondary resistance at 75 ° C		
	Knee Point Voltage		
	Excitation Current		
6.2	CT for Metering		
	Class		
	Secondary resistance at 75 ° C		
6.3	CT for Protection		
	Class		
7.0	Voltage Transformer		
a	Make		
b	Type		
c	Rated frequency		
d	Class of Insulation		
e	Voltage ration		
8.0	Meters		
a	Make		
b	Type		

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S. No.	DESCRIPTION	UNIT	DATA
8.1	Voltmeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
8.2	Ammeter		
a	Make		
b	Type		
c	Applicable standards		
d	Accuracy class		
9.0	Indicating lamps		
a	Make		
b	Type		
c	Voltage	V	
d	Wattage of lamp	W	
10.0	Push buttons		
a	Make		
b	Type		
c	Contact rating	A	
11.0	Space heater		
a	Make		
b	Type		
c	Rated voltage	V	
d	Power rating	W	
12.0	Wiring and terminal blocks		
a	Voltage grade		
b	Insulation		
c	Minimum size of conductor for:		
d	Power wiring	Sq.mm	
e	Control wiring	Sq.mm	
f	Type of terminal blocks:		

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Technical Specification For R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

S. No.	DESCRIPTION	UNIT	DATA
g	I) For Withdraw able Type		
h	II) For Fixed Type		
i	Minimum current rating of terminal blocks	A	
13.0	ABT Panel		
a	Make		
b	Type		
c	Panel thickness	mm	
14.0	Relays		
a	Make		
b	Model Number		
c	Parameter		

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13.0 VARIABLE FREQUENCY DRIVE

S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
1	Manufacturer Name		
2	Model No.		
3	Application		
4	Quantity		
5	Enclosure Protection Rating		
6	Output Current Rating at ambient temperature		
7	% derating considered for specific ambient		
8	Rated Voltage (volts) Input		
9	Output Frequency Range (Hz)		
10	Number of Phases and Frequency (Hz)		
a.	Short time current rating		
b.	Dynamic rating		
11	Rectifier type & Design		
12	Inverter type & Design		
13	Min/Recommended / Max switching frequencies (kHz)		
14	Filters		
a.	Line Side		
b.	Load Side		
15	Drive Input		
16	Output Modulation Method		
17	Speed Accuracy (+ /- %)		
18	Response time (speed)		
19	Response time (Torque)		
20	Type of cooling		
21	Whether VVFD is suitable for outdoor installation		
22	Drive Control Capabilities		
a.	Start/Stop Push button		
b.	Modbus control		
23	Permissible % variation		
a.	Voltage		
b.	Frequency		
24	Load parameters at rated voltage & frequency		
a.	Output Frequency (Hz)		
b.	Full Load current (Amp)		
c.	VVF Heat dissipation (w)		
25	VVF Efficiency		
a.	At Full rated Torque		
b.	At 75% of full load torque		
c.	At 50% of full load torque		
26	Drive Power factor range		
	At rated speed, Torque		
27	DC Voltage		

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Technical Specification For R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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S.No	Technical Parameters	6.6 kV (HV)	415 V (LV)
28	Fundamental power factor		
29	Switching Frequency		
a.	Drive Dimensions		
b.	Length		
c.	Height		
d.	Depth		
e.	Weight		
30	Metering		
a.	Applicable Standards		
b.	Accuracy Class		
c.	Make		
d.	Type		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ASH HANDLING SYSTEM
(PACKAGE NUMBER: R&M-SP-05)
VOLUME-III
PART-C
TECHNICAL SCHEDULES-I&C**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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* * * * *

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

COAL HANDLING PLANT (PACKAGE NUMBER: R&M-SP-04)

VOLUME-III, PART-C TECHNICAL SCHEDULES-I&C (TO BE FILLED BY BIDDER)

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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1 PROGRAMMABLE LOGIC CONTROLLER (PLC)

Table 1.1
Data Sheet for PLC

S.N	Feature	To be Filled by Bidder
1	Type of the system offered and Model No.	
2	Make	
3	Year of launching of the system	
4	Is the system offered, the latest system available/ being marketed in the international market by the vendor	
5	Place of Manufacturing	
6	Is the offered system confirms to the Specification provided in the tender document with regard to Spare Capacity, Expandability, Redundancy,	
7	Is the System offered is with open system architecture to enable integration of third party hardware/ software applications	
8	Support direct connectivity to Ethernet based LAN	
9	Deterministic and secure architecture	
10	On-line removal/replacement of I/O modules/ drive control modules possible without switching off power supply to the corresponding rack & without affecting controller operation	
11	Total I/O handling capacity of Controller	
12	No. of Tags handling capacity of Controller	
13	Total Power requirement for the offered system	
14	Total Heat Load of all cabinets	
15	Scanning rate for	
a	Analog Signal	
b	T/C Signal	
c	RTD Signal	
d	Binary Signal	
16	Loop Execution Time for	
a	Interlocks	

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b	Close loops	
17	Auto switchover to backup redundancy Level	
a	Controller Level	
b	Power supply Level	
c	Communication Level	
18	Output Status on Controller Failure	
19	Battery back-up duration for control processor	
20	Non-volatile memory capacity to store programs, standard software to perform control, DAS & Diagnostic functions	
21	Maximum no. of Channels for	
a	Analog Input module	
b	T/C Input module	
c	RTD Input module	
d	Analog Output module	
e	Binary Input Module	
f	Binary Output module	
22	Optical Isolation for Binary Input/Output provided.	
23	Galvanic isolation for Analog Input/Output provided	
24	Can the analog and binary controls be implemented at different execution speeds, in the multi-function controllers.	
25	Simulation of Analog/Digital Input/Output possible.	
26	Data Transmission speed for	
a	Ethernet LAN	
b	Data Highway	
c	I/O Bus	

Table 1.2
Data Sheet for High Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	No. of Inputs/Module	
2	Types of Input (Linear)	
3	Accuracy	

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S.N	Feature	To be Filled by Bidder
4	A/D Converter	
5	Temperature Effect	
6	CMRR	
7	NMRR	
8	MTBF	
9	Stability	
10	Diagnostic	
11	Isolation	

Table 1.3
Data Sheet for Low Level Analog Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input (Grounded/ Ungrounded)	
4	Cold junction compensation	
5	Accuracy	
6	A/D Converter	
7	Temperature Effect	
8	CMRR	
9	NMRR	
10	MTBF	
11	Stability	
13	Diagnostic	
14	Isolation	

Table 1.4
Data Sheet for Binary Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	

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7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Contact Bounce Filtering Provided	

Table 1.5
Data Sheet for SOE Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Time stamping provided	
14	Time Resolution	
15	Filter Delay Time	

Table 1.6
Data Sheet for Smart Transmitter Interface Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Protocol	
6	Accuracy	

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S.N	Feature	To be Filled by Bidder
7	Function	
8	Diagnostic	
9	Isolation	

Table 1.7
Data Sheet for Pulse Input Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Inputs/Module	
3	Types of Input	
4	MTBF & MTTR	
5	Isolation	
6	Interrogation Voltage	
7	Input Current	
8	Surge Withstand	
9	Maximum Switching Frequency	
10	Diagnostic	
11	Isolation	
13	Minimum Pulse Width	

Table 1.8
Data Sheet for Analog Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Isolation	
6	Accuracy	
7	Load	
8	Diagnostic	
9	Isolation	
10	Power supply	
11	Short circuit Protection	

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Table 1.9
Data Sheet for Binary Output Module

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	No. of Outputs/Module	
3	Types of Output	
4	MTBF & MTTR	
5	Contact rating	
6	Contact Voltage	
7	Switching Frequency	
8	Contact Life	
9	Power supply	
10	Isolation	

Table 1.10
Data Sheet for Controller

S.N	Feature	To be Filled by Bidder
1	Model No.	
2	Processor make	
3	Type of Processor/minimum word length	
4	Memory Size	
5	No. of Loops	
6	No. of I/O	
7	Configuration	
8	Battery Backup Available	
9	Duration of Battery backup	
10	Redundancy	
11	Change Over Time	
12	Failure of any one of the processor not to affect system operation	
13	What could be the maximum loading of the Controller CPU with the configuration offered	
14	Cycle Time	
15	Expansion facility available	
16	Data Transfer mode	
17	MTBF & MTTR	

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Table 1.11
Data Sheet for Engineering Station

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Processor	
3	Cache Memory	
4	RAM	
5	Hard disk Drive	
6	CD Drive	
7	Video card	
8	Operating System	
9	Interfacing Ports	
10	Monitor	
a	Type	
b	Size	
c	Resolution	
d	Colors	
e	Sync	
f	Dot per inch	
g	Glare Filter	
h	Make & Model no.	
11	keyboard	
a	Type	
b	Make & Model No.	
c	Key lock control	
12	Mouse	
a	Type	
b	Make & Model no.	
13	Is on line program modification (Control algorithms, logic, sequence programs etc.) and loading possible from Engineering console through data highway without taking the controller in 'standby' mode? Specify limitation, if any	
14	Is it possible to access the control	

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S.N	Feature	To be Filled by Bidder
	configurations (both regulatory and discrete) along with dynamic updating of process variables (analog values and binary status) from the Engineering station.	
15	Can the system configuration modified and loaded into controller from engineering station	
16	Programming language used for implementing logics / control schemes	

Table 1.12
Data Sheet for Laser Printer

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Printer memory	
4	Speed	
5	Resolution	
6	Colors	
7	Duty Cycle	
8	Power Supply	
9	Paper Size	
10	Cartridge Life	
11	Diagnostic	
12	Interfaces	

Table 1.13
Data Sheet for Interposing Relays

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Coil Voltage	
4	Contact	
5	Contact Rating	
6	Coil Insulation Class	

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S.N	Feature	To be Filled by Bidder
7	Mechanical Life	
8	Coil Protection	
9	Connection	
10	Mounting	

Table 1.14
Data Sheet for Operator Work Stations

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	Monitor Support	
5	CD Drive	
6	Power Supply	
7	Keyboard	
8	Pointing Device	
9	Monitor	

Table 1.15
Data Sheet for Servers

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	RAID	
5	Monitor Support	
6	CD Drive	
7	Power Supply	
8	Keyboard	
9	Pointing Device	
10	Monitor	

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Table 1.16
Data Sheet for LCD

S.N	Features	Minimum Requirements
1	Viewable Picture Area	
2	Resolution	
3	Aspect Ratio	
4	Display Colors	
5	LCD Panel	
6	Contrast Ratio	
7	Brightness	
8	Viewing Angle	
9	Computer Interface	
10	Cabinet Material	
11	Finish	
12	Mounting	
13	Power supply	
14	Accessories	

Table 1.17
Data Sheet for Engineering Laptop

S.N	Features	To be filled by bidder
1	Processor	
2	Memory	
3	Hard Disk	
4	CD Drive	
5	Power Supply	
6	Communication Ports	
7	Screen size	
8	Battery	

Table 1.17
Data Sheet for RTD Module

S.N	Feature	To be Filled by Bidder
1	Input Range	
2	Output Voltage range	

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S.N	Feature	To be Filled by Bidder
3	Output Current Range	
4	Accuracy	
5	Zero & Span Adjustment Range	
6	Input Bias Current	
7	Input Resistance	
8	Noise	
9	Output Rise Time from 10% to 90% Span	
10	Common Mode Voltage (CMV)	
11	Common Mode Rejection (CMR)	
12	Normal Mode Rejection (NMR)	
13	Sensor Excitation Current	
14	Lead Resistance Effect	
15	Input Protection	
16	Voltage Output Protection	
17	Current Output Protection	
18	Power Supply Voltage	
19	Mechanical Dimension	
20	Environmental Performance Details	

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2 FIELD INSTRUMENTS

Table 2.1
Data Sheet for Transmitter

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Working Principle	
3	Type	
4	Turn Down ratio	
5	Accuracy	
6	Repeatability	
7	Enclosure Class	
8	Sensor Type	
9	MOC of Housing	
10	Process Connection	
11	Calibration	
12	Operating Voltage	
13	Output Signal	

Table 2.3
Data Sheet for RTD

S.N	Features	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	No. of Elements	
4	Wire Gauge	
5	Protection tube OD/ Material/ Filling	
6	Response time	
7	Accuracy	
8	Characteristics	
9	MOC Head/ protection class	
10	Cable connection	

Table 2.4
Data Sheet for Thermowell

S.N	Features	To be Filled by Bidder
1	Make	
2	MOC	

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S.N	Features	To be Filled by Bidder
3	Process Connection	
4	Immersion Length	

Table 2.5
Data Sheet for Pressure Gauge/DP Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Sensing Element Material	
4	Movement Material	
3	Case Material / Protection Class	
5	Dial Size	
6	Scale	
7	Over range Protection	
8	Adjustment	
9	Element Connection	
10	Process Connection	
11	Accuracy	
12	Repeatability	
13	Response time	
14	Chemical Seal Unit	

Table 2.6
Data Sheet for Temperature Gauge

S.N	Feature	To be Filled by Bidder
1	Make/Model No.	
2	Type	
3	Stem	
4	Movement Materials	
5	Case Material/Protection class	
6	Dial Size	
7	Scale	
8	Adjustment	

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S.N	Feature	To be Filled by Bidder
9	Range Selection	
10	Over range Protection	
11	Instrument Connection	
12	Process Connection	
13	Accuracy	
14	Repeatability	
15	Response Time	

Table 2.7
Data Sheet for Level Gauge

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing Element & material	
4	Body Material	
5	End Connection	
6	Accuracy	
7	Housing	
8	Zero / Span adjustment	
9	Packing material	

Table 2.8
Data Sheet for Pressure/DP Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Sensing Element material	
4	Wetted Parts material	
5	Case Material	
6	Over range for Pressure / Vacuum Switch	
7	Process Connection	
8	Switch Configuration	
9	Switch Rating	

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S.N	Feature	To be Filled by Bidder
10	Cable Connection	
11	Enclosure Class	
12	Accuracy	
13	Repeatability	

Table 2.9
Data Sheet for Capacitance Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Sensing elements	
3	Probe Material	
4	Repeatability	
5	Accuracy	
6	Probe length	
7	End connection	
8	Rating of contacts	
9	Enclosure class	
10	Housing material	
11	Electrical Connection	

Table 2.10
Specification for Ultrasonic Level Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	

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S.N	Feature	To be Filled by Bidder
10	Mounting	
11	Transmitter housing material/enclosure class	

Table 2.11
Data Sheet for Radar Type Level Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Principle	
4	Sensor Material	
5	Output	
6	Resolution	
7	Accuracy	
8	Repeatability	
9	Power supply	
10	Mounting	
11	Transmitter housing material/enclosure class	

Table 2.12
Data Sheet for RF Type Level Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Particle size	
3	Insertion length	
4	Mounting	
5	Process connection	
6	Protection Class	
7	Cable connection	

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash Handling System Volume-III, Part-C	[16]	25.09.2014

Table 2.13
Data Sheet for Flow Glass

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Type	
3	Size	
4	Body Material	
5	Glass material	
6	Pressure Rating	
7	Temperature Rating	
8	Protection class	
9	Connection	

Table 2.14
Data Sheet for Pneumatic Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Diaphragm Material	
4	Spring Material	
5	Body Material	
6	Stem material	
7	Coupling type & material	
8	Pneumatic Connection	
9	Action on Air Failure	
10	Angle of operation	
11	Signal Range	
12	Manual Operation	

Table 2.15
Data Sheet for Electrical Actuator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Motor rating	

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S.N	Feature	To be Filled by Bidder
4	Power supply	
5	Control Supply	
6	Electrical Connection	
7	Body Material & Protection Class	
8	Gear Train Material	
9	Input Signal	
10	Output Signal	
11	Manual Operation	

Table 2.16
Data Sheet for I-to-P Converter

S.N	Feature	To be Filled by Bidder
1	Make & Model no.	
2	Air Supply	
3	Input Signal	
4	Output Signal	
5	Linearity	
6	Hysteresis	
7	Mounting	
8	Protection class	
9	Enclosure	
10	Drift	
11	Direct/Reverse action Facility	

Table 2.17
Data Sheet for Smart Positioner

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Input	
3	Power Supply	
4	Type of Electronics	
5	Valve position sensing	
6	Enclosure Type/Material	

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S.N	Feature	To be Filled by Bidder
7	Operating Range	
8	Modes of operation	
9	Flow characteristics	
10	Fail safe/Freeze feature	
11	Air supply pressure	
12	Process Connection	

Table 2.18
Data Sheet for Air Filter Regulator

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Type	
3	Inlet Pressure	
4	Output	
5	Filter Element size	
6	Filter Element Material	
7	Drain	
8	Bowl Material	
9	Enclosure Protection class/ Material	
10	Process connection	

Table 2.19
Data Sheet for Position Transmitter

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Power Supply	
3	Type	
4	Output	
5	Accuracy	
6	Enclosure Protection class/ Material	
7	Cable Entry	

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Table 2.20
Data Sheet for Limit Switch

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Sensing Element	
3	Material	
4	Repeatability	
5	No. of Contacts	
6	Contact Ratings	
7	Enclosure type/material	
8	Electrical Connection	
9	Set point	
10	Mounting	

Table 2.21
Data Sheet for Solenoid Valve

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Operating Principle	
3	Coil Voltage Rating	
4	Body	
5	Trim	
6	Manual Operation	
7	Duty	
8	Sealing	
9	Coil enclosure	
10	Coil Insulation Class	
11	Cable Connection	

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3 PROCESS CONNECTION PIPING & ACCESSORIES

Table 3.1
Data Sheet for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	

Table 3.2
Data Sheet for Impulse Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	

Table 3.3
Data Sheet for Copper Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Schedule/Thickness	
5	Test Pressure	
6	PVC Coating thickness	

Table 3.4
Data Sheet for Fittings for Impulse Piping

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Fitting	
3	Material	

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S.N	Feature	To be Filled by Bidder
4	Size	
5	Pressure Rating	
6	Temperature Rating	

Table 3.5
Data Sheet for Compression Fittings for Impulse Tubing

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Fitting	
3	Material	
4	Size	
5	Ferrule	
6	Pressure Rating	
7	Temperature Rating	

Table 3.6
Data Sheet for Ball Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	
9	Ball Material	
10	Seat Material	
11	Stem material	

Table 3.7
Data Sheet for Globe Valves

S.N	Feature	To be Filled by Bidder
1	Make	
2	Size	
3	Rating	

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S.N	Feature	To be Filled by Bidder
4	Design Pressure	
5	Design Temperature	
6	Bore	
7	End Connections	
8	Body Material	
9	Ball Material	
10	Seat Material	
11	Stem material	

Table 3.8
Data Sheet for Air Header

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Thickness	
5	Test Pressure	
6	Inlet Connection	
7	Outlet Connection	
8	Drain Connection	
9	Inlet Valve type/size	
10	Drain Valve type/size	
11	Distribution Valve type/size	

Table 3.9
Data Sheet for Instrument Manifolds

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size	
4	Type	
5	Ports	
6	Rating	
7	Connection	

Document Number	Rev No.	Description	Page No.	Date of Issue
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4 INSTRUMENTATION CABLES & ACCESSORIES

Table 4.1
Data Sheet for RTD Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Triads	
4	Conductor Material/Size	
5	Conductor Type	
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Triad Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 4.2
Data Sheet for Instrumentation Signal Cable

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type	
3	No. of Pairs	
4	Conductor Material/Size	
5	Conductor Type	

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S.N	Feature	To be Filled by Bidder
6	No. of Strands/Area of cross section	
7	Resistance	
8	Core Insulation	
9	Lay	
10	Shielding	
11	Drain Wire	
12	Pair Identification	
13	Inner Sheath	
14	Inner screen	
15	Armour	
16	Outer Sheath	
17	No. of Twist per metre	
18	Color Coding	
19	Voltage Grade	
20	Code/Standard	

Table 4.3
Data Sheet for Fibre Optic Cable (Single Mode)

S.N	Feature	To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@1310 nm
		@1550 nm
2	Mode field Diameter	@1310 nm
		@1550 nm
3	Maximum Cable Cut-off Wavelength	
4	Maximum Zero Dispersion Wavelength	
5	Minimum Zero Dispersion Wavelength	
6	Maximum Zero Dispersion Slope	
7	Maximum Polarization Mode Dispersion	
8	Gigabit Ethernet Length 1000BASE-LX	
9	Ten Gigabit Ethernet Length	10GBASE-LX
		10GBASE-LX4
10	Maximum Core/cladding Concentricity Error	

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S.N	Feature	To be Filled by Bidder
11	Cladding Diameter	
12	Cladding Non-circularity	
13	Coating Diameter	
14	Maximum Coating Concentricity Error	
15	Temperature Dependence (-60 to + 85C)	
16	Temperature & Humidity Cycling (-10 to + 85C, 4 to 90% RH)	
17	Minimum Proof Test	
18	Bending Induced Attenuation (100 turns, 75mm diameter)	

Table 4.4
Data Sheet for Fibre Optic Cable (Multi Mode)

S.N	Feature	To be Filled by Bidder
1	Maximum Uncabled Attenuation Coefficient	@850 nm
		@1300 nm
2	Overfilled Launch Bandwidth	@850 nm
		@1300 nm
3	Gigabit Ethernet Length	1000BASE-SX
		1000BASE-LX
4	Ten Gigabit Ethernet Length	10GBASE-SR
		10GBASE-LX4
5	Numerical Aperture	
6	Core Diameter	
7	Maximum Core Non-circularity	
8	Maximum Core/cladding Concentricity Error	
9	Cladding Diameter	
10	Cladding Non-circularity	
11	Coating Diameter	
12	Maximum Coating Concentricity Error	
13	Temperature Dependence (-60 to + 85C)	
14	Temperature & Humidity Cycling (-10 to + 85C, 4 to 90% RH)	

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash Handling System Volume-III, Part-C	[26]	25.09.2014

S.N	Feature	To be Filled by Bidder
15	Minimum Proof Test	
16	Bending Induced Attenuation (100 turns, 75mm diameter)	

Table 4.5
Data Sheet for Cable Tray

S.N	Feature	To be Filled by Bidder
1	Make	
2	Material	
3	Size (Width/Height)	
4	Perforation	
5	Length	
6	Thickness	
7	Coating of Hot dip Galvanizing	
8	Accessories	
9	Code/Standard	

Table 4.6
Data Sheet for Cable Glands

S.N	Feature	To be Filled by Bidder
1	Make	
2	Type of Protection	
3	Compression	
4	Threading Type	
5	Material	
6	Check Nut	

Document Number	Rev No.	Description	Page No.	Date of Issue
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5 SYSTEM CABINETS & JUNCTION BOX

Table 5.1
Data Sheet for Cabinets

S.N	Feature	To be Filled by Bidder
1	Make	
2	Cabinet Dimension	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Anti vibration pad	
8	Painting	
9	Gland Plate thickness	
10	Grounding	
11	Ventilation	
12	Lighting	
13	Lifting arrangement	
14	Tag Plates	

Table 5.2
Data Sheet for Junction Box

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Dimension	
3	Mounting	
4	Protection class	
5	Material & Thickness	
6	Doors	
7	Cable entry	
8	Gasket	
9	Painting	
10	Gland Plate thickness	
11	Grounding	
12	Tag Plates	
16		

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LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash Handling System Volume-III, Part-C	[28]	25.09.2014

Table 5.3
Data Sheet for LIE/LIR

S.N	Feature	To be Filled by Bidder
1	Make & Model No.	
2	Mounting	
3	Protection class	
4	Material & Thickness	
5	Doors	
6	Cable entry	
7	Gland Plate thickness	
8	Air Connection	
9	Sample line Entry	
10	Drain Pipe	
11	Painting	
12	Anti Vibration Pad	
13	Grounding	
14	Tag Plates	
15	Dimension	

Signature : _____

Name : _____

Designation : _____

Date : _____

Seal of Company

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-005	01	Tender Document for Selection of R&M Contractors – Ash Handling System Volume-III, Part-C	[29]	25.09.2014



**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-I
COMMERCIAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	-------------------

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
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Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Not Used
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Not Used
		Part-D	Detailed Technical Specifications - Civil
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	---	Part-D	Not Used

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors– Electrical Balance of Plant Volume-I	[i]	25.09.2014

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1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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LII-GETS12021-G-00129-004	01	Tender Document for Selection of R&M Contractors– Electrical Balance of Plant Volume-I	[ii]	25.09.2014

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2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
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1. Detailed Technical Specification-Electrical
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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules -Electrical

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

ELECTRICAL BALANCE OF PLANT (eBOP) (PACKAGE NUMBER: R&M-SP-06)

VOLUME-I COMMERCIAL

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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List of Acronym

CIF	:	Cost Insurance Freight
CIP	:	Carriage insurance paid
CPBG	:	Contract Performance Bank Guarantee
EDI	:	Electronic Data Interchange
EUR	:	Euro
FOB	:	Free on Board
GCC	:	General Condition of Contract
GOI	:	Government of India
GST	:	Goods & Service tax
ICB	:	International Competitive Bidding
INR	:	Indian Rupees
I&C	:	Instrumentation & Control
ITB	:	Instruction to Bidder
LOA	:	Letter of Award
LOI	:	Letter of Intent
MoEF	:	Ministry of Environment and Forests
PAM	:	Permanent Arbitration Machinery
PERT	:	Program evaluation and review technique
RBI	:	Reserve Bank of India
R & M	:	Renovation and Modernization
SCC	:	Special Condition of Contract
TMCR	:	Turbine Maximum Capacity rating
UNCITRAL	:	United Nations Commission on International Trade Law
USD	:	US Dollar
VAT	:	Value added Tax

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
--	--------------------------

1.0 INVITATION FOR BID

Tender No : [-----]

1.1 Introduction

[Give brief introduction about the name, ownership, business & Power Projects of the utility inviting tender for R & M work]

[XXX is undertaking Renovation & Modernization of XXX MW Unit no.-XX ----- of the Power Plant]

1.2 Invitation

[Name of The Utility], hereinafter referred to as “Employer / Owner / Purchaser”, invites sealed Tenders in English language from Prequalified Bidders for the Renovation & Modernization of Electrical Balance of Plant (eBOP) package of Unit No.*[XXX]* of the *[XXX]* Power Plant on International Competitive Bidding (ICB) basis as per the scope of work given in Technical Specification Volume-II.

1.3 Brief Scope of Work

The scope of work under this R&M package involves disassembly of existing equipment / systems, replacement of specified equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing and forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre-assembly, fabrication, repair, servicing/ overhauling, erection, all associated civil works including supply of cement, steel etc., testing & commissioning, successful completion of trial operation and guarantee tests for *[Electrical Balance of Plant (eBOP)]* package of Unit no. *[XXX] of [XXX]* Power Plant. The detailed scope of work is given in Technical Specification Vol. II.

The brief scope of work is given below: -

[-----]
[-----]
[-----]
[-----]
[-----]

For detailed Scope of Work & Services, refer Section-I of Volume-II of this Specification.

1.4 Tender Details

(a)	Cost of Tender Documents	:	INR <i>[---]</i> / USD <i>[---]</i> / EUR <i>[---]</i>
(b)	Bid Guarantee Amount	:	INR <i>[-----]</i> / USD <i>[-----]</i> / Euro <i>[-----]</i>
(c)	Date of issuance of Tender Document	:	<i>[-----]</i>
(d)	Date & Time of pre-Bid Conference	:	<i>[-----]</i>

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(e)	Last Date & Time of Receipt of Bid (Both Part I & Part II)	:	[-----]
(f)	Date & Time of Opening of Unpriced Techno-Commercial Bid (Part-I)	:	[-----]

1.5 Time Schedule

The time schedule for completion of facilities and performance guarantee test shall be as per SCC.

1.6 Bid Submission

- (a) The Tender Documents are issued to bidders already qualified in a pre-qualification process. The Tender documents are not transferable.
- (b) The Bid proposals are to be submitted in two parts in separate sealed covers as follows:

Part I : Bid Guarantee and Technical & Commercial Proposal without prices

Part II : Price Schedule and Schedule of Functional Guarantee parameters with values.
- (c) All other terms and conditions along with the Technical Specifications, General Conditions of Contract, Special Conditions of Contract, Time Schedule, Bid Guarantee details, Validity of Bid and Instructions to Bidders, etc. are contained in the Tender Documents.
- (d) Bidder shall submit the bid on or before the scheduled date and time as specified. Any offer received after the expiry of the time specified for receiving the completed bids are liable for rejection. The bid shall be submitted to:
[Designation, Address and Contact details.....]
.....]
- (e) Issuance of Tender Documents to a Bidder shall not be construed to mean that such Bidder would be automatically considered.
- (f) The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the respective quoted Foreign Currencies.
- (g) Bids submitted by E-mail, Fax, E-tender etc. will not be accepted.
- (h) The Tender Documents are meant for the exclusive purpose of bidding against the subject package and shall not be transferred, reproduced or otherwise used for purposes other than for which these are specifically issued.

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2 INSTRUCTIONS TO BIDDERS

2.1 Introduction

[Name of Utility], the Owner, intends to carry out the Renovation & Modernization of [Unit no.-XX ----- of the XXXX Power Plant].

Under the subject Tender, [Utility] invites bid for Renovation & Modernization of Electrical Balance of Plant (eBOP) package of the said Renovation & Modernization work to be carried out as per the accompanying Technical Specifications. The Bidder shall submit the offer for complete scope of work indicated in the Technical Specification.

2.2 Address and Contact Details of Owner

[Designation, Address and Contact details

-----]

2.3 General Project Information

General information about the plant and R&M project is indicated in section 3.0 on General Project Information.

2.4 Owner's Consultant

[-----], hereinafter referred to as "Consultant" is the Consulting Engineer for the project, appointed by the Owner, [-----], to provide project consultancy services.

2.5 Sources of Fund

[Utility] intends to finance the subject Package of the said renovation & modernization work, through Internal and other sources & External/ Domestic Commercial/ Borrowing from international development funding agencies. [Utility] has tied up the required fund for this package.

2.6 Cost of Bidding

The Bidder shall bear all costs associated with the preparation and submission of its bid, and the Owner will in no case be responsible or liable for these costs, regardless of the conduct or outcome of the bidding process.

2.7 Non-Transferability of Bid document

Transfer of Bid documents issued to one intending bidder to another is not permissible.

2.8 Scope of Work & Single Bidder Responsibility

The scope of the work shall be on the basis of single Bidder responsibility, covering the complete scope of work specified under these specifications and documents. It shall include the following:

- (a) Disassembly of existing equipment/ systems as required.
- (b) Detailed design of the systems/equipment covering all Mechanical, Electrical, Control & Instrumentation, Civil and Structural works.
- (c) Complete manufacture, including shop inspection and testing.
- (d) Providing engineering drawings, data, operational & maintenance manuals, etc., for the Owner's review/ approval.

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- (e) Packing, forwarding and transportation including insurance from the manufacturer's works to plant site and transportation from storage yard to erection site.
- (f) Receipt, storage, preservation and conservation of system/equipment at site including construction of storage facility viz. covered, semi-covered, air-conditioned, open yard at the space allocated at site by Owner including storage-cum-erection and all other specified & statutorily required insurance.
- (g) Pre-assembly, if any, erection, testing, commissioning, completion of plant and equipment/ system, conducting trial operation, performance guarantee test and handing over of all the plant and equipment/ system covered under this specification.
- (h) Carrying out all related civil and structural works at site including construction of foundations, buildings, structures etc. Including supply of cement and steel and all other required materials.
- (i) Supply of mandatory spares and tools & tackles.
- (j) Training of Owner's personnel.

Detailed scope is provided in Volume-II of the Technical Specifications.

Bids not covering the entire scope mentioned hereinabove may be treated as incomplete and hence are liable for rejection.

2.9 Time Schedule

The completion Time Schedule for Completion of R&M work and Performance Guarantee Tests shall be as given in the SCC.

2.10 Tender Documents

The scope of contract, technical specification, bidding procedures and contract terms are prescribed in the Tender Documents. The Tender Documents comprise, inter alia, the following volumes:

Volume – I	:	Commercial
Volume – I, Chapter-1	:	Invitation for Bid
Volume – I, Chapter-2	:	Instructions To Bidders
Volume – I, Chapter-3	:	General Project Information
Volume – I, Chapter-4	:	General Condition of Contract (GCC)
Volume – I, Chapter-5	:	Special Condition of Contract (SCC)
Volume – I, Chapter-6	:	Forms & Schedules
Volume – II	:	Technical Specifications
Volume – II , Section-I	:	Project Technical Specification
Volume – II, Section-II, Part-A	:	Not Applicable
Volume – II, Section-II, Part-B	:	Detailed Technical Specification-Electrical
Volume – II, Section-II, Part-C	:	Not Applicable
Volume – II, Section-II, Part-D	:	Detailed Technical Specification-Civil

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Volume – III	:	Technical Schedules
Volume – III, Part-A	:	Not Applicable
Volume – III, Part-B	:	Technical Schedule-Electrical
Volume – III, Part-C	:	Not Applicable

The Bidder is expected to examine all instructions, forms, terms and specifications in the Tender Documents including clarifications/corrigendum/amendments for completeness and obtain clarifications, if any, from the Owner.

The Bidder is expected to examine all instructions, forms, terms, conditions, specifications and other information in the bidding documents. Failure to furnish all information required as per the bidding documents or submission of a bid not substantially responsive to the bidding documents in every respect will be at the Bidder's risk and may result in rejection of its bid.

A prospective Bidder requiring any clarification to the Tender Documents may notify the Owner in writing by post or by e-mail followed by postal confirmation at the Owner's address indicated in ITB. The Owner will respond in writing by post or by e-mail followed by post confirmation to any request for clarification or modification of the bidding documents that it receives not later than twenty-one (21) days prior to the deadline for submission of bids prescribed by the Owner. Owner's response will be sent to all prospective Bidders that have been issued the Bidding Documents.

The Bidder is advised to visit the plant and obtain on its own responsibility all information that may be necessary for preparing the bid. The Owner will facilitate the bidder to collect such information about the plant in the manner that does not interface with plant operation and does not in any way adversely impact the interest of the Owner. The costs of visiting the site including engaging any third party consultant by Bidder, if required as per the assessment of Bidder, shall be borne by the bidder fully.

The Bidder, its personnel and agents will release and indemnify the Owner and its personnel and agents from and against all liability during such information collection and will be responsible for death or personal injury, loss of or damage to property and any other loss, damage, costs and expenses incurred as a result of the inspection.

At any time prior to the deadline for submission of bids, the Owner may, for any reason, whether at its own initiative, or in response to a clarification requested by a prospective Bidder, amend the bidding documents.

The amendment will be notified in writing by post or by e-mail followed by post confirmation to all prospective Bidders that have received the bidding documents and will be binding on them.

At any time prior to the deadline for submission of bids, the Owner, at its discretion may extend the deadline for submission of the bids.

2.11 Preparation of Bids

2.11.1 Language of Bid

The bid prepared by the Bidder and all correspondence and documents related to the bid shall be in English language, provided that any printed literature furnished by the Bidder may be written in another language, as long as such literature is accompanied by a translation of its pertinent passages in English language in which case, for purposes of interpretation of the bid, the translation shall govern.

2.11.2 Bidding Procedure

Single Stage Two Part Bidding Procedure will be followed for this package.

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The bidders are required to submit, the bids for the Renovation and Modernization work in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical Data Sheets, List of Tools & Tackles, Deviations to Technical and Commercial Specifications/Conditions, Overall Completion Time Period & L-1 Network Schedule, Resource Deployment Schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part-II Bid will comprise Quoted Price and Quoted Performance Guarantee Parameters. Initially, only the Part-I Bid will be opened and Part-II Bid will be kept in safe custody.

After evaluation of the Techno-Commercial (Part-I) Bids, each Bidder who has submitted a broadly responsive Part-I Bid, will be invited for Techno-Commercial Discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a memorandum. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions. The date & time for opening of Price Bid will be intimated separately.

Techno-Commercial Bid should not contain any price data.

Price Bid should not contain any matter in respect of Technical and / or Commercial aspects other than the details specifically sought by the Owner.

2.11.3 Bid Submission

- (1). Bid proposals shall be accepted from only those eligible bidders who are found qualified during the pre-qualification process & are issued Tender Documents. Unsolicited bids shall not be taken into cognizance.
- (2). All Bid proposals shall be prepared and submitted in two parts, part-wise in separate sealed covers, with all pages serially numbered. All bids shall be prepared in the English language only, by typing or printing.
- (3). **[One original and 9 (nine) identical]** copies of the original with all enclosures shall be submitted by each Bidder for Part-I and Part-II, clearly indicating the original and the number of the copy (i.e., "Original", "Copy No. 1", "Copy No. 2" etc.).
- (4). All these covers shall be individually sealed and put in an outer cover which also shall be sealed and super scribed as in other covers.
- (5). The covers should be pasted properly before applying the wax seal. Failure to do so may result in rejection of such bids.
- (6). The Bidder's Bid and the documents attached thereto shall be considered as forming part of the Contract documents.
- (7). In the event of discrepancy between "Original" and any copy of the bids, the hard copy of Original shall prevail.
- (8). The Bid shall be submitted to [-----]. Bid submitted to any other office of Owner is liable for rejection. Bids submitted by Telefax or e-mail will be rejected
- (9). Owner will receive Bids in respect of all the equipment/systems and scope of work as set forth in the accompanying Technical Specifications. All bids shall be prepared and submitted in accordance with the Tender Documents.

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- (10). Failure to furnish all information required in the Tender Documents or submission of a Bid not substantially responsive to the Tender Conditions and Technical Specifications in every respect or bids received in incomplete shape shall be liable for rejection. A bid shall be determined as substantially responsive in every respect, if it conforms to all the terms, conditions and specifications specified in Tender Documents without material deviations, objections, conditionality or reservations.
- (11). A material deviation, objection, conditionality or reservation is one:
 - (i). That affects in any substantial way the scope, quality or performance of the contract;
 - (ii). That limits in any substantial way, inconsistent with the Tender Documents, the Owner's rights or the successful Bidder's obligations under the contract.
- (12). Deviation(s) to vital clauses listed under the Tender Documents shall be considered to be material deviation(s).
- (13). Notwithstanding any information and data, which may be contained in these Tender Documents, the Bidder has to make independent inquiries and generally obtain his own information on all matters that may in any way affect prices, risks and obligations of the Contractor under the Contract.
- (14). Either the Indian agent or the foreign Principal directly could bid in a tender, but not both. The same applies to an Indian agent/dealer representing any Indian manufacturer. In case both submit the tenders, the tender of the manufacture will alone be considered.
- (15). An agent representing one manufacturer in a tender will not be allowed to quote on behalf of another manufacturer along with previous manufacturer in a subsequent / parallel tender for the same item.

2.11.4 Bid Guarantee

- (1). The Bid shall be accompanied by Bid Guarantee either in the form of Bank Guarantee valid for [---] days from the scheduled date of opening of the Bids (Part-I) or Demand Draft of equivalent amount drawn in favour of "[-----]" payable at "[-----]".
- (2). The Bank Guarantee shall be from any scheduled commercial Bank in India authorized by Reserve Bank of India,, to issue such Bank Guarantee on a non-judicial stamp paper of value not less than Rs. [---]/-.The stamp paper shall be purchased in the name of the Bank. Foreign Bidders may submit the Bank Guarantee from any bank in India as above or from any foreign bank which is in the approved list of RBI.
- (3). Unless otherwise expressly stated,
 - a) The Bid Guarantee shall be executed only on behalf of the Bidder in whose name the Tender Documents have been issued.
 - b) The Bid and other documents shall be submitted only by the Bidder in whose name the Tender Documents have been issued.
 - c) The Bid Guarantee shall be executed only as per the format prescribed by Owner at ([-----]). In the event of any deviation in this regard, the decision of Owner as to whether the same could be accepted or not, will be final and binding on the Bidder.
 - d) In case of foreign Bidder, the Bid Guarantee amount shall be in US Dollar / Euro/ Indian Rupee.

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- (4). The Bidder shall arrange for extension of validity of Bid and that of the Bid Guarantee upon request from the Owner.
- (5). No interest shall be paid on Bid Guarantee amount. The offer without Bid Guarantee or with short Bid Guarantee or Bid Guarantee in the form other than that specified herein above or from banks not specified hereinabove will be liable for rejection.
- (6). Any Bid not accompanied by the Bid Guarantee shall be rejected and the Bidder shall not be permitted to participate in the tender.
- (7). The Bid Guarantee shall be forfeited if the Bidder withdraws / modifies / changes / impairs / derogates the bid proposal on its own after the Bids are opened or submits forged/bogus certificates or fails to accept the Letter of Award issued by Owner or fails to submit Contract Performance Guarantee.
- (8). The Bid Guarantee of all unsuccessful Bidders shall be returned after price cover opening and price evaluation. The Bid Guarantee of the successful Bidder shall be returned after furnishing of the Contract Performance Bank Guarantee to the Owner and acceptance thereof.

2.11.5 Bid Opening

1. This is a single stage two part tender. On the specified date and time of opening, Part– I Bid containing Bid Guarantee and Technical and Commercial Proposal without Prices will be opened. At the time of opening of Part–I of the bids, the names of the bidders who submitted their bids shall be read out and other such details as Owner, at its discretion, may consider appropriate, shall be read out. The Part – II (Price Bid) will be lodged and opening date of the same will be intimated separately to those Bidders whose Part-I Bid will be determined to be substantially responsive to Tender Conditions and Technical specifications in all respects.
2. If the Bidder desires to be present at the time of opening of Part-I of bids, it shall depute its representatives (not more than two persons) in time with due authorization for participating in the Bid opening.
3. Owner takes no responsibility for delays, loss or non-receipt of Bid documents or any letters sent by post/courier either way and also reserve the right to reject any Bid in part or full without assigning any reasons thereof.

2.12 Composition of Techno Commercial Bid (Part-I Bid)

This part shall, inter alia, include the following in the same order as listed below. One original and 9 (nine) identical copies shall be submitted.

- (i). Duly filled in "Form of Bid" (As per Annexure-B of this Volume).
- (ii). Power of Attorney/Authorization with the seal of the company in favour of the person signing the Bid.
- (iii). Deleted.
- (iv). Letter of Unequivocal Consent to be furnished by the Bidder and Assignee as per Annexure-E of this Volume
- (v). Bid Guarantee- as per Annexure A.
- (vi). Schedule of Prices as per Schedule – F1 (Table 1 to Table-7) with the word "Quoted" in lieu of Price data and all other details except price data.
- (vii). Mandatory spares as per Technical Specifications (with the word "Quoted" in lieu of Price data)

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- (viii). Recommended spares (with the word “Quoted” in lieu of Price data)
- (ix). Tools & Tackles as per Technical Specifications (with the word “Quoted” in lieu of Price data)
- (x). Schedule of Performance Guarantees- as per Schedule – F1 (Table-8) with the word “Quoted” in lieu of Performance Guarantee parameters
- (xi). Signed copy of all the corrigendum’s/amendments/clarifications, if any issued for the tender
- (xii). Overall Time Schedule as per Schedule – F2 and Bar chart/PERT Network schedule to achieve the time schedule
- (xiii). Deviations to the Commercial specification, if any, as per Schedule – F3.
- (xiv). Deviations to Technical Specifications, if any, as per Schedule – F4.
- (xv). Requirements of the Contractor at site, as per Schedule – F5.
- (xvi). Resource deployment schedule as per Schedule – F6
- (xvii). Details of the present commitments of the Bidder, details of contracts in hand
- (xviii). Details of Sub-Contractors/Sub-Suppliers/Sub-Vendors, if any
- (xix). Quality Assurance Programme
- (xx). Technical Details to be furnished with the Bid as called for in the Technical Specification Volume-II and Technical Bid Data Sheet Volume-III.
- (xxi). Schedule of weights and dimensions
- (xxii). Coefficients and indices for price variation formula

The Part-I Bid shall not contain any Price data.

2.13 Composition of Price Bid (Part-II Bid)

The Bidders are requested to quote the Prices and the Performance Guarantee parameters only in the specified format. Price given in Part-II should cover the entire scope of work as given in Part-I of the offer including list of mandatory spares and Tools & tackles with itemized price and should be as per Schedule of Price enclosed. *[One original and 9 (Nine) identical]* copies shall be submitted.

1. **The Price Bid shall contain the following :**
 - (i). Duly filled in Form of bid as per Annexure-C
 - (ii). Completely filled in Schedule of Prices Schedule – F1 (Table 1 to Table-7)
 - (iii). Completely filled in Schedule of Performance Guarantees Schedule – F1 (Table-8).
2. The Bidder shall quote his price against each item of the schedules as indicated in the enclosed formats. The Bidder shall quote the prices only once after considering all the pros and cons, risks and contingencies. Rebate percentage etc., if any, should be spelt out by the Bidder in the first Bid itself.
3. The amount shall be quoted both in figures and words clearly and legibly. No overwriting is allowed. All scoring and cancellations should be countersigned by the Bidder. In case of illegibility, the interpretation of the Owner shall be final. All entries shall be in English language only.
4. The Bid may be made in Indian Rupees as well as in Foreign Currencies (maximum three foreign currencies) and all payments for the entire scope will be made in Indian Rupees as well as in the quoted Foreign Currencies.

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5. Prices in Indian supply shall be quoted on Ex-works supply of plant & equipment basis including Packing & forwarding. Inland transportation, Insurance charges, etc. shall be indicated separately.
6. Prices of imported supply of plant & equipment directly consigned to site shall be quoted on CIF Indian port of entry basis. The bidder shall also quote separately for FOB port of shipment price for ocean freight for Marine insurance, all port charges including customs clearance and inland transport charges from port of destination to Owner's site.
7. Custom Duty, Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation.

2.14 Bid Prices

Bidders shall quote for the entire scope of work on single responsibility basis & the total bid price covers all the Contractor's obligations mentioned in tender document specification or to be reasonably inferred from the tender documents/ specification in respect of the disassembly/ dismantling of existing equipment facility as specified, design, manufacture, including procurement and subcontracting (if any), delivery, construction, installation, commissioning, completion of the facilities and conductance of Performance Guarantee tests for the facilities including supply of mandatory spares, recommended spare & tools/ tackles (if any). This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the facilities, conducting Guarantee tests and, where so required by the tender documents, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the tender documents, all in accordance with the requirements of the Conditions of Contract and Technical Specifications.

Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the tender documents.

Prices quoted by the Bidder shall be subject to adjustment during performance of the Contract to reflect changes in the cost of labour, material, etc. A bid submitted with a fixed price quotation will not be rejected, but the price adjustment will be treated as zero. The price adjustment provision will not be taken into consideration in bid evaluation.

2.15 Signature of Bids

Each page of the Bid must be signed and stamped by the Bidder with his usual signature. The names of all persons signing should also be typed or printed below the signature. Satisfactory evidences of authority of a person signing on behalf of the Bidder shall be furnished with the Bid. Erasures or corrections in the Bid documents if any shall be signed by the person signing the Bid. Printed literature, if enclosed need not be signed. Bids not conforming to the above requirements are liable to be treated as non-responsive.

2.16 Clarifications/Corrigendum/ Amendment of Tender Specifications

1. At any time prior to the deadline for submission of Bids, the Owner may, for any reason, whether at his own initiative or in response to clarification(s) requested by a prospective Bidder, modify the Tender Specifications by amendment.

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2. Clarifications/Corrigendum/Amendment shall be construed to be an integral part of the Tender Specifications, which will be notified. Amendments will be hosted in Owner's website. Bidders are requested to visit Owner's website and note amendments, if any, before submission of bid. Owner shall not be responsible if any bidder fails to notice any amendment.
3. Amendment shall be numbered serially. Signed copies of amendments & clarifications shall be enclosed in Part-I of bid by bidder.

2.17 Modification of Bids

The Bidder is not permitted to modify his Bid suo-moto after the Bid submission.

2.18 Information to be Furnished with the Bid

1. The Bid (Part-I) must clearly indicate the name of the manufacturer, the type or model of each principal item of equipment proposed to be supplied and erected. The Bid should also contain drawings and descriptive materials indicating general dimensions, material from which the parts are manufactured, principles of operation and the extent of pre-assembly involved, major erection equipment required to be deployed, method of erection and the proposed erection Organization structure.
2. The above information shall be provided by the Bidder in the form of separate sheets, drawings, catalogues, etc.
3. Any Bid not containing sufficient descriptive material to describe accurately the system / equipment proposed may be treated as incomplete and hence rejected. Such descriptive materials and drawings submitted by the Bidder will be retained by the Owner. Any major departure from these 'drawings and descriptive material submitted will not be permitted during the execution of the Contract' without specific written permission of the Owner.
4. Oral statements made by the Bidder at any time regarding quality, quantity or arrangement of the equipment or any other matter will not be considered.
5. Standard catalogue pages and other documents of the Bidder may be used in the Bid to provide additional information and data as deemed necessary by the Bidder.
6. In addition to the hard copy of Part-I Bid, the Bidder shall submit soft copy of all data sheets, Schedule, List of Mandatory spares, tools & tackles and Bar Chart/PERT as well as deviation tables in a compact disk (CD). However, hard copy alone will be considered as authentic for evaluation. Bidder shall submit all the filled in datasheet also in soft copy. Bidder shall also furnish soft copies and hard copies of Data Sheet with filled in details wherever details are required to be indicated by the Bidder.

2.19 Policy of Bids under Consideration

Bids shall be deemed to be under consideration immediately after they are opened. While the Bids are under consideration, Bidder's and/or their representatives or other interested parties are advised to refrain from contacting by any means, the Owner and/or his employees/ representatives on matters related to the Bids under consideration. The Owner, if necessary will obtain clarifications on the Bids by requesting for such information from any or all the Bidders, in writing as may be necessary.

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2.20 Validity of Bid

1. The Bid shall be kept valid for acceptance for **[180 days]** from the schedule date of opening of the Part-I Bid.
2. The Bidder will not be permitted to change the substance of the Bid suo-moto, after Bid has been opened.
3. Unilateral revision or withdrawal of offer by the Bidder within the subsistence of the validity period of offer shall not be permitted. Violation of this condition shall result in rejection of the Bid without notice, besides forfeiture of Bid Guarantee. The Bidder shall also be debarred either permanently or for a fixed period, at the discretion of Owner from participating in any of the Owner's tenders.

2.21 Understanding & Clarification on Documents & Specifications

1. The Bidder is required to carefully examine the specifications and documents and fully inform himself as to all the conditions and matters which may in any way affect the 'Renovation and Modernization work to be carried out or the cost thereof. Bidders are required to visit the plant to get familiarized with local conditions. However, the Bidders' visit to site shall be at their cost and risk, without any liability on part of the Owner.
2. Bidders may seek clarifications to the prescribed clauses and / or different part of the Tender Specifications. Such a request for clarifications, if any, should reach the Owner at least **[7 (seven) days]** before the date stipulated for pre-bid meeting. The Owner then will issue interpretations and clarifications as it may think fit in during the pre-bid meeting. After pre-Bid meeting, Bidder may seek further clarification till **[21 days]** prior to schedule opening date of Part-I Bid. After receipt of such clarifications, the Bidder may submit its Bid but within the time and date as specified in the Invitation for Bid or as amended by the Owner. All such clarifications and the relevant exchange of correspondence between the parties shall be construed to form part of the tender specifications.
3. Pre-Bid Conference will be organized and outcome of the pre-bid conference is binding on all the Bidders. Outcome of the Pre-Bid Conference will be intimated by the Owner to all the Bidders.
4. A copy of such clarifications duly signed and stamped shall be enclosed with the Bid (Part-I). In case any queries remain un-replied, it shall be construed that in respect of those queries, the respective stipulations of the Tender Specifications/Conditions shall continue to apply and/or no new stipulations are made with respect to those queries.
5. No extension of time for submission of Bid will be granted on account of Bidders' request for interpretation/clarifications.

2.22 Latest Hour for Receipt of Bids

Bids must reach the designated Office of Owner not later than **[-----]** Hrs, Indian Standard Time (IST) on the date fixed for receipt of the Bid as indicated in the Invitation for Bid. Bids delivered / received after the time and date fixed for the receipt of the bids shall be liable for rejection.

2.23 Single Bidder Responsibility

1. The scope of supply and services shall be under single Bidder responsibility.
2. The successful Bidder should not sub contract the entire work on back to back basis or otherwise.

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2.24 No Claim for Compensation for Submission of Bid

1. The submission of any Bid connected with these documents and specifications shall constitute an agreement that the Bidder shall have no cause of action or claim against the Owner for rejection of his Bid.
2. Regardless of the conduct or outcome of the bidding process, Bidder shall not be entitled to claim any costs, charges and expenses incidental to or incurred by him through or in connection with his submission of Bid or its consideration by the Owner, even though the Owner may elect to modify/withdraw the Invitation for Bid or does not accept the Bid(s).

2.25 Deputation of Representatives for Discussion

After opening of the Bid, if the Owner desires to have techno-commercial discussion on the Bid, the Bidder shall be in a position to depute his competent representatives of various disciplines at short notice with full authority for finalising technical parameters as well as Commercial Terms and Conditions of the Tender.

2.26 Evaluation of Bid

1. For evaluation and comparison of price bid, the prices indicated at [-----] summary of Prices as per Schedule [-----] will be considered. The Bids received will be evaluated by the Owner to ascertain the lowest evaluated substantially responsive Bid vis-à-vis the Tender Specifications. The Bidder has to satisfy himself that full information is furnished as required in the specifications. Lack of particulars or incomplete information furnished will run the risk of rejection of the bid. The following major procedures would be followed for evaluation of bids.
2. All the Bidders would be brought on par with reference to Technical Specification, Commercial Condition, Instructions to Bidders and subsequent techno-commercial discussions/ clarifications.
3. After the evaluation of Part-I bids (techno-commercial bids) and before opening of Part-II bids (Price Bids), in case the bidders are asked to make changes to their techno commercial offer that may have price implications, Owner may give the bidders opportunity to submit addendum to price bid covering the price implication only against such changes before the opening of Part-II bids (Price Bids). All the bidders will be notified, at least 15 days before the Price Bid opening date, about such changes against which they can submit addendum to Price Bid.
4. Commercial loading would be done for non-compliance of commercial terms and conditions of the Tender Specifications other than the vital clauses, as the case may be.
5. To facilitate evaluation and comparison, the Owner will convert all bid prices expressed in foreign currencies into Indian Rupee at State Bank of India Bills Selling exchange rates prevailing on the date of opening of the price bid.
6. The Bidder is eligible for a price variation as per Tender Condition. However Price variation shall not be considered for Bid evaluation.
7. Technical loading will be done for omission of price data in respect of equipment/facilities, spares, tools & tackles, etc. The highest quoted corresponding price will be loaded against such omission. If no quoted price is available, the loading will be done as per the corresponding price as estimated by the Owner.

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8. The Bidder has to meet the minimum functional performance levels indicated in Volume-II Technical Specification for all categories of Guarantees. If one or more of Functional Performance Parameters offered by the Bidder is inferior to the minimum functional performance level (i.e. higher or lower than maximum or minimum value specified in Technical Specification), then such bid will be considered non-responsive and rejected.
9. The quoted values for Performance Guaranteed Parameters given in Table below would be evaluated using evaluation factors specified. The evaluation factors shall be applicable to the differential values calculated from among the Bidders of corresponding item with appropriate highest or lowest value (i.e., the best quoted value) as the base. The evaluation will be based on the guarantee parameters inclusive of all tolerance furnished at the Guaranteed Condition. Bidders to note that the values indicated in the Schedule of Performance Guarantees shall be inclusive of all tolerances including measurement uncertainty.

Table-Bid Evaluation Factors

Sl. No.	Functional Performance Parameter	Evaluation Factor Rate
1.	Copper Losses	[-----] INR per kW
2.	Iron Losses	[-----] INR per kW
3.	Auxiliary Power	[-----]INR per kW

The basis on which the Functional Performance Parameters are to be quoted shall be as per Volume-II Technical specification.

The evaluation factors rate shall be prorated for any fractions of the specified value.

- (1). Arithmetical errors will be rectified on the following basis:
 - If there is any discrepancy between the unit price and the total price that is obtained by multiplying the unit price and the quantity, the unit price shall prevail and the total price will be corrected.
 - If there is a discrepancy between the total Bid Price and the sum of total prices, the sum of the total prices shall prevail and the total Bid Price will be corrected.
 - If there is discrepancy between the rates in figures and in words, the rates expressed in words shall only prevail and shall be adopted.
- (2). All the Sl. Nos. and columns in the 'Schedules of Prices' shall be quoted. If no prices are envisaged for any of the entries, 'Nil' shall be mentioned. In this context "Nil" mentioned against any item shall construe that the Bidder shall not charge any amount separately for that item from the Owner. If the terms, such as 'not applicable' "-----" or blank are mentioned against any Sl. Nos./columns, the highest amount quoted for the concerned entry among all Bidders will be loaded for purposes of evaluating the Price Bids.

2.27 Local Conditions

1. The Bidder shall inspect the site and shall satisfy himself of the site conditions and shall apprise himself of the procedure for engagement of agencies/labour

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and shall collect any other information, which may be required before submitting the Bid.

2. Wages not less than Minimum wages for Contract labour shall be paid as applicable in this region from time to time. Claims and objections due to ignorance of site conditions will not be considered after submission of Bid.
 - (i). The Bidder is required to carefully examine the Technical & General Specification, commercial Terms and Conditions, drawings and other details relating to work given in the Tender Specification and get fully acquainted as to all conditions and matters which may in any way affect the work or the cost thereof.
 - (ii). The Bidder shall be deemed to have exhaustively examined the Tender Specifications including the Form of Contract, to have obtained all information and clarifications on all matters whatsoever that might affect the carrying out of the work and to have satisfied himself as to the adequacy of his Bid. He is deemed to have known the scope, nature and magnitude of the work and the requirements of materials and labour involved etc. and as to all work he has to complete in accordance with the Contract for the adequacy of his Bid.
 - (iii). The Bidder shall be deemed to have visited and carefully examined the plant/ site and surroundings, to have satisfied himself about the nature and details of all existing structures, if any, and also as to the nature and conditions of the railways, roads, bridges and culverts, means of transport and communications, whether by land, water or air and as to possible interruptions thereto and the access to and from the site, to have made independent enquiries, examined and satisfied himself as to the sources for obtaining earth, gravel, sand, stones, bricks and all other construction materials, the site for disposal of surplus earth and debris, the available accommodation, underground existing services, sub-soil water conditions, storms, prevailing winds, climatic conditions and all other similar matters which may affect the work.
 - (iv). The Bidder shall be deemed to have acquainted himself with the Indian Income tax Act, 1961, Indian Companies Act, 1956, Indian Customs Act, 1962, Indian Central Excise Act, Value Added Tax, Indian Sales Tax Act, Indian Electricity Act, Central Electricity Authority Regulations, Indian Boiler Regulations, Factories Act, Pollution Control Regulations and other related Acts & Laws prevalent in the State of [-----] and in India and as amended from time to time. The Owner shall not entertain any request for clarifications from the Bidders regarding such local conditions.
 - (v). Any neglect or omission or failure on the part of the bidder in obtaining necessary and reliable information as stated above or on any other matter affecting the Bidder shall not relieve him from any risk or liabilities or the entire responsibility for completion of the work in accordance with the Tender Specifications.

2.28 Deviations

1. Normally, deviations are not permitted in commercial terms & conditions and technical specification. Nevertheless, if the Bidder takes any deviation, it shall be clearly indicated in the deviation schedule (Schedule – [-----] and Schedule- [-----] with a soft copy in MS-Word format in compact disc, with “Original” of Part-I of the Bid). Deviation listed elsewhere in the Bid shall be summarily rejected and

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ignored. Separate printed standard terms and conditions of the Bidder shall not be taken into cognizance and shall be totally rejected.

2. No alterations or disfigurement, other than filling in particulars wherever called for in the formats of the Tender Specifications shall be made in the Bid. Any changes/modifications made by the Bidder in Bid documents itself shall not be taken into consideration.
3. If at any later date, it is found that documents, information, averments and data submitted by the bidder in the Bid, based on which the Bidder has been considered eligible or successful or has been awarded the Contract is incorrect or false to the extent that had the correct or true information been made available to the Owner at time of tender evaluation, the Bid would have been declared ineligible or unsuccessful, the Bidder shall be forthwith disqualified or, as the case may be, the Contract awarded based on such incorrect or false information shall be cancelled and the Bid Guarantee / contract performance Guarantees deposited shall be appropriated by the Owner towards Owner's cost, loss and damage to Owner.

2.29 Blacklisting/Debarring

In case, certificates submitted by the Bidders are found to be a forged/untrue, the Bidder will not only be disqualified for this tender but also would be black listed/debarred by the Owner.

2.30 Award of Contract

1. Award Criteria

- The Owner will award the contract to the successful Bidder whose Techno-commercial bid has been determined to be substantially responsive and Price Bid to be the lowest evaluated bid, provided that the Bidder is determined to be qualified to perform the contract satisfactorily.
- The Owner reserves the right to vary the quantity of any of the Items / Spares and / or delete any Item / Spares altogether at the time of Award of Contract.

2. Owner's Right to Accept Any Bid and to Reject Any or All Bids

The Owner reserves the right to accept or reject any bid, for any reasons including National defense and security consideration and to annul the bidding process and to reject all bids at any time prior to award of contract, without thereby incurring any liability to the affected Bidder or bidders or any obligation to inform the affected Bidder or bidders of the grounds for the Owner's action.

3. Notification of Award

Prior to the expiration of the period of bid validity, the Owner will notify the successful Bidder in writing by registered letter (Letter of Award or LOA) or by email to be confirmed in writing by registered letter, that its bid has been accepted. The notification of award will constitute the formation of the contract.

Upon the successful Bidder's furnishing of the performance securities the Owner will promptly notify each unsuccessful Bidder and will discharge its bid security.

4. Signing the Contract Agreement

At the same time as the Owner notifies the successful Bidder that its bid has been accepted, the Owner will send to the Bidder the Contract Agreement provided in the bidding documents, incorporating all agreements between the parties.

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Within *[twenty-eight (28)]* days of receipt of the Contract Agreement, the successful Bidder / assignee of foreign bidder (if applicable) shall sign and date the Contract Agreement and return it to the Owner.

5. Corrupt or Fraudulent Practices

The Owner requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. In pursuance of this policy, *[Name of Utility]* requires that Bidders, Contractors and Suppliers observe the highest standard of ethics during the procurement and execution of the contracts. The Employer may reject a Bid Proposal of a successful Bidder if it emerges that the Bidder recommended for award has engaged in Corrupt or Fraudulent practices in competing for the subject contract. The Employer may declare a Bidding firm ineligible for participation in future tenders of the Employer, either indefinitely or for a stated period of time, if it at any time it emerges that the firm has engaged in Corrupt or Fraudulent practices in competing for or in executing a contract of the Owner. Corrupt Practice means the offering, giving, receiving or soliciting of anything of value to influence the procurement process or contract execution. Fraudulent practice means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Employer and includes collusive practice among Bidders designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition.

2.31 Agency Commission

No Agency commission shall be payable under the Contract.

2.32 Contract Performance Bank Guarantee (CPBG)

As a Contract security, the successful Bidder, to whom the work is awarded, shall be required to furnish a Contract Performance Bank Guarantee (CPBG) in the Format attached as Annexure- G, in favour of the Owner within 30 days from the date of issue of Letter of Award (LOA). The guarantee amount shall be equal to ten percent (10%) of the 'Contract Price' and it shall guarantee the faithful performance of the 'Contract' in accordance with the terms and conditions specified in these documents and specifications. The CPG shall be valid till the end of 'Warranty Period' plus Ninety (90) days grace period. If the contract price is in more than one currency, CPBG shall be 10% of respective currency.

In case of a successful foreign bidder, if the Owner accepts to enter into the Second Contract and / or Third Contract with the assignee, then, within Thirty (30) days after receipt of Letter of Award, the assignee shall furnish an additional Contract Performance Bank Guarantee for five percent (5%) of the value of the Contract entered into with the assignee (i.e. for five percent of aggregate value of component Contract(s) entered into with the assignee).

2.33 Contract Quality Assurance

1. The Bidder shall include in his Bid a detailed Quality Assurance Programme containing the overall quality, management and procedures which he proposes to follow in the performance of the 'Works' during various phases.

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2. After Letter of Award (LOA), the detailed Quality Assurance Programme to be followed for the execution of the 'Contract' will be mutually discussed and agreed to and such agreed Programme shall form a part of the 'Contract'.

2.34 Codes & Standards

Specifications give reference to Indian or internationally accepted Standards. However, equipment or materials meeting other recognized National or International Standards, which ensure an equal or superior quality than Standards specified, will also be accepted. For details of codes and standards refer Technical specification, Volume-II.

2.35 Vital Clauses

The following clauses in the Tender Specification & Draft Contract are vital. Bidder is advised not to take deviations to these clauses. If deviations are taken from the stipulations of these clauses, such Bids would be liable for rejection:

- Scope of Work
- Time Schedule
- Price Basis
- Contract Performance Guarantee
- Warranty
- Liquidated Damages
- Force Majeure
- Arbitration
- Taxes & Duties
- Bid Guarantee
- Patents, Indemnity
- Validity of Bids

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3 GENERAL PROJECT INFORMATION

3.1 Project & Site Information

- Owner / Purchaser : [-----]
- Consultant : [-----]
- Project Title : [-----]
- Location : [-----]
- Latitude : [-----]
- Longitude : [-----]
- Elevation above MSL : [-----]
- Nearest Railway Station : [-----]
- Nearest Sea Port : [-----]
- Nearest Airport : [-----]
- Road Access/Approach to Site : [-----]

For Project & Site related detailed information, refer Clause No. 2 of Section-I of Volume-II.

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4 GENERAL CONDITIONS OF CONTRACT (GCC)

4.1 Definitions

- i. **"Applicable Laws"** means the laws of any national, state, local or municipal legislature in India, or of any other Competent Authority, including all laws, acts, judgments, statutes, rules, regulations, ordinances, orders, decrees, injunctions, governmental authorizations, requirements of Applicable Permits and any agreements, decisions, acts, instructions, requirements, directions and notifications of any competent or other Competent Authority or court or tribunal or arbitrator having jurisdiction over the matter in question, including those related to taxes, assessments, expropriation and duties, or authoritative interpretation, as amended, modified, enacted, reinterpreted or revised from time to time hereafter.
- ii. **"Applicable Permits"** means all permits, licenses, authorizations, consents, decrees, waivers, privileges, acknowledgements, concessions, approvals, rulings, decisions and visas from, filings with or applications submitted to, any Competent Authority or court or tribunal of competent jurisdiction necessary from time to time for or in relation to the performance of the Works, including as detailed in this GCC.
- iii. **"Agreement"** means the Contract Agreement (entitled "Contract Agreement") executed by the parties to which these Conditions are annexed and also includes supplements & amendments to the Contract.
- iv. **"Contract"** means the Agreement entered into between Owner and Contractor as per the 'Contract Agreement' signed by the parties, including contract documents, all attachments and appendices thereto and all documents incorporated by reference therein.
- v. **"Contract Documents"** means the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. All such documents shall be listed in the Contract Agreement.
- vi. **"Contractor's Equipment"** means all plant, facilities, equipment, machinery, tools, apparatus, appliances or things of every kind required in or for installation, completion and maintenance of Facilities that are to be provided by the Contractor, but does not include Plant and Equipment, or other things intended to form or forming part of the Facilities.
- vii. **"Contractor"** means the person(s), Firm or a Company whose bid to perform the Contract has been accepted by the Owner and shall be named as such in the Contract Agreement, and includes the legal successors or permitted assigns of the Contractor.
- viii. **"Contract Price"** means any sum or sums finally accepted by the Owner for the execution of this contract, subject to such additions and adjustments thereto or deductions there from, as may be made pursuant to the Contract.
- ix. **"Contractor's Representative"** means any person nominated by the Contractor & approved by the Owner hereof to perform the duties delegated by the Contractor.
- x. **"Consulting Engineer"** means Owner's Engineer appointed by the Owner. Also refers to any other firm(s) or person(s) as may be appointed by the Owner from time to time.

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- xi. **“Commissioning”** means the construction of plant and equipment for operation of the Facility at rated capacity are complete and the plant and equipment achieves the designated full load/full capacity, at designated fuel/input.
- xii. **“Completion”** means that the Facilities (or a specific part thereof where specific parts are agreed) have been completed operationally and structurally and put in a tight and clean condition, and that all work in respect of pre-commissioning of the Facilities or such specific part thereof has been completed and commissioning has been attained as per Technical Specifications.
- xiii. **“Competent Authority”** means any agency, authority, department, inspectorate, ministry or statutory person (whether autonomous or not) of GOI, [Name of the State], Ministry of Environment and Forests (MoEF) any other State of the Republic of India or any local authority.
- xiv. **“Day”** means calendar day of the Gregorian calendar.
- xv. **“Defect Liability Period”** means the period of validity of the warranties given by the Contractor, commencing at completion of the Facilities or a part thereof, during which the Contractor is responsible for defects with respect to the Facilities.
- xvi. **“Effective Date”** means the date from which the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor shall be determined.
- xvii. **“Erection Services”** means those entire services ancillary to the supply of the plant and equipment for the Facilities, to be provided by the Contractor under the Contract. e.g. transportation and provision of marine or other similar insurance, inspection, expediting, site preparation works (including the provision and use of Contractor's Equipment and the supply of all construction materials required), installation, testing, Pre-commissioning, commissioning, operations, maintenance, the provision of operations and maintenance manuals, training of Employer's Personnel etc.
- xviii. **“Facilities”** means the plant and equipment to be supplied and installed, as well as all the Erection Services to be carried out by the Contractor under the Contract.
- xix. **“Force Majeure”** means mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected.
- xx. **“GCC”** means the General Conditions of Contract hereof.
- xxi. **“Good Industry Practice”** means the exercise of that degree of skill, diligence and prudence which would reasonably and ordinarily be expected from a skilled and experienced Contractor, equipment manufacturer or operator applying the standards generally adopted by global Contractors, global equipment manufacturers and operators in the construction or operation of power generation facilities or the manufacture of equipment therefore, except in so far as inconsistent with any applicable Indian law or directive.
- xxii. **“Guarantee Test(s)”** means the test(s) specified in the Technical Specifications to be carried out to ascertain whether the Facilities or a

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specified part thereof is able to attain the Functional/Performance Guarantees specified in the Technical Specification.

- xxiii. **"Incoterms"** means International rules for interpreting trade terms published by the International Chamber of Commerce (latest edition), Paris (France). Unless inconsistent with any provisions of the contract, the meaning of any trade term and the rights and obligations of the parties there under shall be as prescribed by Incoterms.
- xxiv. **"Inspector/Inspecting Engineer"** means the Owner or any person nominated by the Owner from time to time, to inspect the equipment of works under the contract and/or the duly authorized representative of the Owner.
- xxv. **"Latent Defect"** means the defects inherent in the material or arising out of design deficiency which does not manifest itself during the Warranty Period/Defect Liability Period, as described in this GCC.
- xxvi. **"Letter of Intent (LOI)/Letter of Award (LOA)"** means the official letter issued by the Owner notifying the Contractor that its Bid Proposal has been accepted.
- xxvii. **"Month"** means calendar month of the Gregorian calendar.
- xxviii. **"Manufacturer's Works" or "Contractor's Works"** means the place used by the Contractor, its manufacturer, supplier, collaborators or sub-contractors/vendors/sub-vendors for the performance of the works.
- xxix. **"Operational Acceptance"** means the acceptance by the Owner of the Facilities (or any part of the Facilities where the Contract provides for acceptance of the Facilities in parts), which certifies the Contractor's fulfillment of the Contract in respect of performance guarantees of the Facilities.
- xxx. **"Owner" or "Purchaser"** shall means the [Name of the Utility], and includes its legal successors or permitted assignees.
- xxxi. **"Person"** means any natural person, firm, corporation, company, voluntary association, partnership, joint venture, trust, and incorporated organization, unincorporated organization, Competent Authority or other entity.
- xxxii. **"Pre-commissioning"** means the testing, checking and other requirements specified in the Technical specifications that are to be carried out by the Contractor in preparation for commissioning.
- xxxiii. **"Project"** means the Owner's [-----] in respect of which the Contract has been signed.
- xxxiv. **"Project Consultant" or "Owner's Consultant"** means the engineering firm or person(s) appointed by the Owner to render engineering project consultancy services for the project.
- xxxv. **"Project Manager"** means the person appointed by the Owner thereof and named as such, to perform the duties delegated by the Owner.
- xxxvi. **"Plant and Equipment"** means permanent plant, equipment, systems, machinery, apparatus, articles and things of all kinds to be provided and incorporated in the Facilities by the Contractor under the Contract (including the spare parts to be supplied by the Contractor under the Contract Agreement), but does not include Contractor's Equipment.
- xxxvii. **"SCC"** means the Special Conditions of Contract hereof.

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- xxxviii. **“Site”** means the land and other places upon which the Facilities are to be installed, and such other lands or places as may be specified in the Contract as forming part of the Site.
- xxxix. **“Sub Contractor”, including “Vendors/Sub-Vendors”**, means any firm or person to whom execution of any part of the Facilities, including preparation of any design or supply of any plant and equipment is subcontracted directly or indirectly by the Contractor, and includes its legal successors or permitted assignees.
- xl. **“Technical Specification / “Tender Documents”** means the document, setting out a description and specification of the Works and statement of the technical and other standards to which the Works are to be performed including any modifications thereto made in accordance with the Conditions. This includes the technical & commercial specifications and other Tender Documents forming a part of the Contract and such other Schedules and drawings as may be mutually agreed upon.
- xli. **“Tenderer”/“Bidder”** means the Person(s), Firm/Company who has submitted its Bid Proposal in response to the bid invitation by the Owner, for the Project.
- xl. **“Time for Completion”** means the time within which completion of the Facilities as a whole (or of a part of the Facilities where a separate time for completion of such part has been specified) is to be attained in accordance with the stipulations and provisions of the Contract.
- xl. **“Warranty Period” or “Defect Liability Period”** means the period during which the Contractor shall remain liable for repair or replacement of any defective part of the works performed under the contract, free of cost.
- xl. **“Work(s)”** means and includes the tasks of furnishing of equipment, labour & services, transport, handling, unloading and storage at site, civil construction and complete erection, testing, commissioning putting into satisfactory operation and completion of successful performance tests, reliability tests and any other guaranteed parameters as defined in the Contract, replacement, modification, repair of defective parts or equipment during warranty period and rectification of latent defects during latent defect period.
- xl. **“Writing” or “Written”** shall include any manuscript, type-written or printed statement, under or over signature and/or seal as the case may be.

When the words "Approved", "Subject to Approval", "Satisfactory", "Equal to", "Proper", "Requested", "As Directed", "Where Directed", "When Directed", "Determined by", "Accepted", "Permitted", or words and phrases of similar importance are used, the approval, judgment, direction, etc., is understood to be a function of the Owner. Words implying persons or the gender neutral pronoun 'it', shall include firms, companies, corporation, associations or body of individuals whether incorporated or not. Words implying masculine gender or singular number shall also include the feminine gender and plural number and vice-versa where the context so requires or permits.

Terms and expressions not herein defined shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

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4.2 Contract Documents

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.
- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Owner.

4.3 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Notification of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing submitted by the contractor.
- vi. The bid & schedules/ attachment.

4.4 Interpretation

All Contract Documents, all correspondence and communications to be given, and all other documentation to be prepared and supplied under the Contract shall be written in English, and the Contract shall be construed and interpreted in accordance with English language.

The singular shall include the plural and the plural the singular, except where the context requires otherwise.

Unless inconsistent with any provision of the Contract, the meaning of any trade term and the rights and obligations of parties there under shall be as prescribed by Incoterms. Incoterms means latest edition of International Rules for Interpreting Trade Terms published by the International Chamber of Commerce Paris, France.

4.5 Construction of the Contract

The Contracts to be entered between the Owner and the Contractor shall be as under:

- 'First Contract' for CIF/CIP (Indian Port of Entry) Supply of all Offshore Plant & Equipment including Mandatory Spares and technological and miscellaneous structures with all accessories to be supplied from abroad.
- 'Second Contract' for Ex-Works Supply of all indigenous Plant & Equipment including Mandatory Spares of Indian origin and technological and miscellaneous structures with all accessories.
- 'Third Contract' for providing all services i.e. Port Handling, Port Clearance and Port Charges for the imported goods, further Loading and Inland Transportation for Delivery at Site, Unloading, Storage, Handling at Site, Erection, Insurance Covers other than inland transit insurance, Testing, Commissioning and Conducting Guarantee Tests in respect of all the Equipment supplied under the First Contract & the Second Contract, Civil works including supplies such as cement & reinforcement steel and all other services specified in the Tender Documents.

All the above Contracts will contain a cross-fall breach clause specifying that breach of one Contract will constitute breach of the other Contracts which will confer a right on

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the Owner to terminate the other Contracts also at the risk and the cost of the Contractor.

The foreign bidder, however, has the option, to be exercised as a part of its bid proposal, to propose an Assignee in its bid to execute the Second Contract and/or the Third Contract. Such foreign bidder shall furnish a written unequivocal consent (with Part-I Bid) of the proposed Assignee to work as independent Contractor on the terms and conditions offered by the bidder For the scope of work envisaged by the foreign bidder, in its bid, to be executed by Assignee, the Assignee should have relevant/required capacity and experience of executing similar job. The bidder shall substantiate with relevant/required documents in the bid to establish capacity and experience of the Assignee.

If the foreign bidder has proposed an Assignee in its bid to execute the Second Contract and/or the Third Contract and has also furnished written unequivocal consent of the proposed Assignee to work as an independent Contractor on the terms and conditions offered by the bidder and if the Owner is satisfied with the capacity and experience of the Assignee proposed in the bid, the Owner will enter into the "Second Contract" and/or the "Third Contract" with the Assignee. However, if the Owner in its judgment does not find acceptable the Assignee proposed in the bid as its Contractor, then on the request of the Owner, the Bidder shall have option to propose an alternate Assignee on the same terms and conditions and cost as offered in its bid. In case the Assignee option is not exercised by the Bidder or if the Assignee fails to enter into Contract(s) with the Owner or if the Owner in its judgment does not find acceptance of the Assignee as its Contractor, then the foreign bidder shall be obliged to enter into and execute all the contracts envisaged to be entered upon this Tender with the Owner covering the entire scope of work envisaged in the Tender Documents on the same terms and conditions and cost as offered in its Bid.

If any foreign bidder has proposed an Assignee in his bid to execute the Second Contract and/or the Third Contract and has also furnished written unequivocal consent of the proposed Assignee to work as independent Contractor on the terms and conditions offered by the bidder and if the Owner is satisfied with capacity and experience of the Assignee, the Owner will enter into the 'Second Contract' and/or 'Third Contract' with the said Assignee. In case no Assignee has been proposed by the foreign bidder in his bid or if the Assignee fails to enter into the Second Contract and/or Third Contract with the Owner or if the Owner in its judgment does not find acceptance of the proposed Assignee as its Contractor, then the foreign bidder shall be obliged to enter into and execute all the three Contracts with the Owner.

If the Owner accepts to enter into Second Contract and/or Third Contract with the Assignee of foreign bidder, the said Assignee, in addition to the Contract Performance Securities to be provided by the foreign Contractor shall provide within *[twenty eight (28)]* days of Notification of Award, separate Contract Performance Bank Guarantee equivalent to five percent (5%) of the value of the Contract(s) entered into with the Assignee for the due performance of the Contract, with an initial validity up to *[ninety (90) days]* beyond the scheduled Defects Liability Period.

The award of the separate Contracts shall not in any way dilute the responsibility of the Contractor for the successful completion of the Facilities as per Contract Documents and a breach in one Contract shall automatically be construed as a breach of the other Contract(s) which will confer a right on the Owner to terminate the other Contract(s) also at the risk and the cost of the Contractor.

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4.6 Independent Contractor

The Contractor shall be an independent contractor performing the Contract. The Contract does not create any agency, partnership, joint venture or other joint relationship between the parties hereto.

Subject to the provisions of the Contract, the Contractor shall be solely responsible for the manner in which the Contract is performed. All employees, representatives or Subcontractors engaged by the Contractor in connection with the performance of the Contract shall be under the complete control of the Contractor and shall not be deemed to be employees of the Owner, and nothing contained in the Contract or in any subcontract awarded by the Contractor shall be construed to create any contractual relationship between any such employees, representatives or Subcontractors and the Owner.

4.7 Joint Venture or Consortium

Not Used.

4.8 Non-Waiver

No relaxation, forbearance, delay or indulgence by either party in enforcing any of the terms and conditions of the Contract or the granting of time by either party to the other shall prejudice, affect or restrict the rights of that party under the Contract, nor shall any waiver by either party of any breach of Contract operate as waiver of any subsequent or continuing breach of Contract. Any waiver of a party's rights, powers or remedies under the Contract must be in writing, must be dated and signed by an authorized representative of the party granting such waiver, and must specify the right and the extent to which it is being waived.

4.9 Severability

If any provision or condition of the Contract is prohibited or rendered invalid or unenforceable, such prohibition, invalidity or unenforceability shall not affect the validity or enforceability of any other provisions and conditions of the Contract.

4.10 Origin

"Origin" means the place where the materials, equipments and other supplies for the Facilities are mined, grown, produced or manufactured, and from which the services are provided.

4.11 Notices

All notices to be given under the Contract shall be in writing, and shall be sent by personal delivery, or post, or special courier, or telefax, or E-mail to the address of the relevant party indicated in the Contract.

Either party may change its postal address, telefax number, or addressee-mail for receipt of such notices by ten (10) days' notice to the other party in writing

Notices shall be deemed to include any approvals, consents, instructions, orders and certificates to be given under the Contract.

4.12 Governing Laws

The Contract shall be governed by and interpreted in accordance with laws in force in India. The Courts of [.....] shall have exclusive jurisdiction in all matters arising under the Contract.

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4.13 Settlement of Disputes

a) Mutual Consultation

If any differences/ dispute arises between the Owner and the Contractor in connection with or arising out of the Contract, before or after the termination, abandonment or breach of the Contract—the Owner & Contractor shall seek to resolve any such dispute or difference by mutual consultation. If the parties fail to resolve such a dispute or difference by mutual consultation, then the dispute shall be referred in writing by either party to the Arbitrator, with a copy to the other party.

b) Arbitration

Either Owner or the Contractor may, of its intention to commence arbitration, as to the matter in dispute, and no arbitration may be commenced unless such notice is given.

Any dispute, in respect of which a notice of intention to commence arbitration has been given, as above shall be finally settled by arbitration. Arbitration may be commenced prior to or after completion of the Facilities

Any dispute submitted by a party to arbitration shall be heard by an arbitration panel composed of three arbitrators, in accordance with the provisions set forth below.

The Owner and the Contractor shall each appoint one arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the two arbitrators do not succeed in appointing a third arbitrator within *[twenty eight (28)]* days after the latter of the two arbitrators has been appointed, the third arbitrator shall, at the request of either party, be appointed by the Appointing Authority for arbitrator is given below.

Appointing Authority for Arbitrator:

- President, Institution of Engineers in case of an Indian Contractor.
- President, International Chambers of Commerce, Paris in case of a Foreign Contractor.

If one party fails to appoint its arbitrator within *[forty-two (42)]* days after the other party has named its arbitrator, the party which has named an arbitrator may request the Appointing Authority to appoint the second arbitrator.

If for any reason an arbitrator is unable to perform its function, the mandate of the Arbitrator shall terminate in accordance with the provisions of applicable laws and a substitute shall be appointed in the same manner as the original arbitrator.

Arbitration proceedings as follows:-

- In case of a foreign contractor the arbitration proceeding shall be conducted in accordance with the United Nations Commission on International Trade Law (UNCITRAL) Arbitration Rules of 1976.
- In case of an Indian Contractor Adjudication/Arbitration proceedings shall be conducted in accordance with Indian Arbitration and Conciliation Act 1996.
- In case of a foreign associate of the contractor, the arbitration proceedings shall be conducted in accordance with the United Nation Commission on International Trade Law (UNCITRAL) Arbitration Rules of 1976.

The Place for Arbitration shall be: *[New Delhi]*, India.

The language of arbitration shall be English.

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The decision of a majority of the arbitrators (or of the third arbitrator chairing the arbitration, if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction as decree of the court. The parties thereby waive any objections to or claims of immunity from such enforcement.

Notwithstanding any reference to the arbitration,

- the parties shall continue to perform their respective obligations under the Contract unless they otherwise agree
- The Owner shall pay the Contractor consideration due to the Contractor.

4.14 Scope of Facilities

- a) Unless otherwise expressly limited in the Technical Specifications, Facilities the Contractor's obligations cover the provision of all Plant and Equipments including spares and the performance of all Services required for design, manufacture (including procurement, quality assurance, construction, installation, associated civil works, Structural and others construction works, precommissioning and delivery) of the Plant and Equipment and the installation, commissioning, completion of facilities and performance testing of the Facilities in accordance with the plans, procedures, specifications, drawings, codes and any other documents as specified in the Technical Specifications. Such specifications include, but are not limited to, the provision of supervision and engineering services; the supply of labour, materials, equipment, spare parts and accessories; Contractor's Equipments; construction utilities and supplies; temporary materials, structures and facilities; transportation loading & unloading.
- b) The Contractor shall, unless specifically excluded in the Contract, perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract as being required for attaining Completion of the Facilities.

4.15 Time for Commencement and Completion

- a) The Contractor shall commence work on the scope of work under this Tender from the date of Letter of Award. Contractor shall thereafter proceed with the Facilities in accordance with the time schedule specified in SCC & detailed network schedule agreed & appended to the contract.
- b) The Contractor shall attain Completion of the Facilities (or of a part where a separate time for Completion of such part is specified in the Contract) within the time stated in the SCC subject to time extensions, the contractor is entitled under the contract conditions or time extension expressly grouted by the Owner.

4.16 Spare Parts

In addition to the supply of Mandatory Spare Parts included in the Contract, the Contractor agrees to supply other spare parts (recommended spares) required for the operation and maintenance of the Facilities for 3 years. However, the identity, specifications and quantities of such spare parts and the terms and conditions relating to the supply thereof are to be agreed between the Owner and the Contractor, and the price of such spare parts shall be that given in Price Schedule for recommended spares. The price of such spare parts shall include the purchase price thereof and other costs and expenses (including the Contractor's fees) relating to the supply of spare parts. The prices of recommended spares covered in price schedule shall be

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valid for a period of six months after the date of Notification of Award of Main Equipment and Mandatory Spares.

- The Contractor shall supply the recommended spares at the same terms and conditions as are otherwise applicable to this Contract.
- All the spares for the equipment under the Contract will strictly conform to the Specification and other relevant documents and will be identical to the corresponding main equipment/components supplied under the Contract and shall be fully interchangeable.
- All the Mandatory Spares covered under the Contract shall be manufactured along with the main equipments as a continuous operation and the delivery of the spares will be affected along with the main equipments in a phased manner and the delivery would be completed by the respective dates for the various categories of equipment as per the agreed schedule. If order for the Recommended Spares has been placed with the Contractor prior to commencement of manufacture of the main equipment this shall be applicable for manufacturer of recommended spares as well.
- The Contractor will provide the Owner with the manufacturing drawings, catalogues, assembly drawings and any other document required by the for the recommended spares. Such details will be furnished to the Owner as soon as they are prepared but in any case not later than six months prior to commencement of manufacture of the corresponding main equipment.
- In addition to the spares recommended by the Contractor, if the Owner further identifies certain particular items of spares, the Contractor will submit the prices and delivery quotation for such spares within [30] days of receipt of such request with a validity period of 6 months for consideration by the Owner and placement of order for additional spares, if the Owner so desires.
- The quality plan and the inspection requirement finalised for the main equipment will also be applicable to the corresponding spares.
- The Contractor will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/components/equipment covered under the Contract and will further ensure with his vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.
- The Contractor shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered under the Contract. The same provision will also be applicable to spares supplied by Sub-contractors.
- For the first 6 years from the schedule date of completion of facilities the prices will be derived from the corresponding Ex-Works Price at which the order for such spares have been placed by Owner as a part of Mandatory Spares or Recommended Spares, or from the rates of Mandatory Spares or Recommended Spares as quoted by/negotiated with the Contractor. Ex-Works order price of future spares shall be computed in accordance with the price adjustment provisions covered under the main Contract excepting that the base indices will be counted from the scheduled date of Commissioning of the last equipment under the main project. The Contractor will indicate in advance the delivery period of the items of spares, which the Owner may procure in accordance with this clause. In case of emergent requirements of

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spares, the Contractor would make every effort to expedite the manufacture and delivery of such spares on the basis of mutually agreed time schedule.

- In case the Contractor fails to supply the mandatory or recommended spares in the terms stipulated above, the Owner shall be entitled to purchase the same from the alternate sources at the risk and the cost of the Contractor and recover from the Contractor, the excess amount paid by the Owner over the rates worked on the above basis. In the event of such risk purchase by the Owner, the purchases will be as per the Works and Procurement Policy of the Owner prevalent at the time of such purchases and the Owner at his option may include a representative from the Contractor in finalising the purchases.
- It is expressly understood that the final settlement between the parties in terms of relevant clauses of the Contract Documents shall not relieve the Contractor of any of his obligations under the provision of long term availability of spares and such provisions shall continue to be enforced till the expiry of 6 years period reckoned from the scheduled date of Commissioning of the Plant and Equipment unless otherwise discharged expressly in writing by the Owner.
- The Contractor shall warrant that all spares supplied will be new and in accordance with the Contract Documents and will be free from defects in design, material and workmanship. The defects liability period for spares shall be 12 months from the date it is put to use. In case of failure of any spare part due to fault in design material or workmanship the same part will be replaced by the contractor without any extra cost of the Owner.

In case of any failure in the original component/equipments due to faulty designs, materials and workmanship, the corresponding spare parts, if any, supplied will be replaced without any extra cost to the Owner unless a joint examination and analysis by the Owner and the Contractor of such spare parts prove that the defect found in the original part that failed, can safely be assumed not to be present in spare parts. Any replaced spare parts will have the Defects Liability period of 12 months from the date it is put in use. The discarded spare parts will become the property of the Contractor as soon as they have been replaced by the Contractor. In any case the defect liability of spares will expire at the end of 48 months from the date of their receipt at site

The Defects Liability of spares that are not used within 18 months from the respective date of the delivery at Site will, be subject to condition that all such spares are stored in accordance with Contractor's standard recommended practice, if any, and the same has been furnished to the Owner.

4.17 Contractor's Responsibilities

- a) The Contractor shall design, manufacture (including associated purchases and/or subcontracting), disassemble/dismantle wherever required, install, commission and complete the Facilities and carryout the Guarantee tests with due care and diligence in accordance with the Contract.
- b) Before entering into this contract the Contractor is responsible to have examined the data relating to the Facilities provided by the Owner, and on the basis of information that the Contractor could have obtained from a visual inspection of the Site and of other data readily available to it relating to the Facilities as at one month days prior to bid submission. Any failure to acquaint itself with all such data and information shall not relieve contractor of its responsibility for properly estimating the difficulty or cost of successfully performing its scope of work under this contract.

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- c) The Contractor shall acquire in its name all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings in the country where the Site is located that are necessary for the performance of the Contract, including, without limitation, visas for the Contractor's and Subcontractor's personnel and entry permits for all imported Contractor's Equipment.
- d) The Contractor shall comply with all laws in force in India and the place where the facility is located out. The laws will include all national, provincial, municipal or other laws that affect the performance of the Contract and bind upon the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any and all liabilities, damages, claims, fines, penalties and expenses of whatever nature arising or resulting from the violation of such laws by the Contractor.

4.18 Owner's Responsibilities

- a) The Owner shall be responsible for acquiring and providing legal and physical possession of the Site and access thereto, and for providing possession of and access to all other areas reasonably required for the proper execution of the Contract, including all requisite rights of way.
- b) The Owner shall acquire and pay for all permits, approvals and/or licenses from all local, state or national government authorities or public service undertakings, which such authorities or undertakings require the Owner to obtain them in the Owner's name, are necessary for the execution of the Contract.
- c) If requested by the Contractor, the Owner shall use its best endeavours to assist the Contractor in obtaining in a timely and expeditious manner all permits, approvals and/or licenses necessary for the execution of the Contract from all local, state or national government authorities or public service undertakings that such authorities or undertakings require the Contractor or Subcontractors or the personnel of the Contractor or Subcontractors, as the case may be, to obtain.
- d) The Owner shall be responsible for the continued operation of the Facilities after Completion.

4.19 Taxes & Duties

- a) Custom Duty, Excise Duty, Central sales tax (CST), service tax, Value Added Tax (VAT), VAT on Works Contract, other applicable taxes, duties and Cess shall be clearly indicated by the bidder in the price schedules and these taxes shall be considered for bid evaluation. The reimbursement of these taxes shall be on actual subject to the quoted value of these taxes as ceiling corresponding to the base price. Additional liability of taxes and duties arising out of price variation shall be reimbursed against documentary evidence over and above the ceiling (quoted value). Statutory variation in Indian taxes and duties will be dealt with as per the relevant stipulations of the specification.
- b) Except as otherwise specifically provided in the Contract, the Contractor shall bear and pay all Taxes, Duties, Levies and Charges including Entry Tax, Service Tax, if applicable in connection with the Facilities in India and outside India. All taxes, duties & levies on works contract, if any, shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.
- c) All taxes, duties and levies including entry tax/octroi (if any) in respect of all components, equipments and material to be dispatched directly from the sub-vendor's works to site shall be to the Contractor's account and no separate claim in this regard will be entertained by the Owner.

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- d) In case there is introduction of GST or any other tax in lieu of existing Excise Duty/Service Tax and VAT/ Sales Tax, the contract price will be adjusted for the impact of any differential tax liability subject to documentary evidence. This will be restricted to direct transaction between the owner and contractor, and bought out items directly dispatched from sub-vendor's works to project site.
- e) Further all taxes, duties and levies including sales tax on works contract, Entry Tax, if any, in respect of civil construction works, erection & commissioning if any and custom duty/sales tax as applicable on the materials used for such construction works shall be to the contractor's account and no separate claim in this regard will be entertained by the Owner. Incidence of Service Tax & cess on any component of the Bid Price shall be to the Contractor's account and bidders shall include Service Tax as applicable at the date seven (7) days prior to the date of bid submission in the bid price. The Contract Price will be adjusted for impact of any change in the rate of service tax or cess on service tax subsequent to this date for direct transactions between the Owner and the Contractor.
- f) If any tax exemptions, reductions, allowances or privileges may be available to the Contractor, the Owner shall use its best endeavours to enable the Contractor to benefit from any such tax savings to the maximum allowable extent.

4.20 Intellectual Property

The copyright in all drawings, documents and other materials containing data and information furnished to the Owner by the Contractor herein shall remain vested in the Contractor or, if they are furnished to the Owner directly or through the Contractor by any third party, including suppliers of materials, the copyright in such materials shall remain vested in such third party. The Owner shall however be free to reproduce all drawings, documents and other material furnished to the Owner for the purpose of the contract including, if required, for operation and maintenance.

4.21 Confidential Information

- a) The Owner and the Contractor shall keep confidential and shall not, without the written consent of the other party hereto, divulge to any third party any documents, data or other information furnished directly or indirectly by the other party hereto in connection with the Contract, whether such information has been furnished prior to, during or following termination of the Contract. Notwithstanding the above, the Contractor may furnish to its Subcontractor(s) such documents, data and other information it receives from the Owner to the extent required for the Subcontractor(s) to perform its work under the Contract, in which event the Contractor shall obtain from such Subcontractor(s) an undertaking of confidentiality similar to that imposed on the Contractor.
- b) The Owner shall not use such documents, data and other information received from the Contractor for any purpose other than the operation and maintenance of the Facilities. Similarly, the Contractor shall not use such documents, data and other information received from the Owner for any purpose other than the design, procurement of Plant and Equipments, construction or such other work and services as are required for the performance of the Contract.
- c) The obligation of a party, shall not apply to that information which
 - now or hereafter enters the public domain through no fault of that party
 - can be proven to have been possessed by that party at the time of disclosure and which was not previously obtained, directly or indirectly, from the other party hereto

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- Otherwise lawfully becomes available to that party from a third party that has no obligation of confidentiality.

4.22 Representatives

a) Project Manager

If the Project Manager is not named in the Contract, then within fourteen (14) days of the Effective Date, the Owner shall appoint and notify the Contractor in writing of the name of the Project Manager. The Owner may from time to time appoint some other person as the Project Manager in place of the person previously so appointed, and shall give a notice of the name of such other person to the Contractor without delay. The Owner shall take reasonable care to see that no such appointment is made at such a time or in such a manner as to impede the progress of work on the Facilities. The Project Manager shall represent and act for the Owner at all times during the currency of the Contract. All notices, instructions, orders, certificates, approvals and all other communications under the Contract shall be given by the Project Manager, except as herein otherwise provided.

All notices, instructions, information and other communications given by the Contractor to the Owner under the Contract shall be given to the Project Manager, except as herein otherwise provided.

b) Contractor's Representative & Construction Manager

- If the Contractor's Representative is not named in the Contract, then within *[fourteen (14) days]* of the Effective Date, the Contractor shall appoint the Contractor's Representative and shall request the Owner in writing to approve the person so appointed. If the Owner makes no objection to the appointment within *[fourteen (14)]* days, the Contractor's Representative shall be deemed to have been approved. If the Owner objects to the appointment within *[fourteen (14)]* days giving the reason there for, then the Contractor shall appoint a replacement within *[fourteen (14) days]* of such objection.
- The Contractor's Representative shall represent and act for the Contractor at all times during the currency of the Contract and shall give to the Project Manager all the Contractor's notices, instructions, information and all other communications under the Contract. All notices, instructions, information and all other communications given by the Owner or the Project Manager to the Contractor under the Contract shall be given to the Contractor's Representative or, in its absence, its deputy, except as herein otherwise provided. The Contractor shall not revoke the appointment of the Contractor's Representative without the Owner's prior written consent, which shall not be unreasonably withheld. If the Owner consents thereto, the Contractor shall appoint some other person as the Contractor's Representative.
- The Contractor's Representative may, subject to the approval of the Owner (which shall not be unreasonably withheld), at any time delegate to any person any of the powers, functions and authorities vested in him or her. Any such delegation may be revoked at any time. Any such delegation or revocation shall be subject to a prior notice signed by the Contractor's Representative, and shall specify the powers, functions and authorities thereby delegated or revoked. No such delegation or revocation shall take effect unless and until a copy thereof has been delivered to the Owner and the Project Manager.
- From the commencement of installation of the Facilities at the Site until Operational Acceptance, the Contractor's Representative shall appoint a

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suitable person as the construction manager (hereinafter referred to as “the Construction Manager”). The Construction Manager shall supervise all work done at the Site by the Contractor and shall be present at the Site throughout normal working hours except when on leave, sick or absent for reasons connected with the proper performance of the Contract. Whenever the Construction Manager is absent from the Site, a suitable person shall be appointed to act as his or her deputy.

- The Owner may by notice to the Contractor object to any representative or person employed by the Contractor in the execution of the Contract who, in the reasonable opinion of the Owner, may behave inappropriately, may be incompetent or negligent, or may commit a serious breach of the Site regulations.
- If any representative or person employed by the Contractor is removed.

4.23 Work Program

a) Contractor’s Organization

The Contractor shall supply to the Owner and the Project Manager a chart showing the proposed organization to be established by the Contractor for carrying out work on the Facilities. The chart shall include the identities of the key personnel together with the curricula vitae of such key personnel to be employed within *[twenty one (21)]* days of the Effective Date. The Contractor shall promptly inform the Owner and the Project Manager in writing of any revision or alteration of such an organization chart.

b) Program of Performance

Within *[twenty-eight (28)]* days after the date of Notification of Award of Contract, the Contractor shall prepare and submit to the Project Manager a detailed Program of Performance of the Contract, made in the form specified in the SCC and showing the sequence in which it proposes to design, supply, transport, assemble, install and precommissioning the Facilities, as well as the date by which the Contractor reasonably requires that the Owner shall have fulfilled its obligations under the Contract so as to enable the Contractor to execute the Contract in accordance with the program and to achieve Completion and Acceptance of the Facilities in accordance with the Contract. The program so submitted by the Contractor shall accord with the Time Schedule included in Appendix 4 (Time Schedule) to the Form of Contract Agreement and any other dates and periods specified in the Contract. The Contractor shall update and revise the program as and when appropriate or when required by the Project Manager, but without modification in the Times for Completion.

c) Progress Report

The Progress Report shall be in a form acceptable to the Project Manager and shall indicate: (a) percentage completion achieved compared with the planned percentage completion for each activity; and (b) where any activity is behind the program, giving comments and likely consequences and stating the corrective action being taken.

d) Progress of Performance

If at any time the Contractor’s actual progress falls behind the program, or it becomes apparent that it will so fall behind, the Contractor shall, at the request of the Owner or the Project Manager, prepare and submit to the Project Manager a revised program, taking into account the prevailing circumstances, and shall notify the Project Manager of the steps being taken to expedite progress so as to attain Completion of the Facilities within the Time for Completion.

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e) Work Procedures

The Contract shall be executed in accordance with the Contract Documents and the procedures given in the section on Forms and Procedures of the Contract Documents.

If agreed between the Owner and the Contractor, the Contractor may execute the Contract in accordance with its own standard project execution plans and procedures to the extent that they do not conflict with the provisions contained in the Contract.

4.24 Subcontractors and Subvendors

- a) The Contract Agreement specifies major items of supply or services and a list of approved Subcontractors against each item, including vendors. Insofar as no Subcontractors are listed against any such item, the Contractor shall prepare a list of Subcontractors for such item for inclusion in such list. The Contractor may from time to time propose any addition to or deletion from any such list. The Contractor shall submit any such list or any modification thereto to the Owner for its approval in sufficient time so as not to impede the progress of work on the Facilities. Such approval by the Owner for any of the Subcontractors shall not relieve the Contractor from any of its obligations, duties or responsibilities under the Contract.
- b) The Contractor shall select and employ its Subcontractors/Subvendors for such major items from those listed.

4.25 Design and Engineering

a) Specifications and Drawings

The Contractor shall execute the basic and detailed design and the engineering work in compliance with the provisions of the Contract, or where not so specified, in accordance with good engineering practice. The Contractor shall be responsible for any discrepancies, errors or omissions in the specifications, drawings and other technical documents that it has prepared, whether such specifications, drawings and other documents have been approved by the Project Manager or not, provided that such discrepancies, errors or omissions are not because of inaccurate information furnished in writing to the Contractor by or on behalf of the Owner.

b) Codes and Standards

Wherever references are made in the Contract to codes and standards in accordance with which the Contract shall be executed, the edition or the revised version of such codes and standards current at the date *[twenty eight (28)]* days prior to date of bid submission shall apply unless otherwise specified. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

c) Approval/Review of Technical Documents by Project Manager

The Contractor shall prepare (or cause its Subcontractors to prepare) and furnish to the Project Manager the documents for its approval Any part of the Facilities covered by or related to the documents to be approved by the Project Manager shall be executed only after the Project Manager's approval thereof.

Project Manager shall either return one copy thereof to the Contractor with its approval endorsed thereon or shall notify the Contractor in writing of its disapproval thereof and the reasons there for and the modifications that the Project Manager proposes. The Project Manager shall not disapprove any document, except on the grounds that the document does not comply with some specified provision of the Contract or that it is contrary to good engineering practice. The procedure for

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submission of the documents by the Contractor and their approval by the Project Manager shall be discussed and finalised with the Contractor.

If any dispute or difference occurs between the Owner and the Contractor in connection with or arising out of the disapproval by the Project Manager of any document and/or any modification(s) thereto that cannot be settled between the parties within a reasonable period, then such dispute or difference may be referred to an Adjudicator. If such dispute or difference is referred to an Adjudicator, the Project Manager shall give instructions as to whether and if so, how, performance of the Contract is to proceed. The Contractor shall proceed with the Contract in accordance with the Project Manager's instructions, provided that if the Adjudicator upholds the Contractor's view on the dispute, then the Contractor shall be reimbursed by the Owner for any additional costs incurred by reason of such instructions and shall be relieved of such responsibility or liability in connection with the dispute and the execution of the instructions as the Adjudicator shall decide, and the Time for Completion shall be extended accordingly.

The Project Manager's approval, with or without modification of the document furnished by the Contractor, shall not relieve the Contractor of any responsibility or liability imposed upon it by any provisions of the Contract except to the extent that any subsequent failure results from modifications required by the Project Manager.

4.26 Procurement

a) Plant and Equipment

The Contractor shall manufacture or procure and transport all the Plant and Equipments in an expeditious and orderly manner to the Site.

b) Transportation

The Contractor shall at its own risk and expense transport all the Plant and Equipments and the Contractor's Equipments to the Site by the mode of transport that the Contractor judges most suitable under all the circumstances. Unless otherwise provided in the Contract, the Contractor shall be entitled to select any safe mode of transport operated by any person to carry the Plant and Equipments and the Contractor's Equipment. Upon dispatch of each shipment of the Plant and Equipments and the Contractor's Equipments, the Contractor shall notify the Owner by telex, cable, telefax, facsimile or Electronic Data Interchange (EDI) of the description of the Plant and Equipments and of the Contractor's Equipments, the point and means of dispatch, and the estimated time and point of arrival in the country where the Site is located, if applicable, and at the Site. The Contractor shall furnish the Owner with relevant shipping documents to be agreed upon between the parties.

The Contractor shall be responsible for obtaining, if necessary, approvals from the authorities for transportation of the Plant and Equipments and the Contractor's Equipments to the Site. The Owner shall use its best endeavours in a timely and expeditious manner to assist the Contractor in obtaining such approvals, if requested by the Contractor. The Contractor shall indemnify and hold harmless the Owner from and against any claim for damage to roads, bridges or any other traffic facilities that may be caused by the transport of the Plant and Equipments and the Contractor's Equipments to the Site.

c) The Contractor shall, at its own expense, handle all imported Plant and Equipments and spares and Contractor's Equipments at the point(s) of import and shall handle any formalities for customs clearance.

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4.27 Installation

a) Setting Out/Supervision/Labour

Bench Mark: The Contractor shall be responsible for the true and proper setting-out of the Facilities in relation to bench marks, reference marks and lines provided to it in writing by or on behalf of the Owner.

If, at any time during the progress of installation of the Facilities, any error shall appear in the position, level or alignment of the Facilities, the Contractor shall forthwith notify the Project Manager of such error and, at its own expense, immediately rectify such error to the reasonable satisfaction of the Project Manager. If such error is based on incorrect data provided in writing by or on behalf of the Owner, the expense of rectifying the same shall be borne by the Owner.

Contractor's Supervision: The Contractor shall give or provide all necessary superintendence during the installation of the Facilities, and the Construction Manager or its deputy shall be constantly on the Site to provide full time superintendence of the installation. The Contractor shall provide and employ only technical personnel who are skilled and experienced in their respective callings and supervisory staff who are competent to adequately supervise the work at hand.

The Contractor shall provide and employ on the Site in the installation of the Facilities such skilled, semi-skilled and unskilled labour as is necessary for the proper and timely execution of the Contract. The Contractor is encouraged to use local labour that has the necessary skills. Unless otherwise provided in the Contract, the Contractor shall be responsible for the recruitment, transportation, accommodation and catering of all labour, local or expatriate, required for the execution of the Contract and for all payments in connection therewith.

The Contractor shall at its own expense provide the means of repatriation to all of its and its Subcontractor's personnel employed on the Contract at the Site to their various home countries. It shall also provide suitable temporary maintenance of all such persons from the cessation of their employment on the Contract to the date programmed for their departure. In the event that the Contractor defaults in providing such means of transportation and temporary maintenance, the Owner may provide the same to such personnel and recover the cost of doing so from the Contractor.

The Contractor shall, in all dealings with its labour and the labour of its Subcontractors currently employed on or connected with the Contract, pay due regard to all recognized festivals, official holidays, religious or other customs and all local laws and regulations pertaining to the employment of labour.

b) Contractor's Equipments

All Contractors' Equipments brought by the Contractor onto the Site shall be deemed to be intended to be used exclusively for the execution of the Contract. The Contractor shall not remove the same from the Site without the Project Manager's consent that such Contractor's Equipments are no longer required for the execution of the Contract. Unless otherwise specified in the Contract, upon completion of the Facilities, the Contractor shall remove from the Site all Equipments brought by the Contractor onto the Site and any surplus materials remaining thereon.

The Owner will, if requested, use its best endeavours to assist the Contractor in obtaining any local, state or national government permission required by the Contractor for the export of the Contractor's Equipments imported by the Contractor for use in the execution of the Contract that is no longer required for the execution of the Contract.

c) Site Regulations and Safety

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The Owner and the Contractor shall establish Site regulations setting out the rules to be observed in the execution of the Contract at the Site and shall comply therewith. The Contractor shall prepare and submit to the Owner, with a copy to the Project Manager, proposed Site regulations for the Owner's approval, which approval shall not be unreasonably withheld.

Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Facilities, gate control, sanitation, medical care, and fire prevention.

d) Opportunities for Other Contractors

The Contractor shall, upon written request from the Owner or the Project Manager, give all reasonable opportunities for carrying out the work to any other contractors employed by the Owner on or near the Site. If the Contractor, upon written request from the Owner or the Project Manager, makes available to other contractors any roads or ways the maintenance for which the Contractor is responsible, permits the use by such other contractors of the Contractor's Equipments, or provides any other service of whatsoever nature for such other contractors, the Owner shall fully compensate the Contractor for any loss or damage caused or occasioned by such other contractors in respect of any such use or service, and shall pay to the Contractor reasonable remuneration for the use of such equipments or the provision of such services.

The Contractor shall also so arrange to perform its work as to minimize, to the extent possible, interference with the work of other contractors. The Project Manager shall determine the resolution of any difference or conflict that may arise between the Contractor and other contractors and the workers of the Owner in regard to their work.

The Contractor shall notify the Project Manager promptly of any defects in the other Contractors' work that come to its notice, and that could affect the Contractor's work. The Project Manager shall determine the corrective measures, if any, required to rectify the situation after inspection of the Facilities. Decisions made by the Project Manager shall be binding on the Contractor.

e) Emergency Work

If, by reason of an emergency arising in connection with and during the execution of the Contract, any protective or remedial work is necessary as a matter of urgency to prevent damage to the Facilities, the Contractor shall immediately carry out such work.

If the Contractor is unable or unwilling to do such work immediately, the Owner may do or cause such work to be done as the Owner may determine is necessary in order to prevent damage to the Facilities. In such event the Owner shall, as soon as practicable after the occurrence of any such emergency, notify the Contractor in writing of such emergency, the work done and the reasons there for. If the work done or caused to be done by the Owner is work that the Contractor was liable to do at its own expense under the Contract, the reasonable costs incurred by the Owner in connection therewith shall be paid by the Contractor to the Owner. Otherwise, the cost of such remedial work shall be borne by the Owner.

f) Site Clearance

Site Clearance in Course of Performance: In the course of carrying out the Contract, the Contractor shall keep the Site reasonably free from all unnecessary obstruction, store or remove any surplus materials, clear away any wreckage, rubbish or temporary works from the Site, and remove any Contractor's Equipments no longer

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required for execution of the Contract. Clearance of Site after Completion: After Completion of all parts of the Facilities, the Contractor shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site and Facilities clean and safe.

g) **Watching and Lighting**

The Contractor shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper execution and the protection of the Facilities, or for the safety of the owners and occupiers of adjacent property and for the safety of the public as per specification.

4.28 Testing & Inspections

- a) The Contractor shall at its own expense carry out at the place of manufacture and/or on the Site all such tests and/or inspections of the Plant and Equipments and any part of the Facilities as are specified in the Contract.
- b) The Owner and the Project Manager or their designated representatives shall be entitled to attend the aforesaid test and/ or inspection, provided that the Owner shall bear all costs and expenses incurred in connection with such attendance including, but not limited to, all travelling and board and lodging expenses.
- c) Whenever the Contractor is ready to carry out any such test and/or inspection, the Contractor shall give a reasonable advance notice of such test and/or inspection and of the place and time thereof to the Project Manager. The Contractor shall obtain from any relevant third party or manufacturer any necessary permission or consent to enable the Owner and the Project Manager (or their designated representatives) to attend the test and/or inspection.
- d) The Contractor shall provide the Project Manager with a certified report of the results of any such test and/or inspection. If the Owner or Project Manager (or their designated representatives) fails to attend the test and/or inspection, or if it is agreed between the parties that such persons shall not do so, then the Contractor may proceed with the test and/or inspection in the absence of such persons, and may provide the Project Manager with a certified report of the results thereof.
- e) The Project Manager may require the Contractor to carry out any test and/or inspection not required by the Contract, provided that the Contractor's reasonable costs and expenses incurred in the carrying out of such test and/or inspection shall be added to the Contract Price. Further, if such test and/or inspection impede the progress of work on the Facilities and/or the Contractor's performance of its other obligations under the Contract, due allowance will be made in respect of the Time for Completion and the other obligations so affected.
- f) If any Plant and Equipment or any part of the Facilities fails to pass any test and/or inspection, the Contractor shall either rectify or replace such Plant and Equipment or part of the Facilities and shall repeat the test and/or inspection upon giving a notice.
- g) If any dispute or difference of opinion shall arise between the parties in connection with or arising out of the test and/or inspection of the Plant and Equipments or part of the Facilities that cannot be settled between the parties within a reasonable period of time, it may be referred to the Adjudicator.
- h) The Contractor shall afford the Owner and the Project Manager, at the Owner's expense, access at any reasonable time to any place where the Plant and Equipments are being manufactured or the Facilities are being installed, in order to inspect the progress and the manner of manufacture or installation, provided that the Project Manager shall give the Contractor a reasonable prior notice.

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- i) The Contractor agrees that neither the execution of a test and/ or inspection of Plant and Equipments or any part of the Facilities, nor the witnessing of any test by the Owner, nor the issuance of any test certificate shall relieve the Contractor of any obligation under this Contract.
- j) No part of the Facilities or foundations shall be covered up on the Site without the Contractor carrying out any test and/or inspection required under the Contract. The Contractor shall give a reasonable notice to the Project Manager whenever any such part of the Facilities or foundations is ready or about to be ready for test and/or inspection; such test and/or inspection and notice thereof shall be subject to the requirements of the Contract.
- k) The Contractor shall uncover any part of the Facilities or foundations, or shall make openings in or through the same as the Project Manager may from time to time require at the Site, and shall reinstate and make good such part or parts.

4.29 Completion of the Facilities

- a) As soon as the Facilities or any part thereof has, in the opinion of the Contractor, been completed operationally and structurally and put in a tight and clean condition as specified in the Technical Specifications, excluding minor items not materially affecting the operation or safety of the Facilities, the Contractor shall so notify the Owner in writing.
- b) The Owner shall supply the operating and maintenance personnel specified in to the Form of Contract Agreement for Precomissioning of the Facilities or any part thereof.
- c) As soon as all works in respect of Precomissioning are completed and, in the opinion of the Contractor, the Facilities or any part thereof is ready for Commissioning, the Contractor shall commence Commissioning as per procedures stipulated in Technical Specifications, and as soon as Commissioning is satisfactorily completed, the Contractor shall so notify the Project Manager in writing.
- d) If the Project Manager notifies the Contractor of any defects and/ or deficiencies, the Contractor shall then correct such defects and/or deficiencies.
If the Project Manager is satisfied that the Facilities or that part thereof have reached Completion, the Project Manager shall, within **[seven (7)]** days after receipt of the Contractor's notice, issue a Completion Certificate stating that the Facilities or that part thereof have reached Completion as at the date of the Contractor's notice.
If the Project Manager is not so satisfied, then it shall notify the Contractor in writing of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's repeated notice, and the above procedure shall be repeated.
- e) If the Project Manager fails to issue the Completion Certificate and fails to inform the Contractor of any defects and/or deficiencies within **[seven (7)]** days after receipt of the Contractor's notice, or if the Owner makes use of the Facilities or part thereof, then the Facilities or that part thereof shall be deemed to have reached Completion as of the date of the Contractor's notice, or as of the Owner's use of the Facilities, as the case may be.
- f) As soon as possible after Completion, the Contractor shall complete all outstanding minor items so that the Facilities are fully in accordance with the requirements of the Contract, failing which the Owner will undertake such completion and deduct the costs thereof from any monies owing to the Contractor.
- g) Upon Completion, the Owner shall be responsible for the care and custody of the Facilities or the relevant part thereof, together with the risk of loss or damage thereto, and shall thereafter take over the Facilities or the relevant part thereof.

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4.30 Commissioning & Operation Acceptance

a) Commissioning

Commissioning of the Facilities or any part thereof Acceptance shall be completed by the Contractor as per procedures detailed in the Technical Specifications. The Contractor shall, unless otherwise specified in Contract/ Tender Specifications, supply the and all raw materials, utilities, lubricants, chemicals, catalysts, facilities, services and other matters required for Commissioning.

b) Guarantee Test

The Guarantee Tests (and repeats thereof) shall be conducted by the Contractor after Commissioning of the Facilities or the relevant part thereof to ascertain whether the Facilities or the relevant part can attain the Functional Guarantees specified in the Contract Documents. The Contractor's and Project Manager's advisory personnel shall attend the Guarantee Test. The Owner shall promptly provide the Contractor with such information as the Contractor may reasonably require in relation to the conduct and results of the Guarantee Tests (and any repeats thereof). If for reasons not attributable to the Contractor, the Guarantee Tests of the Facilities or the relevant part thereof cannot be successfully completed within the period from the date of Completion, specified in the SCC or any other period agreed upon by the Owner and the Contractor, the Contractor shall be deemed to have fulfilled its obligations with respect to the Functional Guarantees.

c) Operational Acceptance

Operational Acceptance shall occur in respect of the Facilities or any part thereof when

- the Guarantee Tests have been successfully completed and the Functional Guarantees are met; or
- The Guarantee Tests have not been successfully completed or has not been carried out for reasons not attributable to the Contractor within the period from the date of Completion specified in the SCC or any other agreed upon period as specified in GCC.
- The Contractor may give a notice to the Project Manager requesting the issue of an Operational Acceptance Certificate in respect of the Facilities or the part thereof specified in such notice as at the date of such notice.
- The Project Manager shall, after consultation with the Owner, and within forty five (45) days after receipt of the Contractor's notice, issue an Operational Acceptance Certificate. If within *[forty five (45)]* days after receipt of the Contractor's notice, the Project Manager fails to issue the Operational Acceptance Certificate or fails to inform the Contractor in writing of the justifiable reasons why the Project Manager has not issued the Operational Acceptance Certificate, the Facilities or the relevant part thereof shall be deemed to have been accepted as at the date of the Contractor's said notice.

d) Partial Acceptance

If the Contract specifies that Completion, Commissioning and Guarantee Tests shall be carried out in respect of parts of the Facilities, the provisions relating to Completion and Commissioning including the Guarantee Tests shall apply to each such part of the Facilities individually, and the Operational Acceptance Certificate shall be issued accordingly for each such part of the Facilities. If a part

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of the Facilities comprises facilities such as buildings, for which no Commissioning or Guarantee Tests are required, then the Project Manager shall issue the Operational Acceptance Certificate for such facility when it attains Completion, provided that the Contractor shall thereafter complete any outstanding minor items that are listed in the Operational Acceptance Certificate.

4.31 Completion Time and Liquidated Damage

a) **Completion Time Period**

The Contractor guarantees that it shall attain Completion of the Facilities (or a part for which a separate time for completion is specified in the SCC) within the Time for Completion specified in the SCC.

b) If the Contractor fails to attain Completion of the Facilities or any part thereof within the Time for Completion, the Contractor shall pay to the Owner liquidated damages in the amount computed at the rates specified in the SCC. The aggregate amount of such liquidated damages shall in no event exceed the amount specified as "Maximum" in the SCC.

However, the payment of liquidated damages shall not in any way relieve the Contractor from any of its obligations to complete the Facilities or from any other obligations and liabilities of the Contractor under the Contract.

c) No bonus will be given for earlier completion of the facilities or part thereof.

4.32 Defects Liability

a) The Contractor warrants that the Facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the Plant and Equipments supplied and of the work executed.

b) The Defects Liability Period shall be [eighteen (18)] months from the date of Completion of the Facilities (or any part thereof) or [twelve (12)] months from the date of Operational Acceptance of the Facilities (or any part thereof).

If during the Defects Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipments supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect. The Contractor shall not be responsible for the repair, replacement or making good of any defect or of any damage to the Facilities arising out of or resulting from any of the following causes:

- improper operation or maintenance of the Facilities by the Owner
- operation of the Facilities outside specifications provided in the Contract
- Normal wear and tear.

c) The Owner shall give the Contractor a notice stating the nature of any such defect together with all available evidence thereof, promptly following the discovery thereof. The Owner shall afford all reasonable opportunity for the Contractor to inspect any such defect.

d) The Owner shall afford the Contractor all necessary access to the Facilities and the Site to enable the Contractor to perform its obligations.

e) If the repair, replacement or making good is of such a character that it may affect the efficiency of the Facilities or any part thereof, the Owner may give to the Contractor a notice requiring that tests of the defective part of the Facilities shall be

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made by the Contractor immediately upon completion of such remedial work, whereupon the Contractor shall carry out such tests.

- f) If the Contractor fails to commence the work necessary to remedy such defect or any damage to the Facilities caused by such defect within a reasonable time (which shall in no event be considered to be less than fifteen (15) days), the Owner may, following notice to the Contractor, proceed to do such work, and the reasonable costs incurred by the Owner in connection therewith shall be paid to the Owner by the Contractor or may be deducted by the Owner from any monies due to the Contractor or claimed under the Performance Security.

If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defects Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the Defects Liability Period extended by a period of *[twelve (12) month]* from the time such replacement/repair of the Facilities or any part thereof.

4.33 Functional Guarantees

The Contractor guarantees that during the Guarantee Tests, the Facilities and all parts thereof shall attain the Functional Guarantees as per the Contract. If, for reasons attributable to the Contractor, Functional Guarantees are not met either in whole or in part, the Contractor shall, within a mutually agreed time, at its cost and expense make such changes, modifications and/or additions to the Plant or any part thereof as may be necessary to meet such Guarantees. The Contractor shall notify the Owner upon completion of the necessary changes, modifications and/or additions, and shall seek the Owner's consent to repeat the Guarantee Test. If the specified Functional Guarantees are not established even during the repeat of the Guarantee Tests, the Owner may at its option, either reject the plant and equipment and recover from the Contractor payments already made or Accept the equipment/system/plant after levying Liquidated Damages as specified.

4.34 Patents Indemnity

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Owner may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Contract by reason of: (a) the installation of the Facilities by the Contractor or the use of the such Facilities.

4.35 Limitation of liability

Except in cases of criminal negligence or wilful misconduct by the Contractor, the aggregate liability of the Contractor to the Owner, whether under the Contract, in tort or otherwise, shall not exceed the total Contract Price, provided that this limitation shall not apply to any obligation of the Contractor to indemnify the Owner with respect to patent infringement.

Except in cases of criminal negligence or wilful misconduct by the Contractor, the Contractor shall not be liable to the Owner, whether in contract, tort, or otherwise, for any indirect or consequential loss or damage, loss of use, loss of production, or

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loss of profits or interest costs, provided that this exclusion shall not apply to any obligation of the Contractor to pay liquidated damages to the Owner.

4.36 Transfer of Ownership

Ownership of the Plant and Equipments (including spare parts) to be imported into India shall be transferred to the Owner upon loading on to the mode of transport to be used to convey the Plant and Equipments from the country of origin to that country.

Ownership of the Plant and Equipments (including spare parts) procured from within India shall be transferred to the Owner when the Plant and Equipments including spares are loaded on to the mode of transport to be used to convey the Plant and Equipments including spares from the works to the site and upon endorsement of the despatch documents in favour of the Owner. Ownership of the Contractor's Equipments used by the Contractor and its Subcontractors in connection with the Contract shall remain with the Contractor or its Subcontractors. Ownership of any Plant and Equipments in excess of the requirements for the Facilities shall revert to the Contractor upon Completion of the Facilities or at such earlier time when the Owner and the Contractor agree that the Plant and Equipments in question are no longer required for the Facilities, provided quantity of any Plant and Equipments specifically stipulated in the Contract shall be the property of the Owner whether or not incorporated in the Facilities. Notwithstanding the transfer of ownership of the Plant and Equipments, the responsibility for care and custody thereof together with the risk of loss or damage shall remain with the Contractor until Completion of the Facilities.

4.37 Care of Facilities

The Contractor shall be responsible for the care and custody of the Facilities or any part thereof until the date of Completion of the Facilities, where the Contract provides for Completion of the Facilities in parts, until the date of Completion of the relevant part, and shall make good at its own cost any loss or damage that may occur to the Facilities or the relevant part thereof from any cause whatsoever during such period. The Contractor shall also be responsible for any loss or damage to the Facilities caused by the Contractor or its Subcontractors in the course of any work carried out.

4.38 Loss of or Damage to Property; Accident or Injury; Indemnification

The Contractor shall indemnify and hold harmless the Owner and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, in respect of the death or injury of any person or loss of or damage to any property (other than the Facilities whether accepted or not), arising in connection with the supply and installation of the Facilities and by reason of the negligence of the Contractor or its Subcontractors, or their employees, officers or agents, except any injury, death or property damage caused by the negligence of the Owner, its contractors, employees, officers or agents.

4.39 Insurance

- a) The Contractor shall at its expense take out and maintain in effect, or cause to be taken out and maintained in effect, during the performance of the Contract, the insurances set forth below in the sums and with the deductibles and other conditions as specified. The identity of the insurers and the form of the policies shall be subject to the approval of the Owner, who should not unreasonably withhold such approval.

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- Cargo Insurance during Transport:-Covering loss or damage occurring while in transit from the Contractor's or Subcontractor's works or stores until arrival at the Site, to the Plant and Equipments (including spare parts thereof) and to the Contractor's Equipments.
 - Installation All Risks Insurance:-Covering physical loss or damage to the Facilities at the Site, occurring prior to Completion of the Facilities, with an extended maintenance coverage for the Contractor's liability in respect of any loss or damage occurring during the Defects Liability Period while the Contractor is on the Site for the purpose of performing its obligations during the Defects Liability Period.
 - Third Party Liability Insurance: - Covering bodily injury or death suffered by third parties (including the Owner's personnel) and loss of or damage to property occurring in connection with the supply and installation of the Facilities.
 - Automobile Liability Insurance:-Covering use of all vehicles used by the Contractor or its Subcontractors (whether or not owned by them) in connection with the execution of the Contract.
 - Workers' Compensation:-In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Owner's Liability: - In accordance with the statutory requirements applicable in any country where the Contract or any part thereof is executed.
 - Other Insurances Such other insurances as may be specifically agreed upon by the parties.
- b) The Owner shall be named as co-insured under all insurance policies taken out by the Contractor pursuant except for the Third Party Liability, Workers' Compensation and Owner's Liability Insurances, and the Contractor's Subcontractors shall be named as co-insured's under all insurance policies taken out by the Contractor except for the Cargo Insurance During Transport, Workers' Compensation and Owner's Liability Insurances. All insurers' rights of subrogation against such co-insured's for losses or claims arising out of the performance of the Contract shall be waived under such policies.
- c) The Form of Contract Agreement, deliver to the Owner certificates of insurance (or copies of the insurance policies) as evidence that the required policies are in full force and effect. The certificates shall provide that no less than twenty one (21) days' notice shall be given to the Owner by insurers prior to cancellation or material modification of a policy.
- d) The Contractor shall ensure that, where applicable, its Subcontractor(s) shall take out and maintain in effect adequate insurance policies for their personnel and vehicles and for work executed by them under the Contract, unless such Subcontractors are covered by the policies taken out by the Contractor.
- e) The Owner shall at its expense take out and maintain in effect during the performance of the Contract those insurances specified.
- f) the Owner may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Contractor under the Contract any premium that the Owner shall have paid to the insurer, or may otherwise recover such amount as a debt due from the Contractor. If the Owner fails to take out and/or maintain in effect the insurances the Contractor may take out and maintain in effect any such insurances and may from time to time deduct from any amount due the Owner under the Contract any premium that the Contractor shall have paid to the insurer, or may otherwise recover such amount as a debt due from the

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Owner. If the Contractor fails to or is unable to take out and maintain in effect any such insurances, the Contractor shall nevertheless have no liability or responsibility towards the Owner, and the Contractor shall have full recourse against the Owner for any and all liabilities of the Owner herein.

- g) The Owner shall give to the Contractor all such reasonable assistance as may be required by the Contractor. With respect to insurance claims in which the Owner's interest is involved, the Contractor shall not give any release or make any compromise with the insurer without the prior written consent of the Owner. With respect to insurance claims in which the Contractor's interest is involved, the Owner shall not give any release or make any compromise with the insurer without the prior written consent of the Contractor.
- h) Wherever total damages/loss of equipments/materials, would occur, the Contractor will be entitled to payment of all payments received from the underwriters except the following amounts:
 - The amount paid to the Contractor under the Contract in respect of equipments/materials damaged/lost (excluding the pro-rata initial advance) but including the entire amount of escalation, if any, already paid to the Contractor.
 - Custom Duties and taxes which have already been paid by the Owner.
 - In case of damage to any equipments/materials during any stage, the Contractor upon rectification of the damaged equipment to the satisfaction of the Owner shall be paid to the extent of full claims settled by the underwriters.
- i) All the Plants & Equipment being supplied by the Owner free of cost for installation of the equipment, cabling, earthing and lightning protection etc. by the Contractor, covered by this specification shall be kept insured by the Contractor against loss, damage, theft, pilferage, fire etc. from the point of unloading at Site up to the time of taking over by the Owner including handling, in plant transportation, storage, installation, testing and commissioning, etc. and the Contractor shall be fully responsible for making good of any loss or damage at his own cost within a reasonable time as mutually agreed upon by the Owner and the Contractor. Any loss/damage shall be brought to the Owner's notice immediately. The premium paid by the Contractor to the Insurance Company for such insurance shall be reimbursed by the Owner to the Contractor at actual against documentary proof to be furnished by the Contractor. The Contractor shall obtain competitive quotation for such insurance and shall take prior approval from the Owner before taking the insurance. The insurable value of the equipment being procured by the Owner will be intimated to the Contractor for the purpose of insurance.
 - It will be the responsibility of the Contractor to lodge, pursue and settle all claims with the Insurance Company in case of any damage, loss, theft, pilferage, fire, etc. and the Owner shall be kept informed about it. The losses, if any, will have to be borne by the Contractor, if the claims are not lodged and pursued properly or in the time or if the same are not settled by the Insurance Company.

4.40 Change in Laws & Regulation

- a) If, after the date [seven (7)] days prior to the date of Bid submission, in India, any law, regulation, ordinance, order or by-law having the force of law is enacted, promulgated, abrogated or changed (which shall be deemed to include any change in interpretation or application by the competent authorities) that subsequently affects the costs and expenses of the Contractor and/or the Time

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for Completion, the Contract Price shall be correspondingly increased or decreased, and/or the Time for Completion shall be reasonably adjusted to the extent that the Contractor has thereby been affected in the performance of any of its obligations under the Contract. However, these adjustments would be restricted to direct transactions between the Owner and the Contractor and not on procurement of raw materials, intermediary components etc. by the Contractor. Notwithstanding the foregoing, such additional or reduced costs shall not be separately paid or credited if the same has already been accounted for in the price adjustment provisions wherever applicable.

4.41 Force Majeure

- (a) Force Majeure" shall mean any event beyond the reasonable control of the Owner or of the Contractor, as the case may be, and which is unavoidable notwithstanding the reasonable care of the party affected. Force Majeure events include Acts of God, Acts of Government, war, sabotage, riots, civil commotion, revolution, flood, earthquake, cyclone, fire, epidemic etc.
- (b) If either party is prevented, hindered or delayed from or in performing any of its obligations under the Contract by an event of Force Majeure, then it shall notify the other in writing of the occurrence of such event and the circumstances thereof within *[fourteen (14)]* days after the occurrence of such event.
- (c) The party who has given such notice shall be excused from the performance or punctual performance of its obligations under the Contract for so long as the relevant event of Force Majeure continues and to the extent that such party's performance is prevented, hindered or delayed.
- (d) The party or parties affected by the event of Force Majeure shall use reasonable efforts to mitigate the effect thereof upon its or their performance of the Contract and to fulfil its or their obligations under the Contract, but without prejudice to either party's right.
- (e) No delay or non-performance by either party hereto caused by the occurrence of any event of Force Majeure shall
 - constitute a default or breach of the Contract
 - to any claim for damages or additional cost or expense occasioned thereby
 if and to the extent that such delay or non-performance is caused by the occurrence of an event of Force Majeure.
- (f) If the performance of the Contract is substantially prevented, hindered or delayed for a single period of more than *[sixty (60)]* days or an aggregate period of more than one hundred and *[twenty (120)]* days on account of one or more events of Force Majeure during the currency of the Contract, the parties will attempt to develop a mutually satisfactory solution.
- (g) Force Majeure shall not apply to any obligation of the Owner to make payments to the Contractor herein.

4.42 Change in the Facilities

(a) Introducing a Change

- The Owner shall have the right to propose, and subsequently require, the Contractor during the performance of the Contract to make any change, modification, addition or deletion to, in or from the Facilities (hereinafter called "Change"), provided that such Change falls within the general scope of the Facilities and does not constitute unrelated work and that it is technically practicable, taking into account both the state of advancement of the Facilities

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and the technical compatibility of the Change envisaged with the nature of the Facilities as specified in the Contract.

- The Contractor may from time to time during its performance of the Contract propose to the Owner (with a copy to the Project Manager) any Change that the Contractor considers necessary or desirable to improve the quality, efficiency or safety of the Facilities. This includes any additional scope of work that the contractor thinks is essential for achieving the minimum performance level specified in the SCC or the Contract. The Owner may at its discretion approve or reject any Change proposed by the Contractor.
- No change made necessary because of any default of the Contractor in the performance of its obligations under the Contract shall be deemed to be a Change, and such change shall not result in any adjustment of the Contract Price or the Time for Completion.

(b) Changes Originating from Owner

- If the Owner proposes a Change, it shall send to the Contractor a "Request for Change Proposal," requiring the Contractor to prepare and furnish to the Project Manager as soon as reasonably practicable a "Change Proposal," which shall include the following:
 - ✓ brief description of the Change
 - ✓ effect on the Time for Completion
 - ✓ estimated Cost of the Change
 - ✓ effect on Functional Guarantees (if any)
 - ✓ effect on any other provisions of the Contract.
- The pricing of any Change shall, as far as practicable, be calculated in accordance with the rates and prices included in the Contract. If the rates and prices of any change are not available in the Contract, the parties thereto shall agree on specific rates for the valuation of the Change.
- If before or during the preparation of the Change Proposal it becomes apparent that the aggregate effect of compliance therewith and with all other Change Orders that have already become binding upon the Contractor to increase or decrease the Contract Price as originally set forth in the Contract Agreement by more than fifteen (15) percent, the Contractor may give a written notice of objection thereto prior to furnishing the Change Proposal as aforesaid. If the Owner accepts the Contractor's objection, the Owner and the Contractor shall agree on specific rates for valuation of the change.
- Upon receipt of the Change Proposal, the Owner and the Contractor shall mutually agree upon all matters therein contained including agreement on rates if such rates are not available in the Contract or if the limit of 15% set forth has been exceeded. Within *fourteen (14)* days after such agreement, the Owner shall, if it intends to proceed with the Change, issue the Contractor with a Change Order.
- If the Owner is unable to reach a decision within *fourteen (14)* days, it shall notify the Contractor with details of when the Contractor can expect a decision.
- If the Owner decides not to proceed with the Change for whatever reason, it shall, within the said period of *fourteen (14)* days, notify the Contractor accordingly.

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- If the Owner and the Contractor cannot reach agreement on the price for the Change, an equitable adjustment to the Time for Completion, or any other matters identified in the Change Proposal, the Owner may nevertheless instruct the Contractor to proceed with the Change by issue of a "Pending Agreement Change Order."

Upon receipt of a Pending Agreement Change Order, the Contractor shall immediately proceed with effecting the Changes covered by such Order. The parties shall thereafter attempt to reach agreement on the outstanding issues under the Change Proposal.

(c) Changes Originating from Contractor

- The Contractor shall submit to the Project Manager a written "Application for Change Proposal," giving reasons for the proposed Change and including the information. Upon receipt of the Application for Change Proposal, the parties shall follow the procedures indicated above for "Request for Change Proposal."

4.43 Extension of Time for Completion

- (a) The Time(s) for Completion specified in the SCC shall be extended if the Contractor is delayed or impeded in the performance of any of its obligations under the Contract by reason of any of the following:
- Any Change in the Facilities or
 - any occurrence of Force Majeure or
 - any suspension order given by the Owner or reduction in the rate of progress or
 - any changes in laws and regulations or
 - any default or breach of the Contract by the Owner, or any activity, act or omission of any other contractors employed by the Owner or
 - any other matter specifically mentioned in the Contract;
- By such period as shall be fair and reasonable in all the circumstances and as shall fairly reflect the delay or impediment sustained by the Contractor.
- (b) Except where otherwise specifically provided in the Contract, the Contractor shall submit to the Project Manager a notice of a claim for an extension of the Time for Completion, together with particulars of the event or circumstance justifying such extension as soon as reasonably practicable after the commencement of such event or circumstance. As soon as reasonably practicable after receipt of such notice and supporting particulars of the claim, the Owner and the Contractor shall agree upon the period of such extension.
- (c) The Contractor shall at all times use its reasonable efforts to minimize any delay in the performance of its obligations under the Contract.

4.44 Suspension

- (a) The Owner/ Project Manager may, by notice to the Contractor, order the Contractor to suspend performance of any or all of its obligations under the Contract. Such notice shall specify the obligation of which performance is to be suspended, the effective date of the suspension and the reasons thereof. The Contractor shall thereupon suspend performance of such obligation (except those obligations necessary for the care or preservation of the Facilities) until ordered in writing to resume such performance by the Project Manager/ Owner.

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If, by virtue of a suspension order given by the Project Manager/ Owner, other than by reason of the Contractor's default or breach of the Contract, the Contractor's performance of any of its obligations is suspended for an aggregate period of more than *[ninety (90)]* days, then at any time thereafter and provided that at that time such performance is still suspended, the Contractor may give a notice to the Project Manager requiring that the Owner shall, within *[twenty eight (28)]* days of receipt of the notice, order the resumption of such performance or request and subsequently order a change, excluding the performance of the suspended obligations from the Contract.

- (b) If the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas;

Then the Contractor may by *[fourteen (14)]* days' notice to the Owner suspend performance of all or any of its obligations under the Contract, or reduce the rate of progress. If the Contractor's performance of its obligations is suspended or the rate of progress is reduced, then the Time for Completion shall be extended, and any and all additional costs or expenses incurred by the Contractor as a result of such suspension or reduction shall be paid by the Owner to the Contractor in addition to the Contract Price, except in the case of suspension order or reduction in the rate of progress by reason of the Contractor's default or breach of the Contract.

- (c) During the period of suspension, the Contractor shall not remove from the Site any Plant and Equipment, any part of the Facilities or any Contractor's Equipment, without the prior written consent of the Owner.

4.45 Termination

(a) Termination for Owner's Convenience

The Owner may at any time terminate the Contract for any reason by giving the Contractor a notice of termination. Upon receipt of the notice of termination, the Contractor shall either immediately or upon the date specified in the notice of termination

- (i) cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition.
- (ii) terminate all subcontracts, except those to be assigned
- (iii) remove all Contractor's Equipments from the Site, repatriate the Contractor's and its Subcontractors' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition
- (iv) The Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as at the date of termination, and, as may be required by the Owner, in

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any subcontracts concluded between the Contractor and its Subcontractors

- ✓ Deliver to the Owner all non-proprietary drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

In the event of termination of the Contract for Owner's convenience, the Owner shall pay to the Contractor the following amounts

- ✓ the Contract Price, attributable to the parts of the Facilities executed by the Contractor as on the date of termination
- ✓ the costs reasonably incurred by the Contractor in the removal of the Contractor's Equipment from the Site and in the repatriation of the Contractor's and its Subcontractors' personnel
- ✓ any amounts to be paid by the Contractor to its Subcontractors in connection with the termination of any subcontracts, including any cancellation charges
- ✓ costs incurred by the Contractor in protecting the Facilities and leaving the Site in a clean and safe condition
- ✓ the additional cost of satisfying other obligations, commitments and claims that the Contractor may in good faith have undertaken with third parties in connection with the Contract.

(b) Termination for Contractor's Default

- (i) The Owner, without prejudice to any other rights or remedies it may possess, may terminate the Contract forthwith in the following circumstances by giving a notice of termination and its reasons thereof to the Contractor:

If the Contractor becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, if the Contractor is a corporation, a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Contractor takes or suffers any other analogous action in consequence of debt

If the Contractor assigns or transfers the Contract or any right or interest therein in violation of the provision.

If the Contractor, in the judgement of the Owner has engaged in corrupt or fraudulent practices in competing for or in executing the Contract.

For the purpose of this Sub Clause:

"corrupt practice" means the offering, giving, receiving or soliciting of anything of value to influence the action of a public official in the procurement process or in contract execution.

"fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of a contract to the detriment of the Owner and includes collusive practice among Bidders (prior to or after bid submission) designed to establish bid prices at artificial non-competitive levels and to deprive the Owner of the benefits of free and open competition.

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(ii) If the Contractor

- has abandoned or repudiated the Contract
- has without valid reason failed to commence work on the Facilities promptly the progress of Contract performance for more than *[twenty eight (28)]* days after receiving a written instruction from the Owner to proceed
- persistently fails to execute the Contract in accordance with the Contract or persistently neglects to carry out its obligations under the Contract without just cause
- refuses or is unable to provide sufficient materials, services or labor to execute and complete the Facilities in the manner specified in the program at rates of progress that give reasonable assurance to the Owner that the Contractor can attain Completion of the Facilities by the Time for Completion as extended

then the Owner may, without prejudice to any other rights it may possess under the Contract, give a notice to the Contractor stating the nature of the default and requiring the Contractor to remedy the same. If the Contractor fails to remedy or to take steps to remedy the same within *[fourteen (14)]* days of its receipt of such notice, then the Owner may terminate the Contract forthwith by giving a notice of termination to the Contractor.

(iii) The Contractor shall, either immediately or upon such date as is specified in the notice of termination,

- cease all further work, except for such work as the Owner may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
- terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d) below
- deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
- to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Works and to the Plant and Equipment as at the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
- Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as at the date of termination in connection with the Facilities.

(iv) The Owner may enter upon the Site, expel the Contractor, and complete the Facilities itself or by employing any third party. The Owner may, to the exclusion of any right of the Contractor over the same, take over and use with the payment of a fair rental rate to the Contractor, with all the maintenance costs to the account of the Owner and with an indemnification by the Owner for all liability including damage or injury to persons arising out of the Owner's use of such equipment, any Contractor's Equipments owned by the Contractor and on the Site in connection with the Facilities for such reasonable period as the Owner considers expedient for the supply and installation of the Facilities.

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Upon completion of the Facilities or at such earlier date as the Owner thinks appropriate, the Owner shall give notice to the Contractor that such Contractor's Equipment will be returned to the Contractor at or near the Site and shall return such Contractor's Equipments to the Contractor in accordance with such notice. The Contractor shall thereafter without delay and at its cost remove or arrange removal of the same from the Site.

- (v) The Contractor shall be entitled to be paid the Contract Price attributable to the Facilities executed as at the date of termination, the value of any unused or partially used Plant and Equipments on the Site, and the costs, if any, incurred in protecting the Facilities and in leaving the Site in a clean and safe condition. Any sums due to the Owner from the Contractor accruing prior to the date of termination shall be deducted from the amount to be paid to the Contractor under this Contract.
- (vi) If the Owner completes the Facilities, the cost of completing the Facilities by the Owner shall be determined.

If the sum that the Contractor is entitled to be paid, plus the reasonable costs incurred by the Owner in completing the Facilities, exceeds the Contract Price, the Contractor shall be liable for such excess.

The Owner and the Contractor shall agree, in writing, on the computation described above and the manner in which any sums shall be paid.

(c) Termination by Contractor

- i. If
 - the Owner has failed to pay the Contractor any sum due under the Contract within the specified period, has failed to approve any invoice or supporting documents without just cause pursuant to [-----] (Terms and Procedures of Payment) of the Form of Contract Agreement, or commits a substantial breach of the Contract, the Contractor may give a notice to the Owner that requires payment of such sum, requires approval of such invoice or supporting documents, or specifies the breach and requires the Owner to remedy the same, as the case may be. If the Owner fails to pay such sum, fails to approve such invoice or supporting documents or give its reasons for withholding such approval, fails to remedy the breach or take steps to remedy the breach within [fourteen (14) days] after receipt of the Contractor's notice, or
 - the Contractor is unable to carry out any of its obligations under the Contract for any reason attributable to the Owner, including but not limited to the Owner's failure to provide possession of or access to the Site or other areas or failure to obtain any governmental permit necessary for the execution and/or completion of the Facilities which the Owner is required to obtain as per provision of the Contract or as per relevant applicable laws of the country,

then the Contractor may give a notice to the Owner thereof, and if the Owner has failed to pay the outstanding sum, to approve the invoice or supporting documents, to give its reasons for withholding such approval, or to remedy the breach within [twenty eight (28) days] of such notice, or if the Contractor is still unable to carry out any of its obligations under the Contract for any reason attributable to the Owner within twenty eight

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(28) days of the said notice, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.

- ii. If the Owner becomes bankrupt or insolvent, has a receiving order issued against it, compounds with its creditors, or, being a corporation, if a resolution is passed or order is made for its winding up (other than a voluntary liquidation for the purposes of amalgamation or reconstruction), a receiver is appointed over any part of its undertaking or assets, or if the Owner takes or suffers any other analogous action in consequence of debt, then the Contractor may terminate the Contract forthwith by giving a notice of termination to the Owner.
- iii. If the Contract is terminated, then the Contractor shall immediately
 - cease all further work, except for such work as may be necessary for the purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition
 - terminate all subcontracts, except those to be assigned to the Owner pursuant to paragraph (d)(ii)
 - remove all Contractor's Equipment from the Site and repatriate the Contractor's and its Subcontractor's personnel from the Site
 - In addition, the Contractor, subject to the payment, shall
 - ✓ deliver to the Owner the parts of the Facilities executed by the Contractor up to the date of termination
 - ✓ to the extent legally possible, assign to the Owner all right, title and benefit of the Contractor to the Facilities and to the Plant and Equipments as of the date of termination, and, as may be required by the Owner, in any subcontracts concluded between the Contractor and its Subcontractors
 - ✓ Deliver to the Owner all drawings, specifications and other documents prepared by the Contractor or its Subcontractors as of the date of termination in connection with the Facilities.
- iv. If the Contract is terminated, the Owner shall pay to the Contractor all payments, and reasonable compensation for all loss or damage sustained by the Contractor arising out of, in connection with or in consequence of such termination.
- (d) The expression "Facilities executed" shall include all work executed, Erection Services provided, any all Plant and Equipments acquired (or subject to a legally binding obligation to purchase) by the Contractor and used or intended to be used for the purpose of the Facilities, up to and including the date of termination.
- (e) In calculating any payment due from the Owner to the Contractor, account shall be taken of any sum previously paid by the Owner to the Contractor under the Contract, including any advance payment paid.

4.46 Assignment

The Contractor shall not, without the express prior written consent of the Owner, assign to any third party the Contract or any part thereof, or any right, benefit, obligation or interest therein or there under, except that the Contractor shall be entitled to assign either absolutely or by way of charge any monies due and payable to it or that may become due and payable to it under the Contract

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5 SPECIAL CONDITIONS OF CONTRACT (SCC)

5.1 Contract Details

- **Name of Contract:** Renovation & Modernization of Electrical Balance of Plant (eBOP) Package for [-----]
- **Bid Document No. :** [-----]
- **The Owner is:**

Name of Owner: [-----]

Address of Owner: [-----]

Telephone No. : [-----]

Fax No: [-----]

E-Mail: [-----]
- **The Project Manager is:**

Name of Project Manager: [-----]

Address of Project Manager: [-----]

Telephone No. : [-----]

Fax No: [-----]

E-Mail: [-----]

5.2 Effective Date

The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. This Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor.

The following three activities will be completed within [two (2)] months from the date of Letter of Acceptance:

(a) The contract agreement will be executed by the Owner and the Contractor. (b) The Contractor will submit to the Owner the Contract Performance Bank Guarantee, any Additional Contract Performance Bank Guarantee by assignee if applicable, and the Advance Payment Bank Guarantee.

(c) The Owner will pay the Contractor the Advance Payment as per the Terms of Payment.

The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.

5.3 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Owner shall be as follows:

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Owner) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Owner may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

5.4 Liquidated Damage for Delay

5.5 Rate of Liquidated Damage for Delay

If the Contractor fails to successfully achieve completion of R&M activities and commissioning of the retrofitted facilities as per the scope of work within the time period specified in SCC, the Contractor shall pay to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

1.	Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	Liquidated Damage payable at the rate Rs.[.....] for each week of delay
2.	Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	Liquidated Damage payable at the rate Rs [.....] for each day of delay

The Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender are independent and shall be applied separately.

5.6 Liquidated Damage for Non-fulfillment of Functional Guarantees

If the Contractor fails to successfully achieve the Functional Guarantees during Performance Guarantee Test as per the Tender Specification, the Contractor shall pay

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to the Owner amount calculated as per the rates given in the following table as Liquidated Damage and not as penalty.

Sl. No.	Functional Guarantee Parameter	Rate of Liquidated Damage
1	Copper Losses	[.....] INR per kW increase
2	Iron Losses	[.....] INR per kW increase
3	Auxiliary Power in kW	[.....] INR per kW increase

The reference condition for Performance Guarantee Parameters shall be as per Volume-II Technical Specification.

The Liquidated Damage for non-fulfillment of the different Functional Guarantee Parameters are independent of one another and shall be applied separately.

{Note: The rate of LD for any functional guarantee parameter shall be at least 1.5 times the corresponding Bid Evaluation Factor}

5.7 Maximum Leviable Liquidated Damages

The amount of Liquidated Damage for delay shall be limited to a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd)contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares. This limit is applicable for the Liquidated Damage for Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network and Liquidated Damage for Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender taken together.

The aggregate amount **of Liquidated Damage for non-fulfilment of functional guarantee shall be limited to** a maximum of 10 % of the total contracts price (i.e. sum of Ist, IInd and IIIrd)contracts, as applicable) price including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The limit on maximum leviable Liquidated Damage for Delay and maximum leviable Liquidated Damage for non-fulfillment of functional guarantee are independent of each other and shall apply separately.

5.8 Payment of Liquidated Damages

Contractor shall pay to the owner any Liquidated Damages that are payable as per the provisions of the Contract within thirty (30) days of receipt of Owner's invoice setting forth amount of Liquidated Damages that are then due and payable. If Contractor delays payment of Liquidated Damages that are payable under the provisions of the Contract beyond thirty (30) days, Owner, at its discretion, shall be entitled to recover such amounts by either setting off the relevant unpaid amount against any payment(s) due to the Contractor or by making a demand under Contract Performance Bank Guarantee.

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5.9 Contract Price

- a) The Contract Price shall be as (Contract Price and Terms of Payment) of the Form of Contract Agreement.
- b) The Contractor shall be deemed to have satisfied itself as to the correctness and sufficiency of the Contract Price, which shall, except as otherwise provided for in the Contract, cover all its obligations under the Contract.

5.10 Terms of Payment

- a) The Contract Price shall be paid as Terms and Procedures of Payment to the Form of Contract Agreement. The procedures to be followed in making application.
- b) No payment made by the Owner herein shall be deemed to constitute acceptance by the Owner of the Facilities or any part(s) thereof.
- c) The currency or currencies in which payments are made to the Contractor under this Contract to the Form of Contract Agreement, subject to the general principle that payments will be made in the currency or currencies in which the Contract Price has been stated in the Contractor's bid.

5.11 Contract Securities (Bank Guarantees)

- a) The Contractor shall provide the Bank Guarantees specified below in favour of the Owner at the times, and in the amount, manner and form specified below.
- b) Advance Payment Bank Guarantees
 - The Contractor shall, within *[thirty (30)]* days of the Notification of Contract Award, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with a initial validity of up to *[ninety (90)]* days beyond the date of Completion of Facilities.
 - The security shall be in the form of an Unconditional Bank Guarantee. The Advance payment Bank Guarantees shall be reduced prorata every three (3) months after First Running Account Bill/Stage Payment under the Contract based on the value of equipment/facilities received. The cumulative amount of reduction at any point of time shall not exceed ninety percent (90%) of the advance corresponding to cumulative value of the Facilities supplied and received as per a certificate issued by the Project Manager and the balance of 10% shall be released on Completion of those Facilities. It should be clearly understood that reduction in the value of security for advance shall not in any way dilute the Contractor's responsibility and liabilities under the Contract including in respect of the Facilities for which the reduction in the value of security is allowed.

c) Performance Bank Guarantees

The Contractor shall, within *[thirty (30)]* days of the notification of award, provide a Bank Guarantees for the due performance of the Contract for ten percent (10%) of the Contract Price with an initial validity upto *[ninety (90)]* days beyond the Defects Liability Period. If the Owner enters into the Contract with the Assignee of a foreign Contractor, the said Assignee, in addition to the Contract Performance Bank Guarantees to be provided by the Contractor for ten percent (10%) of the value of all the Contracts shall provide within *[thirty (30)]* days of the Notification of Award, a separate Contract Performance Bank Guarantees equivalent to five percent (5%) of the value of Contract entered into with the assignee (i.e. five percent of the aggregate value of the component Contracts entered to with the Assignee), for the due performance of Contract with an initial validity up to *[Ninety (90)]* days beyond the Defects Liability Period.

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- d) The performance Bank Guarantee shall be denominated in the currency or currencies of the Contract, or in a freely convertible currency acceptable to the Owner,.

5.12 Sequential Supply

The Contractor is required to supply the material and equipment under the Contract in a sequential manner as per the requirement at site for erection. If Contractor supplies any material/equipment ahead of the requirement as per the agreed Detailed Time Schedule, the Owner, at its discretion, may withhold progressive payment for such material/equipment till the time it is due for supply as per the agreed Detailed Time Schedule.

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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6 FORMS AND SCHEDULES

The Tender Document comprises the following Forms and Schedules:

I	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	Not Used
Annexure-E	Sample Format Letter of Unequivocal Consent to be Furnished by the Bidder and The Assignee
Schedule F1 Table-1	Summary of Price Schedule
Schedule F1 Table-2	Price Schedule for Supply of Plant and Equipment Including Packing and Forwarding Charges
Schedule F1 Table-3A	Price Schedule for Mandatory Spares
Schedule F1 Table-3B	Price Schedule for Recommended Spares
Schedule F1 Table-4	Price Schedule for Tools & Tackles .
Schedule F1 Table-5	Price Schedule for Erection Services Including Dismantling / Disassembly, Unloading, Handling, Storage, Preservation at Site, Erection, Testing, Commissioning and Performance Guarantee Tests of Plant and Equipment
Schedule F1 Table-6	Price Schedule for Civil works
Schedule F1 Table-7	Price Schedule for Training Charges
Schedule F1 Table-8	Schedule of Performance Guarantee Parameters
Schedule F2	Overall Time Schedule
Schedule F3	Deviation Schedule to Tender Document Vol-I Commercial
Schedule F4	Deviation Schedule to Technical Specification
Schedule F5	Requirements of the Contractor at Site

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Schedule F6	Contractor's Resource Deployment Schedule
Schedule F7	Coefficients and Indices for Price Variation Formula
II	Forms and Appendices to form part of Contract
Annexure-F	Form of Contract Agreement
Contract Schedule-1	Terms of Payment
Contract Schedule-2	Price Adjustment
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Approved Subcontractors
Contract Schedule-5	Scope of Works and Supply by the Owner
Contract Schedule-6	Functional Guarantees
Contract Schedule-7	Quality Assurance
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Bank Guarantee

ANNEXURES & SCHEDULES

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ANNEXURE - A

FORMAT OF BID GUARANTEE

1. This Guarantee should be furnished by a scheduled commercial Bank in India authorized by RBI to issue a Bank Guarantee in the same format as given below. [Name of Utility], reserves its right to reject the Bank Guarantee if the same is not in the specified format.
2. This Bank Guarantee should be furnished on stamp paper of value not less than [Rs.....]
3. The stamp paper should have been purchased in the Name of the Bank executing the guarantee.

Ref.: _____ Bank Guarantee No: _____
Date _____ :

To:
[Details of Designated Official]
[-Name of Utility]

Dear Sirs,

In accordance with your "Invitation for Bid" under your Tender No [.....] dated [.....] M/s [Name of Bidder] hereinafter called the Bidder, having its registered/head office at [.....] with the following persons on its Board of Directors/Partners of the firm:

- | | |
|----|-----|
| 1. | 2. |
| 3. | 4. |
| 5. | 6. |
| 7. | 8. |
| 9. | 10. |

wish to participate in the said Bid for [Name of package and R&M project], India, as an irrevocable Bank Guarantee against Bid Guarantee for a sum of [.....] (in words and figures) valid for 300 days from [.....] (the date of Bid Opening) is required to be submitted by the Bidder as a condition precedent for participation in the said bid, which amount is liable to be forfeited on the happening of any contingencies mentioned in the Bid Documents, we, the [.....] Bank at (local address) [.....] having our Head Office at [.....] guarantee and undertake to pay immediately on first demand by [Name of Utility] the amount of [.....] (in figures and words) to the said [Name of Utility] without any reservation, protest, demur and recourse. Any such demand made by [Name of Utility] shall be conclusive and binding on the Bank irrespective of any dispute or difference raised by the Bidder.

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This Guarantee shall be irrevocable and shall remain valid upto [.....] If any further extension of this Guarantee is required, the same shall be extended to such required period on receiving instructions from M/s [Name of Bidder] on whose behalf this Guarantee is issued.

IN WITNESS WHEREOF the Bank, through its authorised officer, has set its hand and stamp on this [.....] day of [.....] 201 [.] at [.....]

Signature :
 Name :
 Designation :
 Staff Code No. :

Banker's Seal :
 Date :

Witness:

1. Signature :
 Full name in block letters :
 Designation :
 Address :

2. Signature :
 Full name in block letters :
 Designation :
 Address :

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ANNEXURE - B

FORMAT OF BID

To be submitted by the Bidder in
Part-I [Techno-commercial] Bid

From:

[Bidder Details]

[.....]

[.....]

To:

[Details of Designated Official]

[-Name of Utility] [.....]

Sub : ____ (Name of Package) [.....]

Tender

No.

[.....]

Having carefully examined the Tender Specifications issued to us for your Tender No. [.....] dated _____, and its Amendments / Corrigendum / Clarifications issued till the date of tender opening:

1. We agree to complete the 'works' in conformity with all the terms and conditions stated in Tender Specifications and its Amendments/Corrigendum/Clarifications issued till the date of tender opening and as per time schedule given in Tender Specification. The plant, equipment and systems offered are of the best and latest technology and of international standards.
2. We undertake, in case our Bid is accepted, to commence the work from the date of Letter of Award and to complete and deliver the whole of the work and responsibilities comprised in the Contract within as per Time schedule given in SCC of Tender Specification.
3. We are submitting the Bid Guarantee for a sum of INR _____ (Indian Rupees [.....] only)/US\$ _____ (US Dollars [.....] only)/Euro _____ (Euro [.....] only) in the form _____ as instructed by you. This Bid Guarantee shall be governed as per the stipulations provided in the "Instructions to Bidders".
4. We agree to abide by and keep our Bid valid initially for a period of 180 (One Hundred and Eighty) days from the date of opening of bids by Purchaser and it shall remain binding on us and may be accepted at any time before the expiry of that period.
5. Should our Bid be accepted, we hereby agree to abide by and fulfill all terms and conditions of Tender Specification as accepted by us and in default thereof, to forfeit and pay to [Name of Utility], assignees or authorized nominees such sums of money as are stipulated in conditions contained in Tender Specification and agree to furnish Bank

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Guarantee for Contract Performance as per the proforma prescribed by Purchaser and for the sum equal to 10% of the "Contract Price", for the entire scope of work within 30 days from the date of Letter of Award.

6. We understand that Purchaser is not bound to accept the lowest or any Bids received and Purchaser has the right to reject any Bid, without assigning any reason whatsoever.
7. This Bid together with written acceptance thereof shall constitute a binding Contract between Purchaser and ourselves till a formal Contract is executed.

Signed this _____ day of _____

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

Witness:

1. Signature :
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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ANNEXURE - C

FORMAT OF BID

To be submitted by the Bidder in
Part-II – [Price Bid]

Tender No. : [-----]

Bid No : [-----]

From:

Dated:

[-----]
[-----]
[-----]

To :

[-----]
[-----]
[-----]

Dear Sirs

Having carefully examined and understood the Tender Specification including the amendments/Corrigendum/Clarifications issued till the date of Bid Opening, if any:

1. We hereby agreed to carry out the entire works as described in the specifications in conformity with the specifications and Tender Specifications, as per prices quoted by us in the Schedule of Prices and Schedule of Performance Guarantees [Schedule] enclosed herewith
2. In the event of our proposal being accepted, we agree to furnish a Bank Guarantee for Contract Performance as per the proforma prescribed by Employer [Name of Utility] and for the sum equal to 10% of the "Contract Price". The Bid Guarantee shall be released only after the Contract Performance Guarantee issued in favour of Employer is received and accepted by the Employer

Signed this _____ day of _____ 201[--] _____

Signature :

Name :

Designation :

Company :

Company Seal

Date :

Witness:

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1. Signature
 Full name in block letters :
 Occupation :
 Address :

2. Signature :
 Full name in block letters :
 Occupation :
 Address :

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ANNEXURE – D

NOT USED

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ANNEXURE – E

SAMPLE FORMAT

LETTER OF UNEQUIVOCAL CONSENT TO BE FURNISHED BY THE BIDDER AND THE ASSIGNEE

We hereby declare that the undersigned firm [-----] (Name and Complete address of the Assignee) hereby agree to act as a Assignee to the Firm [-----] (Name and Complete address of the Bidder) for the successful completion of part scope of work as enclosed in the attachment (authenticated by the Bidder and the Assignee) of [-----] Package for the [-----] Project at [-----] in the state of [-----], India. We also hereby undertake to ensure the quality of manufacture, timely delivery and the successful performance of the equipment/system covered in our scope of [-----] package, fully meeting the guarantee and also depute our technical experts from time to time for advice on procedures and guidance during design, engineering, manufacture, erection, testing and commissioning, as applicable to the place of work / Owner's Project site.

We, the Assignee, agree to work as an independent contractor, with respect to the 2nd/3rd Contract or both, on such additional terms and conditions, as may be agreed to, between the Owner and the Foreign Bidder.

On award of LOA, we the ASSIGNEE agree to furnish an additional Contract Performance Bank Guarantee for 5%, of the aggregate value of the component contracts entered in to with us.

1. **Witness**

For Assignee

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address

Seal of the Company

2. **Witness**

For Bidder

Signature:

(Signature of the Authorized Signatory)

Name:

Name:

Designation:

Designation:

Office Address:

Seal of the Company:

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ATTACHMENT TO THE LETTER OF UNEQUIVOCAL CONSENT

1 Scope of Work of the Assignee:

For Bidder

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

For Assignee

(Signature of the Authorized Signatory)

Name:

Designation:

Seal of the Company

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SCHEDULE – F1: TABLE - 1

SUMMARY OF PRICE SCHEDULE

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.1	Supply of imported Plant & equipment including technological and misc. structures with all accessories (FOB) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum and firm price basis.		
1.2	Ocean freight on lumpsum and firm price basis for 1.1 above.		
1.3	Marine insurance on lumpsum and firm price basis for 1.1 above.		
1.4	CIF Cost (1.1+1.2+1.3)		
2.	All port charges including port handling, port rent, and port clearance on lumpsum and firm price basis.		
3.	Supply of indigenous Plant & Equipment including Technological and misc. structures with all accessories (Ex-Works) including design, engineering, manufacturing, shop testing, packing and forwarding charges on lumpsum price basis.		
4.	Sales Tax Payable on Indigenous equipment - on Ceiling basis. (a) VAT (b) Central Sales Tax (CST)		
5.	(a) Inland transport of imported plant & equipment on lumpsum and firm price basis.		
	(b) Inland transport of Indigenous plant & equipment on lumpsum and firm price basis		
6.	Lumpsum price for Civil Works including, supplies such as cement, reinforcement steel, all foundation bolts etc.at site cost, including Design & Engineering and Construction of entire Civil works.		
7.	Erection services including dismantling/disassembly, unloading, handling, storage and preservation at site, Erection, testing, commissioning and PG tests of plant & equipment on lumpsum price basis		
8.	Marine cum erection insurance on lumpsum and firm price basis (excluding marine insurance indicated in Sl. No. 1.3 above)		
9.	Foreign supervision charges in India during erection, commissioning & PG test on firm price basis with ceiling.		

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(In Figures and Words)

S.No.	Description	Foreign Currency	INR
10.	Training charges on firm price basis with ceiling.		
11.	VAT on Works Contract on ceiling basis		
12.	Service Tax including Education Cess on Ceiling basis		
13.	Others, if any (Please specify),		
14.	Total price of package (excluding mandatory spares and Tools & Tackles. (Total of SI.Nos.1.4 + 2 to 13).		
15.	Mandatory Spares on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-3)		
16.	Tools & Tackles on lumpsum and firm price basis. (Landed cost at site) (Breakup to be indicated in Table-4)		
17.	Grand total price of package including Mandatory Spares and Tools & Tackles. (Total of SI Nos 14+15+16).		

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 2

**PRICE SCHEDULE FOR SUPPLY OF PLANT AND EQUIPMENT INCLUDING
PACKING AND FORWARDING CHARGES**

(In Figures and Words)

S.No.	Description	Foreign Supply	Indigenous Supply
		FOB Price in Foreign Currency	Supply price including packing and forwarding in INR
1	Mechanical Equipment		
1.1			
1.2			
...			
...			
...			
...			
...			
...			
	Sub Total (1)		
2.	Electrical Equipment		
2.1			
2.2			
...			
...			
...			
	Sub Total (2)		
3	Control & Instrumentation Equipment		
3.1			
3.2			
...			

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(In Figures and Words)

S.No.	Description	Foreign Supply	Indigenous Supply
		FOB Price in Foreign Currency	Supply price including packing and forwarding in INR Ex-works including and in INR
...			

	Sub Total (3)		
4	Total (1 + 2 + 3)		

Signature :
 Name :
 Designation :
 Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3A
PRICE SCHEDULE FOR MANDATORY SPARES

(In Figures and Words)

S. No.	Description	Foreign Price In Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Mandatory Spares including Packing and Forwarding on lumpsum and firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	CIF Cost (1.1 +1.2+1.3)		
2	All port charges including port rent, port handling charges, port clearance on lumpsum and firm price		
3	Supply (Ex-works) of Mandatory Spares including Packing and Forwarding on lumpsum and Firm Price		
4.	a) Inland transport for Imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5	Insurance excluding 1.3 above (Lumpsum and firm price basis)		
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7	Total price of Mandatory Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE – 3B
PRICE SCHEDULE FOR RECOMMENDED SPARES

(In Figures and Words)

S. No.	Description	Foreign Price In Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Recommended Spares including Packing and Forwarding on lumpsum and firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	CIF Cost (1.1 +1.2+1.3)		
2	All port charges including port rent, port handling charges, port clearance on lumpsum and firm price		
3	Supply (Ex-works) of Recommended Spares including Packing and Forwarding on lumpsum and Firm Price		
4.	a) Inland transport for Imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5	Insurance excluding 1.3 above (Lumpsum and firm price basis)		
6	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7	Total price of Recommended Spares (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SCHEDULE – F1: TABLE-4
PRICE SCHEDULE FOR TOOLS & TACKLES

(In Figures and Words)

S. No	Description	Foreign Price in Foreign Currency	Indigenous Price in INR
1.1	Supply (FOB) of Tools and Tackles including Packing and Forwarding on Lumpsum and Firm Price		
1.2	Ocean freight on lumpsum and firm price		
1.3	Marine insurance on lumpsum and firm price		
1.4	C.I.F Cost (1.1 + 1.2 + 1.3)		
2.	All port charges including port rent, port handling charges, port clearance on Lumpsum and firm price		
3.	Supply (Ex-works) of Tools and Tackles including Packing and Forwarding on Lumpsum and firm Price		
4.	a) Inland transport for imported items on lumpsum and firm price basis.		
	b) Inland transport for indigenous items on lumpsum and firm price basis.		
5.	Insurance excluding 1.3 above (lumpsum and firm price basis)		
6.	Sales Tax on Indigenous Spares on Ceiling basis a) VAT b) CST		
7.	Total price of Tools and Tackles (landed cost at site). (Total of Sl. Nos 1.4 + 2 to 6)		

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE-5

**PRICE SCHEDULE FOR ERECTION SERVICES INCLUDING
DISMANTLING/DIASSEMBLY, UNLOADING, HANDLING, STORAGE,
PRESERVATION AT SITE, ERECTION, TESTING, COMMISSIONING AND
PERFORMANCE GUARANTEE TESTS OF PLANT AND EQUIPMENT**

(In Figures and Words)

S.No.	Description	Total Price for complete work at Site in Indian Rupees
1	Mechanical Equipment	
1.1		
1.2		
...		
...		
...		
...		
...		
...		
	Sub Total (1)	
2.	Electrical Equipment	
2.1		
2.2		
...		
...		
...		
	Sub Total (2)	
3	Control & Instrumentation Equipment	
3.1		
3.2		
...		
...		
	Sub Total (3)	
4	Total (1 + 2 + 3)	

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Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 6

PRICE SCHEDULE FOR CIVIL WORKS

(In Figures and Words)

S.No.	Description	Foreign Currency	INR
1.			
2			
3			
4			
5			
.....			
.....			
	Total		

Signature :
 Name :
 Designation :
 Company :

Company Seal

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SCHEDULE – F1: TABLE - 7

PRICE SCHEDULE FOR TRAINING CHARGES

S.No.	Description	PRICE
1.		
2		
3		
4		
5		
.....		
.....		
	Total	

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F1: TABLE - 8

SCHEDULE OF PERFORMANCE GUARANTEE PARAMETERS

The Bidder shall furnish performance guarantee of the Package in respect of all items listed below.

Category – I: Performance Guarantees under Liquidated Damages [L.D]

S. No	Particulars	Unit	Value inclusive of design, manufacture and all other Tolerances including measurement uncertainty
1			
2			
3			
.....			
.....			

Category – II: Mandatory Performance Guarantees

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			

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S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
3			
.....			
.....			

Category -III: Requirement under Demonstration Category

S. No	Particulars	Unit	Value Inclusive of design, manufacture and all other tolerances including measurement uncertainty
1			
2			
3			
....			
.....			
.....			

Signature :

Name :

Designation :

Company :

Company Seal

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SCHEDULE – F2
OVER ALL TIME SCHEDULE
(Bidder to fill-in and submit with its Bid)

S.No	Work Description	Days from Effective Date	
		Start	Finish
1	Design & Engineering		
2	Manufacture of Plant/Equipment		
	(a)		
	(b)		
	(c)		
		
		
3	Delivery of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
4	Dismantling/Disassembly of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
5	Civil work at Site		
6	Erection of of Plant/Equipment & Systems		
	(a)		
	(b)		
	(c)		
		
		
7	Trial Operation & Provisional Take Over		
8	Performance Guarantee tests Completion and Final Take Over		

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Signature :

Name :

Designation :

Company :

Company Seal

Date :

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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SCHEDULE – F3

DEVIATION SCHEDULE TO TENDER DOCUMENT VOL-I (COMMERCIAL)

All deviations to commercial condition (Tender Document Vol-I) shall be filled in by the Bidder clause by clause in this schedule.

S.No	Clause	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the commercial condition (Tender Document Vol-I) . The Bidder further confirms that in the event any other data or information presented in the Bidder's proposal and accompanying documents are at variance with the specific requirements laid out in the commercial condition (Tender Document Vol-I) , then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
Name :
Designation :
Company :

Company Seal

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SCHEDULE – F4

DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION

All deviations from the Technical Specification shall be filled in by the Bidder, clause by clause, in this Schedule:

S.No	Volume / Section	Clause No	Description	Deviation	Reason for Deviation

The Bidder hereby certifies that the above mentioned are the only deviations from the Purchaser's Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder's proposal and accompanying documents including drawings, catalogues, etc are at variance with the specific requirements laid out in the Purchaser's Technical Specifications then the latter shall govern and shall be binding on the Bidder for the quoted price.

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE – F5
REQUIREMENTS OF THE CONTRACTOR AT SITE
(Bidder to fill-in and return with its Bid)

The Bidder shall state his requirements against each of the following including the basis of requirements:

A.	Requirements Description	Quantity

Signature :
Name :
Designation :
Company :

Company Seal

Date :

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SCHEDULE - F6
CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE

A) Construction Equipment

The Bidder shall indicate the schedule of construction equipment, proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
1									
2									
3									
...									
...									

B) Resource Deployment Schedule

The Bidder shall indicate the schedule of manpower resources proposed to be deployed at the site for executing the works as per the pro-forma below:

S. No.	Type of Resource	Months							
2.	Human Resources								
2.1	Engineering Category								
2.1.1	Project Engineers								
2.1.2	Mechanical Engineers								
2.1.3	Electrical Engineers								
2.1.4	Civil Engineers								
2.1.5	C&I Engineers								
2.1.6	Commissioning Engineers								
2.1.7	Structural Engineers								
2.1.8	Others (bidder shall indicate) as applicable for the work								
2.2	Supervisory Category								
2.2.1	Const. Manager								
2.2.2	Electrical Supervisors								
2.2.3	Mechanical Supervisors								
2.2.4	C&I Supervisors								
2.2.5	Civil Supervisors								
2.2.6	Purchase Officer (s)								
2.2.7	Finance/Site Office								
2.2.8	Inspection/Quality Control								
2.2.9	Others (Bidder shall indicate) as applicable for the work								

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S. No.	Type of Resource	Months						
2.3	Labour Category							
2.3.1	Welder							
2.3.2	Fitter							
2.3.3	Rigger							
2.3.4	Un-skilled labour							
2.3.5	Others (Bidder shall indicate) as applicable for the work							

Signature :

Name :

Designation :

Company :

Company Seal

Date :

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SCHEDULE – F7
COEFFICIENTS AND INDICES FOR PRICE ADJUSTMENT FORMULA

Ex-Works price component of Plant and Equipment excluding mandatory spares				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Erection Services Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Civil Works Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

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Civil Works Component				
SI No	Item	Value of Coefficient	Name of index	Value of Index on Base Date

Note: Bidder to fill up value of all Coefficients, names of indices and value of indices on the base date for Price Adjustment as per Contract Schedule-2. This schedule must be submitted along with Part-I Bid (Techno Commercial Bid) Bidders to use continuation sheets if required.

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Form of Contract Agreement

Document Number	Rev No	Description	Page No.	Date of Issue
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Form of Contract Agreement

THIS CONTRACT AGREEMENT is made the _____day of _____, 20_____.
 BETWEEN (1) [Name of Employer], a corporation incorporated under the laws of [country of Employer] and having its principal place of business at [address of Employer] (hereinafter called “the Employer”), and (2) [name of Contractor], a corporation incorporated under the laws of [country of Contractor] and having its principal place of business at [address of Contractor] (hereinafter called “the Contractor”)

WHEREAS the Employer desires to engage the Contractor to dismantle/disassemble, design, manufacture, test, deliver, install, complete and commission certain Facilities, viz.

[.....]
 [.....]
 [.....]

(“the Facilities”) and the Contractor have agreed to such engagement upon and subject to the terms and conditions hereinafter appearing.

NOW IT IS HEREBY AGREED as follows:

1.1 Contract Documents

- a) Contract Documents means this signed Contract agreement and its annexure/appendices, and the complete documents, which are the basis of finalization of the contract, including correspondence exchanged from issue of tender till date of signing the contract. The following will constitute the Contract Documents:
 - i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
 - ii. Letter of award.
 - iii. Special Condition of Contract
 - iv. General Condition of Contract
 - v. Technical specification & Tender Drawing.
 - vi. The bid & its schedules/ attachment submitted by the contractor.

- a) All documents forming part of the Contract (and all parts thereof) are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.

- b) The Contract will be signed in three originals and the Contractor shall be provided with one signed original and the rest will be retained by the Employer.

1.2 Order of Precedence of Contract Documents

In case there is any ambiguity of conflict between different contract documents, the order of precedence shall be as follows:-

- i. The signed Contract Agreement & the annexure/ appendices thereto (highest precedence)
- ii. Letter of award.
- iii. Special Condition of Contract
- iv. General Condition of Contract
- v. Technical specification & Tender Drawing.
- vi. The bid & schedules/ attachment submitted by the contractor.

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1.3 Definitions

" The Definitions of terms and expressions shall be as per GCC clause 4.1. Terms and expressions not defined in GCC shall have the same meaning as are assigned to them in the Indian Sale of Goods Act (1930), failing that in the Indian Contract Act (1872) and failing that in the General Clauses Act (1897) including amendments thereof, if any.

1.4 Contract Price

The Employer hereby agrees to pay to the Contractor the Contract Price in consideration of the performance by the Contractor of its obligations hereunder: The Contract Price shall be the aggregate of: [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures], or such other sums as may be determined in accordance with the terms and conditions of the Contract.

1.5 Term of Payment

The terms and procedures of payment according to which the Employer will reimburse the Contractor are given in Contract Schedule 1 (Terms and Procedures of Payment) hereto.

1.6 Time for Commencement and Completion

The Time Schedule for the execution of the scope of work by the Contractor under this tender and commencement of unit shut down by Employer shall be as follows:

1.	Time for completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network	By [.....] months from Effective Date
2.	Time for Commencement (by Employer) of Unit Shut Down. (Note: In case Contractor fails to complete the engineering, supply and mobilization activities as at serial no.1, Employer may, at its discretion, reschedule commencement of unit shut down	By [.....] months from Effective Date
3.	Time for Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work under this tender	By [.....] days from start of unit shut down
4.	Performance Guarantee Test (By Contractor)	By [.....] months from the completion of trial operation after completion of R&M activities

The detailed Time Schedule shall be as per Contract Schedule 2.

Contract Schedules

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The Contract Schedules listed in the attached list of Contract Schedules shall be deemed to form an integral part of this Contract Agreement.

Reference in the Contract to any Contract Schedule shall mean the Contract Schedules attached hereto, and the Contract shall be read and construed accordingly.

IN WITNESS WHEREOF the Employer and the Contractor have caused this Agreement to be duly executed by their duly authorized representatives the day and year first above written.

Signed by for and on behalf of the Employer

-----[Signature]

-----[Title]

In the presence of -----

Signed by for and on behalf of the Contractor

-----[Signature]

-----[Title]

In the presence of -----

CONTRACT AGREEMENT

dated the -----day of-----, 20_-----

BETWEEN

["The Employer"]-----

and

["The Contractor"]-----

Contract Schedules:

Contract Schedule 1 :	Terms of Payment
Contract Schedule 2 :	Price Adjustment
Contract Schedule 3 :	Time Schedule
Contract Schedule 4 :	List of Approved Subcontractors
Contract Schedule 5 :	Scope of Works and Supply by the Employer
Contract Schedule 6 :	Functional Guarantees

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Contract Schedule-1

Terms of Payment

The Owner shall pay the Contractor in the following manner and at the following times, on the basis of the Price Break down given in the Section on Price Schedules. Payments will be made in the currencies quoted by the Bidder unless otherwise agreed between the parties. Application for payment in respect of part deliveries may be made by the Contractor as work proceeds.

I. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares) supplied from Abroad:

1	10% of the total FOB price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	50% of FOB price for each identified equipment as progressive payment and 100% of Ocean Freight and Marine Insurance Charges pro-rata to the value of the equipment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of FOB price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer
4	20% of the total FOB price	On Completion of Facilities
5	5% of the total FOB price	Successful completion of Performance Guarantee Test

II. Terms of Payment for Supply of Plant and Equipment (excluding Mandatory Spares and Recommended Spares) supplied from within India:

1	10% of the total Ex-Works price	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	50% of Ex-Works price for each identified equipment as progressive payment	Upon dispatch of the identified equipment after dispatch clearance by employer on raising of Invoice by the Contractor and submission of evidence of shipment
3	15% of Ex-Works price for each identified equipment	On receipt of equipment at site and physical verification and certification by the Employer

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4	20% of the total Ex-Works price	On Completion of Facilities
5	5% of the total Ex-Works price	Successful completion of Performance Guarantee Test

III. Terms of Payment for Supply of Mandatory Spares and Recommended Spares

1	70% of the CIF Price of each Spare from Abroad or 70% of the Ex-Works Price of each Spare from within India	Upon dispatch of the identified Spare after dispatch clearance by employer on raising of invoice by the Contractor and submission of evidence of shipment
2	30% of the CIF Price of each Spare from Abroad or 30% of the Ex-Works Price of each Spare from within India	On receipt of Spare at site and physical verification and certification by the Employer

IV. Terms of Payment for Local Transportation, Inland Transit Insurance and port clearance charges & port charges

For Plant & Equipment except Spares		
1	100% of Local Transportation, Inland Transit Insurance and Port Clearance & Port Charges pro-rata to value of the equipment	On receipt of Equipment at site and upon raising of Invoice by the Contractor
For Spares		
2	100% of Local Transportation, Inland Transit Insurance and Port Clearance & Port Charges pro-rata to value of Spare	On receipt of Spare at site and upon raising of Invoice by the Contractor

V. Terms of Payment for Erection of Plant & Equipment

1	10% of Total Price for Erection of Plant & Equipment	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Erection of Plant & Equipment as progressive payment pro-rata to value of plant & equipment erected	On certification by Employer of successful erection of plant & equipment and successfully passing of quality checks
3	10% of Total Price for Erection of Plant & Equipment	On Completion of Facilities
4	5% of Total Price for Erection of Plant & Equipment	Successful completion of Performance Guarantee Test

VI. Terms of Payment for Civil Works

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1	10% of Total Price for Civil Works	Initial Advance on Acceptance of Letter of Award by the Contractor, Signing of Contract Agreement and submission of Contract Performance Bank Guarantee, Additional Contract Performance Bank Guarantee and Advance Payment Bank Guarantee by Contractor
2	75% of Price for Civil Works as progressive payment	On certification by Employer regarding value of work completed & successfully passing of quality checks
3	10% of Total Price for Civil Works	On Completion of Facilities
4	5% of Total Price for Civil Works	Successful completion of Performance Guarantee Test

VII. Terms of Payment for Price Adjustment Amount

Any increase in the Price of any component Contract shall be paid as per the Terms of Payment for base price. The initial 10% advance payment pertaining to increase in price shall be paid along with progressive payment of that equipment. Reduction to the Contract Price, if any, due to price adjustment provisions, shall be effected by recovering 100% of the reduction amount (including advance) from any of the Contractor's bills falling immediately due for payment.

VIII. Terms of Payment for Taxes & Duties

Any Tax or Duty payable by Employer as per the Terms & Conditions of Contract and is directly payable to Statutory Authorities/Government as per law shall be directly paid to the concerned authority or Government by the Employer. Any other Tax or Duty payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon receipt of corresponding Plant & Equipment or Spare at site and submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such Taxes & Duties.

IX. Terms of Payment for Statutory Variation in Taxes & Duties

Any amount towards statutory variation in Taxes & Duties payable by Employer as per the Terms & Conditions of Contract shall be reimbursed to the Contractor/Assignee upon submission of evidence by the Contractor/Assignee to the Employer as to the Contractor/Assignee having paid such variation.

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Contract Schedule-2

PRICE ADJUSTMENT

- (i) The Contract Price shall be subject to price adjustment during performance of the Contract to reflect changes in the cost of labour and material in accordance with the provisions described below.
- (ii) Only following components of the Contract Price will be subject to Price adjustment :
 - (a) Ex-Works (India) price of plant and equipment excluding Mandatory Spares manufactured within India and FOB price component for plant and equipment excluding Mandatory spares supplied from abroad. The price adjustment amounts towards these price components shall be without any ceiling.
 - (b) Erection Services component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
 - (c) Civil Works component of the Contract Price. The price adjustment amounts towards this price component shall be without any ceiling.
- (iii) Price adjustment amounts towards aforesaid components of Contract Price shall be paid in the respective currencies of Contract.
- (iv) The indices for price adjustment shall necessarily be of the country of origin of goods/labour and shall be well established and nationally recognized in that country. Preferably Government indices shall be used.
- (v) The price adjustment formula for the components of the Contract Price above shall be as stipulated hereinafter.
- (vi) **Ex-Works/FOB price component of Plant and Equipment excluding mandatory spares**

The price component of the equipment for any shipment/ dispatch comprises of a fixed portion (designated as 'F' and the value of which is specified hereunder) and a variable portion linked with the indices for various materials and labour.

The amount of price adjustment towards variable portion payable/recoverable on each shipment/dispatch shall be computed as under:

$$ES = ES_1 - ES_0$$

ES₁ will be computed as follows:

$$ES_1 = ES_0 \left\{ F + a \times \frac{A_1}{A_0} \times f_1 + b \times \frac{B_1}{B_0} \times f_2 + c \times \frac{C_1}{C_0} \times f_3 + Lb \times \frac{L_1}{L_0} \times f_{lb} \right\}$$

Where

ES = Adjustment to Ex-Works/FOB price component expressed in the currency of the Contract payable to the contractor for each shipment/dispatch

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ES₁ = Adjusted amount of Ex-works/FOB price component expressed in the currency of the Contract payable to the Contractor for each shipment/dispatch

ES₀ = Ex-works/FOB price for the plant and equipment in the currency of the Contract, shipment/dispatch wise.

- The fixed portion of the ex-works/FOB component of the Contract Price (F) shall be 0.15.

- a, b, c etc. shall be co-efficient of major materials/items involved in the ex-works/FOB component of the Contract Price. The sum of these co-efficient shall be between 0.50 to 0.60.

- A, B, C etc. shall be published price indices of corresponding major materials/items. Such indices shall necessarily be of the country of origin of goods.

- 'Lb' shall be co-efficient for labour component in the ex-works/ FOB component of the Contract Price which shall be between 0.25 to 0.35.

- 'L' shall be labour index.

- Sum of all the material co-efficient and the labour co-efficient shall be 0.85.

f₁, f₂, f₃, f_{lb} etc - f₁, f₂, f₃ etc. are Exchange rate correction factors for the respective materials and f_{lb} is the exchange rate correction factor for labour with reference to the currency of the country of origin of index and the respective contract currency, such that

$$f = \frac{Z_0}{Z_1}$$

where Z is the no. of units of the currency of the country of the origin of index, which is equivalent to one unit of the respective contract currency. The exchange rates to be used for calculation of factor 'f' shall be as per State Bank of India Bills Selling Exchange Rates.

For the indices(A, B, C etc.), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid.. For 'Z₀', subscript 'o' refers to value as on the date of opening of Part-I Bid.

Subscript '1' refers to indices/exchange rates as of:

(a) three months prior to the date of shipment/dispatch for labour, and

(b) six months prior to the date of shipment/dispatch for material.

In case of shipments/dispatches which are delayed beyond the schedule date of shipment/dispatch for reasons attributable to the Contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of shipment/dispatch and the actual date of shipment/dispatch.

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The above formula for price adjustment will be applicable if the currency in which the contract price is expressed is different from the currency of the country of origin of labour and material indices. In other case, formula shall be applied without the exchange rate correction factor 'f'.

(vii) Erection Services Component

The price component for erection services comprises of a fixed portion and a variable portion linked with the index of labour.

The monthly price adjustment amount for the erection services component of the Contract Price will be computed separately for Indian currency and for foreign currency part, if any, related to expatriate supervision/labour as per the formula given below:

(a) Indian Rupee part of the Erection Services

$$ER = ER_1 - ER_0$$

ER₁ will be computed as follows:

$$ER_1 = ER_0 \left(0.15 + 0.85 \frac{FL_1}{FL_0} \right)$$

Where:

ER	=	Adjustment to erection services component of contract price expressed in Indian Rupees payable to the contractor for each billing.
ER ₁	=	Adjusted amount of erection services component of Contract Price expressed in Indian Rupees payable to the Contractor.
ER ₀	=	Value of the Erection work done in the billing period (month)
FL	=	Indian field labour index namely, All India Consumer Price Index for Industrial Workers (All India Monthly Average) as published by Labour Bureau, Simla, Government of India.

(b) Foreign Currency portion of the Erection Services

$$EE = EE_1 - EE_0$$

EE₁ will be computed as follows:

$$EE_1 = EE_0 \left(0.15 + 0.85 \frac{EF_1}{EF_0} \times f \right)$$

Where:

EE = Adjustment to erection services component of Contract Price expressed in foreign currency payable to the contractor for each billing.

EE₁ = Adjusted amount of erection services component of Contract Price expressed in foreign currency payable to the contractor for each billing.

EE₀ = Value of foreign currency portion of Erection work done in the billing period (month)

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EF = Index for Expatriate field labour component of the Erection Price of Installation work. Such index shall necessarily be of the country of nationality of the labour.

f = Exchange rate correction factor for expatriate labour with reference to currency of country of origin of index for expatriate labour and the respective contract currency, such that

$$f = \frac{Z_0}{Z_1}$$

where Z is the no. of units of the currency of the country of origin of index, which is equivalent to one unit of the respective contract currency. The ex-change rates to be used for calculation of factor 'f' shall be as per State Bank of India Bills Selling Exchange.

For the indices, subscript 'o' refers to indices as on 30 days prior to date set for opening of bids. For 'Z₀', subscript 'o' refers to value as on the date of opening of Part-I Bid.

For the indices, subscript '1' refers to the indices as applicable for the month of execution of the erection work. For the exchange rates, subscript '1' refers to the exchange rates as applicable on the last day of the month of execution of the erection work.

In case of erection activities which are delayed beyond the schedule date for reasons attributable to the contractor, the price adjustment provision shall not be applicable for the period of time between the schedule date of completion and actual date of completion of the respective erection activity.

(viii) The following components of the contract price shall not be subject to price adjustment and shall remain firm during the execution of the contract :

- (1) Ocean Freight and Marine Insurance for Plant and Equipment, mandatory spares and recommended spares.
- (2) Ex-works/FOB price component for Mandatory spares & Recommended Spares.
- (3) Inland Transportation charges (including Inland Transit Insurance, port clearance, port handling & port charges) for plant & equipment and Spare Parts.

(ix) Civil Works Component

The Price of Civil Works for any month comprises a fixed part designated as 'F' and variable parts linked to indices for labour, steel, cement, other commodities and Fuel & Power. The monthly price adjustment amount for the civil works component of the Contract Price will be computed as per the formula given below:

$$EC = EC_1 - EC_0$$

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EC₁ will be computed as follows:

$$EC_1 = EC_0 \left\{ F + a \times \frac{MI_1}{MI_0} + b \times \frac{LI_1}{LI_0} + c \times \frac{FI_1}{FI_0} + d \times \frac{SI_1}{SI_0} + e \times \frac{CI_1}{CI_0} \right\}$$

Where

EC = Adjustment to Civil Works price component expressed in the currency of the Contract payable to the contractor for each month

EC₁ = Adjusted amount of Civil Works price component expressed in the currency of the Contract payable to the Contractor for each month

EC₀ = Value of Civil Works done expressed in the currency of the Contract for the billing period (month).

- The fixed portion (F) of the Civil Works component of the Contract Price shall be 0.15.

- 'a' is the coefficient for material cost other than cement and steel involved in the Civil Works component of the Contract Price and it shall be 0.15.

'b' is the coefficient for labour cost involved in the Civil Works component of the Contract Price and it shall be 0.3.

'c' is the coefficient for Fuel & Power cost involved in the Civil Works component of the Contract Price and it shall be 0.05.

'd' is the coefficient for steel cost involved in the Civil Works component of the Contract Price and it shall be 0.25.

'e' is the coefficient for cement cost involved in the Civil Works component of the Contract Price and it shall be 0.10.

- MI shall be All India Whole Sale Price Index for all commodities as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry.

LI shall be All India Consumer Price Index for industrial labour as published by Labour Bureau, Government of India

FI shall Index Number of Wholesale Price for group Fuel & Power as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

SI shall Index Number of Wholesale Price for Steel as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

CI shall Index Number of Wholesale Price for Cement as published by the Economic Adviser to Government of India, Ministry of Commerce & Industry

For the indices(MI, LI,FI, SI and CI), subscript 'o' refers to indices as on 30 days prior to original scheduled date for opening of Part-I Bid. Subscript '1' refers to indices as of one prior to the month for which Civil Works is being billed.

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Contract Schedule-3

TIME SCHEDULE

[Detailed Time Schedule agreed between Employer and Contractor shall be placed]

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Contract Schedule-4
LIST OF SUB-CONTRACTORS
[List of approved subcontractors shall be placed]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Contract Schedule-5

SCOPE OF WORKS AND SUPPLY BY THE EMPLOYER

[Scope of Works and Supply by the Employer shall be placed]

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]	[Logo of Utility]
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Contract Schedule-6
FUNCTIONAL GUARANTEES
[Functional Guarantees shall be placed]

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ANNEXURE - G

CONTRACT PERFORMANCE BANK GUARANTEE FORMAT

[To be furnished by Contractor]

[Bank Guarantee shall be executed on non-judicial stamp paper of appropriate value]

Place:	Bank Guarantee No:	Date:
--------	--------------------	-------

To:

[Name & Address of Owner (Utility)]

.....
]

Dear Sirs,

1 In consideration of the [.....] hereinafter referred to as the 'OWNER', which expression shall, unless repugnant to the context or meaning, thereof include its successors, representative and assignees, having awarded in favour of M/s.....[Contractor's Name] having its registered office at.....hereinafter referred to as the 'CONTRACTOR', which expression shall, unless repugnant to the context or meaning thereof include its successors, administrators, representatives and assignees, a Contract, hereinafter referred to as the "CONTRACT" for the.....on terms and conditions set out inter alia, in the OWNER's Contract/Letter of Award No.....dated.....as well as 'CONTRACT' documents, valued at [amount of foreign currency in words], [amount in figures], and [amount of local currency in words], [amount in figures] and the same having been unequivocally accepted by the CONTRACTOR and the CONTRACTOR having agreed to provide a **Contract Performance Bank Guarantee** for the faithful performance of the entire CONTRACT including the Warranty Obligations /Liabilities under the CONTRACT equivalent to 10% (ten percent) of the said value of the CONTRACT to OWNER amounting to Rs.....(Rupees.....only) as Contract Security in the form of a Bank Guarantee.

2 We,.....[Name & Address of Bank] and having its Head Office at....., hereinafter referred to as the 'Bank' which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, representatives and assignees do hereby irrevocably guarantee and undertake to pay the OWNER merely on demand without any previous notice and without any demur and without referring to any other source, any and all monies payable by the CONTRACTOR by reason of any breach of the said CONTRACTOR of any of the terms and conditions of the said CONTRACT including non-execution of the 'CONTRACT AGREEMENT', to the extent of(%)..... of the Contract price to OWNER amounting to Rs.....(Rupees.....only). Any

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such demand made by the OWNER on the Bank shall be conclusive and binding, absolute and unequivocal notwithstanding any difference between the OWNER and CONTRACTOR or any dispute or disputes raised/ pending before any Court, Tribunal, Arbitrator or any other authority. The Bank agrees that the guarantee herein contained shall continue to be enforceable till this sum due to the OWNER is fully paid and claims satisfied or till the OWNER discharges this Guarantee.

- 3 The Bank further irrevocably guarantees and undertakes to pay any amount due and payable by the CONTRACTOR by reasons of non-fulfilment of any of the following obligations of the Contractor:
 - (a) Successful and satisfactory operation of the plant & equipment supplied and erected under the said Contract as per the Technical Specifications and other Tender/Contract documents.
 - (b) That the equipment installed under the said Contract shall be new and in accordance with Contract Documents and be free from all defects in design, engineering, material workmanship and performance for a period of 12 calendar months after final takeover of the equipment by the OWNER and that upon written notice from the OWNER, the CONTRACTOR shall remedy free of any expense to the OWNER, such defects as noticed and developed under the normal use of the said plant & equipment, within the said guarantee period.
- 4 The OWNER shall have the fullest liberty without affecting in any way the liability of the Bank under this guarantee, from time to time, to extend the time of Performance by the CONTRACTOR. The Bank shall not be released from its liabilities under these presents by any exercise of the OWNER of the liberty with reference to the matter aforesaid.
- 5 The OWNER shall have the fullest liberty, without affecting this guarantee to postpone from time to time the exercise of any powers vested in them or of any right which they might have against the CONTRACTOR and to exercise the same at any time in any manner, and either to enforce or to forbear to enforce any covenants, contained or implied in the CONTRACT between OWNER and the CONTRACTOR or any other course or remedy or security available to the OWNER and the Bank shall not be released of its obligations/liabilities under these presents by any exercise by the OWNER of his liberty with reference to the matters aforesaid or any of them or by reasons of any other act or forbearance or other acts of omission or commission on the part of the OWNER or any other indulgence shown by the OWNER or by any other matter or thing whatsoever which under law would, but for this provision, have the effect of relieving the Bank Guarantee. The Bank further undertakes not to revoke this guarantee during its currency without the previous consent of the OWNER.
- 6 The Bank further agrees that the decision of the OWNER as to the failure on the part of the CONTRACTOR to fulfill their obligations as aforesaid and/or as to the amount payable by the Bank to the OWNER hereunder shall be final, conclusive and binding on the Bank.
- 7 The OWNER shall have the fullest liberty to lodge their claim for encashment of the guaranteed sum either in full or part, in the manner suitable to them. However, payment made for a sum lesser than the guaranteed amount shall not relieve or discharge the bank from their obligations guaranteed under the bank guarantee, till the contractual obligations are fully performed by the Contractor or the Bank Guarantee is discharged by the OWNER, as the case may be and the Bank Guarantee shall continue to be in force till such time.
- 8 The Bank also agrees that the OWNER shall be entitled at his option to enforce this guarantee against the Bank as a Principal Debtor, in the first instance notwithstanding any other security or guarantee that it may have in relation to the CONTRACTOR's liabilities.

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- 9 This guarantee will not be discharged due to the change in the constitution of the Bank or the CONTRACTOR(S).
- 10 Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to Rs..... (Rupees.....) and it will remain in force upto and including..... and shall be extended from time to time for such period as may be desired by [Name of Contractor.....] on whose behalf this guarantee has been given.
- 11 Signed at.....this.....day of.....20.....

Signature :
Name :
Designation :
Staff Code No :

Bank Seal

Date :

Witness:

1. Signature :
Full name in block letters :
Occupation :
Address :

2. Signature :
Full name in block letters :
Occupation :
Address :

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-I
PROJECT TECHNICAL SPECIFICATION**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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2. Instruction to Bidder
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4. General Condition of Contract (GCC)
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6. Forms and Schedules

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1. Intent of Specification
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4. Scope of Supply & Services
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- A. Not used.
- B. Detailed Technical Specification-Electrical
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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

- A. Not used
- B. Technical Schedules - Electricals
- C. Technical Schedules – C&I
- D. Not used

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

ELECTRICAL BALANCE OF PLANT (eBOP) (PACKAGE NUMBER: R&M-SP-06)

VOLUME-II SECTION-I PROJECT TECHNICAL SPECIFICATION

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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ABBREVIATIONS TO BE USED

{The utilities are advised to use the following standard abbreviations while preparing Model Tender Document for their power plant.}

ACB	Air Circuit Breaker
AHP	Ash Handling Plant
AVR	Automatic Voltage Regulator
BOP	Balance of Plant
CCTV	Closed Circuit Television
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CHP	Coal Handling Plant
CMMS	Computerized Maintenance Management System
CLCS	Closed Loop Control System
CT	Current Transformer
CV	Control Valve
CW	Cooling Water
DCDB	Direct Current Distribution Board
DCS	Distributed Control System
DDCMIS	Digital Distributed Control Monitoring Information System
eBOP	Electrical Balance of Plant
FAT	Factory Accepted Test
GT	Generator Transformer
HMI	Human Machine Interface

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HT	High Tension
HVAC	Heating, Ventilation and Air Conditioning
HVWS	High Velocity Water Spray System
ICB	International Competitive Bidding
I/O	Input / Output
IPBD	Isolated Phase Bus Duct
IPR	Inter Posing Relay
LDB	Lighting Distribution Board
LE	Life Extension
LT	Low Tension
LV	Low Voltage
LVS	Large Video Screen
MCC	Motor Control Centre
MCCB	Module Case Circuit Breaker
MOCB	Minimum Oil Circuit Breaker
MoEF	Ministry of Environment & Forest
MV	Medium Voltage
NSPBD	Non Segregated Phase Bus Duct
OPC	Object linked embedded Process Control
OWS	Operator Working Station
PLF	Plant Load Factor
PLC	Programmable Logic Controller

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PMCC	Power & Motor Control Centre
R&M	Renovation & Modernization
RfP	Request for Proposal
RfQ	Request for Qualification
RLA	Residual Life Assessment
RTD	Resistance Temperature Detector
SPBD	Segregated Phase Bus Duct
TFT	Thin Film Transistor (Monitor)
TMCR	Turbine Maximum Continuous Rating
TPS	Thermal Power Station
TC	Thermocouple
UCR	Unit Control Room
UE	Unearthed
UPS	Uninterruptible Power Supply
VT	Voltage Transformer
VWO	Valve Wide Open

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1 INTENT OF SPECIFICATION

- 1.1 The intent of this specification is to Renovate and Modernize various Electrical equipment/s & systems of Electrical Balance of Plant Package (eBOP) including but not limited to [Switchyard and its Auxiliaries, Substation Automation System (SAS), Control & Protection Panel of Switchyard, Generator Transformer (GT), Unit Transformer (UT), Station Transformer(ST), Control, Protection and Metering panel of Station Transformer, Plant Communication system, Electrical Lab equipments, Energy Management system, Cable carrier system, Illumination System, Earthing and Lightning protection system. Switchyard Auxiliaries shall include equipments of LV Transformer, 415V Switchgear/MCC and DBS, Motor& motorized actuators, 220V DC& UPS system, 415V non Segregated Phase Bus duct(NSPBD), Variable frequency drives, HV Cable, LV Cable, Control & Instrumentation Cables and associated Civil & Structural work]. The renovated Equipment/s or System should be capable of operating to its design parameters. Technical particulars of Equipments, Bidder's scope of services and Terminal points of eBOP Package of the R & M of Unit No. [...] Of [Name of the Power Plant] is given in subsequent section of this Specification.
- 1.2 The Bidder shall carry out the required replacement / refurbishment / retrofitting of the Switchyard & its Auxiliaries and Power Transformers and associated auxiliary equipments of Switchyard as per the requirements of his design so as to make the same capable of operating for an extended life of [20/25] years and producing the output at the desired parameters mentioned in the respective equipment tabulation of this specification. The scope of replacement / refurbishment / retrofitting shall include but shall not be limited to the scope of work mentioned at clause 4 which is based on the recommendation of RLA/CA and EA studies conducted during [.....]. However, any other items/systems which have not been specifically mentioned but are considered necessary by the Bidder for giving the intended performance of equipments of eBOP package, shall also be included in the scope of Bidder and shall be separately highlighted by the Bidder in his proposal.
- 1.3 The modified/replaced/retrofitted equipment will conform to the requirements of the Specification prescribed in Section-II of Volume-II.
- 1.4 Bidders are required to carry out necessary modifications / replacement in the existing electrical equipment or systems including related civil/structural works as per Specification requirement and also based on their own assessment. Bidders are required to quote performance guarantee values for

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Transformer output, Transformer Efficiency, Losses etc. in their Bid. Bidder shall guarantee the Transformer output and Transformer Efficiency after R&M. Suitable credit shall be given to the Bidder offering higher output & better efficiency during evaluation of the Bid.

- 1.5 The scope of work for R&M shall include designing / re-designing, basic and detailed engineering, re-engineering, refurbishing / retrofitting, supply, inspection and testing at supplier's works, packing, forwarding to site, forwarding from site to Bidder's facilities, unloading and storage at site, pre-assembly, machining if required, site fabrication, erection, replacing of various equipment and systems, carrying out all pre-commissioning checks/ tests and any other work required to complete the system, commissioning and trial operation, performance tests of various equipment and systems covered under this Specification. Bidder's scope shall also include dismantling of the existing equipment/ facilities, including unloading & transportation to designated storage / disposal yard, wherever required as a result of augmentation of existing electrical, mechanical, I&C and civil/structural/ architectural works. The Bidder shall restore the equipment/ facilities, whenever applicable, after carrying out necessary renovations/modifications under the scope of R&M works.

All the tools & tackles, labour and other facilities required for dismantling and restoration shall also be in the scope of the Bidder.

Bidder shall also put back into service all the systems/equipment of the units after completion of R&M works, whether any modification is carried out on the same or not. All necessary tools, tackles, labour, instruments, spares, consumables etc. required for putting back into operation shall also be provided by the Bidder.

- 1.6 It is not the intent to specify completely herein all aspects of services and equipment to be provided by the Bidder who in any case shall be responsible for fulfillment of the intent of Specification. Irrespective of whether specifically mentioned or not, the services, equipment and systems to be provided in accordance with this Specification shall also form a part of the scope of work and shall conform in all respects to the highest standard of engineering, design, quality and workmanship so that after completion of R&M work by the Bidder, the equipment shall be capable of performing completely in a safe, reliable and sustained manner as acceptable to the Owner.

- 1.7 Unless otherwise specifically clarified by the Owner, interpretation by the Owner in respect of scope of supplies & services and the meaning of the Specifications, drawings, requirements of operation, maintenance, redundancy etc., shall be final and binding on the Bidder. Owner shall have the right to reject or accept any work or material which in his assessment is not technically complete and proven to meet the requirements of this

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Specifications and/or applicable National and International Codes & Standards mentioned elsewhere in this Specification.

- 1.8 The requirements, conditions, appendices etc, given in various parts/ sections of technical Specifications shall form integral part of this Specification. Bidder is required to carefully examine and understand the Specifications and seek clarifications, if required, to ensure that he has understood the Specifications as intended by the Owner. In the absence of any specific clarifications made to the Owner during Bidding stage, the interpretation of Owner shall be final. The Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. All such points are required to be clarified & resolved during Bidding stage.
- 1.9 Any deviation or variation from the scope of supply and services or the intent of the Specification shall be clearly brought out under the schedule of Technical / Commercial deviations, irrespective of the fact that such deviation / variation may be standard practice or possible interpretation of the Specifications by the Bidder. In case, no clear and specific deviation is taken by the Bidder in the relevant schedule of Bid Proposal Sheet while making his Bid proposal, it will be construed that the Bidder shall comply with the stipulations of the Specification fully with regard to scope of services and supplies to be provided by him to achieve the objective of R&M. Further, unless otherwise specifically clarified by the Owner, the interpretation by the Owner in respect of scope of supplies and services to be performed by the Bidder shall be final and binding.
- 1.10 If the Bidder feels that, in his opinion certain features brought out in his offer are superior to what has been specified, these may be highlighted separately in the Bid. The Bidder at his own discretion may also make Alternate offers, which in his opinion are of superior technology, material etc. to the specified requirements leading to better performance like efficiency / output etc. of the units after renovation. In such case, the Bidder shall carry out a comprehensive study and clearly identify the scope of offer in his alternate proposal. The Bidder shall furnish that detailed study to Owner along with the Bid where the Bidder shall bring out in detail the scope of modifications required to be carried out by him in the various systems and equipment including but not limited to *[Switchyard and its Auxiliaries, Substation Automation System (SAS), Control & Protection Panel of Switchyard, Generator Transformer (GT), Unit Transformer (UT), Station Transformer(ST), Control, Protection and Metering panel of Station Transformer, Plant Communication system, Electrical Lab equipments, Energy Management system, Cable carrier system, Illumination System, Earthing and Lightning protection system. Switchyard Auxiliaries shall include equipments of LV Transformer, 415V Switchgear/MCC and DBS, Motor& motorized actuators, 220V DC& UPS system, 415V non Segregated Phase Bus*

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duct(NSPBD), Variable frequency drives, HV Cable, LV Cable, Control & Instrumentation Cables and associated Civil & Structural work].

Such Alternate proposals shall be supplemented with sufficient amount of information like specified design standards and performance requirements, Bidder's experience, operating feedback, provenness, etc. for justifying such proposals. Implications of such Alternate offers on the performance, output, efficiency, auxiliary power consumption, etc. shall be clearly brought out in the Bid to enable the Owner to determine the advantages, superiority and acceptability of the proposals.

However the Bidder's Base offer shall necessarily be in line with the Specification requirements. Under no circumstances the equipment and services as specified shall be brought out as an Alternate offer.

The Base offers will be evaluated as per procedure outlined in the Bid documents and the Alternate Offers of the lowest evaluated Bidder will only be considered for acceptance or otherwise. Owner may reject alternative proposals submitted by the Bidder at his sole discretion, without assigning any reason what so ever.

- 1.11 In the event of conflict between requirements of any two clauses of the Specification documents or requirements of different Codes/ Standards specified, the more stringent requirement as per the interpretation of the Owner shall apply, unless confirmed otherwise by the Owner in writing.
- 1.12 The General technical conditions pursuant to the Contract, placed separately in this Specification, shall form an integral part of the Specification. These conditions shall supplement all the detailed technical Specification and requirement identified in this Specification.
- 1.13 Out of complete unit comprising of mechanical, electrical, C&I systems and equipment, some components/systems are envisaged to be replaced with new ones having better design features while some of the other components are to be refurbished / upgraded by the Bidder under present R&M Work. It shall be the responsibility of the Bidder to ensure that components/ equipment/ systems being supplied new OR components/ equipment/ systems being refurbished / upgraded by him are fully compatible and integrated with the existing equipment / systems so as to give safe, reliable and sustained operation of the complete unit. Modifications needed on the assembled equipment to ensure complete integration are to be brought out by the Bidder in the Bid and such modifications, if any, after Owner's approval shall be carried out by the Bidder to the satisfaction of the Owner.
- 1.14 The equipments shall be designed to operate continuously in base load and cyclic load operation. The systems shall operate without any restriction over the entire range of operating conditions. The Bidder shall ensure that after R&M there are no restrictions/ alterations in modes of operations of this unit,

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as per the original/existing plant operation philosophy, including achieving base load, peak load and cyclic load operation.

- 1.15 As the various equipment/ systems/ components are to be fitted in the unit, Bidder is advised to visit the plant site to get fully conversant with the job, site conditions, and constraints, and collect all the information as required and as available before quoting against this Specification.
- 1.16 A brief extract of the existing equipment/systems, the original design details/ performance parameters along with plant details, operating history and known problem areas; wherever possible are brought out in the successive section of this Specification. Relevant plant layout drawings and certain key schematic drawings, as available, have also been provided in Annexure-I of this section of the specification for the purpose of familiarization & guidance only. The successful Bidder shall prepare and provide the additional drawings and documents describing the design and engineering details and the manuals for carrying out erection, commissioning and operation of the renovated unit.

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2 SITE & PROJECT SPECIFIC INFORMATION

2.1 Project Name

Project Title: [...]

Existing Capacity: [X xMW]

2.2 Project Location

The proposed project site is located at [...], in District [...] in the state of [...]. The location details of the project site are as indicated below:

Table: 2.1

Latitude	[... ° ...' ..."] N
Longitude	[... ° ...' ..."] E
Height above mean sea level	[...] m
Seismic Zone	Zone - [...]
Distance from [.....] town	[...] km
Distance from national highway No. [...]	[...] km
Distance from state highway No. [...]	[...] km
Distance of nearest airport [...]	[...] km
Distance of nearest seaport [...]	[...] km

2.3 Climatological Data

Table: 2.2

Highest monthly mean of daily maximum temperature	[...] °C
Lowest monthly mean of daily maximum temperature	[...] °C
Highest monthly mean of daily minimum temperature	[...] °C

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Lowest monthly mean of daily minimum temperature	[...] °C
Annual mean of daily maximum temperature	[...] °C
Annual mean of daily minimum temperature	[...] °C
Extreme highest temperature	[...] °C
Extreme lowest temperature	[...] °C
Design ambient temperature (unless specified otherwise)	{50} °C
Relative Humidity: Maximum	[...] %
Minimum	[...] %
Average annual rainfall	[...] cm
Heaviest rainfall in 24 hours so far	[...] cm
Number of rainy days in a year	[...]
Highest monthly mean of wind speed	[...] km/h
Lowest monthly mean of wind speed	[...] km/h
Maximum wind speed	[...] km/h

Table: 2.3

Season	Dry bulb temperature	Wet bulb temperature
Summer	[...] °C	[...] °C
Monsoon	[...] °C	[...] °C
Winter	[...] °C	[...] °C

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3 EXISTING PLANT DETAILS

The Power Plant, having a configuration of [...x...MW] is located at [...], in District [...] in the state of [...]. The Unit no. [...] of the power plant, which is proposed to be taken up for Renovation and Modernization was first commissioned in the year [...]. For the above unit, M/s [...] and M/s [...] are the Original Equipment Manufacturers (OEMs) for the Boiler and Turbo-Generator, respectively. The Original Equipment supplier of respective eBOP equipment are provided in the respective equipment's section at Clause No. 3.2 of this section of the specification. Power generated from the unit is being supplied to [...State/Central grid]. Power is being evacuated through [...numbers of 220/400kV Double/Single Circuit lines] to [... substation.] The primary fuel is [domestic/imported/blended] [coal/lignite] fuel being sourced from [...&...] coal mines. The consumptive water for the power plant is being sourced from [...river/...sea].

3.1 Operational Background

Unit No [...] of [...] Thermal Power Station having a Generating Capacity of [210 MW] was commissioned in the year [...]. The boiler is of [...] design and the turbine is of [LMZ] design. Various Electrical equipment of Electrical Balance of Plant system has under gone degradation in its original design parameters with respect to its name plate design parameters and also in terms of parameters like efficiency, losses and number of outages etc over the years of its life. The deterioration experienced over the years in Plant's Equipment performance parameters and its current operating parameters is shown below.

3.1.1 Equipment's Average Performance Parameters over the life

{Indicate in the table below the average performance parameters of individual equipments which are being taken out for retrofit/replacement as per RLA, LE study for past [25] years.}

Equipm ent Name	Years after Install ation	Effici ency (%)	Availabi lity (%)	Output (MVA/Am p/ KW)	Losses (%)	Forced Outages (Nos)	Insulation Strength
[...]	5	[...]	[...]	[...]	[...]	[...]	[...]
	10	[...]	[...]	[...]	[...]	[...]	[...]
	15	[...]	[...]	[...]	[...]	[...]	[...]
	20	[...]	[...]	[...]	[...]	[...]	[...]

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Equipm ent Name	Years after Install ation	Effici ency (%)	Availabi lity (%)	Output (MVA/Am p/ KW)	Losses (%)	Forced Outages (Nos)	Insulation Strength
	25	[...]	[...]	[...]	[...]	[...]	[...]
[.....]	5	[...]	[...]	[...]	[...]	[...]	[...]
	10	[...]	[...]	[...]	[...]	[...]	[...]
	15	[...]	[...]	[...]	[...]	[...]	[...]
	20	[...]	[...]	[...]	[...]	[...]	[...]
	25	[...]	[...]	[...]	[...]	[...]	[...]

3.1.2 Equipment's Average Performance Parameters during the last five years

{Indicate in the table below the average performance parameters of individual equipments which are being taken out for retrofit/replacement as per RLA, LE study for the past [5] years.}

Equip ment Name	Period	Effici ency (%)	Availabil ity (%)	Output (MVA/Am p/ KW)	Losses (%)	Forced Outages (Nos)	Insulation Strength
[.....]	Four Years back	[...]	[...]	[...]	[...]	[...]	[...]
	Three Years back	[...]	[...]	[...]	[...]	[...]	[...]
	Two Years back	[...]	[...]	[...]	[...]	[...]	[...]
	One Year back	[...]	[...]	[...]	[...]	[...]	[...]
	Current year	[...]	[...]	[...]	[...]	[...]	[...]

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Equip ment Name	Period	Effici ency (%)	Availabil ity (%)	Output (MVA/Am p/ KW)	Losses (%)	Forced Outages (Nos)	Insulation Strength
[.....]	Four Years back	[...]	[...]	[...]	[...]	[...]	[...]
	Three Years back	[...]	[...]	[...]	[...]	[...]	[...]
	Two Years back	[...]	[...]	[...]	[...]	[...]	[...]
	One Year back	[...]	[...]	[...]	[...]	[...]	[...]
	Current year	[...]	[...]	[...]	[...]	[...]	[...]

3.1.1 Feedback from the Plant Operators

Detailed discussions were held with the Plant operators who provided the feedback about the design and operation related problems of various Equipment. These are listed in the Table below.

Feedback from the Plant Operators

S. No.	Name of the Equipment	Type of Problem	Probable Solution as per the Operators
1	[.....]	[.....]	[.....]
2	[.....]	[.....]	[.....]
3	[.....]	[.....]	[.....]
4	[.....]	[.....]	[.....]
5	[.....]	[.....]	[.....]
6	[.....]	[.....]	[.....]

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S. No.	Name of the Equipment	Type of Problem	Probable Solution as per the Operators
7	[.....]	[.....]	[.....]
8	[.....]	[.....]	[.....]
9	[.....]	[.....]	[.....]
...	[.....]	[.....]	[.....]

3.1.3 Tripping and Maintenance Record

{Indicate in the table below the tripping and maintenance record of individual equipment which are being taken out for retrofit/replacement as per RLA, LE study for the past [3] years.}

Equipment Name	Year	Total Trippings	No. of Tripping due to Generator Trip	Other Major Causes of Trippings	Maintenance carried out
	Two Years Back	[.....]	[.....]		[.....]
	One Year Back	[.....]	[.....]		[.....]
	Current Year	[.....]	[.....]		[.....]

3.1.4 Record of Reportable Accidents

{Indicate in the table below the reportable accidents for the past three years of individual equipment which are being taken out for retrofit/replacement as per RLA, LE study for the past [3] years.}

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Equipment Name	Year	Man hours lost due to accidents	No. of Fatal Accidents	No. of Accidents leading to Permanent Disablement	Actions taken to reduce the number of accidents
	Two Years Back	[.....]	[.....]	[.....]	[.....]
	One Year Back	[.....]	[.....]	[.....]	[.....]
	Current Year	[.....]	[.....]	[.....]	[.....]

3.1.5 Operation & Maintenance Difficulties due to Plant Limitations

[Difficulties are being experienced in day to day maintenance of the plant due to design deficiency, layout of the plant, obsolescence of equipment and non availability of spare parts etc. These are mentioned in the Table below]

S.No.	Nature of Difficulty	Specific Reason (Design deficiency/ layout of the plant / obsolescence of equipment / non availability of spare parts etc)
1	[.....]	[.....]
2	[.....]	[.....]
3	[.....]	[.....]
4	[.....]	[.....]
5	[.....]	[.....]

3.2 Salient Technical Features of Power Plant

{Describe in this chapter, the Important Design Parameters and Salient Features of all the Equipment and Systems of Electrical Balance of Plant package of the Power Plant is mentioned below}

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3.2.1 Substation & Auxiliaries

[The Substation is 220kV/400kV Air/Gas Insulated or Hybrid substation, type. The Major design parameters of the Substation are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[....]
Model No		[If applicable]
Installation		[Indoor/Outdoor.]
Insulating Medium		[Air/SF6]
Nominal voltage	kV	[....]
Highest System voltage	kV	[....]
Short circuit current	kA	[....]
Insulation Level		
Impulse withstand voltage	kV (Peak)	[....]
One minute power frequency withstand voltage	kV (rms)	[....]
Switching Impulse withstand Voltage	kV (Peak)	[....]
Creepage Distance	mm/kV	[....]
Reference ambient temperature	°C	[....]
Rated Current	Amp	[....]
Switching Scheme		[....]

[And in addition to Control and Protection panels of substation, separate Protection & Metering Panel for Station Transformer is also provided. There are two groups of protection each are physically, mechanically and electrically separated into two separate systems. Separate Metering systems

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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are provided which comprises of Metering requirements of Station transformer. The design parameters of Station Transformer Protection panel and Metering Panel are furnished below:]

Description	Unit	Design Parameters
Make/Manufacturer of Panel		[.....]
Model No		[.....] {For Protection/Metering panel}
Panel Designation		[.....] {Relay/Metering panel of Station Transformer}
Type of Panel		[.....] {Simplex/Duplex}
Sheet Steel Thickness		
(a) Load bearing members	mm	[.....]
(b) Non-loading members	mm	[.....]
Colour Shade of Panel		[.....]
Cable Entry of Panel		[.....] {Top/Bottom}
Degree of protection		[.....]
Auxiliary Voltage Requirement of Panel		
(a) AC		[.....]
(b) DC		
Minimum rating of contacts for auxiliary relays :		
(a) Voltage	V, DC	[.....]
(b) Continuous current	A, DC	[.....]
(c) Make & carry for 1 sec.	A, DC	[.....]

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Description	Unit	Design Parameters
(d) Breaking capacity (i) Resistive (ii) Inductive	Watts	[.....] [.....]
Weight of Each Panel	kg	[.....]
Dimension of each panel	mm	[.....]
Relay type and protection [For Station Transformer]		[.....] <i>{List out protections envisaged for Station Transformer in Group I and Group II separately}</i>
Tripping Relays		
(a) Make / designation		[.....]
(b) Static / Electromagnetic		[.....]
(c) Rated voltage	V, DC	[.....]
Trip circuit Super Vision Relays		
(a) Make / designation		[.....]
(b) Static / Electromagnetic		[.....]
(c) Rated voltage	V, DC	[.....]
Indicating Lamps		
Type		[.....]
Ratings		
(a) Voltage	V	[.....]
(b) Wattage	W	[.....]
Energy Meters		
Make		
Type of measurement		[.....]

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Description	Unit	Design Parameters
Measuring range in primary watts.		[.....]
CT ratio	A/A	[.....]
VT ratio	V/V	[.....]
Accuracy class		[.....]
Burden		[.....]
(a) Current coil	VA	[.....]
(b) Voltage coil	VA	[.....]
Transducers		
a) Output		[.....]
b) Accuracy		[.....]
c) Burden	VA	[.....]

3.2.2

Substation Automation System (SAS):

[The Substation Automation system based on IEC 61850 is provided for integrated protection, control, and communication and monitoring of the various switchyard equipment in the 400 kV/200kV switchyard. The design parameters of the Substation Automation System are furnished below:]

Description	Units	Design Parameters
BAY CONTROL UNIT		
Make/Manufacturer		[.....]
Model		[.....]
Communication Protocols supported		[.....]
Protocol for time synchronization		[.....]
Communication		
Serial		[.....]
IRIG-B		[.....]

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Description	Units	Design Parameters
Ethernet		[.....]
Digital Input Board		
Model		[.....]
Input voltage	V DC	[.....]
No. of channels		[.....]
Digital Output Board		
Model		[.....]
Burden		[.....]
No. of Channels		[.....]
Analog Input Board		
Model		[.....]
Burden		[.....]
No. of Channels		[.....]
ETHERNET FIBER SWITCH		
Make		[.....]
Model		[.....]
Type		[.....]
GATEWAY		
Make		[.....]
Mounting		[.....]
Dimensions (W X D)		[.....]
FIBER OPTIC CABLE		

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Description	Units	Design Parameters
Make		[.....]
Cable Type		[.....]
Fibre Type		[.....]

3.2.3 Generator Transformer

[The Generator Transformer is designed to evacuate individual unit output power under Valve Wide Open (VWO) condition without considering units auxiliary consumption. The design parameters of the Generator Transformer are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Transformer application		[..GT
No of Winding		[..2/3
Installation		[.....]
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Rated frequency	Hz	[.....]
Rating at different cooling methods	MVA	
ONAN		[..... %.....]
ONAF		[..... %.....]

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Description	Units	Design Parameters
OFAF/ODAF		[.....%.....]
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap		[.....]
Winding connection and vector group		[.....]
Temperature Rise above [50 deg] ambient a) In Oil by Thermo meter b) In winding by Resistance.	Deg C Deg C	[.....] [.....]
System fault level	kA	[HV.....]; [LV.....]
Insulation Level: a) One minute Power frequency withstand voltage b) Impulse withstand voltage c) Switching impulse withstand voltage(if applicable)	kV KV(peak) kV(Peak)	[.....] [.....] [.....]
System earthing (a) HV		[...Solidly earthed.....]

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Description	Units	Design Parameters
(b) LV		[...Non effectively earthed.....]
Type of tap changer		[.....Off circuit/OLTC.....]
a) Range of Taps		[.....]
b) No of steps.		[.....]
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at	%	[.....]
a) Full load		
b) 75% load		
No of Cooler Bank and Capacity	No & %	[.....]
Online Dissolved Gas Analyzer (DGA) provided	Yes/No	[.....]
CT details		[.....]
a) HV side		[.....]
b) HV Neutral Side		[.....]
c) LV side		[.....]

3.2.4 Unit Transformer

[The Unit Transformer is designed to cater 50% of unit load and 2 x50% configuration is followed for each unit. The design parameters of the Unit Transformer are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Transformer application		[..UT] { Feeding Unit auxiliaries load}

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Description	Units	Design Parameters
No of Winding		[..2/3]
Installation		[.....]
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Rated frequency	Hz	[.....]
Rating at different cooling methods	MVA	
ONAN		[..... %.....]
ONAF		[..... %.....]
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap		[.....]
Winding connection and vector group		[.....]
Temperature Rise above [50 deg] ambient		
a) In Oil by Thermo meter	Deg C	[.....]
b) In winding by Resistance.	Deg C	[.....]

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Description	Units	Design Parameters
System fault level	kA	[HV.....]; [LV.....]
Insulation Level: a) One minute Power frequency withstand voltage b) Impulse withstand voltage	kV (rms) KV(peak) kV(Peak)	[.....] [.....] [.....]
System earthing (a) HV (b) LV		[.....] [...Non effectively earthed.....]
Type of tap changer a) Range of Taps b) No of steps.		[.....Off circuit/OLTC.....] [.....] [.....]
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at a) Full load b) 75% load	%	[.....]
No of Cooler Bank and Capacity	No & %	[.....]
Online Dissolved Gas Analyzer (DGA) provided	Yes/No	[.....]
CT details a) HV side b) HV Neutral Side c) LV side		[.....] [.....]

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Description	Units	Design Parameters
		[.....]

3.2.5 Station Transformer

[The Station Transformer is designed to cater 100% of Power plant Common load and 2 x100% configuration is followed for the entire power plan of plant having units more than one. The design parameters of the Station Transformer are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Transformer application		[..ST] { Feeding Common loads of station }
No of Winding		[..2/3]
Installation		[.....]
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Rated frequency	Hz	[.....]
Rating at different cooling methods	MVA	
ONAN		[.....%.....]
ONAF		[.....%.....]
OFAF/ODAF		[.....%.....]

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Description	Units	Design Parameters
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap		[.....]
Winding connection and vector group		[.....]
Temperature Rise above [50 deg] ambient a) In Oil by Thermo meter b) In winding by Resistance.	Deg C Deg C	[.....] [.....]
System fault level	kA	[HV.....]; [LV.....]
Insulation Level: a) One minute Power frequency withstand voltage b) Impulse withstand voltage c) Switching impulse withstand voltage(if applicable)	kV (rms) KV(peak) kV(Peak)	[.....] [.....] [.....]
System earthing (a) HV		[...Solidly earthed.....]

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Description	Units	Design Parameters
(b) LV		[...Non effectively earthed.....]
Type of tap changer		[.....Off circuit/OLTC.....]
a) Range of Taps		[.....]
b) No of steps.		[.....]
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at	%	[.....]
a) Full load		
b) 75% load		
No of Cooler Bank and Capacity	No & %	[.....]
Online Dissolved Gas Analyzer (DGA) provided	Yes/No	[.....]
CT details		[.....]
a) HV side		[.....]
b) HV Neutral Side		[.....]
c) LV side		[.....]

3.2.6

LV Transformer

[The LV transformer of Oil/Dry type is designed to cater 100% of Switchyard auxiliary loads with 2 x 100% configuration is followed. The design parameters of the Service Transformer are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]

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Description	Units	Design Parameters
Type		[Oil/Dry.....]
Transformer application		[..Service
Installation		[...Indoor/Outdoor.]
Rating of transformer	MVA	[.....]
No load voltage ratio at principal tap HV/LV	kV	[.....]
Rated frequency	Hz	[.....]
Impedance value at principal tap on rated MVA base.	%	[.....]
Tolerance on impedance at nominal tap		[.....]
Winding connection and vector group		[.....]
System fault level	kA	[HV.....]; [LV.....]
Insulation Level: a) One minute Power frequency withstand voltage b) Impulse withstand voltage	kV (rms) KV(peak)	[.....] [.....]
System earthing (c) HV		[.....]

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Description	Units	Design Parameters
(d) LV		[.....Solidly earthed.....]
Type of tap changer		[.....Off Circuit.....]
a) Range of Taps		[.....]
b) No of Steps		[.....]
Guaranteed no load loss	kW	[.....]
Guaranteed load loss	kW	[.....]
Guaranteed efficiency at	%	[.....]
a) Full load		
b) 75% load		

3.2.7 Neutral Grounding Resistor (NGR)

[The Unit auxiliary load and Station Common Auxiliaries loads are fed by Unit Transformer and Station Transformer respectively at 6.6kV level. Further in order to feed LV loads, 6.6kV level is stepped down by using Service Transformers. In power plant it is followed that 6.6kV system is non effectively earthed through resistor and LV system is solidly earthed. The Design parameters of Neutral Grounding Resistor (NGR) are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Application		[.....](For UT/ST)
Installation		[.....]
Current Rating	Amp	
a) For UT		[.....]
b) For ST		[.....]

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Description	Units	Design Parameters
Rated Voltage a) For UT b) For ST	kV	[.....] [.....]
Frequency	Hz	[.....]
Duty Rating	Sec	[.....]
Resistance		
a) For UT b) For ST	Ohm	[.....] [.....]
a) For UT b) For ST	Ohm	[.....] [.....]

3.2.8 415V Switchgear, MCC & DBs

[415V Switchgear/MCC is provided with two incomers and bus coupler or single bus with one incomer (DB) with outgoing feeders intend for specific Auxiliary services of Switchyard. The design parameters of the LV Switchgear /PDB are furnished below:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Rated voltage, phases & frequency	V, Hz	[.....]
System neutral earthing		[.....]
Maximum system voltage	V	[.....]
One minute power frequency Voltage		[.....]
Continuous current		[.....]

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Description	Units	Design Parameters
rating of bus bars		
Short Circuit rating of Bus bar with duration	kA & sec	[.....]
Bus bar Material	Al/Cu	[.....]
Type- Fully Draw out/Fixed		[.....]

3.2.9

220V DC System

[The 220V DC system of Switchyard is provided with 2 x100% battery with Battery Charger. The design parameters of the DC system comprising of Battery and Battery Charger are furnished below:]

Description	Units	Design Parameters
BATTERY		
Make/Manufacturer		[.....]
DC System Voltage	V	[220V.....]
Battery Type		[.....]
AH Rating/Rated Capacity	AH	[.....]
Number of cells		[.....]
End Cell Voltage	V	[.....]
Expected fault level at bus due to battery	kVA	[.....]
AH Efficiency at Rated load	%	[.....]
BATTERY CHARGER		[.....]

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Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type of Battery Charger		[...Float & boost/Float cum Boost.....]
Battery Charger Rating	Amp	[.....]
AC Input Voltage , Phase , Frequency	V, Hz	[.....]
Short Circuit Level	kA/Sec	[.....]
Efficiency of Charger	%	[.....]
Guaranteed Efficiency		[.....]
a) At 50% load	%	[.....]
b)At rated load	%	[.....]
Power Factor		[.....]
a) At 50% load		[.....]
b)At rated load		[.....]

3.2.10 UPS System

[The UPS system of Switchyard is provided with 2 x100% Configuration with 1 x 100% / 2x 100% independent batteries. The design parameters of the UPS system are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
UPS output Rating	KVA	[.....]
Installation		[.....]
Input Rated Voltage,	V, Hz	[.....]

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Description	Units	Design Parameters
Phase and Frequency		
Output Rated Voltage, Phase and Frequency	V, Hz	[.....]
Type of UPS		[.....]
Fault Level	KA	[.....]
Harmonics at input side	%	[.....]
Servo controlled voltage stabilizer (SCVS) required	Yes/No	[.....]
Efficiency at rated load	%	[.....]
<u>BATTERY</u>		
Make		[.....]
DC link voltage		[.....]
No. of 100% capacity batteries		[.....]
Type of battery cell		[.....]
Battery backup time		[.....]
AH Rating		[.....]
No. of cells		[.....]
End cell voltage		[.....]
Float charging voltage / current	V / A	[.....]
Trickle charging voltage / current	V / A	[.....]

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Description	Units	Design Parameters
Type of Rectifier		[.....]
Over Load Capacity of Inverter	%	[...% for 10Min.....] [.....% for 1Min.....] [.....% for 5ms.....]

3.2.11 Non Segregated Phase Bus Duct (NSPBD)

[The Non Segregated Phase Bus Duct (NSPBD) connects Service Transformer to LV Switchgear. The design parameters of the NSPBD are furnished below]:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Type of bus duct		[.....]
Rated voltage and No. of phase	V	[.....]
Material of Busbar and Enclosure		[.....]
Rated Current	A	[.....]
Designation (From and To)		[.....]
Type of cooling (NSPBD)		[.....]
Maximum temperature rise of conductor over 50°C ambient	°C	[.....]
Maximum temperature rise of enclosure over 50°C ambient	°C	[.....]
One minute power	KV (rms)	[.....]

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Description	Units	Design Parameters
frequency voltage withstand		
Continuous current rating at 50°C design ambient air temperature	A	[.....]
One second short circuit withstand rating	KA (rms)	[.....]
Momentary short circuit withstand current	KA (Peak)	[.....]

3.2.12

HV Cables

[The HV cables of 6.6kV UE Voltage grade is used for feeding Switchyard LV transformer from Station Board. The design parameters of the HV Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]

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Description	Units	Design Parameters
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

3.2.13

LV Cables

[The LV cables of 1.1kV Voltage grade are used for feeding LV Auxiliary load of switchyard as well as for sub distribution system boards. The design parameters of the LV Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]

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Description	Units	Design Parameters
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

3.2.14

Control (Core) Cables

[The Control cables of 1.1kV Voltage grade are used for Protection, CT, VT connection and feedback/interlock signals of Switchyard. The design parameters of the LV Cables are furnished below:

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
System Neutral Earthing		[.....]
No. of Cores		[.....]
Conductor Material		[.....]
Conductor (stranded/solid)		[.....]
Conductor Screen		[.....]

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Description	Units	Design Parameters
Insulation		[.....]
Insulation Screen		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Armoured/Unarmoured		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

3.2.15

Instrumentation (Pair) Cables

[The Instrumentation cables of 0.6kV Voltage grade are used for transmitting Process related field signals of equipment in terms of 4-20mA as well as analog information and feedback signals of equipments covered in eBOP package. The design parameters of the Instrumentation Cables are furnished below:]

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Voltage Grade		[.....]
Nominal Power System Voltage	kV	[.....]
Maximum System Voltage	kV	[.....]
No. of Pairs		[.....]
Type of Cables		
Conductor Material		[.....]
Color Coding		[.....]

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Description	Units	Design Parameters
Insulation		[.....]
No of Twist		[.....]
Inner Sheath		[.....]
Outer Sheath		[.....]
Material of Amour		[.....]
Material of cable drum		[.....]
Type of End Sealing		[.....]

3.2.16

Illumination System

[The illumination system is categorized mainly as Normal, Emergency and DC lighting. The illumination system of indoor area/Building (Other than Boiler area, TG Building, Ash Handling Plant and Coal Handling Plant), Outdoor area and Road lighting of Switchyard and Power Transformer area are covered in this eBOP Package. Lighting Distribution Board (LDB) is getting normal supply from 415V Switchgear. Each LDB is provided with lighting transformer for isolation of lighting circuit from power circuit and also for limiting short time current rating. Outgoing circuits of LDB feeds Lighting panels which is placed local to fixtures. Separate LDB for indoor as well as for outdoor area is provided. Emergency Lighting system is same as normal system however gets supply from Emergency 41V Switchgear backed up with DG set. The Design parameters of Illumination System and its major components comprising of LDB with transformer, Lighting Panel, Lighting Fixtures, Lighting wires and Lighting Poles are furnished below]:

{Note: Lighting system for Boiler area, TG area, AHP, CHP and mechanical BOP are covered in respective package itself. However complete plant illumination and common road/street lighting other than above mentioned package are covered in eBOP Bidder scope of work.}

Description	Units	Design Parameters
Lighting System:		
Voltage		[.....]

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Description	Units	Design Parameters
a)AC system		[.....]
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
b)DC system		[.....]
Rated Voltage	V	[.....]
Maximum Voltage	V	[.....]
One Minute Withstand Voltage	V	[.....]
System Short-Circuit Level		[.....]
a) 415V AC	kA(rms)	[.....]
b) 220V DC	kA(DC)	[.....]
LDB/LP:		
Manufacturer Name		[.....]
Mounting		
a)LDB		[...Floor.....]
b) LP		[... Wall.....]
Installation		[.....](For each application ie for Indoor/Outdoor and area)
Type, No of Circuits/Feeder rating		[.....]
Lighting Transformer:		
Make of Transformer		[.....]

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Description	Units	Design Parameters
Type of Transformer		[...Dry.....]
Rating	KVA	[.....]
Voltage Ratio		[.....]
Impedance	%	[.....]
Lighting Wires:		
Make		[.....]
Voltage Grade	V	[.....]
Conductor Material	Cu/Al	[.....]
Size	Sq.mm	[.....]
Lighting Fixtures:		
Make		[.....]
Type of Luminaries		[.....]
Ballast Type		[.....]
Lighting Poles:		
Make		[.....]
Type of Poles		[.....]

3.2.17 Cable Carrier System

[The Cable Carrier system is described as below: Indoor Buildings are provided with Cable cellar/Trench and outdoor areas are provided with Pipe cum cable rack/Duct bank/Trench. Separate Tray is provided for HV cables. LV cables, Control cables and Instrumentation cables in the order that HV cables Tray at the top followed by LV, Control and Instrumentation Tray. Ladder type tray is used for MV, LV and Control cables; however Perforated Tray is used for Instrumentation cables. The Design parameters of Cable Carrier System are furnished below]:

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{Note: The Cable carrier system of Boiler, TG, AHP, CHP and Mechanical BOP are covered in respective package itself. However cable carrier system for equipments and system covered in eBOP package and complete interplant cable carrier system is in eBOP Bidder scope of work.}

Description	Units	Design Parameters
Make/Manufacturer		[.....]
Size of Tray	mm	[.....]
Material		[.....]
Application		[.....] (I.e. HV/LV/Control/Inst.)
Type of Tray		[.....] (i.e.Ladder/Perforated)
Thickness of Tray	mm	[.....]
Thickness of Galvanization	mm	[.....]
Tray Cover Size	mm	[.....]
Cable Tray Accessories		
Tee	mm	[.....] {List out all size}
Cross	mm	[.....]{List out all size}
Bends	Deg	[.....]{List out all size}
Reducer	mm	[.....] to [.....]{List out all size}
Steel Supports		
a) ISMC b) ISA	mm	[.....]{List out all size} [.....]{List out all size}

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3.2.18 Earthing and Lightning System

[The Earthing & Lightning System is described as below: Switchyard, Transformer yard and BTG area are provided with earth mat of [...] mm dia MS Rod conductor buried below 600mm from ground level. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system comprises of shield wire/Lightning Mast protection and down comers and connecting to Lightning rod with test link. The Design parameters of Earthing and Lightning System are furnished below]:

{Note: Above ground earthing by taking risers from earth mat and connecting to equipments and peripheral earthing for building of eBOP battery limit as well as complete plant earthing and Lightning system (Other than Boiler, TG, AHP, CHP and Mechanical BOP). are in the scope of eBOP Contractor. However underground peripheral earthing of other packages is in eBOP Contractor scope of work.}

Description	Units	Design Parameters
Earthing System:		
Make/Manufacturer		[.....]
Main Earthing Conductor		[.....]
a) Material		[.....]
b) Dia		[.....]
Treated Earth Pit/Earth Rod(Dia and Length)	mm & m	[.....]
Size of Earth Conductor		[.....]{List out size of Flat Earth conductor used for different equipments of Power plant and no of points }
a) LV Switchgear		
b) Control panel, LPBS Etc.		
c) Transformer Body		
d) Transformer Neutral List out Transformer wise}	mm x mm	
e) Any other panel/Equipments		

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Description	Units	Design Parameters
Lightning System:		
Air Termination Rod		[.....]
a) Dia & Length b) Material		[.....]
Down comer		[.....]
a) Material b) Size		[.....]
Lightning Electrode with test link		[.....]
a) Material b) Dimension(Length and Dia)		[.....]

3.2.19

Plant Communication System

[The Plant Communication system consists of EPABX system, Public Address system and paging system, etc. Complete plant communication system is covered in this package. The Design parameters of Plant communication system) are furnished below]:

Description	Units	Design Parameters
TELEPHONE EXCHANGE		
Make/Manufacturer		[.....]
Model No		[.....]
Exchange is microprocessor based	YES/NO	[.....]
Multiplexing and Modulation technique used.		[.....]
IS system suitable for using		[.....]

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Description	Units	Design Parameters
DP/DTMF/DECT and DMKT telephones		
Compatibility of the exchange with ISDN Network.		[.....]
Does the exchange have provision access to public exchange network?	YES/ NO	[.....]
Does the exchange have provision for direct inward dialing from public exchange network?	YES/ NO	[.....]
CHARGER		
Manufacturer		[.....]
Model No		[.....]
Input		
a) Voltage	Volt	[.....]
b) Current	Amp	[.....]
Output		
a) Voltage	Volt	[.....]
b) Current	Amp	[.....]
BATTERY		
Manufacturer		[.....]
Model No		[.....]
AH Rating		[.....]
Voltage	Volt	[.....]
LSTB SYSTEM		

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Description	Units	Design Parameters
Manufacturer		[.....]
Make, Model no and Type		[.....]
GENERAL ANNOUNCEMENT SYSTEM		
Capacity of working and standby Amplifier		
Make		
Signal to noise ratio		
UHF/VHF COMMUNICATION SYSTEM		
Hand held sets		
Model No.		
Frequency range	Hz	
RF Power output	Watts	
No. of Channels , Whether programmable		
Channel spacing		
Type of Antenna		
Whether the battery charger offered shall charge Ni-MH, Li-ION, Ni-CD batteries	YES/ NO	

3.2.20 Energy Management System

{The Energy Management System for the entire plant with remote end packages like AHP, CHP etc is covered in this specification. EMS acquires data from relay as well as meters and from PLC and same is communicated to Data Concentrator through Fiber Optic Communication. The Design parameters of existing EMS shall be indicated in this section.}

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3.2.21 Electrical Lab Equipments

{The details of the existing Electrical Lab Equipment shall be furnished in this section.}

3.2.22 Civil Works

Bidder shall go through the details of the existing Buildings / Structures / Foundations / Facilities mentioned hereunder (but not limited to) for thorough understanding of conditions of the same. In order to assess the quantum of Civil / Structural / Architectural R&M work within the package, Bidder shall also carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions at site and identification of modification requirements in any other structure or foundation not included here. Conditional details of important buildings / structures / foundations / facilities which require major modifications have been described below:

{Details of the existing buildings / structures and their foundations in the Electrical Balance of Plant area like substation & switchyard structures, transformer pits, control rooms, ~~GCB foundation structures~~, fire walls, illumination system structures etc. shall be indicated in this section. Also the available GA/Construction Drawing including Load Data shall also be provided.}

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4 SCOPE OF SUPPLY & SERVICES

4.1 The scope of supply and services to be provided by the Bidder shall include all such activities as required to meet the target and intent of this specification. The scope for each equipment shall generally cover, but will not be limited to the following:

- i. Replacement of some of the existing components with new components of improved and better design.
- ii. Incorporation of new systems / components wherever required in line with the specification.
- iii. Refurbishing / retrofitting of some of the components in the existing equipment/system.
- iv. All types of civil/structural works like modification and strengthening of foundation of existing and upgraded equipment, making new structures or foundations (if applicable), dismantling, restoration, supply and erection of any temporary supports or any other construction work required for implementation of renovation work.

All structural modifications/strengthening of existing structures or buildings of [substation & switchyard structures, transformer pits, control rooms, GGB supporting structures, fire walls, illumination system structures] etc. including supply, fabrication and erection of any new structure and provision of any additional platform if required for access to new equipment etc.

- v. Design, engineering, submission of design calculations for review and approval, manufacturing, inspection and testing at suppliers' works, packing, forwarding to site, unloading, erection, supervision, pre-commissioning, testing and commissioning and performance testing of the equipment / system and works indicated in this technical specification.
- vi. Mandatory spares, start-up and commissioning spares. The general requirements in respect of various types of spares are given in Clause 9 of this section of Technical Specification.
- vii. Packing, transportation and transit insurance of all materials required for renovation / replacement work as per this specification from the supplier's/sub supplier's works to [Name of the Plant], unloading, preservation and storage at site. Packing, transportation, transit insurance, clearance from all concerned agencies etc. of all components/materials required to be forwarded from [Name of the Plant] to Bidder's facilities and back to [Name of the Plant].
- viii. Dismantling of the systems, reassembly and re-erection / reinstallation along with associated inspection, testing, commissioning and trial run of equipment individually as well integrated with the overall plant trial operation.
- ix. Materials which are removed from the existing machines but are not re-used during the re-assembly of the machines as well as those components which are found to be beyond refurbishment shall be the property of Owner and

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shall be deposited at Owner's designated stores. Bidder shall prepare a record of all such dismantled material and hand it over to the Owner.

- x. Loading, transportation, unloading and disposal of scrap to scrap yard.
- xi. It shall be responsibility of the Bidder to obtain on behalf of the Owner the necessary approvals of Inspection Authority as may be required for design and design calculations, manufacturing, erection procedure repairing / servicing and renovation as called for. Bidder shall also be responsible for obtaining approval from the other statutory authorities in India, as may be required, for other plants and systems supplied by him. All such documentation submitted to statutory authorities shall also be submitted to the Owner for his review.
Handling of materials at site including handling / transportation as required to take equipment components to the workshop for carrying out the modification work and to bring it back for installation. All arrangement for such activities is to be done by the Bidder.
- xii. Erection of all material supplied new for renovation (including erection of components, replacing old components). Re-erection of any component / equipment removed for modification so as to make complete equipment//system ready for commissioning.
- xiii. Insurance for all items / activities in line with the provisions of General Condition of Contract, Erection condition of Contract, General Technical Condition under Technical Specification.
- xiv. Making arrangement for proper electrical grounding of all systems, supplied by him as required by the system design and as per scope of work as mentioned in this specification.. All required accessories including grounding cables are also included in Bidder's scope.
- xv. Installation, Interconnection laying and termination of all Bidder supplied cables, testing and commissioning of all equipment/systems furnished by the Bidder.
- xvi. Civil / Mechanical work (such as grouting, cutting, welding etc.) related to mounting of New Cabinets, CRT / Keyboards, laying & termination of associated Cables.
- xvii. Supply of all necessary tools, tackles, commissioning spares, test instruments and deputing of experienced personnel for completion of the above erection, testing and commissioning work.
- xviii. Dismantling of existing instrument cabinets along with associated cabling, for eBOP package related to the equipment for retrofitting the new instrument systems, based on requirement.
- xix. Providing all site supervision by qualified and experienced engineering personnel during execution of all works under the scope of Bidder. Also providing all facilities and qualified personnel for implementing the approved quality assurance programme.
- xx. Dismantling of the existing Instrumentation Cables and relaying of new cables as may be required.

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- xxi. Provision of facilities for inspection and witness of shop and site tests by representatives of Owner. The Bidder shall conduct all shop and site tests as per the requirements of this specification and Owner approved "Quality Assurance Program" to be finalized before the award of this Contract.
- xxii. Construction Water
[Construction water shall be made available to Bidder at a single point in a suitable location. The Bidder shall arrange at his own cost the required pumps, distribution pipe line network for further distribution as required to carry out construction work.]
- xxiii. Construction Power
[Construction power shall be made available to bidder at single point at [...] kV level. Further distribution as required to carry out the construction work shall be carried out by Bidder at his own cost. Bidder to indicate the construction power requirement in kVA in his Bid]
- xxiv. Providing all other services necessary for meeting the intent and requirement of this specification. This shall include but not limited to system engineering, furnishing drawings, data, information for owner's review, participation in meeting & reviews, system warranty.

4.2 Tools & Tackles

One (1) set of special tools and tackles required for the maintenance of equipment/systems have to be supplied by the Bidder. These tools and tackles shall be separately packed and brought to site. These shall not be used for erection/commissioning purposes and shall be in an unused and new condition, when they are handed over to the Owner. A list of all such special tools and tackles shall be submitted along with the offer.

For C&I system, Bidder shall supply one set for each unit of special non standard tools, module testing kit, cables, and any other equipment required for erection commissioning, testing, trouble shooting, calibration, maintenance and inspection of all systems / equipment provided. Any tools required to make changes (DIP shunt cutter, soldering irons, tips, wire wrap guns and bit unwrapping tools, strippers, terminal guard, connector repair tool, dies etc.) shall also be supplied.

Bidder's scope shall also include supply of all scaffolding, special tools and tackles, jigs and fixtures as may be required during modification / erection and commissioning. Those items specifically brought to site solely for erection / modification purpose and if no more needed for regular maintenance of the equipment, can however, be taken back by the Bidder after completion of the work at site.

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4.3 Safety

The design of the equipment shall incorporate every reasonable precaution and provision for the safety of all personnel and for the safety and security of all persons and property. The design shall comply with all appropriate statutory regulations relating to safety.

Newly constructed structures and equipment shall be designed and constructed to withstand every foreseeable static and dynamic loading condition, including loading under earthquake conditions, with an adequate margin of safety.

Ready and safe access with clear head room shall be provided to all the newly supplied parts of the plant for operation, inspection, cleaning and maintenance.

While carrying out the R&M work as per this specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items/ equipment supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipment / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipment / foundations / structure and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

4.4 Training Requirements

Bidder shall include in his offer the training programme for Owner's Operation & Maintenance staff in view of introduction of new systems/ equipment. This training shall be organized before handing over the unit.

4.5 In case there is any difference in scope of work and services as described in this section of the specifications and individual specification volumes, then more stringent of the Scope of work and services shall prevail.

4.6 Detail Scope of Work:

{Describe in this chapter, all the equipment/components which need to be replaced/refurbished/retrofitted as finalized in the DPR on the basis of RLA/CA and EA report. Scope with regard to Electrical, Civil, structural and architectural work as required for the Power Plant due to incorporation of new Electrical equipment/components shall also be incorporated in this chapter.}

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- 4.6.1 The Bidder shall include in his scope the following works for the R&M of the Unit, which are based on RLA/CA and EA studies. The overall scope of work shall include but shall not be limited to the scope of work mentioned below. Any other items not specifically mentioned but considered necessary by the Owner/Bidder for carrying out the R&M work, shall also be included in his scope so as to meet the intended performance of Equipment /system as specified in Clause No. 1.0.

Equipment	Scope of Work	Quantity
400kV/220kV Switchyard		
[Circuit Breaker]	[.....]	[.....]
	[.....]	[.....]
[Isolator]	[.....]	[.....]
	[.....]	[.....]
[Earth Switch]	[.....]	[.....]
	[.....]	[.....]
[Clamp & connectors]	[.....]	[.....]
	[.....]	[.....]
[Bus bar- Al.Tube/String conductor]	[.....]	[.....]
	[.....]	[.....]
[Bus Post Insulator]	[.....]	[.....]
	[.....]	[.....]
[Wave trap]	[.....]	[.....]
	[.....]	[.....]
[CVT]	[.....]	[.....]
	[.....]	[.....]
[Lightning Arrester]	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Current Transformer]	[.....]	[.....]
	[.....]	[.....]
[Voltage Transformer]	[.....]	[.....]
	[.....]	[.....]
[SCADA/SAS system]	[.....]	[.....]
	[.....]	[.....]
[Any other equipment/system]	[.....]	[.....]
	[.....]	[.....]
[Substation Automation system]	[.....]	[.....]
	[.....]	[.....]
Station Transformer Protection and Metering panel		
[Relays]	[.....]	[.....]
	[.....]	[.....]
[Meters]	[.....]	[.....]
	[.....]	[.....]
[Any other components]	[.....]	[.....]
	[.....]	[.....]
Generator Transformer		
[Transformer HV/LV coil]	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Tap changer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of Generator]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Unit Transformer		

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Transformer HV/LV coil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Tap changer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of Unit transformer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
Station Transformer		
[Transformer HV/LV coil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Tap changer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of station transformer]	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
LV Transformer		
[Transformer HV/LV coil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Tap changer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bushing]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Marshalling box]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transformer oil]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
Service transformer(oil type/dry type)	[.....]	[.....]
	[.....]	[.....]
Generator Circuit Breaker		
Motor operated Disconnectors	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Earth switches	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Control panel	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Voltage transformer	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Flexible connector	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Support structures	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
[Any other part/system of GCB]	[.....]	[.....]
	[.....]	[.....]
415V Switchgear ,MCC & DBs		
[Air circuit breaker/MCCB/SFU/MCB]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[CT/PT]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Numerical relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[AC/DC Starters]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Electronic over load relay]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Transducers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of *[Name of the Power Plant]*

[Logo of Utility]

Equipment	Scope of Work	Quantity
<i>[Ground bus]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[space heater]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Switch socket]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Push button station]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Terminal block]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Any other part/system of LV Switchgear (PMCC/PDB)]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
220V DC System		
<i>Battery charger</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
Battery system	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
DCDB	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Air break switch	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Annunciation system	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system DC system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
UPS System		
Inverter	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
UPS ACBD	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system UPS system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
NSPBD		
[Bus duct enclosure]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Bus duct conductor]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Support insulators]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Disconnecting link/flexibles]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[support structure]	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of NSPBD]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
MV Cables		
[Joint and termination kit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of HV cables]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
LV Power & Control cables		
[Lugs and Glands]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of LV power and control cable]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Instrumentation cables		
[Lugs and Glands]	[.....]	[.....]

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LII-GETS12021-G-00129-006	01	Tender Document for Selection of R&M Contractors – Electrical Balance of Plant Volume-II, Section-I	[61]	25.09.2014

Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
---	-------------------

Equipment	Scope of Work	Quantity
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of LV power and control cable]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Illumination System		
[Distribution boards]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lighting transformer]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Emergency light with self contained batteries]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Lamps and fixtures]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Industrial socket outlet]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
<i>[Fan and regulators]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Switches and switchboards]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Street or road light poles]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[High mast tower]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Lighting junction box and conduits]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
<i>[Any other part/system of lighting system]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>
Cable Carrier System		
<i>[Cable Tray]</i>	<i>[.....]</i>	<i>[.....]</i>
	<i>[.....]</i>	<i>[.....]</i>

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
[Conduit]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Trench/Duct bank]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Termination/joints]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of Cable carrier system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Earthing & Lightning Protection system		
[Electrode]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[GI flat/wire]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Air terminals]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Clamp/test links]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Shielding mast]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of earthing and lightning protection]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Neutral Grounding Resistor		
a) For UT	[.....]	[.....]
b) For ST	[.....]	[.....]
Electrical Lab Equipments		
[Meters]	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
	[.....]	[.....]
<i>[Any testing equipment]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Any tools and tackles]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Any other part/system of electrical lap equipments]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Energy Management System		
<i>[Communication port]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[Data connector]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
<i>[RS ports]</i>	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Fiber optic communication cables]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other cable and accessories].	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[UPS system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Printers]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Work stations]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[HMI system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[EMS software (if applicable)]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]

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Equipment	Scope of Work	Quantity
[Any other part/system of Energy management system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Plant Communication System		
[EPABX Exchange]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Telephone system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Telephone handsets]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Loud Speaker]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Talk Back System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[General Announcement]	[.....]	[.....]

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Equipment	Scope of Work	Quantity
system]	[.....]	[.....]
	[.....]	[.....]
[UHF Wireless System]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Audio Conferencing system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[GPS]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Master & slave clock]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[DC Power supply system]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Cables and other accessories]	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
[Any other part/system of	[.....]	[.....]

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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Equipment	Scope of Work	Quantity
earthing and lightning protection]	[.....]	[.....]
	[.....]	[.....]
Erection, Testing & Commissioning		
	[.....]	[.....]
	[.....]	[.....]
	[.....]	[.....]
Civil Works		
[Switchyard Structures]	[.....]	[.....]
[Transformer Pits & Foundations]	[.....]	[.....]
[Switch Yard Control Room]	[.....]	[.....]
[GCB foundation structure(if applicable)]	[.....]	[.....]
[GIS Building(if applicable)]	[.....]	[.....]
[Firewalls]	[.....]	[.....]
[Illumination System Structures/Foundation]	[.....]	[.....]
[Any other Civil / Structural Work]	[.....]	[.....]

4.6.2 Miscellaneous

- a. In addition to the above listed works, scope of civil / structural / architectural works and supplies shall be as detailed below.

Bidder shall carry out a brief or detailed survey (as required) of the site to acknowledge and obtain any other information/data about present conditions of the buildings, structures, foundations & facilities mentioned in this

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specification and identification of modification requirements in any other structure or foundation not included here.

Subsequently Bidder shall prepare and submit for approval by Owner, a detailed scheme including methods techniques, requirements etc. for carrying out civil/structural/architectural R&M works to executed in the plant.

Bidder shall be provided with the following drawings and documents by the Owner to facilitate the civil / structural / architectural repair, refurbishment and replacement works.

- 1) [Geotechnical Investigation Report of the site]
- 2) [Construction/As built drawings of the existing structures & foundations in the package, if available]
- 3) [Design documents of the existing structures in the package, if available]
- 4) [Road, drains, trench layouts etc.]

Bidder to refer Annexure-I of Section-I for exhaustive list of as Build/RFC drawing.

b. The scope of Civil / Structural / Architectural works to be carried out by the Bidder under this package shall generally cover the following:

- Inspection and checking the design adequacy of the foundations of existing structure like [substation & switchyard structures, transformers, control rooms, fire walls, illumination system structures etc.] for all the applicable loads and construction of new foundations / modification of existing, wherever required.
- Inspection and checking the design adequacy of existing structures [substation & switchyard structures, transformer pits, control rooms, fire walls, illumination system structures etc.] for any corrosion/damage and rectification / strengthening of the same.
- Carrying out all interior / exterior architectural repair and replacement works [such as flooring, painting, plastering, door/windows, roof finishing, water proofing, sheet cladding, roof sheeting, new false ceiling, glass partitions, lighting works replacement or modification of AC duct where ever applicable] is also included in contractors scope. etc.
- Any other civil related work required in buildings / structures of the package from aesthetics ambience & ease of operation point of view.

In addition to this any other modification/alteration to existing nearby foundation/structural steel/concrete/underground pipes work if required for satisfactory execution of intended work covered under this specification shall be carried out by the Bidder. Supply of all material required for the above work is included in Bidder's scope

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c. Supplies for Civil/Structural Work

The Bidder shall supply all material needed for completion of all civil, structural and architectural **works** as per this specification. The Bidder's scope of supply generally includes but is not limited to the following:

- Supply of cement, steel (for reinforcement as well as for any other use), grout, admixture for RCC work, sand and all other construction/ architectural / building materials as may be required for any repair/modification of existing civil works / foundation or for construction of new foundation / civil works.
- Supply of structural steel for all structural erection / modification / strengthening.
- Supply of all foundation bolts, and nuts base plates, embedments with lugs, miscellaneous steel where ever needed
- *[Supply of steel helical springs and viscous dampers for new equipment (if any)].*

d. Construction Enabling Works

[The owner shall provide the following facilities to the by Bidder to carry out the construction work.

- *Temporary Stores to store construction material.*
- *Fabrication Yard]*

e. Quality Control Laboratory

[To conduct acceptance test on all construction material, weldments, concrete cubes etc laboratory facilities if available in the existing unit shall be used. In case the laboratory facility is not available within the unit, Bidder shall get the testing at his own cost from a reputed test laboratory approved by the Owner.]

- f. Construction Tools & Materials Supplied By the Bidder.** The Bidder shall arrange adequate number and type of machinery and equipment for proper setting out and timely completion of the various works covered under the scope of the work. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expense.

The Bidder shall provide all fuels and lubricants required for the operation and maintenance of construction machinery and equipment as well as his transport vehicles at his own cost.

- g.** The Bidder shall furnish manufacturer's test certificate for all the manufactured items supplied by him. Representative specimens of the material shall also be submitted to the Owner and shall be tested at a recognised testing laboratory at the Bidder's cost in case Owner so desire.

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h. Work Execution and Supervision:

The Bidder shall have at the site accredited and qualified engineers and foremen / supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the works.

i. The Bidder shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner with full understanding of the importance of work for a R&M project of this magnitude.

j. In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accident. He shall also report such accidents to all the competent authorities wherever such reports are required by those authorities.

k. Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner is not in accordance with the specification / bid document.

l. During inclement weather, rains etc., the Bidder shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at the Bidder's cost and any damage to works shall be made good by the Bidder at his own expense.

m. **Safety of Adjacent Plant/Equipment and Civil Structure**

While carrying out the R&M work as per this specification, the Bidder may have to modify the existing equipment foundations, or do the excavation work and make new foundations. The Bidder may also have to make new supporting arrangements with / without modified loads for the items / equipments supplied by him. Under all such conditions Bidder shall be solely responsible for ensuring the safety of the adjacent equipments / foundations and of the existing supporting structures. The R&M work by the Bidder shall be carried out in such a manner that no damage is caused to existing equipments / foundations / structures and all precautions, including strengthening of existing structures, as may be necessary, shall be taken by the Bidder to ensure safety of existing plant / equipment / foundation / structures.

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4.6.3 Spares

All spares as specified in Annexure -II of this section of the specification in accordance with Clause 9 of Part-B of this Technical Specification.

4.6.4 Consumable, Oil & Lubricants

All the first fill and consumables such as greases, oil, lubricants, servo fluids/control fluids, gases and essential chemicals etc. required up to commercial operation of the equipment are covered in the scope of Bidder. Suitable standard lubricants as available in India are preferable. Efforts should be made to limit the variety of lubricants to minimum.

4.6.5 Embedded Parts & Fixture

All fixtures, embedded parts, steel embedment including fixing lugs and welding between them, foundation plates, grouting, nuts, bolts etc. for fixing all the equipment, piping on civil works shall be included in scope work of this package. All structures which would be required by the bidder for supporting the piping shall also be included in scope of work of this package.

4.6.1 Other Services

The scope of Erection, Commissioning and Testing shall include the following:

- a) Complete pre-commissioning work.
- b) Supply of all consumables.
- c) Supply of all temporary equipment for successful conductance of pre-commissioning and commissioning activities. All temporary equipment and instruments shall be clearly listed out in the Bid.
- d) Providing safety barricades and signage during dismantling, erection and testing etc.
- e) Supply of all labour, skilled/semi skilled supervisors, engineers and any other manpower.
- f) All the erection materials and consumables like shims, welding rods, soldering and brazing alloys, industrial gases insulating tapes, compounds, chemicals etc. required for the erection and commissioning works.

Note: The temporary equipment specifically brought by the Bidder solely for the pre-commissioning and commissioning work shall, on completion of these activities, remain the property of the Bidder.

The selection of material of all the temporary equipment/instruments shall be compatible with the service conditions expected during pre-commissioning/ commissioning activities.

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5 TERMINAL POINTS & EXCLUSIONS

5.1 Terminal Points

Between equipments which are covered under eBOP package, supply and termination at both ends are in the scope of eBOP contractor. Between equipment supplied by eBOP contractor and others, scope of work is defined as below, However for control cables, supply and termination at both ends is covered in this package.

- **Substation:**

- a) Termination at the switchyard line take off gantry for [220/400] kV lines with line side insulators. Line will be provided by others, but all line equipment such as CTs, EMVTs, CVTs, and PLCC equipment, LAs, clamps & connectors for droppers to equipment connections are included in eBOP contractor scope of work.
- b) HV terminal of Switchyard LV Transformer for termination and supply are in the scope of eBOP contractor.
- c) Emergency ACDB incomer for Supply and Termination of incoming cables.
- d) Control cable and Termination at switchyard equipments/panels to other equipments supplied by others.

- **Generator Transformer:** LV terminals for connection with IPBD. IPBD with adaptor boxes and termination at LV side of GT are in the scope of TG package Contractor.

- **Unit Transformer:** HV terminals for connection with IPBD and LV terminals for connection with 6.6kV SPBD. IPBD tap-offs and SPBD with adaptor boxes and termination are in the scope of TG package Contractor.

- **Station Transformer:** LV terminals / Cable termination box for connection with 6.6 kV SPBD / 6.6kV cable. SPBD with adaptor boxes / 6.6kV cable and termination are in the scope of TG package.

- **6.6 KV Power Supply for Switchyard Auxiliary Service Transformer:** At the terminal of 6.6 kV Station switchgear of TG package. All Power and control cables from the terminals of 6.6 kV Station Switchgears and termination are included in the scope of eBOP package.

- **6.6kV Power Supply for Mechanical BOP Package:** At the terminal of 6.6 kV Station/Unit switchgear of TG package. All Power and control cables from the terminals of 6.6kV Station/Unit Switchgears are included in the scope of Mechanical BOP package

- **415 V Emergency Power Supply for Switchyard:** Power supply at 415V level at the outgoing terminals of 415 V Unit Emergency Switchboard of TG package. All cables from the terminal point are included in the scope of eBOP package.

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- **415 V Power Supply for Power Transformers:** Power supply at 415V level at the outgoing terminals of 415 V Unit/Station Switchboard of TG package. All cables from the terminal point are included in the scope of eBOP package.
- **UPS Power Supply:** At the outgoing terminals of Unit UPS ACDB. Power Cables interconnection between Unit UPS ACDB to the UPSDBs of Switchyard & Power Transformers and termination is included in scope of eBOP Package.
- **Grounding & Lightning:** Complete plant underground grid is in eBOP package scope of work. Under Ground earthing grid & interconnections of BOP package and grounding connection to all equipment / structures are included in scope of BOP package.
- **Cable Carrier system:** Complete plants inter cable carrier system which inter connects other package of Boiler, TG, AHP, CHP, Mechanical BOP are in the scope of eBOP Bidder.

Note:

- a) Only relay contacts (1 NO/1 NC) shall be provided by the other package contractor. The required auxiliary relays, control cables including their laying & termination shall be in the scope of eBOP Bidder. Similarly, necessary contact (1 NO/1 NC) required by other package Contractors shall be provided by eBOP Bidder.
- b) Wherever Power is tapped from Purchaser's board, Bidder's scope starts from the outgoing terminals of the respective board. Bidder has to include all necessary termination materials, cables, trays, conduits, supporting structure, terminations, and necessary earthing accessories in his scope.

5.2

Exclusions

Following equipment / systems are excluded from the scope of BOP package.

- a) Generator Bus duct (IPBD) with adopter boxes
- b) 6.6kV Unit and Station switchgears
- c) DG set & associated system
- d) SPBD / Cable for connecting UT& ST to the 6.6kV boards.
- e) Fire Detection and alarm system
- f) Fire protection System.

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6 GENERAL TECHNICAL REQUIREMENTS

6.1 Codes & Standards

Apart from some specific application, the proposed R&M equipment shall comply with the appropriate Indian Standard / DIN or equivalent international Standard. Specification as listed below in this section and mentioned in detailed specifications, each incorporating the latest revisions at the time of tendering.

Wherever specified or required the Plant & Equipment shall conform to various statutory regulations such as Indian Electricity Rules/Act, Factories Act, etc.

In the event of any conflict between the codes and standards referred above, and the requirements of this specification, the requirements, which are more stringent, shall govern.

In case of any change of code, standards and regulations between the date of purchase order and the date, the Bidder proceeds with manufacturing, the Owner shall have the option to incorporate the changed requirements.

6.2 Name Plates

Instruction plates, nameplates or labels shall be permanently attached to each main and auxiliary item of equipment in a conspicuous position. These plates shall be engraved with the identifying name, type and manufacturers serial number, together with the loading conditions under which the item of plant has been designed to operate.

All trade nameplates and labels shall be in English language. All measurements shall be in M.K.S Units.

The size and location of nameplates shall be subject to Approval of the Engineer.

6.3 Operation, Maintenance & Availability

Equipment/works offered shall be designed for high availability, high reliability, low maintenance and ease of operation & maintenance. The Bidder shall specifically state the design features incorporated to achieve high degree of reliability, availability, operability and ease of maintenance. He shall also furnish details of availability records in plants stated in his Experience list.

6.4 Materials

In selecting materials of construction of equipment, the Bidder shall pay particular attention to the atmospheric conditions existing at the Site and the nature of material/fluid handled. Wherever deviations are taken in respect of materials specified, the reasons shall be spelt out clearly in the proposal.

All materials shall be new, and shall be of the quality most suited to the proposed application.

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As far possible; materials shall be in accordance with Indian or international standard specifications and shall be used in accordance with Indian or international codes of practice. Where such standards or codes of practice are not available, sufficient information shall be provided to allow the Engineer to assess the suitability of the material for the particular application.

All materials used shall have performed lengthy satisfactory service in similar or more arduous conditions to those proposed by the Bidder.

All parts which could deteriorate or corrode under the influence of the atmospheric, meteorological or soil conditions at the Site, or under the influence of the working conditions shall be suitably and effectively protected so that such deterioration or corrosion is a minimum over the life of the plant.

6.5 Plant Life and Mode of Operation

On completion of the R&M project, the plant/equipment and systems individually and collectively shall be possible to operate continuously with routine maintenance and overhauls for an economic service life of not less than fifteen [20/25 years] under the prevailing site conditions and for the type of duty intended.

After R&M of respective equipment/System, the equipment/System shall be able to operate to its rated capacity continuously and there shall be no restriction of the operation of the equipment.

6.6 Packaging & Marking

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection.

While packing all the materials, the limitations from the point of view of availability of railway wagon sizes in India should be taken account of. The details of various wagons normally available with Indian Railways for transportation of heavy equipment shall be considered by the Bidder. The Bidder shall be responsible for all loss or damage during transportation, handling and storage due to improper packing.

The identification marking indicating the name and address of the consignee shall be clearly marked in indelible ink on two opposite sides and top of each of the packages. In addition the Bidder shall include in the marking gross and net weight, outer dimension and cubic measurement. Each package shall be accompanied by a packing note (in weather proof paper) quoting specifically the name of the Bidder, the number and date of contract and names of the office placing the contract, nomenclature of contents and Bill of Material.

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6.7 Protection

Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures. Coated surfaces shall be protected against impact, abrasion, discoloration and other damages. Surfaces that are damaged shall be repainted.

Electrical and C&I equipment shall be protected against moisture and water damages. All external gasket surfaces and flange faces, couplings, rotating equipment shafts, bearings and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other substantial type covering to ensure their full protection. All exposed threaded parts shall be greased and protected with metallic or other substantial type protectors.

All piping, tubing and conduit connections on equipment and other equipment openings shall be closed with rough usage covers or plugs. Male threaded openings shall be closed with rough usage covers or plugs. Female threaded openings shall be closed with forged steel plugs. The closures shall be taped to seal the interior of the equipment. Open ends of piping, tubing and conduit shall be sealed and taped.

Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Bidder's expense.

6.8 Painting

General

All exposed metallic surfaces subject to corrosion shall be protected by shop application of suitable coatings. Surfaces not easily accessible after shop assembly shall be treated before-hand and protected for life of the equipment. Surfaces to be finish painted after installation shall be shop painted with at least two (2) coats of primer. Steel surfaces, which are not to be painted, shall be coated with suitable rust preventive compound subject to the approval of the Owner.

All paints shall be used in accordance with the manufacturer's instructions. No thinners or other substance shall be added to the coating material without the approval of the Owner/Owner's Engineer. The quality and vendor of the paints shall require approval of the Owner.

All paints, when applied in a normal full coat, shall be free from runs, sags, wrinkles, patchiness, brush marks or other defects.

All primers shall be well marked into the surface, particularly in areas where pitting is evident, and the first priming coat shall be applied as soon as possible after cleaning, within four hours maximum. If the drying interval between successive coats, which should not exceed one week, has been so long as to

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endanger the adhesion of the following coat, the paint already applied shall be lightly rubbed down with fine abrasive paper before putting on the next coat.

Paint spraying on large surfaces shall not normally be done indoors, except with the approval of the Owner/Owner's Engineer. Spray guns shall not be used outdoors in windy weather or near unprotected surfaces of a contrasting colour and under no circumstances shall spray guns be used where spray may be carried into or onto exposed electrical equipment.

Paint containers shall not be opened until required and the paint shall be mechanically mixed thoroughly before use, and agitated occasionally during use.

Electrical equipment shall be shop finished with one or more coats of primer and two coats of high-grade oil resistant enamel. The interior of all panels' cabinets and enclosures shall be finished with gloss white enamel.

The Bidder shall furnish sufficient touch up paint for one complete finish coat on all exterior factory surfaces of each item of equipment. The touch up paint shall be of the same type and colour as the factory applied paint and shall be carefully packed to avoid damage during shipment. Complete painting instructions shall be furnished.

Shop primer for steel and iron surfaces which will have a continuous operating temperature below [35 °C] shall be selected by the Bidder, in accordance to the relevant standard. Special high temperature primer shall be used on surface exposed to operating temperature above [35 °C].

The colour scheme shall be submitted during execution of contract for approval by the Owner/Owner's Engineer.

Preparation

Oil and grease shall be removed from the surface by washing with a suitable detergent, rinsing with clean water, and drying.

Surfaces to be shot blasted shall be cleaned, and all dust remaining after cleaning shall be removed.

The priming coat shall be applied without delay.

Damaged Paintwork

Any damaged paintwork shall be corrected / modified as follows:

- a) The damaged area, together with an area extending 25mm around its boundary, shall be cleaned down to bare metal.
- b) A priming coat shall be immediately applied, followed by a full paint finish equal to that originally applied and extending 50mm around the perimeter of the original damage.

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- c) The repainted surface shall present a smooth surface. This shall be obtained by carefully chamfering the paint edges before and after priming.

Painting Systems

The requirements for the dry film thickness (DFT) of paint and the materials to be used shall be as stated below, unless otherwise specified elsewhere in this specification.

Surfaces Subject to Weathering

All surfaces shall have a minimum of four coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	35 micron DFT per coat

The total minimum DFT shall be 140 micron.

Surfaces Inside Buildings

All surfaces shall have a minimum of three coats of paint made up as follows:

Primer coat	:	35 micron DFT
Tie coat	:	35 micron DFT
Finishing coat (2 Nos.)	:	25 micron DFT per coat

The total minimum DFT shall be 120 micron.

The type and colour of primer & finish coat shall be selected by the Bidder after approval by the Owner.

6.9 Environment Protection

Environment Protection

The plant & equipment under this R&M project shall be designed for installation and operation in harmony with the surrounding environment and all measures of pollution control shall be ensured by the Bidder to restrict pollution from the liquid effluent within the limits as given below with due consideration of Environment (Protection) Rules.

For Liquid Effluent

During construction activities, Bidder shall maintain the statutory compliance of State Pollution Control Board and MoEF in respect of pollution control and environmental protection within and around plant boundary. Any specific requirement of State Pollution Authorities over and above shall be maintained. In absence of Indian Standard for emission from power plants as on date, for certain gaseous effluents, the internationally accepted World Bank Standard is to be followed.

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Noise Level Requirement

The plant & equipment under this R&M project will be designed, constructed and provided with suitable acoustic measures to ensure the noise level criteria as per the following stipulations of MoEF & State Pollution Control Board.

Maximum noise level shall not exceed 85 dB (A) when measured at 1.0 m away from the noise emission source.

Maximum noise level from its source within the premises shall not exceed 70 dB (A) as per Environment (Protection) Rules 1986, Schedule-III, 'Ambient Air Quality Standards' in respect of noise.

Any statutory changes in stipulations regarding noise limitation that may occur in future according to State Pollution Control Board or Central pollution Control Board or Ministry of Environment & Forest regulation during tenure of the contract, the bidder shall comply with the updated/amended requirement.

6.10

Inspection and Testing

Inspection and Tests during Manufacture

The method and techniques to be used by the Bidder for the control of quality during manufacture of all plant and equipment shall be agreed with the Owner prior to the Award of Contract.

The Owner's general requirements on quality control as mentioned in section II of this volume and shop tests as mentioned in the respective volumes of this tender documents.

Owner shall be informed for witnessing the shop tests of any item of the plant or equipment for checking the compliance with the specification requirement and or related standards prior to leave place of manufacturing.

Advance notice shall be given to the Owner as agreed in the Contract, prior to the stage of manufacture being reached, and the piece of equipment must be held at this stage until the Owner has inspected the piece, or has advised in writing that inspection is waived. If having consulted the Owner and given reasonable notice in writing of the date on which the piece of equipment will be available for inspection, the Owner does not attend, the Bidder may proceed with manufacture having forwarded to the Owner duly certified copies of his own inspection and test results.

The Bidder shall forthwith forward to the engineer duly certified copies of the Test Certificates in [six copies] (one to the Owner and five to the O&M Consulting Engineer) for approval. Further [nine (9)] copies of Shop Test Certificates shall be bound with Instruction Manuals.

All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.

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Where accurate alignment is necessary for component parts of machinery normally Assembled on site, the Bidder shall allow for trial assembly prior to dispatch from place of manufacture.

All materials used for the manufacture of equipment covered under this specification shall be of tested quality. Relevant test certificates shall be made available to the Owner. The certificates shall include tests for Electrical and mechanical properties of representative material.

Performance Tests at Site

The full requirements for testing the system shall be agreed between the Owner and the Bidder prior to Award of Contract. The completely erected System shall be tested by the Bidder on site under normal operating conditions. The Bidder shall also ensure the correct performance of the System under abnormal conditions, i.e. the correct working of the various emergency and safety devices, interlocks, etc.

The Bidder shall provide complete details of his normal procedures for testing, for the quality of erection and for the performance of the erected equipment.

The Bidder shall furnish the quality procedures to be adopted for assuring quality from the receipt of material at site, during storage, erection, pre-commissioning to tests on completion and commissioning of the complete system/equipment.

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7 LAYOUT CONSIDERATION

{Effort should be given to keep the Layout of the newly equipped system / packages under the R&M project unchanged to the extent possible with respect to existing layout to avoid disturbance to the existing equipment & facilities for which any modification/changes are not envisaged based on RLA/LA and EA assessment.}

The Existing layout details of the plant are indicated in the enclosed drawings as Annexure-I. However, the Bidder to suggest his own modified layout arrangement which shall be subject to approval of the purchaser.

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8 PERFORMANCE GUARANTEES

The term "Performance Guarantees" wherever appears in this Section shall have the same meaning and shall be synonymous to "Functional Guarantees".

Similarly the term "Performance Tests" wherever appears in this Section shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

8.1 General Requirements

- 8.1.1 The Bidder shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in this technical Specification.
- 8.1.2 The guaranteed performance parameters furnished by the Bidder in the Bid proposal, shall be without any tolerance values and all margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures.
- 8.1.3 The Bidder shall demonstrate all the guarantees covered herein under Category I & III during functional guarantee / acceptance test. The various tests which are to be carried out during performance guarantee/acceptance test are listed elsewhere in this specification. The guarantee tests shall be conducted by the Bidder at [manufacturer's work/site] as per approved FAT in presence of Owner on the equipment.
- 8.1.4 All costs associated with the tests including the cost associated with the supply, calibration, installation and removal of test instrumentation shall be included in the price offered by Bidder.
- 8.1.5 It shall be the responsibility of the Bidder to make the plant ready for the performance guarantee tests.
- 8.1.6 All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Bidder shall get these instruments calibrated in an independent test institute approved by the Owner. All test instrumentation required for performance tests shall be supplied by the Bidder and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subjected to the approval of the Owner.
- 8.1.7 Tools and tackles, instruments/devices etc. and any special equipment, required for the successful completion of the tests, shall be provided by the Bidder free of cost.
- 8.1.8 The Performance/ Acceptance test shall be carried out as per the agreed procedure. The PG test procedure including demonstration tests shall be submitted within [90 days] of the date of Notification of Award and finalization of the PG test procedure shall be done within [180 days] from the date of Notification of Award. After the conductance of Performance test, the

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Bidder shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. However, preliminary test reports shall be submitted to the Owner after completing each test run.

8.1.9 The PG test procedures shall be submitted for equipment/ system & subsystem under Bidder's scope for all Guarantees under Category I and III as mentioned below, as per latest International codes & standard including correction curves, meeting the Specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.

8.1.10 The Bidder shall submit for Owner's approval the detailed Performance Test procedure containing the following:

- Objective of the test.
- Various guaranteed parameters & tests as per Contract.
- Method of conductance of test and test code.
- Duration of test, frequency of readings & number of test runs.
- Method of calculation.
- Correction curves.
- Instrument list consisting of range, accuracy, least count, and location of instruments.
- Scheme showing measurement points.
- Sample calculation.
- Acceptance criteria.
- Any other information required for conducting the test.

8.1.11 In case, during performance guarantee tests, it is found that the equipment/systems has failed to meet the guarantees, the Bidder shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Owner. However, if the Bidder is not able to demonstrate the guarantees, even after the above modifications/replacements within [ninety (90) days] or a reasonable period allowed by the Owner after the initial performance guarantee tests have been completed, the Owner will have the right to impose the stipulated clauses under Guarantee Category I, III as specified in this Specification:

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8.1.12 For Category-I Guarantees

Reject the equipment/system/plant and recover from the Contractor payments already made

(OR)

Accept the equipment/system/plant after levying Liquidated Damages (LD) as specified in Clause No. 5.6 of Volume I of this specification. The LD's shall be prorated for the fractional parts of the deficiencies.

8.1.13 For Category-II Guarantees

Reject the equipment/plant/system and recover, from the Contractor, the payments already made. Conformance to the performance requirements under Category-II is mandatory.

8.1.14 For Category-III Guarantees

Reject the equipment/system/plant & recover, from the Contractor, the payments already made.

(OR)

Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the contract price an amount equivalent to the damages as determined by the Owner. Such damages shall however be limited to the cost of replacement of the equipment/systems replacement of which shall remove the deficiency so as to achieve the guaranteed performance.

8.2 Performance Guarantees under Category-I

The performance guarantees which will attract liquidated damages shall be as follows:

- (i). **Transformer losses:** Losses covered in Power Transformers. Loss per kW of GT, ST and UT shall be as follows;

A. Guaranteed Copper Losses

B. Guaranteed Iron Losses

8.2.1 Limit of Technical Parameters under Liquidated Damages Applicable For Category-I Guarantees:

Table: 8.1

S.No.	Parameter	Performance Limit
1	Transformer losses at rated load	If Exceeds beyond [0.5%] of guaranteed value [(i.e. + 0.5 %)]
2	Auxiliary Power	Increase beyond [1%] of guaranteed

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value.(ie. + [1.0 %])

8.2.2 Auxiliary Power Consumption

The auxiliary power consumption shall be calculated using the following relationship.

$$P_{au} = \sum P_u$$

P_{au} = Guaranteed Auxiliary Power Consumption.

P_u = Power consumed by each of the auxiliaries of eBOP package Equipment/System.

While guaranteeing the auxiliary power consumption the bidder shall necessarily include all continuously operating auxiliaries of equipments.

[The auxiliaries to be considered shall include but not be limited to the following:

- i) Generator Transformer Auxiliary power consumption for fans and pumps.*
- ii) Station Transformer Auxiliary power consumption for fans and pumps.*
- iii) Unit Transformer Auxiliary power consumption for fans and pumps.*
- iv) Generator Circuit Breaker Auxiliary power consumption (if applicable).*
- v) Switchyard Auxiliary Power Consumption*
- vi) Power consumption of any other Equipment/system]*

Note:

1. The Bidder shall furnish a list of equipment/system to be covered under auxiliary power consumption, which shall be subject to Owner's approval.

8.3 Performance Guarantees under Category-II

Not Applicable.

8.4 Performance Guarantees under Category-III

The parameters/capabilities to be demonstrated for various systems/equipment shall include but not be limited to the following:

8.4.1 Temperature rise at rated load

The temperature rise of Oil and Windings under rated conditions shall be within limits as prescribed in the Tender Specification when measured under specified ambient temperature. In the event, the rated load is not available;

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the temperature rise may be determined by calculation/extrapolation from measured values at any other load as per standards.

8.4.2 Noise

All the equipment and systems covered under this Specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency specified.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 60651 or BS 5969 or IS 9779.

Equivalent "A" weighted Sound pressure shall be measured all around the equipment at a distance of 1.0 m from the Noise emitting source.

A minimum of 6 points around each equipment shall be covered for measurement. Additional measurement points shall be considered based on the applicable standards and the size of the equipment. The measurement shall be done with slow response on the A - weighting scale. The average of A-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed the guaranteed value. Corrections for background noise shall be considered in line with the applicable standards. All the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests.

If the noise level recorded is beyond the limits specified above, the Bidder should provide suitable acoustic cladding to mitigate the noise level to within allowable limits.

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9 SPARE PARTS

The bidder shall include in his scope of supply all the necessary mandatory spares, start up and commissioning spares and recommended spares and indicate these in the relevant schedules. The general requirements pertaining to the supply of these spares is given below:

9.1 Mandatory Spares

The list of mandatory spares considered essential by the purchaser is enclosed in Annexure -II of this specification. The bidder shall indicate the prices for each and every item (except for items not applicable to the bidders design) in the 'Schedule of mandatory spares' whether or not he considers it necessary for the Owner to have such spares. If the bidder fails to comply with the above, the cost of such spares shall be deemed to be included in the contract price. The bidder shall furnish the population per unit of each item in the relevant Schedules. Whenever the quantity is mentioned in "sets" the bidder has to give the item details and prices of each item.

Whenever the quantity is indicated as a percentage, it shall mean percentage of total population of that item in the station (project) unless specified otherwise, and the fraction will be rounded off to the next higher whole number. Wherever the requirement has been specified a 'set' it will include the total requirement of the item for a unit, module or the station or as specified. Where it is not specified a 'set' would mean the requirement for the single equipment/system as the case may be. Also the 'set' would include all components required to replace the item; for example, a set of bearings shall include all hardware normally required while replacing the bearings.

The Owner reserves the right to buy any or all the mandatory spare parts.

All mandatory spares shall be delivered at site at least two months before scheduled date of initial operation of the first unit. However, spares shall not be dispatched before dispatch of corresponding main equipment.

Wherever quantity is specified both as a percentage and a value, the bidder has to supply the higher quantity until and unless specified otherwise.

9.2 Recommended Spares

In addition to the spare parts mentioned above, the Bidder shall also provide a list of recommended spares for five [5] years of normal operation of the plant and indicate the list and total prices in relevant schedule. The list shall take into consideration the mandatory spares specified and should be independent of the list of the mandatory spares. The purchaser reserves the right to buy any or all of the recommended spares. The recommended spares shall be delivered at project site at least two months before the scheduled

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date of initial operation of first unit. However, the spares shall not be dispatched before the dispatch of the main equipment.

Prices of recommended spares will not be used for evaluation of the bids. The price of these spares will remain valid up to execution of the contract. However, the Bidder shall be liable to provide necessary justification for the quoted prices for these spares as desired by the Owner.

9.3 Start-up & Commissioning Spares

Start up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system till the commercial operation of the Plant. The Bidder shall provide all such start up and commissioning spares and keep an adequate stock of the same to be brought by him to the site for the plant erection and commissioning. These must be available at site before the equipment is energized. The unused spares, if any, should be removed from there, only after commercial operation of the plant. All start up spares which remain unused at the time shall remain the property of the Bidder.

9.4 General Requirements

The Bidder shall indicate the service expectancy period for the spares parts (both mandatory and recommended) under normal operating conditions before replacement is necessary.

All spares supplied under this contract shall be strictly inter-changeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desiccators packs as necessary.

All the spares (both recommended and mandatory) shall be manufactured along with the main equipment components as a continuous operation as per same specification and quality plan.

The Bidder will provide Owner with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the Owner to identify and finalize order for recommended spares.

Each spare part shall be clearly marked or labeled on the outside of the packing with its description. When more than one spare part is packed in a single case, a general description of the content shall be shown on the outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.

All cases, containers or other packages are to be opened for such examination as may be considered necessary by the purchaser.

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The Bidder will provide the Owner with all the addresses and particulars of his sub-suppliers while placing the order on vendors for items/ components/ equipment covered under Contract and will further ensure with his vendors that the Owner, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.

The Bidder shall warrant that all spares supplied will be new and in accordance with the Contract documents and will be free from defects in design, material and workmanship.

In addition to the recommended spares listed by the Bidder, if the Owner further identifies certain particular items of spares, the Bidder shall submit the prices and delivery quotation for such spares within 30 days of receipt of such request for consideration by the Owner and placement of order for additional spares if the Owner so desires.

The Bidder shall guarantee the long term availability of spares to the Owner for the full life of the equipment covered in the Contract. The Bidder shall guarantee that before going out of production of spare parts of the equipment covered under the Contract, he shall give the purchaser at least 2 years advance notice so that the latter may order his bulk requirement of spares, if he so desires. The same provision will also be applicable to Sub-Bidders. Further, in case of discontinuance of manufacture of any spares by the Bidder and/or his sub-Bidders, Bidder will provide the purchaser, two years in advance, with full manufacturing drawings, material specifications and technical information including information on alternative equipment makes required by the Owner for the purpose of manufacture/procurement of such items.

The prices of all future requirements of spares beyond 5 years shall be derived from the corresponding FOB/Ex-works price at which the order for such spares have been placed by the purchaser as a part of the mandatory spares or recommended spares. FOB/Ex-works order price of future spares shall be computed in accordance with the price escalation formula to be furnished by Bidder indicating base price reference variation indices for material, labour etc. Based on the formula and considering escalation indices prevailing at the time of order of spares, order price shall be worked out. The base indices will be counted from the scheduled date of successful completion of trial operation of the last plant/equipment under the project. The above option for procuring future recommended spares by the purchaser shall remain valid for the period of fifteen (15) years from the date of successful completion of trial operation of the last plant/equipment. In case the spare parts from the same sub-vendor are not available due to obsolescence or any other reason, the Bidder shall supply the spares for a period of fifteen [15] years from an alternative source.

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10 ANNEXURES

10.1 Annexure –I (List of Existing Drawing)

{Available as Build/RFC drawing of the Existing Equipment/System shall be provided to the Bidder as per the list mentioned in Annexure-I for their information & familiarization of the existing Unit}

10.2 Annexure –II (Mandatory Spares))

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II}

10.3 Annexure-III (List of Sub-Vendor)

{List of Sub-vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as per the format in Annexure-III}

10.4 RLA/CA Study Report

{Not attached with this document. This is to be provided by utilities}

10.5 EA Study Report

{Not attached with this document. This is to be provided by utilities}

10.6 Base line Study Report

{Not attached with this document. This is to be provided by utilities}

10.7 Geotechnical Investigation Report

{Not attached with this document. This is to be provided by utilities}

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-I, ANNEXURE-I
LIST OF EXISTING DRAWING**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-I

List of Existing Drawing

{Available As- Built/RFC drawings of the Existing Unit based on the actual scope of work shall be provided to the Bidders as per the list mentioned below for their information & familiarization of the existing Unit}

i) ELECTRICAL

[Drawings as listed below provide the details/arrangements for all the equipments covered in this specification.]

S.No.	Drawing/Document No.	Title
1	[.....]	[General Layout (Plot Plan)]
2	[.....]	[Key Single Line Diagram]
3	[.....]	[Main Single Line Diagram]
4	[.....]	[General layout battery limit]
5	[.....]	[Symbol /Legends]
6	[.....]	[General Arrangement & Schematic Diagram of Switchyard equipments] {Equipments wise to be provided}
7	[.....]	[General Arrangement of SAS configuration diagram]
8	[.....]	[General Arrangement of ABT Metering configuration diagram]
9	[.....]	[General Arrangement of SCADA architecture configuration diagram for power plant]
10	[.....]	[General Arrangement & Schematic Diagram of Generator Transformer]
11	[.....]	[General Arrangement & Schematic Diagram of Station Transformer]
12	[.....]	[General Arrangement & Schematic Diagram of Unit

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S.No.	Drawing/Document No.	Title
		Transformer]
13	[.....]	[General Arrangement & Schematic Diagram of Switchyard Service Transformer]
14	[.....]	[General Arrangement & Schematic Diagram of Generator Circuit Breaker]
15	[.....]	[General Arrangement and Schematic drawing of LV switchgear]
16	[.....]	[General Arrangement and Schematic drawing of DC and UPS system]
17	[.....]	[General Arrangement and Schematic drawing of Cables]. {Voltage grade as well application wise i.e power , control wise to be provided}
18	[.....]	[General Arrangement and Schematic drawing of NSPBD]
19	[.....]	[Cable Tray Layout and BOQ of Cable Carrier System]. {Building wise to be provided}
20	[.....]	[Lighting Layout and BOQ & Calculation of Lighting System]. {Building wise to be provided}
21	[.....]	[Earthing and Lightning Layout, BOQ and Earth Mat calculation of Earthing and Lightning System]. {Building wise to be provided}
22	[.....]	[Any other drawings /documents for eBOP package(if applicable)]

ii) **CIVIL**

S.No.	Drawing No.	Description
1.	[.....]	[Analysis and Design of Switchyard equipment foundation]
2.	[.....]	[GA and Architecture details of Switchyard]

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S.No.	Drawing No.	Description
		<i>equipment foundation]</i>
3.	<i>[.....]</i>	<i>[Analysis and Design of Switchyard Control Room]</i>
4.	<i>[.....]</i>	<i>[GA and Architecture details of Switchyard Control Room]</i>
5.	<i>[.....]</i>	<i>[Analysis and Design of Switchyard GIS Building (if applicable)]</i>
6.	<i>[.....]</i>	<i>[GA and Architecture details of Switchyard GIS Building(if applicable)]</i>
7.	<i>[.....]</i>	<i>[Analysis and Design of GCB foundation]</i>
8.	<i>[.....]</i>	<i>[Analysis and Design of Power transformer foundation and fire wall] { Application wise i.e. GT/UT/ST to be provided}</i>
9.	<i>[.....]</i>	<i>[GA and RCC details of Power transformer foundation and fire wall] { Application wise i.e. GT/UT/ST to be provided}</i>
10.	<i>[.....]</i>	<i>[Analysis and Design of foundation of Lighting poles etc]</i>
11.	<i>[.....]</i>	<i>[GA and Architecture details of Lighting poles etc]</i>
12.	<i>[.....]</i>	<i>[Any other drawings /documents for eBOP package(if applicable)]</i>

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**RENOVATION & MODERNISATION
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FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-I, ANNEXURE-II
MANDATORY SPARES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-II

Mandatory Spares

{Applicable Mandatory Spares for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as detailed in Annexure-II}

1. ELECTRICAL

S.No / Cl. No.	Item	Unit	Quantity	Remarks
	[400/220kV] SWITCHYARD SPARES			
1	Circuit Breaker			
	(For the following items each type & rating to be repeated)			
1.1	Trip coils for circuit breaker	No.	4	
1.2	Closing coils for circuit breaker	No.	4	
1.3	Gaskets	Set	6	
1.4	Motor for circuit breaker operating mechanism (If applicable)	No	2	
1.5	Valve block with drive cylinder for circuit breakers	Set	2	
1.6	Motor for earthing switch	No.	1	
1.7	Motor for disconnectors	No.	1	
1.8	Operating mechanism for disconnectors	Set	1	
1.9	Operating mechanism for earthing switch	Set	1	
1.10	SF6 gas cylinder with 40 kgs of SF6 gas	No	3	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
1.11	Control switch and auxiliary relay	No	4	
1.12	MCB (as applicable)	No	4	
1.13	Current Transformers	Set	1	
1.14	SF6 Air Bushing	No	3	
2	Voltage/Current Transformer	No.	2	
	(For the following items each type & rating to be repeated)			
2.1	CT/VT of each type	No.	2	
2.2	Oil Seals	Set	1	
2.3	Insulators	No.	1	
2.4	Gaskets (all sizes used)	Set	1	
2.5	Oil filling, draining and sampling plugs	Set	1	
2.6	Oil level gauge	No	2	
3	360 KV LIGHTNING ARRESTERS			
	(For the following items each type & rating to be repeated)			
3.1	Lightning Arrester with accessories	No.	3	
3.2	LA Gaskets (all sizes used)	Set	1	
3.3	Insulator column for lightning arrestors	No,	1	
3.4	LA Surge counter with leakage current monitor	No.	2	
4	WAVE TRAP			
	(For the following items each type & rating to be repeated)			
4.1	Wave Trap complete with all accessories	Set	2	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
4.2	PLCC			
	(For the following items each type & rating to be repeated)			
	Electronic Cards/ of each type	Set	1	
	Relays/ Adaptors/ meters	No	2	
	Line Matching Unit	Set	1	
5	SWITCHYARD EQUIPMENT ACCESSORIES			
5.1	Glazed Brown Insulator	Set	2	
5.2	Suspension Insulator String Assembly Set with Hardware	No.	2	
5.3	ACSR MOOSE Conductor	M	300	
5.4	4.0" AL Tube	M	20	
5	SAS CABINETS AND RELAY PANELS			
5.1	(For the following items each type & rating to be repeated)			
5.2	Relays of each type and rating	Set	2	
5.3	Meters of each type and rating	Set	2	
5.4	Indicating Lamp Each type	Set	6	
5.5	Annunciator each type and colour	Set	2	
5.6	Contactor each type and rating	Set	2	
5.7	Aux. Relay each type and rating	Set	6	
5.8	Switches/MCB of each type and rating	Set	2	
5.9	Electronic cards of each type including I/O Cards	No	1	
5.10	Clamps and connector of each type	set	1	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
6	PROTECTION , CONTROL & RELAY PANELS			
	(FOR Substation and Station Transformer) (to be repeated for each panel)			
6.1	Protective relays of each type	No.	1	
6.2	Trip relays of each type	No.	1	
6.3	Auxiliary relays of each type	Nos.	2	
6.4	Timers of each type	No.	1	
6.5	Power supply module of each type	No.	1	
6.6	Meters of each type	No.	1	
6.7	Energy meter of each type	No.	1	
6.8	Switches of each type	No.	1	
6.9	Push Buttons of each type	Nos.	2	
6.10	Fuses of each type & rating	Nos.	20	
6.11	Disconnecting type Terminal Blocks for CT wiring	Nos.	5	
6.12	Non-disconnecting type Terminal Blocks	Nos.	5	
6.13	Auxiliary CTs of each ratio	No.	1	
6.14	Auxiliary VTs of each ratio	No.	1	
6.15	Transducers of each type	No.	1	
7	[420kV] Isolators			
7.1	Copper contact fingers for female & male contacts of rating 2500A	Set	3	
7.2	Aux. Relays, power contactors, MCBs, switch fuses, push buttons and resistors for electrical control	Set	2 nos. of each type	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
	circuit as per approved schematic		& rating	
7.3	Terminal Connectors (each type)	Set	2	
7.4	Limit switch and auxiliary contact (complete for one MOM box of isolator)	Set	2	
7.5	Motor housing bearing assembly	Set	2	
7.6	Motor with gear and level gear assembly	Set	2	
7.7	Corona shielding ring of each type	Set	1	
7.8	Bearings of each type	Set	1	
7.9	Interlocking coil, timers, key interlock of each type	Set	2	
8	Insulator & Hardware			
8.1	String/Strain insulators with hardware of each type	Nos.	1	
8.2	Bus post insulators	Nos.	3	
9	SCADA			
9.1	Bay control unit (complete with all components)	No.	1	
9.2	Operator work station along with software, monitor, mouse, keyboard, etc.	No.	1	
9.3	Lamps/LEDs used in the system	Nos.	10% of total qty.	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
9.4	Power supply modules used in the system	Nos.	2 nos. of each type	
9.5	Interface cables containing standard length of each type of cable and its connector for each type of peripheral	Sets	2	
9.6	MCBs used in the system	Nos.	10% of total qty.	
10	Clamps & Connectors			
10.1	Clamps, connectors, corona bells, spacers, etc.	Set	10% of total qty.	
11	ACDB & DCDB			
11.1	MCCB	Nos.	1 no. of each type	
11.2	MCBs	Nos.	1 no. of each type	
12	GENERATOR TRANSFORMER			
	(For the following items each type & rating to be repeated)			
12.1	HV bushing	No	1	
12.2	LV bushing	No	1	
12.3	HV neutral bushing	No	1	
12.4	Bushing CT (HV for winding temperature indicator)	set	1	
12.5	Bushing CT (LV for winding temperature indicator)	set	1	
12.6	Neutral Bushing CT (HV)	set	1	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
12.7	Complete set of gaskets	No	1	
12.8	Cooler fan with motor	No	1	
12.9	Oil pump with motor	No	1	
12.10	Valve of each type	set	1	
12.11	Magnetic oil level gauge with contacts	No	1	
12.12	Pressure relief device with contacts	No	1	
12.13	Winding temperature indicator with all accessories	No	1	
12.14	Dial type Oil temperature indicator	No	1	
12.15	Spare winding for one limb consisting of HV/LV in oil filled sealed container.	No	1	
12.16	Silica gel breather	No	1	
12.17	Prismatic Oil level gauge	No	1	
12.17	Power Contactor	No	1	
12.18	Control Contactor	No	1	
12.19	Buchholz relay for transformer	No	1	
12.20	Oil flow indicator	No	1	
12.21	Thermostat for transformer Marshalling box	No	1	
13	UNIT TRANSFORMER			
	(For the following items each type & rating to be repeated)			
13.1	HV bushing	No	1	
13.2	LV bushing	No	1	
13.3	LV neutral Bushing	No	1	
13.4	Bushing CT (HV for winding	set	1	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
	temperature indicator)			
13.5	Bushing CT (LV for winding temperature indicator)	set	1	
13.6	Neutral Bushing CT (LV)	set	1	
13.7	Complete set of gaskets	set	1	
13.8	Cooler fan with motor	No	1	
13.9	Valve of each type	set	1	
14.0	Magnetic oil level gauge with contacts	No	1	
14.1	Pressure relief device with contacts	No	1	
14.2	Winding temperature indicator with all accessories	No	1	
14.3	Dial type Oil temperature indicator	No	1	
14.4	Silica gel breather	No	1	
14.5	Prismatic Oil level gauge	No	1	
14.6	Power Contactor	No.	1	
14.7	Control Contactor	No.	1	
14.8	Buchholz relay for transformer	No	1	
14.9	Thermostat for transformer marshalling box	No	1	
15	STATION TRANSFORMER			
	(For the following items each type & rating to be repeated)			
15.1	HV bushing	No	1	
15.2	LV bushing	No	1	
15.3	HV neutral Bushing	No	1	
15.4	LV neutral Bushing	No	1	
15.5	Bushing CT (HV for winding	Set	1	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
	temperature indicator)			
15.6	Bushing CT (LV for winding temperature indicator)	Set	1	
15.7	Neutral Bushing CT (HV)	Set	1	
15.8	Neutral Bushing CT (LV)	Set	1	
15.9	Complete set of gaskets	Set	1	
15.10	Cooler fan with motor	No	1	
15.11	Valve of each type	Set	1	
15.12	Magnetic oil level gauge with contacts	No	1	
15.13	Pressure relief device with contacts	No	1	
15.14	Winding temperature indicator with all accessories	No	1	
15.14	Dial type Oil temperature indicator	No	1	
15	OLTC motor	No	1	
15.1	Silica gel breather	No	1	
15.2	Prismatic Oil level gauge	No	1	
15.3	Power Contactor	No.	1	
15.4	Control Contactor	No.	1	
15.5	Buchholz relay for transformer	No	1	
15.5	Buchholz relay for OLTC	No	1	
15.6	Thermostat for transformer marshalling box	No	1	
16	LT TRANSFORMER (Oil/Dry type)			
	<i>(for each type and rating of transformers)</i>			
16.1	<i>Complete Winding Temperature indicating equipment</i>	<i>Set</i>	<i>1</i>	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
16.2	CTs of each type and rating	No.	1	
16.3	Support Insulators	Set	2	
16.4	HV bushing	Nos	4	
16.5	LV bushing	Nos	4	
16.6	LV neutral Bushing	Nos	2	
16.7	Bushing CT(LV) of each rating	Nos	2	
16.8	Complete set of gaskets	Sets	2	
16.9	One valve of each type	Sets	2	
16.10	Magnetic oil level gauge with contacts (for oil type)	Nos	2	
16.11	Winding temperature indicator(WTI) with all accessories	Nos	2	
16.12	Dial type Oil temperature indicator(OTI) (for oil type)	Nos	2	
16.13	Silica gel breather	Nos	2	
16.14	Buchholz relay	Nos	2	
16.15	Radiator unit	No.	1	
16.16	Pressure relief device	Nos	2	
16.17	Tap Changer Contact	Set	1	
17	415V SWITCHGEAR (Spares to be repeated for each make of board)			
17.1	Spares for Breaker (Spares for each rating of Breaker)			
17.2	Breaker complete with operating mechanism and truck mounted	Nos.	1	
17.3	Closing & tripping coils each	Nos.	1	
17.4	Fixed and moving contact assemblies of each breaker	Nos.each	2	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
17.5	Spring charging motors	Nos.	2	
17.6	Gaskets	Sets	5	
17.7	Aux.switch assembly, limit position switches	nos. each	3	
17.8	Busbar support insulators of each type	Nos.	10	
17.9	Switches of each type	No.	1	
17.10	Numerical Relays of each type	No.	1	
17.11	Auxiliary relays of each type	No.	1	
17.12	Interposing relay of each type for DDCMIS	No.	1	
17.13	Clustered type LED of each type/colour	Nos.	2	
17.14	CTs of each ratio , type and rating	Nos.	3	
17.15	VTs of each ratio , type and rating	Nos.	3	
17.16	Meters of each type	No.	1	
17.17	Fuse and fuse base assembly of each type & rating	Nos.	10	
17.18	Timer each type	No.	1	
17.19	Check synchronizing relay	No.	1	
17.20	Disconnecting type Terminal block for CT wiring	Nos.	5	
17.21	Non-disconnecting type Terminal Block	Nos.	5	
17.22	Selector switch of each type and rating	Nos.	2	
18	ACDB/PDB PANEL (To be repeated for each board)			
	(For the following items each type & rating to be repeated)			
18.1	Power Fuse	No.	2	
18.2	Control Fuse	No.	5	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
18.4	Push button with contact element	No.	2	
18.5	Ammeter	No.	2	
18.6	Voltmeter	No	2	
18.7	Terminal Blocks	No	2	
18.8	MCB	No.	2	
18.9	SFU/MCCB	No.	2	
19	DC and UPS System			
19.1	BATTERY CHARGER & DCDB			
	Thyristor / SCR	No.	6	
	Diode	No.	6	
	Contactor	No.	2	
	Relay	No	1	
	Selector switch	No.	2	
	Control switch	No	2	
	Meter	No.	2	
	PCB	Set.	2	
	Push Button with contact element	No.	2	
	Control Transformer	No.	2	
	LED indication lamp	No.	5	
	Switch Fuse Unit / MCCB	No.	2	
	Power Fuse	No.	3	
	Control Fuse	No.	3	
	Semi conducting Fuse	No.	6	
	MCB	No.	2	
19.2	UPS (INVERTERS) with ACDB			

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
	IGBT cards	No.	3	
	PCB	No.	1	
	Rectifiers / bridges	No.	2	
	Control cards and auxiliary cards	No.	1	
	Switch Fuse Unit / MCCBs	No.	3	
	Power Fuse	No.	3	
	Control Fuse	No.	3	
	MCB	No.	2	
19.3	415 V NON-SEGREGATED PHASE BUS DUCTS			
19.4	Set of flexible of each type and rating	Nos.	3	
19.5	Gaskets of each type and rating	Sets.	3	
19.5	Space heater set	Set	1	
19.6	Set of seal-off bushing of each type and rating (Applicable for oil type transformer)	Nos.	3	
19.7	Set of flexible of each type and rating	Nos.	2	
19.8	Drain plug with cap	Nos.	3	
19.9	Silica gel breathers	Nos.	3	
19.10	Gaskets of each type and rating	Sets.	3	
19.11	Belleville washers	Nos	5	
19.12	Densal or equivalent compound	Kg.	1	
19.13	Space heater set	Sets	1	
20	ILLUMINATION SYSTEM			
	MLDB/LDB Panel (To be repeated for each board)			
	(For the following items each type & rating to be repeated)			
20.1	Temperature surveillance unit for Lighting Transformer	No.	1	

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
20.2	RTD element for Lighting Transformer	Set	1	
20.3	Busbar support insulators of different sizes	Set	2	
20.4	Power Fuse	No.	2	
20.5	Control Fuse	No.	2	
20.5	Push Buttons with contact element	No.	5	
20.6	Ammeter	No.	1	
20.7	Voltmeter	No	1	
20.8	Power Terminal Block	No	2	
20.9	MCB	No.	2	
20.10	MCCB/SFU	No.	2	
21	ALDB/LDB PANEL			
	(For the following items each type & rating to be repeated)			
21.1	Busbar support insulators of different sizes	Set	2	
21.2	Power Fuse	No.	20	
21.2	Control Fuse	No.	20	
21.3	Push button with contact element	No.	5	
21.4	Ammeter	No.	2	
21.5	Voltmeter	No	2	
21.6	Electronic energy meter	No.	2	
21.7	Terminal Blocks	No	5	
21.8	MCB	No.	5	
21.9	SFU/MCCB	No.	5	
22	PLANT COMMUNICATION			

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
	(For the following items each type & rating to be repeated)			
22.1	EPABX			
	CPU cards(all cards)	Set.	1	
	Power supply card	No.	1	
	Analog Subscriber line card	No.	4	
	PRI card	No.	1	
	Digital line card	No.	1	
	Fuses in EPABX and charger	No	2	
	SMPS module for FCBC	No	1	
22.2	GENERAL ANNOUNCEMENT SYSTEM			
	(For the following items each type & rating to be repeated)			
	Power amplifier PCB card	No.	1	
	Microphone preamplifier PCB card	No.	1	
	Driver Unit for industrial horn speaker	No.	10	
	Industrial type horn	No.	5	
	Speaker for box type speaker	No.	10	
	Switches	No.	2	
	Power Fuses	No.	2	
	Control Fuses	No.	2	
	LEDs	No.	2	
22.3	LOUD SPEAKER TALKBACK SYSTEM			
	(For the following items each type & rating to be repeated)			

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S.No / Cl. No.	Item	Unit	Quantity	Remarks
	Page amplifier PCB card	No.	5	
	Power supply PCB card	No.	5	
	Power supply transformer for the station	No.	5	
	Driver Unit for industrial horn speaker	No.	10	
	Industrial type horn	No.	10	
	Speaker for box type speaker	No.	10	
	Handset with transmitter, receiver & coiled card	No.	10	
	Switches	No.	2	
	Power Fuses	No.	2	
	Control Fuses	No.	2	
	LEDs	No.	2	
22.4	DIGITAL MASTER AND SLAVE CLOCKS			
	(For the following items each type & rating to be repeated)			
	Control and signal PCB card for master clock	No.	1	
	Control and signal PCB card for slave clock	No.	2	
	Power supply transformer for master clock	No.	3	
	Power supply transformer for slave clock	No.	3	
	Switches	No.	2	
	Power Fuses	No.	2	
	Control Fuses	No.	2	

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]

[Logo of Utility]

S.No / Cl. No.	Item	Unit	Quantity	Remarks
	LED	No.	2	
22.5	UHF BAND WIRELESS SYSTEM			
	(For the following items each type & rating to be repeated)			
	Spare batteries	No	25	
	Microphone assembly with PTT and switch	No	10	
	Carrying case for portable sets	No	10	
	Antenna for portable sets	No	10	
	Antenna for fixed stations	No	5	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-I, ANNEXURE-III
LIST OF SUB-VENDOR**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-III

List of Sub-vendor

{List of approved vendor for the equipment system to be replaced / refurbished / retrofitted under the scope of this R&M Tender shall be provided as in the given format.}

A. ELECTRICAL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

B. CIVIL

Sl. No	Item/Equipment Description	Sub Vendors
1.	[.....]	[.....]
2.	[.....]	[.....]
3.	[.....]	[.....]
4.	[.....]	[.....]
5.	[.....]	[.....]
....	[.....]	[.....]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION-ELECTRICAL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Not Used
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Not Used
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Not Used

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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

* * * * *

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SECTION-I: PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II: DETAILED TECHNICAL SPECIFICATION

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2. Detailed Technical Specification-Electrical
3. Detailed Technical Specification-I&C
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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

1. Technical Schedules-Mechanical
2. Technical Schedules-Electrical
3. Technical Schedules-I&C

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

**VOLUME-II,
SECTION-II, PART-B
DETAILED TECHNICAL SPECIFICATION- ELECTRICAL**

**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

Document Number	Rev No.	Description	Page No.	Date of Issue
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1 400/220 KV SWITCHYARD EQUIPMENTS

1.1 General

This specification is intended to cover [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 400/220kV kV switchyard equipments complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table-1

IS-335	New Insulating Oils
IS-398	Aluminum conductors for overhead line purpose
IS-731	Specification for porcelain insulators for overhead power lines with a nominal voltage greater than 1000V
IS-2071	Method of High Voltage Testing
IS-2099	Bushing for Alternating Voltages above 1000V
IS-2121	Conductors and earth wires accessories for overhead power lines
IS-2486	Metal fittings of Insulator for overhead power lines with nominal Voltage greater than 1000V
IS-2544	Porcelain post insulators
IS-2705	Current transformers
IS-3024	Specification for core material
IS-3043	Code of practice for earthing
IS-3070-3	Lightning Arresters for alternating current systems metal oxide surge arresters with gap
IS-3156	Voltage transformers
IS-3188	Characteristics of String Insulator units
IS-3347	Dimensions for porcelain transformer bushings for use in lightly polluted areas
IS-4146	Application guide for Voltage Transformers
IS-4201	Application guide for current transformers

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IS-5082	Wrought Aluminum and aluminum alloy bar rods, tubes and sections, plates and sheets for electrical application
IS-5216	Guide for safety procedure and practices in electrical works
IS-5547	Application guide for Capacitive Voltage Transformers
IS-5621	Hollow Insulators for use in electrical equipment
IS-6209	Methods for partial discharge measurement.
IS-9135	Guide for testing of circuit breaker
IS-9920	HV Switches
IS-9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1000V
IS-10136	Code and practice for selection of disc insulator fittings of highest system voltages of 72.5 kV and above.
IS-13118	High voltage alternating current Circuit Breakers
IS-3070-3	Lightning Arresters for alternating current systems metal oxide surge arresters with gap
IEC-600044-1	Instrument transformers- Current transformers
IEC-60044-2	Instrument transformers- Voltage transformers
IEC-60044-5	Instrument transformers- Capacitive Voltage transformers
IEC-60099-4	Surge arresters- Metal oxide surge arresters with gaps for AC systems
IEC-60099-5	Surge arresters-Selection and application recommendations
IEC-60050-421	International Electro-Technical vocabulary- Power transformers and reactors
IEC-60060	High Voltage Test Techniques
IEC-60071	Insulation Coordination application guide
IEC-60129	Specification for alternating current disconnectors and earthing switches
IEC-60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V
IEC-60185	Current transformers

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IEC-60270	Partial discharge measurement
IEC-60353	Line traps for AC power systems
IEC-60358	Coupling capacitors and capacitor dividers
IEC-60376	Specification of Technical Grade SF6 for use in electrical equipment
IEC-60481	Coupling devices for power line carrier systems
IEC-60495	Single Side Band Power-Line carrier Terminals
IEC-60517	Gas insulated metal enclosed switchgear for rated voltage 72.5 kV and above.
IEC-60529	Degree of protection provided by enclosures (IP code)
IEC-60694	Common clause for High Voltage Switchgear and control gear
IEC-60815	Selection and dimensioning of High Voltage Insulators intended for use in polluted conditions
IEC-61000	Electromagnetic Compatibility
IEC-61128	Alternating current disconnecter-Bus transfer current switching with disconnecter
IEC-62271	High Voltage Switchgear and control gear
IEEE-80	Guide for Safety in AC Substation Grounding
CENELEC / SVDB	Pressure Vessel Codes
CEA	General Guidelines for 765/400/220/132 kV Sub Stations and switchyard of thermal/hydro power projects
CBIP	CBIP manual for Sub Station Equipment

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Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- Switchyard shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchyard shall be suitable for operation in a highly polluted environment.
- Wind velocity, Ice loading and other relevant parameters for sag tension calculation shall be as per relevant project site data.
- 220kV/400kV Switchyard shall be suitable for following voltage & frequency variations as follows:

Table-2

Voltage Variation	(±) 10%
Frequency Variation	(+) 3% to (-)5%
Combined Variation of Voltage & Frequency	10% (absolute sum)
For DC System	(+)10% to (-)15%

- Switching schemes shall be [Double bus/ Double main & transfer bus scheme] for 220 kV systems & [One & Half breaker scheme/ Double main & transfer bus scheme/Double bus scheme] systems for 400kV.
- 220 kV and 400 kV System data shall be as per below table.

Table-3

Sr No	Details	Unit	220kV System	400kV System
1	Rated Voltage	kV	220	400
2	Highest System Voltage	kV	245	420
3	Rated Frequency	Hz	50	50

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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4	Creepage Distance	Mm/kV	[31]	[31]
5	Fault level	KA	[40kA for 1sec]	[40kA for 1 sec]
6	One min power frequency withstand voltage of complete string with corona control rings:	kV _{rms}	460	630(Dry) 680Wet)
7	Switching Impulse withstands Voltage (250/2500μs)-dry and wet.	kV _p	NA	1050
8	Lighting Impulse withstand voltage(1.2/50 μs)	kV _p	1050	1425

- f. For renovation/augmentation of existing substation [AIS, GIS & Hybrid substation] option may be adopted considering space constraints and techno economic viability.
- g. Safety clearances shall be as per voltage level and manufacturer standard practice. [Applicable for GIS and Hybrid substation for all equipment except bus bar].
- h. Thermal rating for all current carrying parts shall be [a minimum of 1 sec at rated voltage] for the rated symmetrical short circuit current. If the maximum short circuit time is extended, the I²x t value shall remain constant.
- i. Safety clearances & bay width for different voltage level shall be as per CBIP Manual, IEC 61936 and IS 10118 Part III. [Applicable for AIS & Hybrid substation]
- j. The lightning protection shall be provided by lightning masts and/or shield wires.
- k. Switchyard control building shall be air conditioned. [If applicable]

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- I. Fencing shall be provided around the outdoor switchyard to restrict unauthorized entry.

1.4 Specific Requirements

1.4.1. Construction

- a. Civil works/structure shall be as per Volume-2/Part D of this specification.
- b. For Hybrid substation bus bar arrangement shall be air insulated and all other switching equipments shall be enclosed in a gas compartment as like as GIS. Therefore all features for bus bar shall be as per AIS and rest of all equipment features shall be as per GIS.
- c. The bays shall be arranged suitably such that skew/deviation of outgoing and incoming connections shall not exceed 30°.
- d. The generator transformer and station transformer shall be suitably connected through overhead lines to switchyard. TG building support/take-off gantry support shall be provided at the opposite ends of each of the above mentioned transformers.
 - i. [Equipment shall be suitable for hot line washing.]
 - ii. Suitable access ways and roadways shall be provided for ease in maintenance of all switchyard equipment and appropriate drainage facilities shall also be provided for outdoor sub-station.
- e. GIS shall be of compact and modular design, fully metal-clad and of the sulphur-hexafluoride (SF₆) insulated type. It shall be constructed for the indicated bus bar system, and shall include all necessary switches and current and voltage transformers, as detailed in the respective attachments. It shall be supplied complete with all auxiliary equipment necessary for operation, routine maintenance, repairs or extensions. [Applicable for GIS & Hybrid]
- f. GIS shall be constructed of suitable material and thickness to withstand the mechanical and thermal stresses due to short circuits and internal arc faults confirming IEC-62271. [Applicable for GIS & Hybrid]
- g. GIS shall be designed for continuous operation under all system operating conditions including sudden change of load and voltage and short circuits within its ratings. The equipment shall be designed to withstand normal operating voltage even if the gas pressure decreases to atmospheric pressure as long as no switching operations are performed. [Applicable for GIS & Hybrid]
- h. Components that may require to be renewed and standard assemblies that may be transferred from one circuit to another, shall be interchangeable and where required this shall be demonstrated by the Bidder. [Applicable for GIS & Hybrid]

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- i. The arrangement of GIS shall be such as to enable dismantling a bay without affecting the adjacent bay. However, to remove the bus bar disconnecter, a shutdown of the relevant section of the bus bar shall be required. *[Applicable for GIS & Hybrid]*
- j. The enclosure and seals shall be designed to withstand the gas pressure encountered under normal and short circuit conditions. The thickness of the enclosures shall be in compliance with relevant code and standard. *[Applicable for GIS & Hybrid]*
- k. Viewing windows shall be provided at the disconnectors and earthing switches to ensure that each contact position can be inspected. Each section shall have plug-in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the operative equipment. *[Applicable for GIS & Hybrid].*
- l. Materials used in the manufacture of the GIS equipment shall be of the type, composition and physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All joint surfaces shall be machined, and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system. *[Applicable for GIS & Hybrid]*
- m. The initial gas filling of the switchgear and sufficient extra SF₆ gas (10% of total) for compensation of possible losses during installation and service shall be supplied. A wheeled maintenance device shall be supplied with pressure vessel, vacuum pump and all required gauges and fittings for the service of the switchgear. Bidder shall guarantee that the pressure loss within each individual gas filled compartment shall not be more than *[0.5 percent per year]*. *[Applicable for GIS & Hybrid]*
- n. Each gas filled compartment shall be equipped with static filters. These filters shall be capable of absorbing any water vapour, which may penetrate into the enclosures. *[Applicable for GIS & Hybrid]*
- o. GIS line-up, when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault condition. Even repeated operations up to the permissible servicing intervals, under full rated fault conditions, shall not lead to diminished performance or significantly shortened useful life of GIS. Arc faults caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. *[Applicable for GIS & Hybrid]*

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- p. Temperature rise of current carrying parts shall be limited to the values stipulated in relevant code and standard under rated current and the climatic conditions at site.
- q. GIS shall be of free-standing, self-supporting dead-front design, with all high-voltage equipment installed inside the gas-insulated, metallic earthed enclosures, and suitably sub-divided into individual arc and gas-proof compartments, at least for
- Bus bar section with associated bus bar Disconnecter
 - Circuit breaker
 - Line disconnectors
- [Applicable for GIS & Hybrid].
- r. The bus bars shall be sub-divided into compartments including the associated bus bar disconnectors. [Applicable for GIS]
- s. Arrangement of the individual substation bays shall be such as to achieve optimum space-saving, neat and logical arrangement, and adequate accessibility to all external components. [Applicable for GIS & Hybrid].
- t. Each line up of substation shall be suitable, and prepared for future extension on one end without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays. [Applicable for GIS & Hybrid].
- u. It shall be impossible to touch live parts of the switchgear unwillingly, i.e. without the use of tools or brute force, or to perform operations that lead to arcing faults. [Applicable for GIS & Hybrid].
- v. The primary design goal shall be the avoidance of all known reasons for internal arcing. The release of pressurized gas into the atmosphere must occur in such a controlled way that personnel standing at the operating position of the switchgear shall not be hurt directly in the process. Furthermore, no part of the enclosure, or any loose parts, may fly off the switchgear in such an event. All earthing connections must remain operational during and after an arc fault. The arc fault withstand duration shall comply with relevant code and standard. [Applicable for GIS & Hybrid].
- w. All interlocks that prevent potentially dangerous mal-operations shall be constructed such that they cannot be defeated easily, i.e. the operator must use tools or brute force to over-ride them.
- i. The actual position of disconnectors and grounding switches shall be positively displayed by means of reliable optical indicators visible from the operating position.

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- ii. Counter measures shall be provided against expansion, vibration and noise of the equipment.
- iii. All the equipment of a GIS shall be electromagnetically compatible and should conform to relevant Indian/international standards.
- iv. The GIS equipment shall be furnished with specially designed stainless steel compensators/bellows to preserve the mechanical strength of the equipment at the connection portions to deal with the following problems:
 - To absorb the expansion and Contraction of outer enclosure and conductor due to temperature variations.
 - Mismatch in various components of GIS
 - To absorb the vibration of the transformer and switching equipment
 - To absorb the dimensional variations due to uneven settling of foundation
 - To withstand seismic forces

[Applicable for GIS & Hybrid]

1.4.2. Bus bars:

- a. [Bus bar current rating shall be as per requirement.]
- b. The bus bar shall be rigid type/strain and flexible type. [Applicable for AIS & Hybrid].
- c. In the rigid type, pipes shall be used for bus bars for making connections to the various equipment wherever required. The bus bars and connections shall be supported on pedestal mounted insulators. In case of a rigid type bus, special care has to be taken in respect of aeolian vibration. Aluminum pipes of grade 63401 WP confirming to IS: 5082 and IS 2673 shall be used for rigid type. [Applicable for AIS & Hybrid].
- d. ACSR/AAC shall be used for connection of the strain / flexible type bus-bars. The Aluminum strands of the steel cored aluminum conductor shall be hard-drawn electrolytic Aluminum rods of E.C Grade, having purity not less than 99.5%. [Applicable for AIS & Hybrid].
- e. The 400kV or 220kV GIS shall be of single phase encapsulated.i.e Bus bar, bus ducts and feeders are single phase enclosures and mounted in horizontal/vertical configuration to suit the switchgear layout. [Applicable for GIS].
- f. The conductors of the bus bars shall be fabricated of either [Copper/Aluminum Alloy] tubular sections with cross sectional area suitable to meet the current rating requirements. The tubular bus sections shall be housed in an aluminum enclosure, filled with pressurized SF₆ gas. [Applicable for GIS]

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- g. The conductors shall be supported from the enclosures by homogeneous epoxy resin insulators shaped to ensure uniform electrical field distribution at rated voltage. *[Applicable for GIS]*
- h. Adequate provision shall be made for absorption of thermal expansion of the conductors and of differential thermal expansion between the conductors and the enclosures. Metal bellow type compensators with adjustable tensions shall be provided, where required. The enclosures shall be designed to eliminate as much as possible all external effects of the flux created by normal and fault currents.
 - i. The power losses in the system shall be kept to a minimum, and induced voltages on the enclosures shall not be allowed to exceed reasonable limits of safety for operating personnel.
 - ii. The Supplier shall furnish supporting calculations in respect of induced voltage and losses guaranteed for the enclosure.
 - iii. Bus end connections shall be made with multi-contact connectors to allow for axial thermal expansion of the bus. Enclosure end connections shall be flanged, and shall be fitted with gaskets or O-ring seals to provide an effective gastight joint between sections. *[Applicable for GIS]*
 - iv. The common point of the two bus bars should be in a separate enclosure with an earthing switch in order to ensure availability of one bus bar in service at all times. *[Applicable for GIS]*
 - v. Each end of the bus bars shall be designed for convenient future extension of the GIS. Bus conductor end connectors and enclosure flanges shall be designed accordingly. *[Applicable for GIS]*
 - vi. All necessary steel supporting structures required for proper erection, the manufacturer shall provide leveling and alignment of the bus bars and bus ducts. *[Applicable for GIS]*
 - vii. In order to provide an improved dielectric withstand capacity, the interior of enclosures may not be required to be painted. *[Applicable for GIS]*
 - viii. The metal enclosure shall be bonded throughout and a sufficient number of defined earthing points shall be provided. *[Applicable for GIS]*

1.4.3. Circuit breaker

- a. *[Circuit breaker rating shall be as per requirement].*
- b. Circuit Breakers shall be outdoor type, comprising three identical single pole units, complete in all respects with all fittings and wiring. *[Applicable for AIS]*

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- c. Each circuit breaker shall comprise of three metal clad breaker poles. They shall be designed for installation in SF₆ gas insulated metal clad switchgear, and shall use SF₆ gas for both insulation and arc quenching. *(Applicable for GIS & Hybrid Substation)*
- d. SF₆ gas shall be as per IEC-60376, 60376A and B. SF₆ Circuit breaker shall be supplied with gas for first filling and *[20% extra gas]* with sealed container shall be provided. *(Applicable for AIS)*
- e. Spring Operating Mechanism / Hydraulic / Pneumatic or any combination of these, one for each pole, shall be employed for closing and tripping the circuit breakers. 220 V DC shall be used for control / tripping. Each circuit breaker shall be designed for single pole switching and auto reclosing.
- f. Circuit breaker shall be spring operated, SF₆ type & shall provided with 2 trip coils and 1 close coil per operating mechanism. It shall be possible to trip the circuit breaker even in the event of failure of auxiliary power supply to the mechanism.
- g. The circuit breakers and accessories shall conform to IEC- 62271-1 and 100.
- h. Mechanical & Electrical Endurance class of these breakers shall conform to relevant Indian/International Standards.
- i. The circuit breakers shall be horizontal/vertical mounted and shall withstand the forces imposed by the earthquake requirements.
- j. Dis-agreement circuit for pole position discrepancy shall be provided for all circuit breakers and auto-re-closing features shall be provided for line feeders and transfer bus.
- k. The interlocking shall prevent any incorrect switching sequence and enable the breakers to be operated without risk, either from the local control cabinet or from the GIS control room. Actuation of the manual operating device shall also disable the electrical control circuits. Interlocks shall be provided to prevent hunting and other dangerous or undesirable operations of the circuit breaker. *(Applicable for GIS & Hybrid Substation)*
- l. The circuit breakers shall be interlocked electrically with their associated disconnectors such that the disconnector cannot be opened or closed unless the associated circuit breakers are open.
- m. The state of the breaker arc quenching and insulating gas shall be monitored by a temperature-compensated density switch with two alarm levels. The first stage alarm shall be set well before any dangerous condition is reached; the second stage shall inhibit breaker operation. *(Applicable for GIS & Hybrid Substation)*

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- n. Circuit breaker shall be controlled from local and remote. Local operation shall be by means of an open/close control switch located in the local control cabinet. Remote control via a remote/local control transfer switch shall be from the power house/ Switchyard control room.
- o. For 400kV systems, circuit breakers shall be provided with pre-Insertion closing resistor (wherever applicable for line feeders) or controlled switching devices (wherever applicable viz. reactor and Transformer switching breakers) suitably designed to limit switching surges.
- p. 400kV circuit breaker shall be provided with single step PIR of class C2-M2 class as per IEC 62271-1. The maximum rating/pre-insertion time shall be 400 ohm/8ms.
- i. Pre Insertion resistor (PIR): The resistor shall have thermal rating for the following duties:
 - Terminal fault: Close-1Min-Open-Close Open 2min-Close-1 min-Open Close Open.
 - Reclosing against Trapped Charges: Duty same as (i) above. The first, third and fourth closing are to be de-energized line while second closing to be made with lines against trapped charges of 1.2 p.u. of opposite polarity.
 - Out of phase closing: One closing operation under phase opposition that is with twice the voltage across terminals.
 - No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. The calculation shall take care of adverse tolerance on resistors values and time settings.
- ii. Controlled Switching device: The control relay shall have facility to record and monitor the switching operations. It shall be provided with self diagnostic facilities, alarms, and downloading and display for the setting and measured values. The controller shall be PC compatible.
- q. For circuit-breaker Mechanical endurance class shall be M2 as per relevant code and standard. *[(Applicable for GIS & Hybrid Substation)]*

1.4.4. Isolators

- a. *[(Isolator current rating shall be as per requirement)].*

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- b. An Isolator is a mechanical switching device, which provides in the open position, an isolating distance meeting the specified requirements. A disconnecter can open & close a circuit when either a negligible current has to be broken or made or when no significant change in voltage across the terminals of each pole of the disconnecter occurs.
- c. System Disconnecter and earth switches shall be motor operated.
- d. Safety Interlocks shall be provided to prevent closing of disconnectors at earth switch closed position.
- e. Disconnecting switches (isolators) covered by this specification shall conform to the latest editions of IS 9921 (Part 1 to 5) and IEC-129. Porcelain post insulators for the isolators shall conform to IS 2544 and IEC 168.
- f. Isolator shall be outdoor [horizontal centre break/double break/ pantograph type] [with/without earth switch] as per IEC 62271-102. It shall be possible to interchange position of earth switch on either side. [Applicable for AIS]
- g. 400kV disconnectors and earth switches shall be individual pole operated and 220kV and below disconnectors shall be gang operated type. However, 220kV tandem disconnectors shall be individual pole operated type.
- h. Disconnectors/ Isolator shall be single pole, group operated with motor operated mechanism as per IEC 62271-102. The provision of emergency manual operation shall also be included. [Applicable for GIS & Hybrid Substation]
- i. All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure. [Applicable for GIS & Hybrid Substation]
- j. Disconnectors shall be of mechanical endurance class [M2] type as per IEC 62271-100.

1.4.5. Current transformer

- a. [CT current rating shall be as per requirement].
- b. CT shall be of multi-ratio type and secondary current rating shall be [1A]. The rated burden and the knee point voltage of various CT cores shall be decided based on the application with a safe design margin. The minimum requirement of accuracy class of the CTs shall be as follows:
 - i. For differential protection -Class PS
 - ii. For other protection -Class 5P20
 - iii. For general metering -Class 0.5
 - iv. For tariff metering (for main & check meters) -Class 0.2S

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[Main and Back-up protective relays shall be fed from separate CT cores]

- c. CT shall be ring/hair pin type, Single phase, oil immersed (with class A Insulation)/SF6 gas filled and self cooled as per IEC 60041-1. It shall be either dead tank or live tank type. The secondary terminals shall be brought out at the bottom to a weather proof (IPW 55) terminal box.
- d. CT shall be ring type and mounted inside metal enclosure. CT shall be provided with effective electromagnetic shields to protect against high frequency transients. CT shall have multi cores with multi ratio, which shall be changeable by means of a taps on the secondary side. *[Applicable GIS and Hybrid]*.
- e. CT secondary winding shall be positioned preferably within the GIS such that the current in the enclosure does not affect the accuracy and the ratio of the device and does not distort the conductor current being measured. Primary insulation for the CT shall preferably be SF6. In 3-phase type design, CT secondary shall be shielded from the high voltage conductor. CT core space shall be dimensioned to accommodate the required number of cores of required capacity and accuracy class. *[Applicable GIS and Hybrid]*
- f. CT terminal box shall be provided with removable gland plate and gland (s) suitable for 1100 volts grade PVC insulated, PVC sheathed, multicore 4 Sq. mm stranded copper conductor cable. The terminal blocks shall be stud type and provided with ferrules indelibly marked or numbered. The terminals shall be rated for not less than 10 Amps. The terminal box shall be dust and vermin proof. Suitable arrangements shall be made for drying of air inside the secondary terminal box. The dimensions of the terminal box and its openings shall be adequate to enable easy access and working space with the use of normal tool.
- g. Polarity shall be indelibly marked on each primary and secondary terminal. Facility shall be provided for short circuiting and grounding of the C.T. secondary terminals inside the terminal box.
- h. CT shall have a short time primary current rating not less than that of the associated switchgear. Secondary windings of each CT shall be earthed at one point only. *[The thermal rating of the current transformer shall allow, at site conditions, a 20% continuous overloading referred to nominal rating of the current transformer]*

1.4.6. Voltage transformers

- a. *[VT current rating shall be as per requirement].*

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- b. Voltage Transformer shall be capacitive voltage divider type (CVT) or Electromagnetic type (EMVT). VT shall single phase oil immersed (with Class A Insulation)/SF6 gas filled and self cooled.
- c. VT shall be of electromagnetic type (EMVT) with SF6 gas insulation as per IEC 60044-2 and mounted inside metal enclosure. [Applicable for GIS & Hybrid]
- d. CVT on line shall be suitable for carrier coupling.
- e. EMVT/CVT shall be provided with [three secondary windings; two windings for protection and one winding for metering].
- f. To prevent ferroresonance, suitable damping devices shall be provided for connector to the transformer secondaries.
- g. Voltage transformers (VT) with multiple secondary windings shall be provided on lines and bus bars for metering, protection and synchronizing requirements. Separate cores with Class 0.2 accuracy shall be provided for Main and Check tariff metering.
 - i. For protection - [Class 3P]
 - ii. For general metering - [Class 0.5]
 - iii. For Tariff metering - [Class 0.2]

VT burden for metering class shall not be less than [50VA].

1.4.7. Lightning arrestors

- a. Lighting arrestor shall be heavy duty, station class and gapless metal oxide type confirming IEC-60099-4.
- b. Arrestor shall be hermetically sealed units suitable for outdoor installation on self supporting base. 220kV SA shall have discharge energy equivalent to class 3 and 400kV SA shall have discharge energy equivalent to class 4.
- c. The surge arrestors shall be designed to incorporate a pressure relief device to prevent shattering of the blocks/ or housing.
- d. The positioning of the arrestors to other equipment shall provide protection to the other equipment according to the requirement of IEC-60099.
- e. Self contained non-resettable discharge counters without any auxiliary supply, suitably enclosed for outdoor application shall be provided for each single pole unit. Leakage current meter (mA) shall be provided. Leakage current meter and surge monitor with discharge counter shall have mechanical protection of IP-66.
- f. The surge arrestor ground connection must be insulated from the enclosure in order to permit monitoring of the leakage current. The ground connection shall be sized for the fault level of the GIS.

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1.4.8. Power Line Carrier Communication

a. General

- i. The carrier terminals shall include transmitter, receiver, high/low filter, HF hybrid filters, Line traps, LMU, telephone, Co-axial cables, and telephone cables etc. and shall be as per relevant codes & standard.
- ii. Telephone handsets and cord and jack shall be provided with carrier sets for the service engineer's use. Space shall be provided inside the carrier terminal cabinet for storing the handset when not in use.
- iii. *[The PLCC equipment for 400 kV lines shall be used for establishment of a PLCC link across the 400 KV Transmission Lines between 400 KV Switchyard of Power Plant and 400KV PGCIL / ----Substations, which is about --- KM & --- KM respectively from site.
The PLCC equipment for 220 kV lines shall be used for establishment of a PLCC link across the 220 KV Transmission Lines between 220 KV Switchyard of Power Plant & existing 220 KV ----- for looping in/out, which is about ----- KM from site.]*
- iv. The PLCC link shall be complete with carrier protection of the 400 KV /220 kV transmission lines with facilities for tele-metering / tele-signaling and speech communication in dialing mode. The required interfacing equipments to facilitate tele metering / tele signaling shall be included as part of PLCC supply.
- v. Wave trap shall be inserted into the extra high voltage transmission lines to prevent undue loss of carrier signal for all power system conditions. The impedance of the wave trap shall be negligible at power frequency (50 Hz) so as not to disturb power transmission but shall be relatively high over the frequency band appropriate to carrier transmission.
- vi. The design shall conform to the best and current engineering practice. It shall ensure reliability, simplicity and provide long continuous service with high economy and low maintenance.
- vii. All equipment shall operate without undue heating, vibration and with minimum possible noise.
Adequate margin shall also be provided while selecting rating of equipment.
- viii. Coupling Device (Line Matching Unit and Protective Devices) for power line carrier circuit is to be interposed between the capacitor voltage transformer and the connection line (Co-axial Cable) to the PLCC terminals to ensure:
 - The efficient transmission of signals from the PLCC equipments to the high voltage line and vice versa.
 - The safety of personnel and protection of low voltage parts of the installation against the effects of power frequency voltage and over voltages.

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- ix. A lightning arrestor shall be connected as directly as possible between the primary and earth terminals and shall be capable of protecting the coupling device and the carrier frequency connection. The lightning arrestor shall have power frequency spark over voltage co-ordinated with the equipment.
- x. The contractor shall specify the capacitance of the CVTs with which the coupling unit may be used for the above transmission band.
- xi. The contractor shall also provide suitable earthing switches for grounding the low voltage terminals of CVT for carrying out maintenance or any other works on coupling unit.
- xii. The coupling device should be suitable for outdoor mounting and shall be fitted on the steel structure. Temperature of metallic equipment mounted [outdoor is expected to rise up to 65°C during maximum ambient temperature of 50°C specified.] The equipment offered shall satisfactorily operate under these conditions.
- xiii. The coupling device shall conform to relevant IEC/IS standards.
- xiv. The connection between coupling device and CVT shall be done [by means of 6 sq.mm. copper wire] taped with 11 KV insulation.

b. High Frequency Cable

High frequency cable shall be supplied to connect coupling unit installed in the switchyard to the PLCC terminals installed indoors. The high frequency cable to be offered by the contractor shall be suitable for being laid directly to the ground or in trenches or in ducts. The cable shall be PVC sheathed and round steel wire armoured. The capacitance of the cable shall be low so as to minimize attenuation at the carrier frequency range. The impedance of the cable shall be so as to match with the output impedance of PLCC terminals and secondary impedance of the coupling units (LMU). The cable shall be insulated to withstand a test voltage of 4 KV rms. for one minute between conductor & outer sheath. Bidder shall offer [Co-axial H.F. cable with 75 Ohms impedance (unbalanced).]

The H.F. cable shall conform to the latest edition of IS Publication No. 5802.

c. Power Line Carrier Terminals

- i. Single side band PLCC terminals of latest version equipped for fixed frequency duplex system working shall be offered for superimposed channels (multipurpose) for speech, tele-metering, and tele-signalling and protection purpose. The PLCC terminals shall be complete with H.F. Hybrid filters and shall have necessary frequency stability so that adjacent channel working is possible.
- ii. The PLCC terminals shall be located at a suitable location in Switchyard Control room. Each PLCC terminals shall be mounted in floor mounting sheet

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metal [(min 2 mm thick)] cabinets. The terminals shall be provided with built in indicating instruments to facilitate checking of important voltage and signal values at different points of the PLCC terminal. Protective fuses should be provided in all important circuits and the fuses shall be so mounted as to allow their easy inspection and replacement. The carrier set shall be provided with suitable supervision and alarm facilities. The individual parts of the carrier set should be accessible from the front, making it possible to place the carrier set cabinets side-by-side, back-to-back, against wall. All component parts of the carrier set shall be suitably tropicalised and protected against bad effects of humidity, fungus etc.

- iii. The PLCC terminals shall be provided with emergency call facilities from the carrier sets for point to point carrier communication (RSI facility) with required telephone set.
- iv. The PLCC terminals should be of vermin proof and provided with, ventilating fan, if required. Necessary socketing arrangement for connection of the H.F. cable from the coupling device shall have to be provided.

d. Wave Trap

- i. The wave trap shall comply with IS: 8792 and shall be broad band type, tuned for the entire carrier frequency range. The resistive component of impedance of the line trap within its bandwidth shall not be less than 570 ohms.
- ii. The coil of wave trap shall be designed to tolerate the short circuit current of the line for a short period and shall withstand the mechanical stress resulting from it. HF tuning elements shall be placed in a separate sealed unit.
- iii. The wave trap shall be provided with a protective device which shall be designed and arranged so that neither significant alteration in its protective function nor physical damage shall result from either temperature rise of the magnetic field of the main coil at continuous rated current or rated short time current. The protective device shall neither enter into operation nor remain in operation following transient actuation by the power frequency voltage developed across the wave trap by the rated short time current.
- iv. The protective device in the form of surge arrester shall be gapless or gapped type. For proper co-ordination with the lightning arresters installed in the substation, its [rated discharge current shall be 10 kA.]
- v. Wave trap shall be provided with suitable corona rings to meet corona and radio interference performance.
- vi. Wave trap shall be outdoor type suitable for mounting on post insulators. The wave trap shall be equipped with suitable bird barriers painted with grey colors.

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1.4.9. Steel Structures

- a. Manufacturer shall supply all equipment supporting structures, required access ladders / stairway/ walkways, transverse and longitudinal beams and supporting members, complete with all necessary hardware. Any temporary scaffolding or a movable platform, required for maintenance, shall also be supplied.
- b. All steel structure members shall be hot-dip galvanized after fabrication. All field assembly joints shall be bolted. Field welding shall not be acceptable. Non-corrosive metal or plated steel shall be used for bolts and nuts throughout the work.
- c. Manufacturer shall provide suitable foundation channels and anchor bolts to support the switchgear assemblies. All mounting bolts, nuts and washers shall be provided to fasten the switchgear base frames to the foundation channels. Foundation channels and anchor bolts shall be installed in the civil works in accordance with instructions provided by manufacturer. *[Applicable for GIS].*

1.4.10. Reactor (If Applicable)

- a. Shunt reactor shall be connected to the 400kV/220kV bus for reactive load compensation and shall be capable of controlling the dynamic overvoltage occurring in the system.
- b. Reactor shall confirm to IEC 60076/IS 2026.400kV reactor shall be tree/single phase type as per rating & transportation limitations.
- c. Reactor shall be oil immersed with natural cooling (ONAN).The Insulating oil supplied with reactor shall confirm all parameter as per IEC-60296.
- d. The shunt reactor shall be either grapped core type or magnetically shielded air core type construction.
- e. Shunt reactors shall be capable of operating continuously at a 5% higher than rated voltage. The thermal & cooling system shall be designed accordingly.
- f. Neutral grounding reactor shall be provided for grounding the neutral point of shunt reactors to limit the secondary arc current and recovery voltages to a minimum value. The NGR of switchable reactor may be bypassed during switching in/out of the reactor.
- g. Temperature rise of reactor shall be as per relevant codes and standard.

1.4.11. GIS Termination Arrangement *[Applicable for GIS and Hybrid]*

- a. For connecting overhead lines with the GIS, SF6-to-Air bushings, mounted on suitable steel structures shall be installed. The bushings shall be Composite Insulator bushing and shall generally conform to relevant code and standard. The bushings shall have adequate Mechanical strength to withstand the Short circuit forces, Wind force and loading for the type connection.

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- b. The SF6-to-Air terminations shall include all necessary materials such as SF6 Bus duct, gas monitoring devices, bus bar extensions and removable links to ensure complete termination. Bimetallic (Al/Cu) material shall be used for the connection and necessary technical characteristics to the dimensioning of connection shall be provided by the bidder during detail engineering.
- c. For Cable termination at GIS, Division of responsibility (DOR) shall be as per relevant code and standard.
- d. For SF6/Air bushings, the GIS Bidder shall provide detailed drawings and information.

1.4.12. Gas monitoring [Applicable for GIS and Hybrid]

- a. All gas zones shall be filled to the design pressure with pure SF6 gas (to IEC 60376/BS5207) and shall be monitored individually by temperature compensated pressure switches and pressure gauges.
- b. A three-stage alarm system (high, falling and low) shall be provided for each gas section adjacent to circuit breakers, including all relays, fascias, etc., These shall be accommodated adjacent to the switchgear. A two stage alarm system shall be provided for all other gas sections. Additional repeat alarms to announce remotely each alarm stage for the group alarms of each switch bay shall be provided. The local control cubicle shall be adequately labeled to allow easy identification of signals from each gas section.
- c. The low pressure/density alarm switches shall be arranged to provide a local and remote alarm to indicate the necessity for manual operation of the circuit breakers and disconnectors adjacent to a faulted gas zone and to subsequently inhibit their further operation until suitable action has been taken.
- d. In view of the dependence of system security on the reliability of the gas density relays, and in view of the large number of relays involved in any regular relay checking procedure, the gas density relays shall have a high degree of reliability. The relay shall be designed to allow easy checking of its proper operation.
- e. Facilities shall be provided to constantly monitor the gas density. A two stage low gas pressure alarm and lock out system with local and remote indications shall be provided on each circuit breaker.
- f. Each gas density device shall be connected to the gas compartment via a self sealing valve to facilitate easy removal of the device for maintenance. The use of stop valves for this purpose is not acceptable.

1.4.13. Sulphur Hexafluoride Gas (SF6)

- a. The sulphur hexafluoride SF6 gas shall comply with the requirements of IEC 60376, IEC 60694 and BS 5207. The SF6 gas shall be supplied in 45 Kg cylinders. The dew point of the gas shall be lower than -45°C.

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- b. Sufficient quantity shall be provided to fill all SF6 equipment supplied under this contract plus an additional 20%.
- c. The high-pressure cylinders in which the SF6 gas is transported to, and stored on site, shall comply with the requirements of local regulations and bye-laws.
- d. It is important that all personnel working on GIS equipment should be fully informed of the potential risks and appropriate health and safety regulations.
- e. It is the responsibility of the GIS equipment supplier to provide:
 - i. Adequate safety training to the owner's staff regarding gas detection, the disposal of arced products and storage.
 - ii. Sufficient numbers of face masks, goggles, hand gloves and
 - iii. Respirators and protective clothing.
 - iv. First aid equipment including an eye wash bottle filled with distilled water.

1.4.14. Gas handling equipment

- a. A mobile gas handling plant for filling, evacuating, and processing the SF6 gas in the switchgear equipment, shall be supplied as part of the Contract to enable any maintenance work to be carried out. The plant shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas as well as any other gases that may be used in the maintenance process.
- b. The capacity of the temporary storage facilities shall be at least sufficient for storing the maximum quantity of gas that could be removed when carrying out maintenance or repair work on the largest section of the switchgear and associated equipment.
- c. The plant provided shall be suitable for evacuating and treating the SF6 gas by the use of desiccants, driers, filters etc., to remove impurities and degradation products from the gas. The capacity of the plant shall be such that the largest gas zone, with the exception of the circuit breaker, can be evacuated in less than one hour.
- d. The plant shall also be capable of reducing the gas pressure within the circuit breaker to a value not exceeding 8 millibars within a time not greater than two hours.

1.4.15. Switchyard Accessories

- a. The bidder shall include all required connectors, clamps, fittings etc required for the erection of the overhead line, tubular conductors and insulators. The bidder shall verify that the buses which are used in tension and overhead ground wire shall be free from joints or splices. The equipment used for stringing the conductors and overhead ground wires shall be such that the conductors are not damaged or injured. All sections of conductors damaged by the application of gripping attachment shall be replaced before the conductors are pegged in place.

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All data such as stringing tables given tension with temperature variations shall be supplied by the Bidder for approval.

b. Clamps and Connectors

- i. All power clamps and connectors shall conform to IS: 5561 & NEMA CC1 and shall be made of materials listed below:

Table - 4

For connecting ACSR conductors	Aluminum alloy casting, conforming to designation A6 of IS:617 and shall be tested for all test as per IS:617
For connecting equipment terminals made of copper with ACSR conductors	Bimetallic connectors made from aluminum alloy casting, conforming to designation A6 of IS 617 with 2mm thick bimetallic liner and shall be tested for all test as per IS 617
For connecting G.I.	Galvanized mild steel shield wire
Bolts, nuts & Plain, washers	Electro galvanized for size below M12, for others hot dip galvanized.
Spring washers for above items	Electro galvanized mild steel suitable for at least service condition 3 as per IS 1573.

- ii. Each equipment shall be supplied with the necessary terminals and connectors, as required by the ultimate design for the particular installation. The conductor terminations of equipment shall be either expansion, sliding or rigid type suitable [for 4.0" IPS aluminum tube or suitable for Quad/ Twin ACSR/ AAAC Conductor].
- iii. Where [copper to aluminum] connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress. The design details of the joint shall be furnished to the Purchaser by the bidder.
- iv. Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal to or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/ connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/ connector, except on the hardware.

c. Disc Insulator

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- i. All disc insulators shall be dimensioned appropriately so as to have the required Electro - Mechanical strength for EHV outdoor duties.
 - ii. All Insulators and fittings shall generally be supplied as per relevant IS amended to date.
 - iii. Insulator shall be wet-process porcelain, brown glazed and free from all blemishes. Metal parts and hardware shall be hot-dip galvanized.
 - iv. When operated at maximum system voltage there shall be no electrical discharge. Shielding rings, as necessary, shall be provided.
 - v. Insulation shall be coordinated with basic impulse level of the system. The creepage distance shall correspond to very heavily polluted atmosphere (31mm/kV).
 - vi. For disc insulator [120KN] of 11KV class shall be considered for 400KV/220KV switchyard.
- d. Post Insulator Stack[Applicable for AIS & Hybrid]
- i. Post insulator stack shall be used to support the [tubular aluminium bus or ACSR conductor] of outdoor EHV switchyard. Height of the stack shall be adequate in order to maintain proper clearance of live conductor from ground surface. Post insulator shall be solid core type.
 - ii. Each post insulator shall be mounted on pipe steel structure. Post insulator shall be complete with necessary fixing clamp at top for clamping of tubular aluminum bus/ACSR conductor, as required. The insulators shall be provided with necessary nuts, bolts and washers.
 - iii. Creepage distance shall be [31 mm/kV]
- e. Galvanized Steel Shield Wire
- i. Galvanized steel shield wire shall conform to the relevant IEC, BS or IS. The steel strands shall be drawn from high carbon steel rods produced by either acid or basic open-hearth process, the electric furnace process or basic oxygen process. The wire shall be hot dip galvanized.
 - ii. Zinc used for galvanizing shall be electrotype high-grade zinc of 99.5% purity and shall conform to IS: 209 - 1966 or equivalent BS specification. The hot dip galvanizing shall be done as per IS: 4826 - 1968 for heavy coating.
 - iii. There shall be no joint of any kind in the finished strand wire entering into the construction of earth wire.
 - iv. [The wire shall be 7/8 SWG galvanized steel wire. The ultimate strength of individual strand shall not be less than 1000 Kgs and that of complete wire shall not be less than 6972 Kgs.]
- f. Bundle Spacers [Applicable for AIS & Hybrid]
- a. Bundle spacers shall have enough strength so as to restore normal spacing of conductors after displacement by winds, short circuits etc. without damage or permanent deformation. The spacers shall have long life without fatigue or wear and shall have gentle but firm grip on conductor. They shall be able to

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withstand all the electromagnetic and electrostatic forces under different operating conditions including dead short circuit.

- b. They shall be of one piece construction and shall not have separate small components.
- c. The materials used in spacers shall be corrosion resistant and made of aluminum alloy of an approved type. All type of nut/bolt/washers shall be made from Stainless Steel.
- d. The spacers shall be flexible enough so as to avoid distortion or damage to the conductor or themselves. Rigid spacers are not acceptable.
- g. Corona Control Rings
 - a. Corona control rings shall be provided in 400kV/ 220KV system with all string hardware fittings.
 - [Corona control rings shall be made of high strength heat-treated aluminum alloy tube with a minimum wall thickness of 2.5mm.]
- h. Fittings and accessories of insulators
Each insulator shall be furnished complete with the fittings and accessories.

1.4.16. Bellows or compensating units[Applicable for GIS]

Adequate provision shall be made to allow for the thermal expansion of the Conductors and of differential thermal expansion between the Conductors and the Enclosures. The Bellows shall be Metallic (preferably of Stainless Steel) of following types or other suitable equivalent arrangement shall be provided wherever necessary.

- a. Lateral / vertical mounting units: These shall be inserted, as required, between Sections of Bus Bars, on Transformer, Shunt Reactor and XLPE Cable etc. Lateral Mounting shall be made possible by a sliding Section of Enclosure and Tubular Conductors.
- b. Axial compensators: These shall be provided to accommodate changes in Length of Bus Bars due to Temperature Variations.
- c. Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.
- d. Tolerance compensators: These shall be provided for taking up Manufacturing, Site Assembly and Foundation Tolerances.
- e. Vibration compensators: These Bellow Compensators shall be provided for absorbing vibrations caused by the Transformers and Shunt Reactors when connected to SF6 Switchgear by Oil - SF6 Bushings.

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1.4.17. Grounding

- a. The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.
- b. As the area involved is small, contractor has to take special measures for the same.
- c. The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS. The GIS supplier must supply the entire material for grounding bus of GIS viz. conductor, clamps, joints, operating and safety platforms etc. The GIS supplier is also required to supply all the earthing conductors and associated hardware material for the following:
 - i. Connecting all GIS equipment, enclosures, control cabinets, supporting structure etc. to the ground bus of GIS.
 - ii. Grounding of transformer and other outdoor switchyard equipments/ structures etc.
- d. Reinforcement bars in concrete slabs, foundations and duct banks shall be connected to the grounding grid by using appropriate thermoweld joints. However care should be taken to ensure that no discharge current flows through the reinforcement bars to the grounding grid. [Applicable for GIS & Hybrid]
- e. If a continuous floor slab is used, a good adjunct measure is to tie its reinforcing steel mesh to the common ground bus (main ground bus) so that both the GIS enclosures and the structural steel in and above the foundation will be approximately the same potential level. The assumption is that this measure should produce better ground and reinforcing bars, being considerably closer together than the wires of a typical ground grid, should produce more even potentials within the floor and at the surface. [Applicable for GIS& Hybrid]
- f. The enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, transformer terminals, cable terminals, surge arrestors, earth switches and at each end of the bus bars. Subassembly to subassembly bonding shall be provided to provide gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.

[Applicable for GIS& Hybrid]

Each marshalling box, local control panel, power and control cable sheaths and other noncurrent carrying metallic structures shall be connected to the grounding

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system of GIS via connections that are separated from GIS enclosures.
[Applicable for GIS& Hybrid]

- g. The grounding connector shall be of sufficient mechanical strength to withstand electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.
- h. All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall be tinned bronze with stainless steel or tinned bronze hardware.
- i. The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, ph. / earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures. The contractor shall provide suitable barrier of non-linear resistor/ counter discontinued SF6/ Air termination, SF6/ Transformer termination, SF6/ HV cable bushing etc. to mitigate transient enclosure voltage.
- j. The bidders shall provide lightning mast/GS shield wire at suitable place for protection of whole sub-station including transformers, GIS cum control room building etc. The bidder shall submit detailed proposal for grounding system of whole substation including indoor and outdoor equipments with Earthmat using [40mm.] dia MS rod for approval of purchaser. The riser shall be GS flat of size [75X12mm] for outdoor equipments and [50X6mm] for indoor.
- k. The bidder shall submit detailed proposal for grounding system for approval of purchaser. Any provision to be made in the building design to take care of earthing requirement shall also be clearly spelt-out.

1.4.18. Partial discharge monitoring system and dew point meter [Applicable for GIS & Hybrid]

- a. Static Contact Resistance Meter and Dynamic Contact Resistance Meter, CB Operational Analyser, SF6 Gas Detector Meter, Partial Discharge Meter (UHF Type) and Dew Point Meter shall be provided.
- b. Dew point meter:
 - i. The Meter shall be capable of measuring the Due Point of SF6 Gas of the Circuit Breaker / GIS Equipment. It should be portable and adequately protected for outdoor use. The Meter shall be provided with Due Point Hygrometer with digital indication to display the Due Point Temperature in

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degree Centigrade, degree Fahrenheit or PPM. It should be capable of measuring the corresponding pressure at which due point is being measured.

- ii. The measurement and use of the instrument must be simple, direct without the use of any other material / chemical like dry ice / acetone etc.
- iii. It should be suitable for operation on 220 Volts, 50 Hz, and AC Mains Supply.
- iv. Measuring Range: Up to - 50 degree Centigrade Dew Point.
- v. Accuracy: ± 2 degree Centigrade
- vi. Display: 4 digit LCD, 0.5 inch. High

c. Portable PD Monitoring System

- i. The Equipment shall be used for detecting different types of defects in Gas Insulated Stations (GIS) such as Particles, Loose Shields and Partial Discharges as well as for detection of Partial Discharges in other types of Equipment such as Cable Joints, CTs and PTs.
- ii. It shall be capable for measuring PD in charged GIS environment as EHV. The instrument shall be able to detect Partial Discharges in Cable Joints, Terminations, CTs and PTs etc, with the hot sticks
- iii. Detection and Measurement of PD and bouncing particles shall be displayed on built - in large LCD display and the measurement shall be stored in the instrument and further downloadable to a PC for further analysis to locate actual source of PD such as free conducting particles, floating components, voids in spacers, particle on spacer surfaces etc.
- iv. Measurement shall be possible in noisy environment.
- v. Stable reading shall be possible in presence of vibrations within complex GIS Assemblies, which can produce signals similar to PD.
- vi. The Equipment shall be battery operated with built - in - battery charger suitable for 230 V, 50 Hz A. C. Input.
- vii. Measurement shall be possible in the charged Switchyard in the presence of EMI / EMC. Supplier should have supplied similar detector for GIS application to other utilities.
- viii. Instrument shall be supplied with standard accessories including laptop and software.
- ix. The Function of Software shall be covering the following: -
 - Data Recording, Storage and retrieval in Computer
 - Data Base Analysis
 - Template Analysis for easy location of fault inside the GIS
 - Evaluation of PD Measurement i.e. Amplitude, Phase Synchronization etc
 - Evaluation of Bouncing / Loose Particles with flight time and estimation on size of particle

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- Report generation
- To prove the suitability in charged Switchyard condition, practical demonstration shall be conducted before acceptance.
- Instrument shall be robust and conform to relevant standard.

1.4.19. Air Conditioning, Ventilation and Handling Equipment System for Switchyard (If Applicable)

a. Air Conditioning System

Table-5

SL. NO	PREMISES	TYPE OF AC TO BE PROVIDED.
1	Relay and Control Room	Water-cooled packaged Air-conditioners, Cooling towers, Pumps, Ducting, Piping, Electrics etc. [3 x 50% configuration shall be followed for all equipments.]

b. Ventilation System

Table-6

SL. NO	PREMISES	TYPE OF VENTILATION TO BE PROVIDED.
1	400 kV/220kV Gas Insulated Switchgear Building, Stores, Battery room, maintenance room, toilets and any other rooms which generate heat.	Exhaust Ventilation with Propeller Fans/axial flow fans
2	LT switchgear room & Cable galleries	Pressurised Ventilation system comprising of Centrifugal Fan /Tube Axial Fan (2 x 50%) with ducting, Filters, grilles, dampers, inlet louvers as required.

1.5 Tests

a. Type Test

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For each type & rating of equipment for [220 kV/400 kV] substation, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

b. Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

i. Current transformer

Each current transformer shall be subject to the following routine tests. As far as practical, the procedure of IEC shall be followed.

- Construction inspection
- Verification of terminal markings
- Power frequency withstand tests (primary and secondary)
- Partial discharge measurement
- Power frequency withstand tests between sections of primary and secondary windings
- Inter turn overvoltage test
- Determination of errors
- Ratio test
- Accuracy test

ii. Capacitor voltage transformers

Each capacitive voltage transformer shall be subject to the following routine tests. As far as practical, the procedure specified by IEC/IS shall be followed:

- Construction Inspection
- Capacitance and dissipation factor measurement of the capacitor divider before and after power frequency withstand voltage (dry) test.
- Power frequency withstand voltage (dry) test for capacitor divider
- Dielectric tests for electromagnetic unit.

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iii. Isolators

Each isolator shall be subject to the following routine tests. As far as practical, the procedure specified by IEC/IS shall be followed:

- Construction inspection
- power frequency voltage dry test
- measurement of resistance of main circuit
- control and secondary wiring check tests
- Mechanical operations test.

iv. Circuit breaker

Each circuit breaker shall be subject to the following routine tests. As far as practical, the procedure specified by IEC/IS shall be followed:

- Construction inspection
- Leakage tests (for SF6 circuit breaker)
- Operating speed check
- Dielectric test
- Control and secondary wiring check test
- Mechanical operations test
- Operating mechanism system check
- Voltage withstand test on Auxiliary circuits
- Measurement of resistance of main circuit of each pole
- Power frequency withstand voltage withstand test on main circuit of each pole and the combination of poles and breaker frame.

v. Lighting Arrester

Each capacitive voltage transformer shall be subject to the following routine tests. As far as practical, the procedure specified by IEC/IS shall be followed:

- Construction Inspection
- Measurement of reference voltage
- Residual voltage test
- Internal partial discharge test.

c. Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different

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parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

d. Test Certificates

- i. Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- ii. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

- e. The Electrical Connections across the Bellows or Compensating Units shall be made by means of suitable Connectors.

1.6 Drawings, Data and Manuals

The following minimum Drawings, data & manuals for the Switchyard and its auxiliaries shall be submitted as indicated below:

- a. *[Dimensional GA drawing of each individual equipment.*
- b. *Data sheets of each individual equipment*
- c. *Switchyard Layout & Single line diagram.*
- d. *Sag Tension Calculation and Short circuit force Calculation.*
- e. *Type test report (short circuit, temperature rise test) for similar rating of equipment manufactured by the proposed manufacturer for each individual equipment.*
- f. *The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]*

1.7 Ratings & Requirements

1.7.1 400kV & 220kV Switchyard

Table - 7

S.NO	DESCRIPTION	UNIT	220 kV	400 kV
1	Nominal / Rated voltage	kV	220	400
2	Maximum System Voltage	kV	245	420
3	Rated Frequency	Hz	50	50
4	No. Of Phases		3	3
5	Rated power frequency	kV	460	630

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S.NO	DESCRIPTION	UNIT	220 kV	400 kV
	withstand voltage (1 min)	(r.m.s)		
6	Rated lighting impulse withstand voltage (1.2/50 μ s)	kVp	1050	1425
7	Rated switching impulse withstand voltage (250/2500 μ s)	kVp	NA	1050
8	Rated Normal Current bus bar	A	[2000]	[2000]
9	Rated Normal Current feeder	A	[2000]	[2000]
10	Rated short breaking Current	kA	40	40
11	Rated peak withstand current	kAp	100	100
12	Rated Short-time withstand current	kA	40	40
13	Leakage rate per year and gas compartment	%	[≤ 0.5]	[≤ 0.5]
14	Auxiliary DC supply (2 wire ungrounded)	V DC	220 \pm 10%	220 \pm 10%
15	Auxiliary AC supply (3 ph. 4 wire, 50 Hz)	V	415 \pm 10%	415 \pm 10%
16	Seismic Acceleration	g	[0.3]	[0.3]
17	Ambient temperature range		[As per specific project site data]	[As per specific project site data]
18	Creepage Distance	mm/kV	31	31

1.7.2 Circuit Breakers

Table - 8

S.No.	DESCRIPTION	220 kV	400 kV
	Service	Ourdoor	Ourdoor

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S.No.	DESCRIPTION	220 kV	400 kV
	Type	SF6	SF6
	Auto Reclosing	1ph./3ph.	1ph./3ph.
	Rated Frequency (Hz)	50	50
	Nominal system voltage	220	400
	Maximum system voltage	245	420
	System Neutral Earthing:	Effectively Earthed	Effectively Earthed
	Mechanical Endurance class	[M2]	[M2]
	Insulating level (kVp)		
	i. 1.2/50 μ sec Lightning Impulse Withstand Voltage		
	a) Between Line terminals and ground (kVp)	± 1050	± 1425
	b) Between terminals with circuit breaker open		± 1425 impulse on one terminal and 240 kVp power frequency voltage of the opposite polarity in the opposite terminal

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S.No.	DESCRIPTION	220 kV	400 kV
	ii. 1 min power frequency withstand Voltage (kV rms)(Dry and Wet)		
	a) Between Line terminals and ground (kVp)	460	520
	b) Between terminals with circuit breaker open (kVp)	460	610
	iii. 250/2500 μ sec switching impulse withstand voltage (dry and wet)		
	a) Between Line terminals and ground (kVp)	-	\pm 1050
	b) Between terminals with circuit breaker open	-	900 kVp impulse on one terminal and 345 kVp power frequency voltage of the opposite polarity in the opposite terminal
	Rated current (Amp)	[2000]	[2000]
	Short time current	40 kA for 1 sec	40 kA for 1 sec

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S.No.	DESCRIPTION	220 kV	400 kV
	Rating		
	Maximum Noise level	As per relevant standards	As per relevant standards
	Min Creepage Distance (mm) b/w ph. To ground and between C.B terminals (heavily polluted atmosphere)	[7595 mm]	[13020 mm in each case]
	Rated breaking time (m.sec)	Not exceeding 60 millise	40 milli sec.
	Total Closing time	Not exceeding 120 millise	
	Rated line charging breaking current (Amps)	125	600
	Rated cable charging breaking current (Amps)	250	400
	Rated operating sequence (O-Operating-C-Closing)	O-0.3sec-CO-3.0min-CO	
	Operating Mechanism	Spring Operated/hydraulic/ Pneumatic operated or a combination of both	Spring Operated/hydraulic/ Pneumatic operated or a combination of both

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S.No.	DESCRIPTION	220 kV	400 kV
	Mode of operation	Gang/Individual Pole Operated	Individual Pole Operated
	No of trip coils	2 per pole	
	Trip coil and closing coil voltage. (DC Voltage)	220 V DC	
	First pole to clear factor	1.3	1.3
	Supply voltage for operating device	415 V, 3-Phase, 50 Hz or 240 V, 1 Phase, 50 Hz	
	Corona extinction voltage kV (rms)(Min.)	156	320
	Maximum radio interference voltage (micro volt) between 0.5 MHz and 2 MHz in all position of equipment	1000 (at 156 kV rms)	1000 (at 320 kV rms)
	Thermal Rating of Auxiliary Contacts	10 A at 220 V DC	

1.7.3 Isolators

Table - 9

S.No	DESCRIPTION	220 kV	400 kV
1.	Maximum System voltage (rms) Um	245 kV	420 kV

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2.	Rated continuous current (A) at design ambient temp.	[2000]	[2000]
3.	Rated short time withstand current of isolator and earth switch	40 kA for 1 Sec	40 kA for 1 Sec
4.	Rated dynamic short circuit withstand current withstand current of isolator and earth switch	100 kAp	100 kAp
5.	Operating mechanism	AC motor operated and manual	AC motor operated and manual
6.	System earthing	Effectively earthed	Effectively earthed
7.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp		
a)	Between line terminals and ground (kVp)	1050	1425
b)	Between terminals with disconnecter contacts open: <ul style="list-style-type: none"> Lightning impulse voltage applied to one terminal (kVp) Power frequency voltage of opposite polarity applied to other terminal (kVp). 	NA NA	1425 240
8.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)		
a)	Between line terminals and ground (kVp)	NA	1050

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b)	Between terminals with circuit breaker contacts open: <ul style="list-style-type: none"> Switching Impulse voltage applied to one terminal (kVp) Power frequency voltage of opposite polarity applied to other terminal (kVp). 	NA	900 345
9.	One Minute power frequency withstand voltage <ul style="list-style-type: none"> Between line terminals and ground Between terminals with disconnectors contacts open 	460 530	520 610
10.	Mechanical endurance class	[M2]	[M2]
11.	No. of spare auxiliary contacts on each isolator	6 NO and 6 NC	6 NO and 6 NC
12.	No. of spare auxiliary contacts on each earthing switch	6 NO and 6 NC	6 NO and 6 NC
13.	Max. radio interference voltage for frequency between 0.5MHz and 2MHz (μ V)	< 1000 (@156 kV rms)	< 1000 (@320 kV rms)
14.	Auxiliary contacts continuous rating (A)	10	10
15.	Auxiliary contacts breaking capacity (for circuit time constant \geq 20ms)	2	2

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1.7.4 Current Transformers

Table – 10

S. No.	DESCRIPTION	220kV	400 kV
1.	Maximum system voltage Um	245 kV (rms)	420 kV (rms)
2.	Rated Primary Current (Amp)	[2000 A]	[2000A]
3.	Rated short time thermal current	40 kA for 1 second	40 kA for 1 second
4.	Rated dynamic current	100 kAp	100 kAp
5.	System neutral earthing	Effectively earthed	Effectively earthed
6.	No. of cores	[5]	[5]
7.	Maximum temperature rise over an ambient temperature of 50°C	As per IEC 60044-1	As per IEC 60044-1
8.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure	1050 kV _P	1425 kV _P
9.	One min power frequency with stand voltage of the housing	460 kV rms	630 kV rms

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S. No.	DESCRIPTION	220kV	400 kV
10.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)	NA	1050 kV
11.	One minute power frequency withstand voltage between secondary terminal & earth	5kV (rms)	5kV (rms)
12.	Radio interference voltage at 1.1 $U_m/\sqrt{3}$ and frequency range 0.5 to 2 MHz	≤ 1000 micro volts	≤ 1000 micro volts
13.	Partial discharge level	≤ 10 pico coulomb	≤ 10 pico coulomb
14.	Corona extinction voltage (min) (kV rms)	156	320

1.7.5 Voltage Transformers

Table – 11

S.No.	DESCRIPTION	220 kV	400 kV
1.	Maximum system voltage U_m	245 kV (rms)	420 kV (rms)
2.	Rated burden	As per requirement with 15% additional margin.	As per requirement with 15% additional margin.

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S.No.	DESCRIPTION	220 kV	400 kV
3.	Maximum temperature rise over an ambient temperature of 50°C	As per IEC 60044-1	As per IEC 60044-1
4.	System neutral earthing	Effectively earthed	Effectively earthed
5.	System fault level	[40 kA for 1 second]	[40 KA for 1 second]
6.	Rated primary voltage	220/√3 kV	400/√3 kV
7.	Rated secondary voltage	110/√3 kV	110√3 kV
8.	Connection group	[Star / Star / Star/ Star]	[Star / Star / Star/ Star]
9.	Number of secondary windings	[Three]	[Three]
10.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure	1050 kV _P	1425 kV _P
11.	One min power frequency with stand voltage of the housing (wet & dry).	460 kV rms	630 kV rms
12.	Switching Impulse withstand voltage (250/2500 μ sec	NA	1050 kV

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S.No.	DESCRIPTION	220 kV	400 kV
	Wavefront) in (kVp)		
13.	One minute power frequency withstand voltage for secondary	3 kV (rms)	3kV (rms)
14.	Radio interference voltage at 1.1 Um/ $\sqrt{3}$ and frequency range 0.5 to 2 MHz	≤ 1000 microvolts	≤ 1000 microvolts
15.	Partial discharge level	≤ 10 Pico coulomb	≤ 10 Pico coulomb
16.	Corona extinction voltage (min) (kV rms)	156	320

1.7.6 220kV Capacitive Voltage Transformer

Table – 12

S.No.	DESCRIPTION	220 kV	400 kV
1.	Maximum system voltage Um	245 kV (rms)	420 kV (rms)
2.	Rated burden	As per requirement with 15% additional margin	As per requirement with 15% additional margin
3.	Maximum temperature rise over an ambient temperature of 50°C	As per IEC 60044-1	As per IEC 60044-1
4.	System neutral earthing	Effectively Earthed	Effectively Earthed
5.	System fault level	[40 kA for 1 second]	[40 KA for 1 second]

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S.No.	DESCRIPTION	220 kV	400 kV
6.	Rated primary voltage	$220/\sqrt{3}$ kV	$400/\sqrt{3}$ kV
7.	Rated secondary voltage	$110/\sqrt{3}$ kV	$110\sqrt{3}$ kV
8.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure	1050 kV _p	1425 kV _p
9.	One min power frequency with stand voltage of the housing (wet & dry).	460 kV rms	630 kV rms
10.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)	NA	1050 kV _p
11.	Connection group	[Star / Star / Star/ Star]	[Star / Star / Star/ Star]
12.	Number of secondary windings	[Three]	[Three]
13.	Equivalent series resistance over the entire carrier frequency range (ohms)	Less than 40	Less than 40
14.	Rated total Capacitance (pF)	4400 (+ 10% /- 5%)	4400 (+ 10% /- 5%)
15.	Acceptable limit of variation of total capacitance over the entire carrier frequency range	80% & 150% of the rated capacitance	80% & 150% of the rated capacitance

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S.No.	DESCRIPTION	220 kV	400 kV
16.	Creepage distance	Not less than 31mm/kV of highest system voltage	Not less than 31mm/kV of highest system voltage
17.	Partial discharge level	≤ 10 Pico coulomb	≤ 10 Pico coulomb
18.	Corona extinction voltage KV (RMS)	156 (min.)	320 (min.)

1.7.7 Lightning Arrestor

Table – 13

S. NO	DESCRIPTION	220 kV	400 kV
1.	Max. system voltage	245 kV	420 kV
2.	Type of arrester	[Station class Zinc oxide surge arrester].	[Station class Zinc oxide surge arrester].
3.	Rated voltage of arrester	[198 kV RMS]	[360 kV RMS]
4.	Maximum continuous operating voltage (MCOV)	[168 kV (RMS)]	[306 kV (RMS)]
5.	Nominal discharge	[10 kA peak (heavy duty) current (8/20 μ sec wave)]	[20 kA peak (heavy duty) current (8/20 μ sec wave)]
6.	Line discharge class	[Class 3]	[Class 4]
7.	Service	Outdoor in polluted atmosphere with carbon &	Outdoor in polluted atmosphere with carbon & conducting dust & with

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S. NO	DESCRIPTION	220 kV	400 kV
		conducting dust & with average design ambient of 50° C	average design ambient of 50° C
8.	Watt loss at MCOV	$\leq 0.25 \text{ W / kV}$	$\leq 0.25 \text{ W / kV}$
9.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure	1050 kV _P	1425 kV rms
10.	One min power frequency with stand voltage of the housing (wet & dry).	460 kV rms	630 kV
11.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)	NA	1050 kV
12.	Long duration discharge class	IEC class III	IEC class III

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S. NO	DESCRIPTION	220 kV	400 kV
13.	High current impulse with stand (4/10 micro sec wave)	100 KA peak	100 KA peak
14.	Creepage distance of the insulating housing	[7595 mm]	[13020 mm]
15.	The thickness of galvanizing of metal parts	Not less than 85 microns.	Not less than 85 microns.

1.7.8 400 kV & 220kV High Voltage Outdoor Bushing-Porcelain Type

Table – 14

S.NO	DESCRIPTION	UNIT	220 kV	400 kV
1.	Max system voltage	kV	245	420
2.	Rated short-circuit withstand current	kA/	[40 KA for 1 sec]	[40 KA for 1 sec]
3.	Rated peak withstand current	kAp	100	100
4.	Material of enclosures		Porcelain	Porcelain
5.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp	kVp	1050	1425
6.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)	kVp	NA	1050

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S.NO	DESCRIPTION	UNIT	220 kV	400 kV
7.	One minute power frequency withstand voltage at minimum operating gas pressure	kVp	460	630
8.	Creepage distance at rated voltage	mm/kV	[31]	[31]

1.7.9 Power Line Carrier Communication

Table – 15

S NO	DESCRIPTION	DATA
1	Mode of Transmission	Single Side Band, Amplitude modulated, with suppressed/reduced carrier.
2	H.F. range	40-500 kHz, programmable
3	Nominal carrier frequency band	1no x4(for single channel sets) 2nox4(for twin channel sets)
4	Effectively transmitted speech frequency band or signal frequency band when only speech or signal is transmitted	300-3400Hz or more
5	Effectively transmitted speech plus signal frequency band in case of multipurpose use	Speech: 300-2000 Hz Signal : 300-3400 Hz or more
6	Nominal Impedance	
	a) Carrier Frequency Side	[150 ohms, balanced/ 75 ohms unbalanced]
	b) VF Side	600 ohms
7	Nominal carrier Frequency Power	As required to maintain the required S/N ratio under adverse case
8	Supply voltage	48V DC, + 15%, -10%
9	Frequency difference	As per relevant IEC/IS

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S NO	DESCRIPTION	DATA
	between voice frequency band transmitter and receiver in a pair of PLC terminals	
10	Stability of carrier frequency from its nominal value	± 10 Hz
13	Telephone signaling channel:	<p>i. Frequency shift keying (pulse distortions) of the telephonic signaling channel at signaling speed of 10 pulse per second shall be less than 5 m. sec. for one pair of terminals.</p> <p>ii. The Signaling channel shall be operated by a potential free open or closed contact at the transmit side and provide a potential free change over contact at the receiver side. All relays to be provided in the speech circuits shall be hermetically sealed.</p>
S NO	DESCRIPTION	DATA
Wave Trap		
1.	Rated Voltage (Nominal/Max)	400/420KV 220/245KV
2.	Rated Frequency	50Hz 50Hz
3.	Rated continuous current at 50 °C	[2000 A]
4.	Rated short time current for 1sec	[40kA] [40kA]
5.	Nominal discharge current of protective device	[20 kA] [20 kA]
6.	Rated inductance	[0.5 mH] [0.5 mH]
7.	Resistive component of impedance within carrier frequency blocking	[Not less than 570 ohms] [Not less than 570

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S NO	DESCRIPTION	DATA	
	range		ohms]
8.	Minimum Corona extinction voltage level	320 kV (r.m.s)	156 kV (r.m.s)
9.	Type of tuning	Broadband	Broadband

1.7.10

Reactor

Table – 16

S NO	DESCRIPTION		220kV	400kV
1.	Maximum system voltage		245 kV (1.0 p.u)	420 kV (1.0 p.u)
2.	Rated MVAR		[60] at rated voltage	[80] at rated voltage
3.	Service		Outdoor	Outdoor
4.	Type Of reactor		Gapped Core type	Gapped Core type
5.	Phases		Three phase	Three phase
6.	Quantity		1 No.	1 No.
7.	Neutral Earthing		Effectively earthed	Effectively earthed
8.	System fault level		[40 kA]	[40 kA]
9.	Connection		Star with neutral brought out	Star with neutral brought out
10.	Insulation level (for winding			
	a)	Lightning impulse 1.2/50 micro-seconds withstand voltage	1050 kVp	1425 kVp
	b)	Switching surge withstand voltage	NA	1050 kV (peak)
	c)	One minute power frequency withstand voltage	460 kV (rms)	630 kV (rms)
11.	Maximum admissible			

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S NO	DESCRIPTION	220kV	400kV
	temp. Rise over an ambient temp of 50°C and at highest Voltage		
	a) of winding measured by resistance method	55°C	55°C
	b) top of oil measured by thermometer	50°C	50°C
12.	Cooling system	ONAN	ONAN
13.	Ratio of zero sequence reactance to positive reactance (X0/X1)	[Between 0.9 and 1.0] (The bidder must clearly specify the exact figure).	[Between 0.9 and 1.0] (The bidder must clearly specify the exact figure).
14.	Range of voltage upto which impedance shall be constant	Up to 1.5 p.u. voltage (The bidder shall furnish complete saturation characteristics of the reactors up to 2.5 p.u. voltage).	Up to 1.5 p.u. voltage (The bidder shall furnish complete saturation characteristics of the reactors up to 2.5 p.u. voltage).
	Guaranteed max, losses at rated voltage and frequency at rated output at 75 deg. C (KW)	[92 kw Max]	[150 kW Max]
15.	Noise Level	As per NEMA	As per NEMA
16.	Magnetizing characteristic	Linear up to 1.5 p.u.	
17.	Harmonics Level	As per relevant standard	As per relevant standard

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1.7.11 ACSR (Moose) Conductor

Table – 17

S NO	DESCRIPTION	DATA	
1.	ACSR Conductor	400 kV	220 kV
2.	Code Name	[MOOSE]	
3.	Overall diameter	31.77mm	
4.	Stranding no. of wire Al/Steel:	54/7	
5.	Nominal Diameter of Strand (Al./Steel)(mm)	3.53/3.53	
6.	Number of Strands		
	a) Steel centre	1	
	b) 1st steel layer	6	
	c) 1st Aluminium layer	12	
	d) 2nd Aluminium layer	18	
	e) 3rd Aluminium layer	24	
7.	Sectional area of aluminium	528.5 sq. mm	
8.	Total sectional area	597.0sq.mm	
9.	Appox. Weight	2000 kg/km	
10.	Calculated DC resistance at 20°. C (calculated from maximum value of resistivity and minimum cross-sectional area)	0.05552 ohm/km	
11.	Ultimate Strength (min)	16250 Kg.	
12.	Co. efficient of liner expansion	19.30x10 ⁻⁶ per °C	
13.	Nominal current rating at 30° C	820 A	

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1.7.12 IPS Aluminum Tubular Bus Bars

Table – 18

S NO	DESCRIPTION	DATA
1.	Tubular Aluminum Conductor	
	a) Type	[Extruded Aluminum Tube]
	b) Size	[4.0" IPS (min)]
2.	Material grade	63401 – WP2
3.	Continuous current carrying capacity (rms) at 50°C ambient temperature	To be provided by manufacturer
4.	Outer diameter	By bidder
5.	Inner diameter	By bidder
6.	Tolerance on diameter	As per IS. No negative tolerance on outer diameter and no positive tolerance on inner diameter
7.	Tolerance on thickness	As per IS
8.	Ovality tolerance	As per IS
9.	Maximum temperature rise over ambient of 50° C	As per IS

1.7.13 Shield Wire

Table – 19

S NO	DESCRIPTION	DATA
	Size & Material	7/8 SWG GI Wire

1.7.14 Connectors / Pg Clamp Assembly

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S NO	DESCRIPTION	DATA	
1.	Material	[Aluminum Alloy]	
2.	Continuous current carrying capacity (rms) at 50° C ambient temperature	[2000A (min)]	
3.	Short time current carrying Capacity	[40kA for 1 sec (400 kV)]	[40kA for 1 sec (220 kV)]

1.7.15

Post Insulator

Table – 21

S NO	DESCRIPTION	DATA	
1.	Type	Post Insulator- cylindrical	
2.	Service	Outdoor/Indoor	
3.	Voltage	220/245 kV (Nom/Max)	400/420 kV (Nom/Max)
4.	System neutral earthing	Effectively earthed	
5.	Insulation Level	220 kV	400 kV
a.	One minute Dry Power frequency Withstand Voltage (kV rms)	460	630
b.	One minute Wet power frequency Withstand Voltage (kV rms)	460	680
c.	Lightning Impulse withstand (kVp)	1050	1425
6.	Creepage distance	[31 mm/kV]	
7.	Type of insulator	Brown glazed porcelain	
8.	Metal parts	Metallic cast iron hot dip	

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S NO	DESCRIPTION	DATA
9.	Applicable standards	IS 2544

1.7.16 String Insulators

Table – 22

S NO	DESCRIPTION	220 kV	400 kV
1.	Type	Tension/suspension	Tension/suspension
2.	Applicable standard	IS 731	IS 731
3.	Type of insulator	Anti Fog	Anti Fog
4.	No. of unit insulators in string	15 minimum	25 minimum
5.	1 min power frequency withstand Voltage of insulator string (kV rms)(Dry and Wet)	460 kVrms	630 kVrms
6.	1.2/50 μ sec Lightning Impulse Withstand Voltage	1050 kVp	1425 kVp
7.	250/2500 μ sec switching impulse withstand voltage (dry and wet)	-	1050 kVp
8.	Electromechanical strength	[120 kN]	[160 kN]
9.	Corona extinction voltage kV (rms)(Min.)	156	320
10.	Unit Insulator rating, type	11 kV, Disc type	11 kV, Disc type
11.	Minimum creepage distance of each disc (so as to meet the total required creepage distance)	430 mm	430 mm

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The following List of attachments is enclosed along with this specification.

[Note: List of attachments is depends on specific project scope of work. R & M consultant may attach the attachments as per project specific scope of work. For reference all attachments are considered in this package as per scope of work considered]

Legend: O: USE, X: NOT USE

Table – 23

Sl.No	Attachment Number	Description	Rev No	Application
1	E1	Motor	R1	O
2	E2	Motorized Actuators	R1	O
3	E3	LV Transformers(Dry type/Oil type)	R1	O
4	E4	415V Switchgear, MCC and DBs	R1	O
5	E5	415V Non Segregated Bus Duct	R1	O
6	E6	220V DC system	R1	O
7	E7	HV Cables	R1	O
8	E8	LV Cables	R1	O
9	E9	Illumination system	R1	O
10	E10	Cable Carrier System	R1	O
11	E11	Earthing and Lightning Protection system	R1	O
12	E12	6.6kV Switchgear	R1	X
13	E13	Variable Frequency Drives	R1	X
14	E14	6.6kV Segregated Phase Bus Duct	R1	X

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2 220 KV/400 KV SWITCHYARD CONTROL AND PROTECTION SYSTEM

2.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 220 kV/400 kV Switchyard Control, metering and Protection System, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] Of [Name of the Power Plant] at [District], [State] for [Name of the Client].

2.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2551	Danger notice plates
IS :2705	Current transformers-specification
IS :3156	Voltage transformer specification
IS :3231	Specification for electrical relays for power system protection
IS :8686	Specification for static protective relays
IS: 13947	Degree of Protection
IS :9000	Quality Management Systems
IEC 60068	Environmental Testing
IEC 60255	Electrical Relays
IEC 60801	Electromagnetic compatibility for industrial-process measurement and control equipment
IEC 61000	Electromagnetic compatibility
IEC 61850	Substation Automation

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Codes	Name of Standard
IEEE/ANSI 37.901(1989) ENV 50140 CLASS III	Electromagnetic compatibility
C37.91-2000	IEEE Guide for Protective Relay Applications to Power Transformers
C37.101-1993 (R2000)	IEEE Guide for Generator Ground Protection
ENV 50204	Radiated electromagnetic field from digital radio telephones - immunity test
CEA	CEA regulations for installation and operation of meters 2006.
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

2.3

Design Criteria

- a. 220 kV/400 kV Switchyard Control And Protection panels shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.
- b. All equipment shall be suitable for following voltage & frequency variations as well:
 - i. Voltage Variation : (±) 10%
 - ii. Frequency Variation : (+) 3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

2.4

Specific Requirement

2.4.1

Control Philosophy for 400 kV Switchyard

The substation automation system (SAS) based on IEC- 61850 shall be provided for integrated protection, control, communication and monitoring of the various switchyard units / equipment in the [400/220] kV switchyard and shall provide two levels of control viz. at the individual bay level and

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centrally at the HMI level. The equipment comprising the Substation Automation System viz Bay Control Unit / Bay Protection Unit / Bay Metering Unit for respective bays, HMI etc. shall be located in the control room of switchyard.

The SAS comprises of HMI, (OWS), OES, SAS panels, marshalling cabinets, communication links, Ethernet, printers, scanners, UPS etc. SAS is an integrated system to control, monitoring, protection, metering and communication functions of all the 400/ 220kV feeders. It has facility of SCADA function as well. It has the capability to link with LDC and energy management. All the meters e.g. kV, kA, MW, MVAR, PF, Hz etc. for all the feeders are located in SAS panel. The requirement of UPS for SAS shall be supplied by SAS manufacturer

Control via SAS shall be possible at the following levels:

- a) At the bay level, the following are envisaged
 - i. Bay control unit (BCU)
 - ii. Bay protection unit (BPU)
 - iii. Bay metering unit (BMU)
- b) At the [220/400] kV switchyard control room level the following are envisaged.
 - i. 2 Nos. data concentrators and controllers providing hot dual redundancy.
 - ii. [2 numbers Operator Work Stations and one number Engineering Work Station with differentiated levels of access. They shall be 64 bit PC based HMI on Windows OS preloaded with application interface software, configuration software, Network management software with dual Ethernet communication, High resolution 21-inch TFT colour monitor with minimum pixel resolution of 1600x1280, non-interlaced refresh rate of min 85 Hz, 32 bit color support as minimum and key board and optical mouse. In addition, the scope shall also include one no. laptop/notebook computer of latest configuration with configuration software for onsite modifications of the control and protection devices.]
 - iii. Two Nos. Ethernet compatible color Laser Jet printers (A3 size) - One printer for event logs and another printer for alarm / fault logs.
 - iv. Industrial, rugged, managed ethernet switches with required number of Fiber optic and copper wire ports and required dual power supply modules. Ethernet switches shall be suitable for dual FO ring. Two additional switches shall be provided to interface the SAS with other systems.

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- v. An industrial, Ethernet network interconnecting all Ethernet switches. Network shall be a dual ring of FO cable.
- vi. It is envisaged that one Bay Control Unit (BCU) shall be provided for each bay. Bus bar protection shall be deemed as an additional bay. The control room shall be provided with air conditioning system. However, the equipment provided shall not degrade in performance if air conditioner fails for a period of 4 hours.
- c) At the Power plant Control room
Two Nos. Engineering cum operating Work Station and One No. Ethernet compatible color Laserjet printer (A3 size)- for event logs shall be provided by extending the SAS data bus, through redundant link on Fibre optic cable in the Central Control Room of Power Plant in TG building for which space will be provided by TG package contractor.

2.4.2 Substation Automation System

- a. The entire sub – systems, items, components etc comprising the SAS shall be latest, state-of-the-art, based on industry standards, suitable for operation under electrical environment present in the EHV switchyards. The architecture of the SAS shall allow for free future extension or maintenance without causing a system shut down. At the sub- system / component level, a single failure shall not result in loss of system functionality. To this end, the components shall be provided with self – diagnostic features and shall be capable of self – supervision. The sub – systems shall be provided with on line testing sub- routines so as to preclude the requirement of periodic testing and maintenance.
- b. The system provided shall be such that it provides for obsolescence guarantee for a period of [25] years and required support from the bidder to meet the hardware and software aspects of obsolescence protection is mandatory.
- c. All software provided as part of supply shall be licensed and the nature of the license shall be such that fresh license / renewal of license is not called for whenever any hardware is updated or changed.
- d. The PC-based Substation Automation System shall monitor and control the entire 400 and 220 kV switchyards. It shall be a fully integrated system and has to fulfill all tasks but not being limited to the following:
 - i. Interface to IEDs for each Bay (Bay Control Unit, Bay protection Unit, Bay Metering Unit) for display of status / alarm / event / disturbance recording on PC,
 - ii. Generation of dynamic mimic on PC and acquisition
 - iii. Preprocessing and display of measured values.
 - iv. Control of switchgear devices. e.g. CBs / Isolators from HMI.
 - v. Sequence of event recording (SOE) / disturbance recording

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- vi. Archiving of data comprising of measured values, event and alarm data, including those obtained from the protection relay such as the disturbance recording.
- e. Software Requirements
 - i. The system shall be based on standard and proven firmware and software which has already been implemented in other systems supplied elsewhere. Software configuration tools shall be available to adapt the system to the specific switchgear layout, to do settings, to create displays, to define event and alarm text etc. Configuration software shall require no knowledge in programming languages or system source code. *[The system must have an open architecture to ease data exchange between different applications and systems.]*
 - ii. System hardware and software shall be configurable and standard type as employed for other similar projects. For future modifications or extensions, it is to be easily extendible by adding new components. For new components, having the same functionality as the original system, additional programming shall not be required, only the configuration data shall be adapted. All software tools required for this purpose have to be included in the scope of supply.
 - iii. The system must be a fully coordinated system, and shall ensure:
 - A common database for all alarms and fault records which come from metering units or protection relays
 - Complete operation and analysis using the same software package.
- f. System Reliability and Availability
 - i. Each component and equipment offered by the bidder shall be of established reliability. The minimum target reliability of each piece of equipment shall be established by the bidder considering its MTBF, MTTR such that the availability of the complete system is assured. If requested the bidder shall furnish back up calculations to prove the system availability figure quoted by him. The guaranteed annual system availability shall not be less than 99.9%. Adequate redundancy shall be built into the system design at hardware and software levels to ensure this availability.
 - ii. The substation automation system shall be self-monitoring. Failure of a module or component shall be immediately detected and displayed thus guaranteeing the highest availability. Depending on the type of fault detected the affected module shall either be reset or blocked. Failure of a single module shall not impact operation of other system components.
 - iii. Self - monitoring and diagnostics shall comprise of:

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- Live monitoring for modules and apparatus
 - Monitoring of internal auxiliary voltages
 - Memory checks
 - Software supervision by watchdog circuit
 - Continuous monitoring of all interfaces
 - LED's on the BPU to indicate internal and external faults
 - Software tools for the diagnosis of the faults
- iv. A loss of power may not cause the loss of configuration data. An additional battery shall not be required for same. After restoration of power the system shall restart automatically. During start-up all output contacts shall be reset and blocked until after the completion of the restart with all settings being set to the default status. To enhance availability neither fans nor mechanical disk drives or any other constantly moving mechanical components are acceptable for use in the system except for the PC.

g. Electromagnetic Interference (EMI)

To avoid electromagnetic interference causing malfunction, the system shall be suitable for operation under the ambient conditions present in EHV switchyards. IEDs as well as the system's Substation Controllers must be shielded and be based on hardware components designed for operation under such conditions. These components shall be of tested design according to applicable international standards.

2.4.3

Functional requirements of Substation Automation System

- a. Operation shall be possible from only one place at a time. Normally operation from the bay controller shall be possible only upon receipt of permission from the Control Room and in such case; the operation of particular bay equipment only shall be possible after verification of all interlocks. The priority for control shall be with the lowest possible control level and this shall be indicated at all levels for the awareness of the operator.
- b. Select-before-execute principle

The command for operation of any field equipment shall always be given in the following stages:

- i. Selection of the object
- ii. Command for operation
- iii. If a permitted command is not executed within a set time, which shall be configurable for each operation, the command shall be cancelled / locked out and the operator shall be required to reset the operation command. A time stamped fault log shall be generated in this event.

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c. Bay level functions

In the decentralized architecture, the functionality shall be as close to the controlled equipment as possible. In this respect, the following functions are allocated at bay level:

- i. Bay control functions including data collection functionality
- ii. Bay protection functions
- iii. Bay metering function

Separate IEDs shall be provided for bay control function and bay protection function. Bay metering system shall take into account the operational state of the switchyard.

d. Bay control functions

- i. Bay level safety and control interlocks for safe switching of equipment
- ii. Operation of CBs / Isolators / Earth switches / Tap change
- iii. Blocking of duplicate / simultaneous commands
- iv. Cancellation of commands if set time is exceeded and fault log generation
- v. Operation count for circuit breakers
- vi. Operating pressure supervision for SF6 gas
- vii. Supervision of faults in operating mechanisms of switching devices/tap changing device
- viii. Display of status of equipments in the bays (MIMIC)
- ix. Alarm/fault annunciation
- x. Display of concurrent measurements
- xi. Local HMI with display on BCU
- xii. Interface to Ethernet switches
- xiii. Local Data storage for fault events
- xiv. Waveform display on request
- xv. Disturbance record on request
- xvi. CT/PT selection scheme for protection and measurement
- xvii. Operation under conditions of dead line – live bus, live line – dead bus, dead bus – dead line
- xviii. Tap position, winding and oil temperature displays for transformer bays
- xix. Facility for changeover of control from HMI to bay controller unit upon failure of HMI operation.

e. Bay protection functions

- i. The bay protection function IED shall be distinct from bay control IED.
- ii. Bay protection IEDs shall be connected to the communication infrastructure for data sharing and shall meet the real-time

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communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

- iii. Each Bay Protection Unit shall comprise one or more numerical relays to meet the protection requirements specified for each type of feeder. The BPU's shall be capable of interfacing with PLCC equipment directly.
- iv. Bay Protection Units for Switchyard Bays shall interact with BCUs over Network to share information related to Bay Level Interlocking, fault data, alarms/events etc. However, the trip commands from Bay Protection Units shall be hard-wired directly to appropriate switchyard equipment. Critical interlocks such as bus differential, bus earth switch etc shall be hard wired additionally to ensure operation of critical functions even when LAN is out of order.
- v. The relay should have high immunity to electrical and electromagnetic interference. It should be compliant with IEC 61850 protocol.
- vi. The offered relay shall have a comprehensive local operator interface. It shall have the following minimum elements so that the features of the relay can be accessed and setting changes can be done locally.
 - Alphanumeric display unit
 - Fixed LEDs for trip/alarm relay available and relay out of service.
 - Keypad for browsing, setting the relay parameters
- vii. The relays should have two communication ports viz. front serial port for local communication for reading / modifying relay settings, extraction and analysis of fault/event/ disturbance records from a laptop and a Rear port on IEC – 61850 standard for connection to network.
- viii. The relays shall have the following features:
 - Fault record – The relay shall have the facility to store fault records with information on cause of trip, date, time, trip values of electrical parameters.
 - Event record – The relay shall have the facility to store time stamped event records with 1ms resolution.
 - Disturbance records – User configurable disturbance records shall be provided in the offered numerical relays.
 - It shall be possible to store this information in the event of an auxiliary supply failure with the help of a battery backup.

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- The relay settings shall be provided with password protection.
 - It shall be possible to change the relay setting from the front panel using the keypads.
 - The relay shall have comprehensive self-diagnostic feature. This feature shall continuously monitor the healthiness of all the hardware and software elements of the relay. Any failure detected shall be annunciated through a output watchdog contact. The fault diagnosis information shall be displayed on the LCD and also through the communication port.
 - The Numerical Relays shall be provided with 1 set of common Windows based software, which shall allow easy settings of relays in addition to uploading of event, fault, disturbance records, measurements. The relay settings shall also be changed from local or remote using the same software.
- f. Bay measurement function
- i. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated. Threshold limit values shall be selectable for alarm indications.
 - ii. Bay Measurement IED shall directly interface with the communication infrastructure. Further, the measurement shall be on true RMS basis with the possibility to read harmonics, if any.

2.4.4 System Level Functions

- a. Status supervision
- i. The position of each switchgear e.g. circuit breaker, isolator, earthing switch, transformer, tap changer etc. shall be supervised continuously. Every detected change of position shall be immediately displayed in the single line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes.
 - ii. The switchgear positions shall be depicted by normally closed (NC) or normally open (NO) contact, which shall give ambivalent signals. An alarm shall be initiated if the time required for operating mechanism to change position exceeds a predefined limit. Further operation on the same switching element shall require a reset command from the operator.
- b. Multi – level password protected access

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The system shall provide password protected access to various user groups and it shall be possible to configure the jurisdictional limits for each user group at the highest access level. The system shall provide a log for any changes made in the security configuration which shall provide the identification of the person making the change, date, time and area of the system modified. The highest security level shall be the system administrator who shall have unlimited access to the SAS and shall be able to modify the user list and assign access rights to various levels of access.

- c. Display and Archiving of Analogue and metered Values
 - i. The HMI in Central control room shall store historical analogue data continuously with a time interval user- definable from 500 msec to 1 day in the database. The archived data shall cover measured analogue values and metered values.
 - ii. The data is to be displayed in diagrams and charts. The operator may select the values and the time period to be displayed, zoom the diagrams and read out values. Settings for recording and display e.g. time resolution or values to be stored can be modified by the operator on-line.
 - iii. An additional tool which comprises at least the functions listed below shall be available to process the data stored in the data base:
 - Read out the data from the data base
 - Display the data in diagrams and tables, calculate and display average values (15 min, per hour, per day)
 - Calculate and display minimum and maximum values (15min, per hour, per day)
- d. Operation of Switchyard through HMI
 - i. On the HMI, the object has to be selected first. In case blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication shall show the possible direction and the appropriate control execution button shall be pressed in order to close or open the corresponding object.
 - ii. Control operation from other places shall not be possible in this operating mode.
- e. Visual Presentation and dialogues
 - i. The normal screen shall be the one line overview of the entire switchyard. However, no control shall be possible in the overview which shall only represent the status of the switching elements. For controlling the equipment of any bay, the operator shall have to zoom to a detailed one-line diagram for a bay.

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- ii. By pointing the cursor at any element of the bay one line diagram and clicking on the mouse, a dialogue box of the controllable element shall open up. The dialogue box shall display the current status of the element/measured value and shall allow the operator to execute the desired action viz opening/closing/tap, raise/ lower tap etc. If the action initiated by the operator is not complying with the safety/control interlocks, the inconsistency shall be highlighted through a pop up alarm window.
 - iii. An alarm line at the top of the screen shall display the latest fault recorded along with time on a FIFO basis.
 - iv. An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.
 - v. Consistent design principles shall be adopted for the HMI display concerning labels, colours, dialogues and fonts.
 - vi. The object status shall be indicated using different status colours for
 - vii. Selected on the screen
 - Not updated, obsolete values, not in use or not sampled
 - Alarm or faulty state
 - Control blocked
 - Normal state etc
 - viii. Objects under transition following a command from the operator shall be shown as rapidly blinking till desired switching state is attained.
- f. Event and alarm handling
- Events and alarms as generated shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms.
- g. Event list
- i. The event list shall contain events that are important for the control and monitoring of the switchyard.
 - ii. The event and associated time (*with 1 ms resolution*) of its occurrence has to be displayed for each event.
 - iii. The operator shall be able to call up the chronological event list on the monitor at any time for the whole switchyard or sections of it.
 - iv. The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least

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one month. The information shall be obtainable also from a printed event log.

v. The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measure.
- Loss of communication

vi. Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date & time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

h. Alarm list

i. Faults and errors occurring in the switchyard shall be listed in an alarm list. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

ii. The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains.

- The date and time of the alarm
- The name of the alarming object
- A description text
- The acknowledgement state
- Acknowledged and cleared

iii. Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop.

iv. The alarm should disappear only if the alarm condition has been cleared and the operator has reset the alarm with a reset command.

v. The state of the alarm shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

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- vi. Audible alarm shall be hooter type to alert the operator and not buzzer (e.g. PC buzzer). Hardware necessary to drive the hooter shall be included.
- vii. Filters for selection of a certain type or group of alarms shall be available as for events.
- i. Input / Output signals

The required Input/Output signals that are not covered by the serial links shall be obtained through hard wiring.

The lists of I/Os shall be finalized during the detailed engineering & execution. The bidder shall provide the number of I/Os as required.

j. Reports

- i. The reports shall provide time related follow ups of measured and calculated values. The data displayed shall comprise:

ii. Trend reports:

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)

iii. Historical reports of selected analogue Values:

- Day (at 15 minutes interval)
- Week
- Month
- Year

iv. It shall be possible to select displayed values from the database in the process display on line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

v. Following printouts shall be available from the printer and shall be printed on demand.

- Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
- Weekly trend curves for real and derived analogue values.
- Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
- Provision shall be made for logging information about breaker status like number of operation with date and time indications.

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- Equipment operation details shift wise and during 24 hours.
- Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.
- Printout on adjustable time period as well as on demand system frequency and average frequency.

k. Trend display (Historical data)

It shall be possible to illustrate all types of process data as trends – input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum or difference) on-line in the window. It shall also be possible to change the update intervals on line in the picture as well as the selection of threshold values for alarming purposes.

l. Automatic disturbance file transfer

All disturbance record data from the IEDs shall be automatically uploaded (event triggered) to the station HMI data concentrator and displayed in the HMI display on request.

m. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the set parameters as well as parameterizing the IEDs from the station HMI. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password. The functionality shall include down loading and uploading of control logic and protection settings, automatic uploading of fault waveforms and fault data. Software for remote parameterization of numerical relays shall also be provided.

n. Automatic sequences

The available automatic sequences in the system should be listed and described (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

o. Mass Storage

The SAS shall include mass storage device in the form of sufficiently sized hard disks as well as disk writing facility to enable mass storage of all information such as application programs, database configurations, historical

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data, alarm and event logs etc. The size of the hard disk shall be adequate for storing data for one month with a minimum size of 200GB.

2.4.5 Managed Ethernet Switches

- a. The Ethernet switches forming a part of the network shall be rugged, industrial type and shall be IEC 61850 compliant. They shall be suitable for the electric environment prevalent in high voltage switchyards as well as the harsh climatic conditions encountered.
- b. In general, the switches shall be suitable for a temperature of 60 °C without performance degradation.
- c. The switches shall include dual power supply and shall be suitable for dual redundant FO bus.
- d. All switches in the control room shall be suitable to connect the FO cable directly & not through FO to Ethernet (Copper) converter.
- e. The number of Ethernet switches shall be as per actual requirement.
- f. Network Management System
 - i. The scope shall include Network Management System (NMS) software for following management functions.
 - Configuration Management
 - Fault Management
 - Performance Monitoring
 - ii. This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in HMI and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall:
 - Maintain performance, resource usage, and error statistic for all managed links and devices and present this information via displays, periodic reports and on demand reports
 - Maintain a graphical display of SAS connectivity and device status
 - Issue alarms when error conditions occurs
 - Provide facility to add and delete addresses and link

2.4.6 Remote Interfaces

- a. The SAS shall have provision, including software and hardware, to provide remote interfaces with local LDC.
- b. Gateway/modem, LAN switches etc as required shall be provided in the switchyard control room.
- c. The communication with local LDC shall be over IEC – 60870-5-101 protocol by providing dedicated gateway for 400 kV & 220 kV switchyards.

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- d. The selected information such as bus voltage, active and reactive power, status of breakers etc to be shared with the LDC shall be finalized during detailed engineering and the effective communication shall be demonstrated on – site.
- e. The required interfacing equipment to provide tele-metering / tele-signalling information through PLCC shall also be included as part of SAS.
- f. Bidder shall include one no. gateway to be located in the Control Room of Power Plant. In addition, two nos. engineering cum Operator Work Station to be supplied which shall be located in the Control Room of Power Plant. It shall be possible to obtain the energy/power data from the metering bus for ABT meters at these terminals as also to trend the data using appropriate energy management software over adjustable time periods.

2.4.7

DDCMIS Communication Link

- a. The SAS shall be networked with the central DDCMIS (this networking shall be under the scope of bidder) on communication link Ethernet TCP/IP based using bidirectional OPC connectivity. Necessary hardware, software and engineering required for the same shall be provided by the bidder. The communication links shall be redundant using fiber optic cable. The link shall be as two physical cables routed in two different physical paths.
- b. SAS shall provide necessary process graphics, alarm status, real time and history trends to the DDCMIS for centralised monitoring. The SAS shall maintain the required controls, logics and interlock required for the Switchyard / sub-station equipments. The GT feeders and tie feeder breakers shall also be controlled from DDCMIS which can be used at time of synchronization with grid. The necessary connection from SAS to DDCMIS shall be provided by bidder.
- c. The spare Ethernet ports shall be provided by the bidder on the DDCMIS side. Bidder shall provide the communication cable (FO cable), necessary interface hardware required on the SAS side, necessary interfacing hardware on the DDCMIS side and OPC connectivity client / server software (as required) on the SAS side.
- d. The bidder shall implement the OPC tags & graphics and establish the communication link. Bidder shall also be responsible to integrate the SAS with the DDCMIS on OPC links and demonstrate the same at site. Bidder shall co-ordinate with the central DDCMIS for proper implementation of communication link and graphics. The parameters to be exchanged between the DDCMIS and SAS shall be finalised during detail engineering.

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2.4.8 Protection Philosophy

- a) Each element of the [400/220kV] system shall be provided with high-speed discriminative protection (main protection) capable of detecting all "credible" faults and issuing tripping commands to the associated circuit breakers within the prescribed time. "Credible" faults shall include all faults whether phase/phase or phase/earth irrespective of whether maximum or minimum plant is connected, account being taken of the fault impedance. "Non-credible" faults are those involving a second order plant failure, for example, a broken conductor lying on high resistance ground and for which extended fault clearance time may be acceptable.
- b) There shall be two sets of main protection such that the loss of one set or the failure of one sets to clear a fault will not result in time tripping for an electrical fault. Redundant auxiliary supplies shall be used and there shall be redundant tripping systems.
- c) In the event of an uncleared external fault or any other abnormal operating condition which may cause damage to plant, time delayed tripping shall be initiated as a back-up action to prevent plant damage.
- d) All relays performing measuring function shall be of numerical design with continuous self-monitoring and supervision. The main numerical relays shall offer instrumentation, disturbance recording, and event logging functions in addition to providing protection. All monitored and recorded information available from the protection relays up to and including the main LV circuits shall be accessible in the central control room via substation automation system (SAS). Protection relays shall be from approved suppliers and they shall be type-tested according to relevant sections of IEC 60255 and IEC 60068.
- e) On the occurrence of an electrical fault on the main generating plant or on the [400/220kV] power system, the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted plant or circuit from the network. Protection equipment associated with adjacent plant or circuits may detect the fault, but there must be discrimination between this protection and that of the faulted plant or circuit. Time delayed tripping is not permitted except where main protection has failed to clear a fault or where plant damage would otherwise occur.

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- f) All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the electrical system. The protection systems shall be designed for a service life of [25 years], allowing for normal maintenance in accordance with manufacturers recommendations being performed during the service life. The period for which life time support will be provided for the protection system equipment shall be stated.
- g) Circuit breaker fail protection shall be provided to cater for the possibility of a single circuit breaker failing to clear fault current when commanded to do so, by either of the two main protection systems. The breaker fail protection shall initiate rapid back-tripping and intertripping of other circuit breakers, as necessary. Automatic reclosing equipment shall be provided for line circuit breakers, to facilitate the rapid reinstatement of transmission circuits following transient fault clearance.
- h) Each [400/220kV] circuit breaker shall be equipped with two independent, separately triggered trip coils. All protection systems shall be divided into two independent groups for detecting and clearing electrical faults, in order to ensure that failure of any single item of protection equipment does not result in shutdown of plant.
- i) The protection systems shall be provided with an adequate numbers of trip and alarm contacts to fulfill all necessary functions and the contacts shall be suitable rated for making, carrying and breaking currents in service. The protection systems shall be suitably interfaced with the SAS.
- j) The protection systems shall continuously supervise the dc auxiliary supplies and the integrity of all EHV circuit breaker tripping circuits with the CBs in the closed or open state. All protection relays shall incorporate comprehensive continuous self-monitoring and diagnostic facilities.
- k) The protection systems shall provide comprehensive records for trip and alarm conditions, including the voltage and current vector parameters at the time of trip initiation, with indications of which element initiated a trip of alarm. Voltage and current waveform disturbance recording and event-logging shall be included as part of the protection system.

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- l) Back-up protection shall be provided to trip the protected plant item in the event of a sustained external fault condition or a sustained power system abnormality that would otherwise damage or significantly reduce the life expectancy of the protected plant.
- m) The [400/220kV] protection panels shall be located in substation relay and control room.
- n) The protection relays shall be from reputable suppliers subject to approval by the Owner/Engineer and shall be type-tested according to relevant sections of the IEC 60255, including the latest Electromagnetic Compatibility (EMC) sections.
- o) Wherever protection relays include monitoring facilities, all monitored and recorded information available shall be accessible in the central control room via the SAS.
- p) Each group of numerical protection relays shall be interfaced to the SAS such that on-line and recorded information can be accessed at control room workstations. There shall be one point of serial communications access for each protection group to facilitate the SAS interfacing. All the necessary interface units and software for the communication with groups of relays shall be engineered and provided by the Contractor to allow remote interrogation of individual protection relays and the uploading of recorded data and relay settings.
- q) The protection system shall be designed to minimize the number of metallic cable connections and on-site wiring required for the plant protection, monitoring and control systems, however the protection tripping and intertripping and circuit breaker closing control shall be effected via hard-wired links.

2.4.9 Transformer Protection

a) Generator Transformer Feeder Protection

As a minimum, the protection system shall comprise the following individual protection functions.

- i. Overhead line connection differential protection (87L)
- ii. Pole discrepancy protection of breaker (EHV) if single pole breakers are used.
- iii. Breaker (EHV) back up protection (protection against breaker failure)

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All other protections of generator transformer like dedicated differential protection, the restricted earth fault protection, overall differential protection, HV side IDMT phase over current protection, transformer back-up earth fault protection including all mechanical protections viz, Buchholz, Oil Temperature Indicator, Winding Temperature Indicator, Pressure Relief Valve operated trip are covered in TG and Auxiliaries Package, under Chapter 2: Protection and Metering.

b) Station transformer protection

As a minimum, the protection system shall comprise the following individual protection functions:

- i. Line Differential Protection (wherever required)
- ii. Transformer differential protection (87T) (2 Nos. for 400kV system only)
- iii. Restricted earth fault protection (64) for [400/220kV] side.
- iv. Restricted earth fault protection (64) for 6.6 kV side.
- v. Back-Up earth fault protection (51N) for [400/220kV] side.
- vi. Back-Up Standby earth fault protection (51N) for 6.6kV side.
- vii. HV side phase over current protection (51).
- viii. Thermal replica overload protection (49).
- ix. Over fluxing protection (99T).
- x. Buchholz Protection (63) for alarm and trip.
- xi. Winding temperature high (49 T) for alarm and trip
- xii. Oil temperature high (49Q) for alarm and trip
- xiii. OLTC oils surge relay [If Applicable]
- xiv. Pressure relief valve (PRV) operated trip

c) Following minimum protection shall be provided for shunt reactor:

- i. Reactor differential protection
- ii. Backup impedance protection
- iii. Restricted earth fault protection
- iv. Mechanical Protection, Viz. Buchhloz protection, Winding temperature protection, Oil temperature Protection, Pressure relief valve Operated.

d) Following minimum protection shall be provided for ICT:

- i. Line differential Protection(Wherever required)
- ii. Transformer differential protection
- iii. Restricted earth fault protection

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- iv. Directional over current (67) on 400 kV and 220 kV.
- v. Directional earth fault on (67N) 400 kV and 220 kV
- vi. Overload protection
- vii. High voltage side Over fluxing protection
- viii. Tertiary over current protection
- ix. Neutral side back up over current protection (51N)
- x. Tertiary Grounding O/C Protection
- xi. Mechanical Protection, Viz. Buchholz protection, Winding temperature protection, Oil temperature Protection, Pressure relief valve Operated.
- e) Following minimum protection shall be provided for Bus coupler:
 - i. Inverse Definite Minimum Time over current protection (51).
 - ii. Inverse Definite Minimum Time earth fault protection (51N).

2.4.10 Overhead line protection requirements

- a) Main-1 distance and directional earth fault protection (21-1, 67G, F/L) – Permissive overreach distance teleoperation scheme with supplementary directional earth fault teleoperation to cover earth fault with levels of resistance that could not be detected by the distance protection elements without the risk of load impedance encroachment. The protection shall also offer three-step basic distance protection and an accurate fault location feature. The distance protection relays shall be compatible with those existing on the network.
- b) Main-2 distance and directional earth fault protection (21-1, 67G) – As for the Main-1 protection, but without the fault location feature.
- c) Protection signaling equipment – two sets of equipment to operate from separately fused dc auxiliary supplies and to utilize redundant communications paths for tele protection and intertripping.
- d) Auto reclose equipment – Single and three phase high-speed and delayed auto reclose equipment with integral synch check equipment or with interfacing to the substation synch check equipment.

2.4.11 Busbar and breaker fail protection requirements

- a) Busbar differential protection scheme (87B1/B2) – Numerical busbar differential protection scheme with differential current measurement for each section of bus bar on each side of the bus sectionalizing bays shall be provided. An auto-testing facility shall also be provided.
- b) Breaker fail protection shall be provided
- c) Pole discrepancy protection – Pole discrepancy protection shall also be provided for the [400/220kV] circuit breakers.

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2.4.12 Digital Fault & Disturbance Recording System

The disturbance recorder for each [400/220kV] line shall meet following requirements:

- a) Used to record the graphic form of the instantaneous values of analog inputs such as voltages and currents in all the three phases, open delta voltage and neutral current in the primary circuits in case of a short circuit (fault) and a disturbance in the Power System, as per technical parameters.
- b) Used to record digital inputs such as protection relays and breaker auxiliary contacts, clearing the system fault or disturbance.
- c) The acquisition unit shall store the fault/disturbance data in its non-volatile solid state memory and transfer the data to its Master station automatically. However, last two disturbance/fault record data shall be always available in it and shall not be erased by the software automatically after its transfer to the Master evaluation unit.
- d) Operation of Digital Fault Recorder (DFR) shall be based on the program stored in the non-volatile solid state memory. The software shall be stable and no inadvertent change of software shall occur. Master station software shall be user-friendly graphic user interface with point & click operation. Fault Record Manager shall be flexible and simple fault/disturbance archiving shall be possible. Suitable mass storage shall be provided in Master station for archiving. Fault / disturbance display logs shall be displayed by any of the following fields:
 - i. Fault date & time (hour, min., sec & ms)
 - ii. Recording module ID
 - iii. Fault ID on one recording module

The sorts shall be in ascending or descending order.

- e) Software analysis capabilities - Master station software shall be capable of harmonic analysis and power system analysis on the fault/disturbance record. The following functions shall be possible:
 - i. RMS/Peak envelop display of any voltage or current input
 - ii. Fundamental power frequency deviation
 - iii. Power calculations such as:
 - Instantaneous Real Power
 - Instantaneous Reactive Power
 - Power Factor angle

Instantaneous values of these quantities shall also be displayed graphically.

- f) The technical parameters as detailed above are tabulated below:

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Table 2.0

1.	Purpose	To record the fault data graphically
2.	No. of Analog Channels	8 Nos. (1R,1Y,1B,1N, V RY , V YB, V BR & Open delta)
3.	No. of digital channels	16
4.	Scan rate of each analog channels or better value	2000Hz
5.	Frequency response of analog channels or better	500 Hz
6.	Pre-fault memory	160 ms
7.	Post-fault memory for max. scan rate	5 sec
8.	Amplitude resolution of the analog channel(min	16 bit
9.	Event resolution of the digital channel (min.)	1 ms
10	No. of records to be stored in the acquisition unit without data compression	2
11	Aux. voltage	220V DC (+10%, -20%)
12	CT Secondary current	1A
13	Voltage input (Phase to neutral)	63.5V

2.4.13 Sequence of Event Logger (EL).

The EL shall be provided as a function of the substation automation system and shall be used to record the state of [400/220kV] Switchyard equipment, relays & alarms. The equipment shall be designed with objectives

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of flexibility, reliability & simplicity for maintenance, repairs and suitability for hostile electrical environment.

The EL shall meet the following requirements:

- a) Record all changes of alarms and state (plant state) of switchyard equipment with alphanumeric display of not less than 60 characters per event.
- b) The date and time of all alarms and plant state changes of switchyard equipment to the nearest one ms.
- c) Have facilities to commit 50 points of sequential memory or 25% of alarm, whichever is greater
- d) Cope with 500 alarms and changes of state [400/220kV] switchyard equipment.
- e) On receipt of an alarm the equipment must
 - i. Print out a message on the printer.
 - ii. Set off an audible alarm and beacon.
- f) Allow normal inputs of
 - i. Accept
 - ii. Alarm demand log.
 - iii. Plant state demand log.
 - iv. Date & Time.
- g) Events occurring whilst a previous event is in process of being printed are to be stored to await printing. Over 100 such events must be stored.
- h) Input point shall be field programmable through use of EEPROM
- i) The system shall have its own time generator, which will be synchronized with the time generator from time synchronization system to be supplied under the contract.
- j) The complete system with all auxiliaries shall work from the switchyard DC supply only. Inverters shall be provided wherever necessary.
- k) The system shall be fully type tested to the relevant international standards.

2.4.14 Distance to Fault Locator.

- a) It shall be provided for each [400/220kV] line and shall be electronic or microprocessor based type.
- b) Shall be 'on-line' type.
- c) Shall be suitable for breaker operating time of 2 cycles.
- d) Shall have built-in display unit.
- e) The display shall be directly in percentage of line length or kilometers without requiring any further calculations.

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- f) Shall have an accuracy of 3% or better for all types of faults and fault levels.
- g) The above accuracy should not be impaired under the following conditions
 - i. Presence of remote end in-feed
 - ii. Predominant DC component in fault current
 - iii. High fault arc resistance
 - iv. Severe CVT transients
- h) Have facility for remote data transmission
- i) Shall meet IEC:60255 or equivalent standards
- j) Shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line
- k) Distance to fault location function as a built-in feature of Disturbance Recorder / Numerical Distance Protection is also acceptable, provided it meets the above mentioned requirements.

The minimum requirement for measurement of switchyard bay parameters at Owner's DDCMIS shall be as follows:

Table 3.0

Sl. No.	Feeder Description	DDCMIS HMI
1.0	GT Bays	Voltage (all phases) , Amps (all phases) , MWh , MW , MVAR , Winding & Oil Temperature
2.0	ST Bays	Voltage (all phases) , Amps (all phases) , MWh , MW , MVAR , Winding & Oil Temperature
3.0	Line Bays	Voltage (all phases) , Amps (all phases) , MWh , MW , MVAR , MVARh
4.0	400 kV buses	Voltage & Frequency

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2.4.15 Tariff Metering Panel

- a) A tariff metering panel consisting of the following meters:
 - i. Main meter at each Line Feeder- [400/220kV] (Line Feeder Main Meter)
 - ii. Main meter at HV side of each station transformer (Import Main Meter)
 - iii. Main meter at HV side of each Generator Transformer
- b) A tariff metering panel consisting of the following meters :
 - i. Check meter at each Line Feeder - [400/220kV] (Line Feeder Check Meter)
 - ii. Check meter at HV side of each station transformer (Import Check Meter)
 - iii. Check meter at HV side of each Generator Transformer
- c) Each meter comprising the Metering System shall have an accuracy class of ± 0.2 .
- d) Each meter comprising the Metering System shall be active or reactive energy meter and as to their technical standards, description, accuracy and calibration, shall comply fully with any applicable requirements of the Electricity Rules, IE Act 2003, Grid Codes & related notifications, and in particular shall meet the followings :
- e) Shall comply with the requirements of IEC: 60687, IEC: 1036, IEC: 13779 and IS: 14697, and shall be microprocessor based with ABT compatibility.
- f) Shall carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3 phase, 4 wire principle suitable for balanced / unbalanced 3 phase load.
- g) C.T.'s shall have accuracy of energy measurement of 0.2S.

2.4.16 Relays

- a. Relays shall be furnished in rectangular /square dust tight, draw out or rugged plug in type, flush /semi flush mounting cases.
- b. The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on microprocessor technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- c. All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in contractor's scope of supply.

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- d. All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 A/5A] CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- e. All protection relays shall be numerical type with communication interface compliant to IEC-61850 protocol. It is proposed to fully utilize the metering, protection and control features of the numerical relays. They shall have programmable logic facility with built-in timers. Apart from the status of operation of the protection functions inbuilt in the relay, it is proposed to utilize the binary inputs of the relay for taking the operation of other non communicable relays (if any) in the protection panel to DDCMIS. The numerical relays shall be selected with suitable number of binary/analog inputs and outputs. Static relays have to be provided for any other protections not adequately afforded by the multifunction numerical relays.
- f. The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme. Contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.
- g. Timers shall be of solid state type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.
- h. Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- i. All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- j. Any alternative / additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered

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separately. The acceptance of this alternative / additional equipment shall lie with the purchaser.

- k. The design of the integrated generator protection shall be based on numerical techniques. Integrated numerical protection along with other standard protections shall be provided. All the analogue signals will be converted into digital data, using analogue-to-digital conversion circuit. The data will be processed by a microprocessor, which will perform digital signal processing and executes various protection algorithms.
- l. The relay shall be provided with one number Laptop-PC of latest generation, for user interfaces, monitoring, testing facility etc. In addition to above a unitized PC based with 21" color monitor shall be provided for configuration and diagnostics of all the numerical relays.
- m. Such Station shall be complete with licensed version of all software for analysis and retrieval of disturbances occurred in the system/equipment. Data/signal from numerical relays will go to SAS through communication protocol and shall be time synchronized through the same.
- n. The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- o. Relay characteristics shall be coordinated for proper functioning in conjunction with associated relays. The Contractor shall co ordinate the characteristics of all relays to suit the system and equipment parameters. Relay ranges and settings shall be selected accordingly.
- p. The relays shall function satisfactorily being located in non AC physical environment.
- q. All protections shall be furnished complete with necessary auxiliary, supervisory, lock out etc, relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- r. Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- s. D.C circuits shall be supervised by relays.
- t. Tripping shall be done through high speed lock out relays.
- u. Tripping relays shall be offered with sufficient redundancy. Operating of these relays shall be continuously monitored through supervising relays.
- v. All protective relays and meters shall be provided with test terminal blocks for secondary injection testing of protection relays and meters.
- w. Relay shall be provided with self reset contacts except trip, lock out relays and interlock relays which shall be manual reset type.

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- x. High speed trip relays: Adequate number of high speed trip relays for each category tripping for both the groups will be provided for the protection of the unit. The quantity of the trip relays will also consider the requirement due to the following:
 - i. Contact requirements from these relays to various systems covered under the scope of this contract.
 - ii. Contacts from each category of tripping relay for annunciation, data acquisition, sequential event recorder and fault disturbance recorder.
 - iii. Contacts for control, protection and interlock in system viz. [400kV] circuit breakers/transfer breaker tripping / close permissive, [6.6] kV aux. Supply breakers trip / close permissive, transformer cooler circuit interlocks, LBB protection etc.
 - iv. 10% spare contacts (both NO and NC).
- y. All alarm and trip conditions of Generator Transformer and Unit Transformer shall be made available in the DDCMIS.

2.4.17

Panel

- a. The Relay Panels shall be totally enclosed, floor mounted, free standing, dead front assemblies conforming to IP-54 degree of protection.
- b. Design, material selection, and workmanship shall be such as to present a neat appearance outside and inside with no welds, rivets, screws or bolt heads apparent from the exterior surface of the Boards. The boards shall have a smooth and uniform matt finish, free from scratches, dents and other imperfections.
- c. The panels shall be liberally sized so as to provide spacious layout of equipment and devices with sufficient working space in between.
- d. Each board may consist of a number of panels mounted side-by-side, in which case, these shall be bolted together to form a compact unit. Where two panels meet, the joints shall be smooth and close-fitting.
- e. The boards shall be of folded sheet steel construction, assembled on channel/angle base plates with ant vibration mountings.
- f. The boards shall be fabricated of minimum 2 mm thick sheet steel, free from all surface defects. The boards shall have sufficient structural reinforcement to ensure a plane surface, to limit vibration, and to provide rigidity during shipment and installation.
- g. All doors and removable covers shall be provided with neoprene gaskets all around and latches sufficiently strong to hold them in alignment when closed. The door operating handle shall have locking arrangement.

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- h. All panels shall have rear door with concealed type hinges and pad locking arrangement. Doors shall be grounded by flexible copper braid.
- i. The boards shall be complete with vibration damping pads, stainless steel kick plates, floor channel sills, anchor bolts, and other necessary hardware for mounting.
- j. Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel / station through a flexible braided copper conductor rigidly.
- k. The panels shall be provided with removable gland plates with glands made of brass suitable for armoured cables. Cable glands shall be double compression type. Cable gland support plate shall be 3 mm thick and mounted not less than 200 mm above floor level
- l. The panels shall have provision of cable entry from the bottom. Bottom plate shall be provided to make entry dust-tight.

2.4.18

Panel Internal Wiring

- a. All wiring shall be carried out with 650/1100 V grade, single core, and stranded copper conductor wires with FRLS PVC insulation and shall be vermin, rodent proof. The minimum size of the stranded copper conductor used for panel wiring shall be as follows
 - i. All circuits except CT & PT circuits: 2.5 mm² per lead
 - ii. CT & PT circuits : 4 mm² per lead
- b. All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- c. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.
- d. Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

2.4.19

Terminal Block

- a. Terminals shall be box clamps and clip-on type, suitable for terminating up to two wires of 4 sq. mm. cross section and provided with marking strips. Terminals for CT secondary leads shall have built-in disconnecting links with facility for shorting. Terminals for CT leads should have adequate cross section for terminating associated CT leads.

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- b. Not more than two wires shall be connected to one terminal. If necessary, a number of terminals shall be shorted together to provide wiring points.
- c. Each terminal shall be identified with designation as per approved schematic. At least 20% of the total number of active terminals shall be furnished as spare in each panel.
- d. The wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.
- e. The terminal blocks shall be located to allow easy access and also to suit floor openings for cable entry.
- f. Terminal blocks shall generally be mounted vertically with adequate spacing (not less than 100 mm) between adjacent rows.
- g. The bottom of the terminal blocks shall be at least 200 mm above the incoming cable gland plate.
- h. There shall be a minimum clearness of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearances between two rows of terminal blocks edges shall be minimum of 150mm.
- i. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included the scope of supply.

2.4.20 Equipment Mounting

- a. All instruments, relays, switches, etc. mounted on the front face of the panels shall be flush or semi flush type.
- b. No equipment shall be mounted on panel door.
- c. All equipment shall be so mounted that removal and replacement may be accomplished individually without interruption of service to others.
- d. All equipment inside the panels shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.
- e. In case cut-outs are provided on any panel for future mounting of equipment, the same shall be properly blanked off.
- f. All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections.
- g. The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawing.

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- h. The centre lines of switches, push buttons and indicating lamps shall be not less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be no less than 450mm from the bottom of the panel.
- i. The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise, the top lines of all meters, relays and recorders etc. shall be matched.

2.4.21 Illumination, Space Heating and Receptacles

- a. Each panel shall be provided with interior fluorescent tube with door switch, space heater with thermostat and switch and 240V, 5A, 3 pin receptacles with plug. Third pin of the socket shall be effectively grounded through the metallic structure.
- b. Lamp, heater and receptacle circuits shall be suitable for available 240V A.C. supply and furnished with individual ON-OFF switch.
- c. The tube shall be located at the ceiling and guarded with protective cage. Space heater shall be located near the floor so as not to pose any hazard to service personnel.

2.4.22 AC/DC Power Supply

- a. Necessary A.C and D.C supplies to each panel as required for control and service shall be arranged by the Contractor. Single feeder shall be arranged for A.C supply but redundant feeders shall be arranged for D.C supply by purchaser.
- b. Indication lamps and audible alarms shall be provided to annunciate failure of main incoming D.C supplies in each panel. Flag relay shall be provided for A.C. supply failure.
- c. MCCB/MCB shall be provided for the incoming AC/DC power supplies. Bus wires shall be run for power distribution to different panels. Power supply isolation switches shall be 4-pole, single throw, for A.C. (considering single feeder) and 2-pole, double throw with OFF, for D.C.

2.4.23 Name Plate

- a. Nameplates shall be provided on each panel and on each instrument or device mounted in the panel.
- b. The material of the nameplates shall be plastic, 3 mm thick, with white letters on black background.
- c. The nameplates shall be held by self tapping screws. The size of nameplate shall be approx. 20 mm x 75 mm for equipment and 40 mm x 150 mm for panels.

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- d. Nameplates for panels shall be provided both on the front and the rear. Nameplates for all devices shall be located below the respective devices.
- e. Instrument and devices mounted on the face of the control boards shall also be identified on the rear with the instrument or device number. The number may be painted on or adjacent to the instrument or device case.
- f. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type, serial number and electrical rating data.

2.4.24

Grounding

- a. Tinned copper ground bus of adequate size shall be provided in each panel, extending along the entire length of the assembly.
- b. Location of earth bus shall ensure no radiation interference for earth systems under various switching conditions of isolators and breakers.
- c. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractors. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.
- d. Provision shall be made on each bus bar of the end panels for connecting Substation earthing gird. Necessary terminal clams and connectors for this purpose shall be included in the scope of supply of Contractors.
- e. Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. Earthing may be done in such a manner that no circulating current shall flow in the panel.
- f. VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.
- g. An electrostatic discharge point shall be provided in each panel connected to earth bus via 1 Mega Ohm resistor.
- h. The ground bus shall have two-bolt drilling with GI bolts and nuts at each end and shall be suitable for connection to 50 x 6 mm G.S. flat.
- i. The ground bus shall be bolted to the panel structure and effectively ground the entire assembly. The cases of meters, relays and switching devices shall be grounded through the steel structure.
- j. Whenever a circuit is grounded, a single wire from the circuit shall be run independently to the ground bus and connected to it.

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2.4.25 Relay test kit

Relay Test kit shall comprise the following:

- a) One dynamic portable relay test system based on type Multi-Amp. PULSAR Cat. 10 E3T3N or equivalent] with 3 current and 3 voltage modules allowing dynamic and steady state testing capabilities The DR recording of the line/generator in standard IEEE COMTRADE or EMTP simulations shall be compatible for transient testing of protections with this test system. Required software for steady state/dynamic testing of the protection relays, energy meters and transducers, along with a Lap top PC shall also be supplied.
- b) Other auxiliary items like phantom loads, etc. shall also be supplied as required for protection relay testing.
- c) Test plugs for modular protections and two relay tool kits.
- d) All commissioning tests on protection relays, energy meters and transducers shall be carried out with the relay test kit being supplied under this contract and the test reports shall be maintained as per agreed protocols.

2.5 Tests

I) Type Test

For each type of relays and equipments, Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted at manufacturer work/site are as follows:

- a) Wiring continuity tests
- b) Insulation tests before and after high voltage test

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- c) Functional tests to ensure operation of the control/protection/metering schemes and individual equipment.
- d) All switches, meters, relays and other devices shall be tested and calibrated in accordance with relevant IEC/IS standards.
- e) HV test on control circuits
- f) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- g) Secondary injection of all metering circuits.
- h) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

2.6 Drawing & Documents

Drawings, data & manuals for the Protection panel and metering panel shall be submitted as indicated below

- a) *[General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening of panels.*
- b) *Bill of Materials.*
- c) *Technical Data sheet and Catalogue.*
- d) *Heat loss of panels*
- e) *Foundation drawing details with bottom view of Panels.*
- f) *Descriptive write-ups and literature for the main equipment offered i.e relays, meters, etc.*
- g) *Control Schematics & Wiring diagram.*
- h) *Inspection and Test Plan (ITP).*
- i) *Suggestive list of protective relays.*
- j) *Transport/shipping dimensions and weights].*

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2.7 Ratings & Requirements

Protection relay panels and meters shall comply with the particulars indicated in the following tables.

Table 3.0

S. No.	Technical Particulars	Unit	Parameters
1.0	General		
1.1	Type (simplex / duplex / panel cum desk)		Simplex type
1.2	Make		[By bidder]
1.3	Maximum dimensions width x depth x height	mm	[800 x 800 x 2300]/[as per existing panels]
1.4	Weight of each panel		[By bidder]
1.5	Degree of protection		IP 52
1.6	Colour shade		[RAL 5012]
1.7	Cold rolled sheet steel thickness		
a	Load bearing members	mm	2.0
b	Non-loading members	mm	1.6
1.8	Cable entry top / bottom		Bottom
1.9	Control cable glands to be supplied		[As per specification/Project specific]
1.10	Purchaser's external cable sizes		2.5 mm ² (control) 4 sqmm (for CT) 2.5 sqmm (for PT) Cu, PVC Multicore 1kV grade Any other sizes will be informed

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S. No.	Technical Particulars	Unit	Parameters
			during detail engg stage
1.11	Any special interconnecting cable between panels to be provided by vendor.		Inter-panel wiring between adjacent panels to be done inside the panels.
1.12	Special requirements:		
a	Matching with existing / new panels of others	Yes/No	Yes
b	Coordination with other suppliers		By Bidder
c	Hardware and accessories for protocol converter and connection to DDCMIS		Shall match with existing system. {Scope of work regarding connection and protocol converter if required shall be finalized during detail engg}
1.13	Earth bus material & size inside the panel		Copper bus
1.14	Equipment list for each panel		Main relays shall be listed in BOQ by vendor. Auxiliary relays required for control and protection interlock schemes should be worked out and provided by the vendor.
1.15	Auxiliary voltages		
a	A.C.	V	230 V, AC 1 phase, 50 Hz, +/- 10% voltage variation
b	DC	V	220 V, ungrounded, + 10% and -15% voltage variation
			24V + 10%, -20% for interposing relays

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S. No.	Technical Particulars	Unit	Parameters
2.0	Particulars of Protective relays		
2.1	Relay type required		Numerical
2.2	Mounting		Pre engineered panels, flush mounted / swing door mounted
2.3	Communication protocol		Compliance to IEC 61850. {Exact protocol will be decided during detail engg}
2.4	Wiring arrangement		Between panels wiring could be from terminal block to terminal block in internal raceways
2.5	Testing facility		Yes
2.6	Minimum rating of contacts for auxiliary and output relays :		[By bidder]
a	Voltage	V, DC	
b	Continuous current	A, DC	
c	Make & carry for 1 sec.	A, DC	
d	Breaking capacity (i) Resistive (ii) Inductive	Watts Watts	
2.7	Relay type and protection [For Generator] (List out all protection and relay type used)		[By bidder]

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S. No.	Technical Particulars	Unit	Parameters
2.8	Relay type and protection [For Generator Transformer] (List out all protection and relay type used)		<i>[By bidder]</i>
2.9	Relay type and protection [For Unit Transformer] (List out all protection and relay type used)		<i>[By bidder]</i>
2.10	Tripping Relays		<i>[By bidder]</i>
a	Make / designation		
b	Static / Electromagnetic		
c	Rated voltage	V, DC	
2.11	Trip circuit Super Vision Relays		<i>[By bidder]</i>
a	Make / designation		
b	Static / Electromagnetic		
c	(Rated voltage	V, DC	
2.12	Indicating Lamps		
a	Type		Clustered LED
b	Ratings		

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S. No.	Technical Particulars	Unit	Parameters
c	Voltage	V	[By bidder]
d	Wattage	W	[By bidder]
3.0	Meters		[By bidder]
3.1	Make		
3.2	Type of measurement		
3.3	Measuring range in primary watts.		
3.4	CT ratio		
3.5	VT ratio		
3.6	Accuracy class		
3.7	Burden		
a	Current coil	VA	
b	(b)Voltage coil	VA	
3.8	Transducers		
a	Output	4-20mA	
b	Accuracy		
c	Burden	VA	
4.0	Timers		[By bidder]
4.1	Make		
4.2	Type designation		

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

S. No.	Technical Particulars	Unit	Parameters
4.3	Range of time delay		
a	On energization	m sec.	
b	On de-energization	m sec.	

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3 POWER TRANSFORMER

3.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of Power Transformers (Generator Transformer- GT, Station Transformer-ST, Unit Transformer-UT & Inter Connecting Transformer-ICT) complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

3.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS 325	:	Three phase induction motors
IS 335	:	New insulating oil for transformers and switchgears
IS 354	:	Method of sampling and test for resins for paints
IS 1271	:	Classification of insulating materials for electrical machinery and apparatus in relation to their stability in service
IS 1866	:	Code of practice for electrical maintenance and supervision of mineral insulating oil in equipment
IS 2026	:	Power Transformers
IS 2071	:	Method of high voltage testing
IS 2099	:	Bushings for alternating voltages above 1000 V
IS 2147	:	Degree of protection
IS 2705	:	Current transformers
IS 3202	:	Code of practice for climate proofing of electrical equipment
IS 3347	:	Dimensions for porcelain transformer bushings for use in different polluted atmosphere
IS 3637	:	Gas operated relays
IS 3639	:	Specification for Fittings and accessories for power transformers
IS 5561	:	Electric power connectors
IS 5578	:	Guide for marking of insulated conductor

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IS 6600	:	Guide for loading of oil immersed transformers
IS 8468	:	On load tap changers
IS 10028	:	Code of practice for selection, installation and maintenance of transformers
IS 12063	:	Classification of degree of protection provided by enclosures of electrical equipment
IEC:137	:	Insulated bushings for alternating voltages above 1000V
IEC 60044-1	:	Current Transformer
IEC 60044-2	:	Voltage Transformer
IEC 60076 Part-7	:	Power transformers
IEEE C57.12.00	:	General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.70	:	Terminal Markings and Connections for Distribution and Power Transformers
IEEE C57.12.90	:	Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.19.00	:	General Requirements and Test Procedure for Apparatus Bushings
IEEE C57.19.01	:	Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings
ANSI C57.91	:	Guide for Loading Mineral-Oil-Immersed Transformers
ASTM D1816	:	Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes
C.B.I.P	:	C.B.I.P. publication Manual on transformers
C.E.A	:	CEA Regulations and Standard Technical Specifications For Main Plant Package.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

3.3

Design Criteria

- a) The Power transformers shall be installed in hot, humid and tropical atmosphere. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- b) All Power Transformers shall be suited for uninterrupted operation under the following variations in voltage and frequency:
 - a. Voltage Variation : $\pm 10\%$
 - b. Frequency Variation : 50Hz (+)3% to (-)5%
 - c. Combined Variation of : 10% (absolute sum)
Voltage & Frequency
- c) The transformer shall be so designed that it shall be capable of operation at 110% of rated voltage continuously, 125% rated voltage for a period of one minute and 140% rated voltage for a period 5 seconds due to sudden load throw off.
- d) The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding for minimum period of two (2) seconds for GT/ST/ICT and [three (3) to five (5)] seconds for UT.
- e) The transformer shall be free from annoying hum or vibration. The design shall be such as not to cause any undesirable interference with radio or communication circuits.
- f) Generated power shall be stepped up to 400 kV/220kV for evacuation into the grid by Generator Transformers.
- g) Unit Transformers (UT), which shall step down generation voltage to 6.6 kV voltage level for supply of power to all unit auxiliaries.
- h) Inter Connecting Auto Transformers shall be installed for interconnection between 400 kV and 220 kV Substations (if applicable).
- i) The Startup/ Shut down (HP-LP By pass) power shall be taken from Station Transformers.
- j) The impedance of the Unit transformers shall be chosen such that the fault level on the MV switchgear does not exceed 40kA including the motor contributions and also voltage dip while starting the motor does not exceed 15% at motor terminal.
- k) Transformers shall accept without injurious heating, combined voltage and frequency variation which produce an over fluxing condition of 120% for one (1) minute.

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- l) Noise level of the transformer shall not exceed the values specified in NEMA TR-1.

3.4 Specific Requirements

3.4.1 Scope of work

The following power transformers along with their fittings and accessories shall be supplied by the bidder:

- a) [Generator Transformers with accessories
- b) Interconnecting Auto-Transformers with accessories (if applicable)
- c) Station Transformer with accessories
- d) Unit Transformers with accessories.
- e) 6.6 kV, [...] Ω , [300 A] Neutral Grounding Resistors (NGR) for the above Unit & Station Transformers
- f) Power/Control cables from OLTC (On Load Tap Changer) /MB (Marshalling Box) /Cooler Control Panel to respective Transformers.
- g) Oil filtration plant (Oil centrifuging unit).
- h) Civil works (if required) like transformer foundations with soak pits, Fire protection walls etc for all Transformers including concrete cable channel for all the Transformers.
- i) Complete civil works like cable trenches with cover, pavements, drainage arrangement to a common sump to be provided within the transformer yard by Bidder for GTs, STs, UTs in the transformer yard and for ICTs in Switchyard.
- j) Rail tracks for movement of GTs, STs, UTs in the transformer yard and also for ICTs in the Switchyard up to and connection to rail for taking the transformers to maintenance bays. Maintenance bays are located in the Power Plant building.
- k) Transformer yard fencing.
- l) Fabricated oil storage tank.]

3.4.2 Construction Requirements

- a) Tank
 - i) The Tank shall be of Bell Type and welded construction and fabricated from good commercial grade low carbon steel of adequate thickness. All seams shall be double welded. All welding

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shall be stress relieved. The core grounding shall be made available outside the tank by means of a disconnectable link for all transformers. The switching devices of the tap changer are to be fitted in a separate part of the transformer tank with its own oil conservator and protection.

- ii) The tank wall shall be reinforced by stiffener to ensure rigidity so that it can withstand without any deformation
 - mechanical shock during transportation
 - oil filling by vacuum.
- iii) All removable covers shall be provided with weatherproof, hot oil resistant, resilient gaskets. The design shall be such as to prevent any leakage of water into or oil from the tank.
- iv) Each transformer tank shall be provided with one set of bi-directional flanged wheels for rolling the transformer parallel to either centre line over rail gauge. Jacking pads, lifting eyes and pulling lugs shall be provided to facilitate movement of the transformer. All heavy removal parts shall be provided with eye bolt for ease of handling.
- v) Transformer tank shall be completely insulated from its wheel so as to have transformer protection as envisaged. Tank shall be provided with necessary valves.
- vi) Manholes / hand holes of sufficient size shall be provided for access to leads, windings, bottom terminals of bushings and taps. Suitable guide shall be provided in the tank for positioning the core and coil assembly.

b) Core

- i) The transformer shall be of core type. The core shall be constructed with high grade, non-aging, low loss, high permeability, grain oriented, cold-rolled silicon steel laminations free from scales and burrs, especially suitable for core materials.
- ii) The Core flux density shall be defined to limit the transformer inrush current.
- iii) The framework and the core bolts shall be efficiently insulated from the core so as to reduce the eddy currents to a minimum.
- iv) The core and its mechanical parts shall be designed to withstand forces produced during normal transportation, short-circuits and earthquakes. The core and winding assembly shall be fixed firmly both at tank bottom, sides and tank top at suitable number of points, to withstand severe impact during transport.
- v) Adequate lifting lugs will be provided to enable the core and windings to be lifted.

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c) Windings

- i) The windings shall be manufactured from electrolytic copper with electrolytic grade and free from scales and burrs and fully insulated for rated voltage. All windings of transformers having voltage less than 66 kV shall have uniform insulation.
- ii) Insulating material shall be of proven design. Windings shall be so insulated that impulse and power frequency voltage stresses are minimum.
- iii) Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. Bracing and other insulation used in assembly of the winding shall be arranged to ensure a free circulation of the oil and to reduce the hot spot of the winding.
- iv) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.

3.4.3

On-Load Tap Changer

- a) The transformer (As Applicable), shall be equipped with motor driven bi-directional On-load tap changer (OLTC) and shall be provided with remote control and monitoring.
- b) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- c) The on load tap changing will be affected by a 3-phase gang operated switch. Arrangement shall be such that switch can be operated at standing height from ground level. The tap changer shall conform to IEC 60214.
- d) The operating handle can be padlocked at any tap position. The design shall be such that lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator and an operation counter.
- e) All contacts shall be silver plated and held in position under strong contact pressure to ensure low contact resistance and avoid pitting. The OLTC switch contacts shall be located in a separate oil-filled chamber complete with its own oil preservation system, Oil Surge relay, shut-off valves, oil level gauge, gas vent, pressure relay etc.
- f) OLTC mechanism and associated controls shall be housed in an outdoor weather-proof cabinet. Internal illumination lamp and thermostat controlled space heater shall be provided in the cabinet. The tap change

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equipment shall be so designed that if the mechanism is stuck in an intermediate position, the transformer shall be capable of delivering full load without any injury.

- g) The OLTC gear shall be suitable for local and remote electrical control and local manual control. Further, there shall be provision of automatic operation through voltage sensing relay wherever specified.

h) Local Tap Changing Cubicle

The local tap changer cubicle shall be provided for housing motor drive mechanism for OLTC. The cubicle shall be fabricated of minimum 2 mm thick sheet steel complete with Control mechanism, all wiring, fuses, links, cubicle illumination lamps, anti-condensation heater with thermostatic control switch, gland plate etc. The Cubicle shall conform to IPW 55 degree of protection. The cubicle shall include the following:

- i) Driving motor (415 V, 3 phase, 50 Hz, AC squirrel cage).
- ii) Mechanically & electrically interlocked motor starting contactors with thermal overload relay, isolating switch and MCCBs.
- iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa shall be provided in transformer cooler control cabinet / marshalling box and one no. outgoing feeder extending to OLTC driving motor cabinet, with appropriate provision for receiving the same.
- iv) Control switch for Raise / off / lower. Remote / local selector switch lockable in remote position.
- v) Mechanical tap position indicator and re-settable maximum and minimum indicators.
- vi) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
- vii) Brake or clutches to permit only one tap change at a time on manual operation. Emergency manual operating device (hand crank or hand wheel).
- viii) Tap Position Indicator, suitable electrical impulses shall be transmitted for remote indication.
- ix) A five digit operation counter.
- x) Interior lighting fixture with lamp door switch and HRC fuses.
- xi) Gasketed and hinged door with locking arrangement.
- xii) Terminal blocks, internal wiring, earthing terminals and double compression cable glands for power and control cables. Necessary relays, contactors, current transformers etc.
- xiii) The following indication/alarms shall be provided locally as well as for remote annunciation.

- AC supply failure

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- Active Tap position.
- Tap changer in Local mode.
- Tap changer in Remote Mode.
- Tap changer faulty.
- Tap change delayed.
- Value of set point of voltage control device.

xiv) It shall be possible to control (issue raise/lower commands, changing the set point of voltage control device) the tap changer locally as well as from plant DDCMIS/RTCC.

i) Remote Tap Changer Control Panel (RTCC)

i) A Remote Tap Changer Control Panel shall be provided and located in the relay room. The following facilities shall be provided in each control cabinet.

- RTCC provided shall be able to communicate to DDCMIS.
- Tap position indicator of each transformer.
- Remote / local selector switch.
- Auto manual selector switch.
- Voltage regulating relay with time delayed under voltage cutout (for out operation only).
- Automatic Voltage Regulator.
- DC supply supervision.

ii) The following indication shall be provided in remote panel:

- Tap change in progress.
- Tap changer faulty
- OLTC in local mode.
- OLTC in remote mode.
- Tap change delayed.
- Value of set point of voltage control device

iii) It shall be possible to control (issue raise/lower commands, changing the set point of voltage control device) the tap changer from plant DDCMIS. Necessary interposing relays and hardware as required shall be provided.

3.4.4 Off-Circuit Tap Changer (As Applicable)

a) Off-circuit taps as specified shall be provided on the high voltage winding.

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- b) The transformer shall be capable of operation at its rated KVA on any tap provided the voltage does not vary by more than $[\pm 10\%]$ of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be provided.
- e) Off circuit tap changer switch where provided shall be 3 phase, hand operated, by an external handle with position markings and pad locking facility and mechanical stops to prevent over cranking beyond extreme positions.
- f) Arrangement shall be such that switch can be operated at standing height from ground level.
- g) The operating handle can be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator with pad locking facility.

3.4.5 Insulating Oil

- a) The transformer shall be filled with mineral insulating oil suitably inhibited to prevent sludging.
- b) First filling of oil along with 10% excess shall be furnished for each transformer. Oil shall be supplied in non-returnable containers suitable for outdoor storage.
- c) Oil preservation shall be by means of bellows/ diaphragm sealed conservator tank with silica gel breather to avoid direct contact between atmosphere and transformer oil. It shall be complete with level gauges, pipes, drain valve etc. The level gauges shall be so placed that same can be readable standing from ground. Necessary device shall be kept to provide annunciation in the event of rupturing of bellow.

3.4.6 Bushing

- a) All bushings exposed to the open atmosphere shall have increased creepage distance of 31 mm/kV. Bushings shall be arranged to facilitate easy access for mounting and dismounting. Where built-in current transformers are provided, bushings shall be arranged to permit their removal without interfering with the current transformers.

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- b) Bushing rated 72.5kV class and above shall be condenser type. Bushing rated 36kV class and below shall be solid porcelain or oil communicating type. Condenser type bushing shall be provided with oil level gauge, bottom drain plug and test terminal for measurement of loss factor (tan-delta) and capacitance.

3.4.7 Terminations

- a) All Terminals shall be brought out through top cover mounted bushings along with necessary turret. HV bushings for GT & ICT shall be suitable for connection to overhead ACSR conductors. LV terminals for GT shall be suitable for isolated phase bus duct (IPBD) connection. LV terminals of ICT shall be suitable for connection to [ACSR conductor / IPS tubes.]
- b) HV bushings for ST shall be provided with necessary clamps and connectors for connection to overhead ACSR conductors. HV terminals of UT shall be suitable for isolated phase bus duct connection. LV terminals of UT shall be suitable for phase segregated bus duct connection. LV terminals of STs shall be suitable for Busduct termination.
- c) LV neutral terminals for UT/ ST shall be housed in neutral air insulated cable box

3.4.8 Transformer Cooling

- a) Detachable type cooler shall be provided for each bank. Nos. of cooling units and capacity of each unit will be decided as required. However, required no. of coolers to be provided with one (1) no. cooler as standby for each phase transformer bank. Each unit cooler shall have its own cooling fans, oil pumps, oil flow indicator, with shut off valves both at top and bottom.
- b) The design shall be such that rated transformer output with specified temperature rise can be maintained:
- (i) Continuously with one pump and one fan in any of the cooling bank out of service.
 - (ii) For at least ten (10) minutes in case of failure of the complete cooling system when the transformer was delivering its rated output.
- c) The radiators shall be detachable type with top and bottom isolation valves to permit the removal of the same without drainage of oil from the tank.
- d) All fans shall have safety guard. Pumps shall be provided with flow indicators for visual indication of oil flow.

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- e) Convenient means shall be provided to remove or replace any pump or fan with the transformer in service.
- f) Complete control for pumps and fans inclusive of all switches, fuses, starters, relays and wiring shall be furnished. Each motor circuit shall have over load and short-circuit protection.
- g) Pump and fan motor controls will be actuated automatically from winding temperature indicator contacts. Provision shall however be kept for manual operation both from local and remote.
- h) Cooler control cabinet
 - i) The transformer cooler control cabinet shall be installed outdoor near the transformer.
Sheet steel, weatherproof, IPW 55 cooler control cabinet shall be provided for each transformer. The frames and the load bearing panels shall be fabricated of not less than 2 mm. thick sheet steel. The doors shall be provided with channel rubber/neoprene gaskets all round.
 - ii) The starting and stopping impulses for fans and oil pumps shall be given by winding temperature detectors at a preset temperature limit. Control shall be such that hunting, i.e., frequent start stop operations for small temperature differentials shall not occur.
 - iii) Selector switches shall be provided for selection of fans and pump equipment to be in 'service' or on 'stand by'.
 - iv) A magnetic contactor with thermal overload relays and MPCBs (motor protection circuit breakers) for short circuit protection shall be provided for each individual oil pump motor and for a maximum of 2 fans. Suitable means shall be provided for isolating any fan or oil pump from supply. Overload relays shall be of hand reset type.
 - v) The following alarm initiating devices having normally open contacts shall be included as applicable for the method of cooling:
 - Cooler power supply auto changeover
 - Cooling fan/fans failure for each radiator bank and/or unit cooler
 - Oil pump failure
 - Low oil flow for each pump.
 - vi) The following initiating contacts shall be provided:
 - Cooling fans start
 - Oil pump start
 - Cooling system on automatic control
 - Cooling system on manual control

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- vii) All contacts shall be potential free and separately brought out to separate terminals. Necessary contacts shall be made available for remote alarm/indication in plant DDCMIS

3.4.9 Neutral Grounding Resistor Requirements:

- a) The neutral grounding resistor (NGR) shall be used for non effective grounding of 6.6 kV system of the plant. Each NGR shall be connected between neutral point of secondary side winding of station, Unit transformers & earth.
- b) The NGR shall limit the magnitude of earth fault current to 300A so that damage of electrical equipment is reduced, enhanced safety of personal is ensured and sensitive as well as selective earth fault can be provided. The NGR shall be air cooled type and suitable for outdoor installation in dust prone, hot, humid and tropical atmosphere. The resistor shall have minimum 10Sec.rating according to IEEE32.
- c) The resistor element shall be made of non-aging stainless steel or equivalent corrosion resistant material having high electrical resistivity and low temperature coefficient of resistance. All element connections shall be bolted type to ensure stable resistance value throughout the working life of the unit.
- d) Each NGR shall have structural steel work enclosed on all sides and also on top by sheet steel. Suitable ventilating louvers shall be provided on sides to ensure proper ventilation. The louvers shall be provided with fire wire mesh to make it vermin proof.
- e) Removable bolted disconnect link shall be provided for the purpose of isolation.
- f) Each cubicle shall be provided with 5A, 3 pin plug socket and door switch controlled cubicle illumination lamp.

3.4.10 Fittings and Accessories

- a) Bushing Current Transformer
 - i) Where bushing CT's are specified, the same shall conform to the specification indicated in the data sheet. Hot spot temperature of CT's shall be as specified for transformers.
 - ii) It shall be possible to remove the CT's at site, without opening the transformer tank cover/active part.
 - iii) All secondary leads shall be wired with 2.5 sq.mm stranded copper wire and including tapings shall be brought to a weatherproof terminal box. Rating and terminal marking plate of the CT shall be mounted on the terminal box. It shall be terminated in a box with

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stud type termination. Conduit wiring from this outlet box up to the transformer marshalling box or control cabinet shall be provided.

- iv) Neutral bushing CTs for back up earth fault protection and restricted earth fault protection shall be provided for transformers as specified in a box with stud type termination.

b) Conservator

- i) All conservator shall be Air Cell type.
- ii) Conservator shall be located in such a position as not to obstruct the electrical connections to the transformer. The conservator volume shall be sufficient to maintain the oil seal from ambient temp. of 5 °C to oil temp. of 90 °C, with oil level varying within min. and max. Levels.
- iii) 150 mm dial type magnetic level gauge with alarm and trip connection shall be provided. In addition, prismatic type oil level gauge with min. and max. levels marked shall also be provided. Taps or valves shall not be fitted to the oil gauge.
- iv) Drain valve shall be designed so that conservator can be completely drained by means of the drain valve provided when mounted as in service. One end of conservator shall be bolted into position so that it can be removed for cleaning purposes. If the sump is formed by extending the feed pipe into the conservator vessel, the extension shall be for at least 25 mm. Oil filling hole with cap shall be provided.
- v) Filling plug and sump valve of 15mm size shall be provided for conservator of diameter up to 650mm and 25 mm size valve shall be provided for conservator above 650mm diameter. Valve for shutting off oil to the transformer shall be provided for conservator.
- vi) A silica gel breather with inspection window and oil seal shall be mounted at 1.4 meter above transformer base with suitable supports and connected to the conservator.
- vii) Separate conservator shall be provided for OLTC.

c) Buchholz Relay

- i) All transformers shall be provided with double float buchholz relay fitted in the pipe connecting the tank and the conservator pipe and shall have the following dimension,
 - 25 mm dia. for transformers up to and including 1000 KVA.
 - 50 mm dia for ratings from 1 MVA to 10 MVA.
 - 80 mm dia for ratings above 10 MVA.
- ii) In addition oil surge relay shall be provided for OLTC.

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- iii) Pipe shall be arranged at a rising angle of 3 to 9 degrees to the horizontal, up to the buchholz relay. Valves shall be provided on either side of relay after providing necessary length of straight pipes.
- iv) The relay shall have pet cocks at the top and bottom, drain plug, inspection windows, calibrated scale to indicate gas present, built in test facility and terminal box with oil tight brass gland.
- v) The relay shall have electrically separate; potential free self reset contacts for alarm and trip. Contacts shall be rated to make, carry & break 0.5 Amp. at 220 V DC. The contacts shall be wired to Marshalling box. The relay shall conform to IS: 3637 (C 1966).
- vi) Copper pipe of nominal diameter 5mm shall be connected from the relay test cock to a valve located about 1.25 M above ground level to facilitate sampling of gas when the transformer in service.

d) Valves and Connections

- i) Valves shall be of forged carbon steel up to 50 mm size and of gunmetal or of cast iron bodies with gunmetal fittings for sizes above 50 mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.
- ii) All valves shall be provided with an indicator to show clearly the position of the valve. Oil sampling valves shall be provided at top and bottom of the main tank and these shall not be fitted on the filter valves. Non-return valves in pump scheme shall be provided. All transformers shall have bottom drain valve, top and bottom filter valves suitable for connecting to oil filtration unit. All transformers shall have bottom drain valve and shall be connected to oil pit through necessary pipes.
- iii) Each transformer shall be provided with following valves on the tank,
 - Two filter valves on diagonally opposite corners, suitable for connecting to oil filtration unit.
 - Oil sampling valves not less than 8 mm, at top, middle and bottom of main tank with provision for fixing PVC pipe.
 - One 15 mm air release plug at all required locations.
 - Valves between radiators and/or coolers.
 - Two plugged pipe outlets for applying vacuum.
 - Drain valve so located as to completely drain the tank to oil choke pit through necessary pipes and with locking arrangements.

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- Shut off valves between OLTC and its conservator.
 - Valves for connecting Online DGA (Dissolved Gas Analyzer) / Monitoring System.
- iv) All screwed valves shall be furnished with pipe plugs for protection.
- e) Joints and Gaskets
- All gaskets used for making oil tight joints shall be of proven material such as granulated cork-bonded synthetic rubber or synthetic rubber gaskets compatible with oil.
- f) Explosion Vent/Pressure Relief Device
- i) Pressure relief device shall be provided for GT, ICT, ST & UT. For all other Transformers, Pressure relief device / Explosion vent shall be provided. Pressure relief device provided shall be of sufficient volume for rapid release of any pressure that maybe generated within the tank and which might result in damage to the equipment. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer tank. Means shall be provided to prevent ingress of rainwater.
 - ii) The relief device shall be mounted on the main tank and if on the cover shall be fitted with skirt projecting 25mm inside the tank and of such a design to prevent gas accumulation.
 - iii) If diaphragm is used, it shall be of suitable design and material and situated above max oil level
 - iv) The equaliser pipe connecting the pressure relief device and conservator shall be provided for relieving or equalising the pressure in the pressure relief device.
- g) Temperature Indicators
- i) 150 mm & dial type top oil, and winding temperature indicator for the HV & LV windings shall be provided for all transformers. Further an additional terminal of winding temperature indicator for automatic control of Blowers shall be provided.
 - ii) Each thermometer shall have potential free NO alarm contact and trip contact. No multiplying contactor / relay shall be used. Temp. Setting of each contact shall be independently adjustable at site. A manual reset type maximum temperature indicator shall be provided for each thermometer.
 - iii) The temperature-sensing element mounted in pockets of oil on the top cover of the transformer shall be connected to the indicating elements through capillary tube.

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- iv) Each winding temp indicator shall have temp. Sensing element, image coil and bushing mounted current transformer.
- v) Each thermometer shall be provided with remote temp. Indicator along with associated Accessories. The remote temperature Indicators shall be mounted on relay panel.
- vi) The local winding temperature indicator shall be provided with necessary contacts for Automatic starting and stopping of cooling fans, alarm and trip functions. Settings for closing and opening contacts shall be independently adjustable.
- vii) All contacts shall be rated to make 0.5A(min) and break 0.2 A (min) at 220V DC. All contacts shall be wired to Marshalling box.
- viii) In addition to the above winding temperature indicators /controllers shall be provided, for control of forced cooling system of the transformer.
- ix) 4-20 mA signals for oil and winding temperatures shall be made available for interfacing with SAS / DDCMIS.

h) Marshalling Box

- i) The transformer marshalling box shall be used for control, interlocking, metering and indication for transformer and shall be installed outdoor near the transformer.
- ii) Sheet steel of 2 mm thick enclosed, outdoor, weather proof Marshalling box conforming to IP-55 enclosure shall be provided for auxiliary equipment of the transformer. The doors shall be provided with channel rubber/neoprene gaskets all round.
- iii) Marshalling box shall accommodate control and protection equipment of transformer, temp. Indicators, bushing CT secondary terminals, stud type terminal blocks, 415V voltmeter etc.
- iv) Tap changing gear cubicle shall accommodate motor drive and associated control Equipment of tap changing gear, terminal block, mechanical indicators etc.,
- v) Space heaters with temperature controller, illuminating lamp and toughened glass windows shall be provided
- vi) All indication. alarm, trip contact etc. shall operate on 220 V \pm 10 % DC and Cooler Control supply shall work on 110 V AC
- vii) Bidder shall supply necessary 415/110 V transformers.
- viii) Mechanical indications, temperature indicators, double compression brass glands with necessary gland plates for terminating cables etc. shall be provided in each box. All auxiliary equipment, protection and signaling contacts shall be wired to these transformer-mounted cabinets.
- viii) Transducers, Auxiliary relays etc required for linking to bidder's SAS system / DDCMIS and spare potential free contacts (for all

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alarm & trip signals) for purchaser's use would be provided in the Marshalling box. All contacts shall be potential free and separately brought out to separate terminals. Necessary contacts shall be made available for remote alarm/indication in plant DDCMIS

- ix) Cabling between the transformers and common Marshalling box shall be through cable trenches included in the scope of this contract. Sufficient space shall be provided in cable trays for cabling from Marshalling box by other vendors.

i) Earthing

- i) Two earthing pads, located on the opposite sides of the tank, shall be provided for connection to ground mat.
- ii) Earthing terminals shall also be provided on marshalling box to ensure its effective earthing. For continuity of earth connection, all gasketed joints shall be provided with braided copper wire jumpers.

j) Wiring

- i) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- ii) Wiring shall be done with [650] V PVC wires in conduit or PVC armored cable. *[Minimum wire size shall be 1.5 sq.mm stranded copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.]*
- iii) Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. *[Terminals shall be stud type, suitable for terminating 2 nos. 2.5 mm² stranded copper conductor and provided with acrylic insulating cover.]*
- iv) All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- v) Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

3.4.11 Terminal Block

- a) Terminal blocks shall be [650] V grade, 10 Amps rated, one piece moulded, complete with insulated barriers, stud type terminals, washers,

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nuts, lock nuts and identification strips. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.

- b) Not more than one wire shall be terminated on either side of a terminal. When it is required to terminate two or more wires on the same terminal, the wires shall be terminated on adjacent terminals and these terminals shall be shorted using suitable shorting links.
- c) At least 10% spare terminals shall be provided.
- d) Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of the suppliers wires on the same terminal
 - i) All circuits except CT circuits: Minimum of 2.5 mm² copper
 - ii) CT circuits: Minimum of 6 mm² copper
 - iii) For instrument signals: Minimum of 0.5 mm² for paired cable 1.5 mm² for core cable.

3.4.12 Auxiliary Supply

- a) A.C. supply will be made available to each transformer by two separate feeders one normal and the other standby.
- b) Isolating MCCB shall be provided for each of the incoming supply along with automatic changeover scheme to switch on to the standby source in case of failure of the normal supply.

3.4.13 Transformer Oil Centrifuging Plant (wherever applicable)

One no. mobile transformer oil centrifuging plant shall be provided. It shall be of sufficient capacity suitable for generator transformer with the following features:

- a) The capacity of the transformer oil centrifuging plant shall not be less than 10KLPH and vacuum in three stage degassing plant shall be better than one torr.
 - i) First stage will be evacuated by a two stage rotary oil sealed pump.
 - ii) Second stage of degassing column will be evacuated by a mechanical booster pump.
 - iii) Third stage of the degassing column will be evacuated by a roots pump.
- b) The plant shall be rated for continuous operation.
- c) The plant shall be mobile with four (4) wheel pneumatic tyres and suitable for being towed on motorable roads.

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- d) The plant shall also be supplied along with transformer evacuation system consisting of roots pump backed by a two stage rotary pump. Provision at suitable place in the path of oil being processed shall also be made for connecting an ionic reaction column to be used for the removal of acidity and product of oxidation and ageing in used transformer oil. The ionic reaction column shall also be supplied with the plant.
- e) The plant shall be complete with on-line testing instruments and annunciating panel.
- f) The following shall be prerequisites for the transformer oil centrifuging plant:
 - i) Dielectric strength : Suitable for 70kV or better with spark gap of 2.5 mm for 1 minute
 - ii) Water content in purified oil : Better than 20 ppm in single pass
 - iii) Suspended particles : 1 Micron
 - iv) Gas content : 0.1% by volume
 - v) Dissipation factor of oil at 90°C after filling into the equipment: 0.05
- g) The centrifuging plant shall be supplied with the essential testing equipments including but not limited to the following :-
 - i) Neutralization valve or total acidity test set to measure neutralization value of or total acidity content of transformer oil (organic or inorganic) as per IEC 296 and IS 335.
 - ii) Gas content measuring instrument to measure dissolved gas content in percentage of volume of same sample of transformer oil.
 - iii) Karl Fischer Apparatus to measure precisely dissolved moisture content in transformer oil.
 - iv) Inter facial tensiometer to measure the inter facial tension of insulating oil against water under non-equilibrium conditions in dynes/cm.
 - v) Relative humidity (RH) and Oil dryness test set to measure accurately water vapor pressure dew point and RH of a sample of insulating oil which in turn shall be used to assess the state of dryness of oil immersed solid insulation.
 - vi) Electronic vacuum gauge to measure with precision high vacuum inside the tank if new transformer supplied with protected nitrogen blanket while the same is being evacuated for filling of oil.
 - vii) Dew point meter to measure the dew point of the gas/ air surrounding the insulation of windings inside the transformer tank in order to determine surface mean moisture content of insulation.
 - viii) Automatic Dissolved Gas Analyzer to extract and measure various gases dissolved in electrical insulating oil of EHV transformers

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which are in service and also the estimation of hydrocarbon gases present in the layers above the transformer oil.

3.4.14 Painting

- a) All Steel surfaces shall be thoroughly cleaned by using seven tank process or by sand blasting, to produce a smooth surface free of scales, grease and rust. Pre treatment of sheet using solutions wire brush etc. shall not be done.
- b) Internal surface which shall be in contact with oil shall be painted with at least two coats of heat resistant, oil insoluble, insulating varnish.
- c) External surfaces, after cleaning shall be given a coat of High quality red oxide or Zinc chromate primer followed by filler coats. Over the filler coat, two coats of epoxy paint of grey shade shall be applied as a finishing coat to a thickness of 80 microns.
- d) The paints shall be carefully selected to withstand tropical heat, rain etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
- e) All supporting structures and hardware shall be hot dip galvanized.

i. Name Plate

Nameplates of approved design shall be furnished at each cubicle (one no. each at front as well as at backside of cubicle) and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black background. Self-tapping screws shall hold the nameplate. *[Nameplate size shall be minimum 20 x 75mm for instrument/device and 40 x 150mm for panels. Caution notice on suitable metal plate shall be affixed at the back of terminal Box.]*

3.5 Tests

I. Type Tests

For each type & rating of LV Transformers, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards, that is IS 2026 and carried out within *[last five]* years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within *[last five]* years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II. Routine tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

The following tests shall be performed on each transformer as a minimum:

The following tests constitute routine tests and they are not in specific order:

- a) Measurement of winding resistance.
- b) Measurement of voltage ratio and check of phase displacement.
- c) Measurement of short-circuit impedance and load losses between pair of windings at rated frequency with approximately sinusoidal voltage.
- d) Measurement of no-load loss and excitation current at 90%, 100%, 110% and 120% of rated voltage at rated frequency with approximately sinusoidal voltage.
- e) Dielectric tests.
- f) Measurement of capacitances and tan delta of winding to earth and between windings.
- g) Measurement of capacitances and tan delta of capacitor bushings that are to be installed on the ordered transformers.
- h) Measurement of Frequency response (Frequency Response Analysis - FRA).
- i) Test on Tap Changer.
- j) Magnetic balance test.
- k) Measurement of single phase short circuit impedance of each limb with single phase 50 Hz, low voltage.
- l) Measurement of single phase excitation current at low voltage at 50 Hz.
- m) Check of core and frame insulation for oil immersed transforms with core or frame.
- n) Winding insulation test, polarization index and absorption Index.
- o) Transient saturation. In rush current test.
- p) Tests on transformer oil. This shall be performed before starting tests on transformers.
- q) Measurement of Sound level as per IEC 60076-10.
- r) DGA test as per IEC 60567, IEC 60599 & IEC 61181.

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III. *Special Tests* (As per agreement between manufacturer and purchaser)

- a) *Measurement of the harmonics of the no-load current.*
- b) *Determination of sound levels. (IEC: 60076-10) for each method of cooling for which a guaranteed sound level is specified.*
- c) *Vibration test.*
- d) *Measurement of zero-sequence impedance(s) on three phase transformers.*
- e) *Measurements of the power consumption by cooling system.*
- f) *Determination and measurement of transient voltage transfer Characteristics.*
- g) *Short-circuit withstand test.*
- h) *Vacuum deflection test.*
- i) *Pressure deflection test.*
- j) *Vacuum tightness test on site.*

Further details have been provided in ient voltage transfer Characteristics.r which a guaranteed so

IV. Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

V. Test Certificates

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.

The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

3.6 Drawings/ Data and Manuals

Drawings, data, and manuals for the transformers shall be submitted as indicated below:

- a) *[General Arrangement Drawing*

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- b) Dimensioned general arrangement drawing showing enclosure, core coil assembly, terminal arrangement, marshalling box and various fittings.
- c) Transport/shipping dimensions with weights, wheel base detail etc.
- d) Foundation plan & loading.
- e) Bus duct/cable termination arrangement.
- f) Control schematics and wiring diagrams.
- g) Test reports and QAP
- h) Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.
- i) Instruction manuals on Transformer and its various fittings The manual shall clearly indicate method of installation, checkups and tests to be carried out before commissioning of the equipment.]

Note: The drawings, data and manuals listed are minimum requirement only. The Bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted.

3.7 Ratings and Requirements

For GT, ICT

Table: 2.0

S.N	DESCRIPTION	GENERATOR TRANSFORMER	INTERCONNECTING TRANSFORMER (if applicable)
1	3 Phase power supply system in which transformer is to be used		
a)	HV side max. Voltage	[420 KV]	[420 KV]
b)	LV side Max.Voltage	[KV] As per Manufacturer standard	[245 KV]
c)	System earthing		
	- Primary Side (HV)	Effectively Earthed	Effectively Earthed
	- Secondary Side (LV)	Non Effectively Earthed	Effectively Earthed
2	Max. 3 phase fault levels		
	- Primary Side (HV)	[40 KA]	[40 KA]
	- Secondary side (LV)	[-- KA]	[-- KA]
3	Direction of power flow	Uni-directional	Bi – directional

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S.N	DESCRIPTION	GENERATOR TRANSFORMER	INTERCONNECTING TRANSFORMER (if applicable)
4	Transformer application	Generator Transformer	Interconnecting Transformer
	Applicable standards	IS: 2026	IS: 2026
5	Transformer type		
A	Indoor/ outdoor	Outdoor	Outdoor
B	Dry type / oil immersed	Oil Immersed	Oil Immersed
C	Core type/ shell type	Core type	Core type
6	Auto wound / two winding/ three winding	Two winding	Auto wound
7	Number of phases	Three	Three (comprising 3 nos single phase unit)
8	Rated frequency	50 Hz \pm 5%	50 Hz \pm 5%
9	Rated no load voltage		
	- HV Winding	[400 KV]	[400 kV]
	- LV Winding	[-- kV] As per existing generator voltage	[220 kV]
10	Cooling		
	a) Method of cooling	OFAF	OFAF
	b) Cooling liquid	Mineral oil (IS: 335)	Mineral oil (IS: 335)
11	Rated MVA at no load voltage & principle tap		
	ONAN	---	---
	ONAF	---	---
	OFAF	---	---
	Tertiary winding (OFAF rating)	---	---
12	Overloading as per IS: 6600	Required	Required
13	Design ambient temperature	50 °C	50°C

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S.N	DESCRIPTION	GENERATOR TRANSFORMER	INTERCONNECTING TRANSFORMER (if applicable)
14	Max. temp. rise at rated MVA & principal tap		
	a Top oil by thermometer method over design ambient temp. of 50 °C	50 °C over 50 °C	50 °C over 50 °C
	b Any winding (HV&LV) by resistance method over design ambient temp. of 50 °C	55 °C over 50 °C	55 °C over 50 °C
	c Hot spot temp. based on the design ambient of 50 °C	As per IS	As per IS
15	Percentage impedance voltage at rated current, frequency, principle tap and 75°C	----	-----
16	Tappings		
	a Off-circuit/ ON load	[Off-circuit tap changer]	[On-load tap changer]
	b Manual /automatic	Manual	Automatic
	c No. of steps	[8]	[16]
	d Percentage variation /step	[-10% to +10% / 2.5%]	[-10% to +10% /1.25%]
	e Winding in which tappings are required	HV	HV
17	External terminal Short circuit withstand capability of transformer on any tapping for 3 phase and line to ground faults across LV winding	[Not less than 2 sec.]	[Not less than 2 sec]

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S.N	DESCRIPTION	GENERATOR TRANSFORMER			INTERCONNECTING TRANSFORMER (if applicable)		
18	Insulation	PF withst and - KV (rms)	Impulse withsta nd KVP	Switching Impulse KVP	PF Voltage	Impuls e voltage	SIV KVP
	HV winding	-	[1300]	[1050]	-	[1300]	[1050]
	LV winding	Shall be decided based on existing generator voltage			[395]	[950]	-
	HV Neutral	[38]	[95]	-	[38]	[95]	-
	Tertiary winding	-	-	-	[70]	[170]	-
	HV Bushing	[630]	[1425]	[1050]	[630]	[1425]	[1050]
	LV Bushing	[50]	[125]	-	[460]	[1050]	-
For 245kV and 420kV maximum voltage- Next higher value of insulation may be adopted for Transformer bushing from its winding							
19	Winding insulation category						
	a HV-uniform/Graded Insulated	Graded Insulated			Graded Insulated		
	b LV-uniform/ Graded Insulated	Uniform			Graded Insulated		
	c Tertiary Winding	-			Uniform		
20	Winding data						
	a No. Of windings	Two			Two (Auto + 1Tertiary)		
	b Winding material	Copper			Copper		
	c Winding connection (HV / LV winding)	Star	Delta		Star	Star	Delta
	d Vector groups HV-LV	[YN d11]			[YNaOd11]		
21	Core laminations						
	- Type	CRGO			CRGO		
	- Material	SILICON STEEL			SILICON STEEL		

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S.N	DESCRIPTION	GENERATOR TRANSFORMER		INTERCONNECTING TRANSFORMER (if applicable)
	- Thickness mm (Max. Permissible)	0.3 mm		0.3 mm
22	Noise level in DB scale when measured 4 ft. from the transformer edge at a height of 5 ft. above the floor at rated voltage and load	As per NEMA Standard-TR-1		As per NEMA Standard-TR-1
23	Bushing current transformers			
	a) Location	On the tank cover and accessible without removing the bushing, tank cover or active parts.		
		HV Line	HV Neutral	HV Neutral
	b) Application	Core1- Differential Core 2-REF	Core 1-REF Core 2-SEF	Core 1-REF Protection Core 2-SEF Protection [REF-Restricted Earth fault] [SEF-standby Earth fault]
	No. of cores on the CT (Quantity)	2	2	2
	Type	Ring	Ring	Window
	Ratio Core 1	[1000 / 1A]	[1000/1A]	[1000/ 1A]
	Core 2	[1000/ 1A]	[1000/1A]	[1000/ 1A]
	Class and Accuracy Core 1	[Class PS]	[Class PS]	[Class PS]
	Core 2	[Class PS]	[5P20]	[5P20]
	Knee point voltage	≥500 Volts	≥500 Volts	≥ 500 Volts
	CT sec. Resistance at 75 °C (for Core 1)	Less than 2 Ohms	Less than 2 Ohms	Less than 2 Ohms
	Burden for Core 2	-	[20 VA]	[20 VA]

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S.N	DESCRIPTION	GENERATOR TRANSFORMER				INTERCONNECTING TRANSFORMER (if applicable)			
	Short time rating for 2 Sec	As applicable for transformer		As applicable for transformer		As applicable for transformer			
	Magnetizing current at $V_k/2$	Not more than 20 mA		Not more than 20 mA		Not more than 20 mA			
	Accessibility	Shall be accessible without removing tank cover and active parts		Shall be accessible without removing tank cover and active parts		Shall be accessible without removing tank cover and active parts			
24	CT for winding Temperature compensation	HV line side		LV line side		HV line side			
	-Type	By bidder		By bidder		By bidder			
	-Ratio	By bidder		By bidder		By bidder			
	-Class	Metering		Metering		Metering			
	-Burden	By bidder		By bidder		By bidder			
25	Bushings	Line bushing		Neutral bushing		Line bushing			Neutral bushing
		HV	LV	HV	LV	HV	LV	Tertiary	HV
	a Type	Porcelain		Porcelain		Porcelain			Porcelain
	g Short time rating	As applicable for transformer				As applicable for transformer			
26.	Terminal Arrangement:								
	a High Voltage	[Suitable for ACSR Double Moose conductors]				[Suitable for ACSR Double Moose conductors]			
	b Low Voltage	[Isolated Phase Bus-duct]				[Suitable for ACSR Double Moose conductors/IPS Tubes]			
	c HV Neutral	Porcelain				Porcelain			
	d LV Neutral	Not applicable				-			

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S.N	DESCRIPTION	GENERATOR TRANSFORMER	INTERCONNECTING TRANSFORMER (if applicable)
27	Radiators	Separately mounted (Detachable type)	Separately Mounted (Detachable type)
28	Transformer mounted on:		
	Rollers/flanged wheels	Flanged wheels	Flanged wheels
	Flanged wheels (removable)	Removable	Removable
	Rail gauge (in both axis)	1676mm Rail gauge	1676mm Rail gauge

Criteria for ST, UT

Table: 3.0

S N.	DESCRIPTION	STATION TRANSFORMER	UNIT TRANSFORMER
1	3 Phase power supply system in which transformer is to be used		
	a) HV side max.Voltage	[245 kV/ 420kV]	[-- kV] based on existing generator voltage
	b) LV side max. Voltage	[7.2KV]	[7.2KV]
	b) System earthing		
	- Primary side (HV)	Effectively earthed	Not applicable
	- Secondary side (LV)	Resistance earthing	Resistance earthing
2	Max. 3 phase fault levels		
	- Primary side (HV)	[-- KA]	[-- KA]
	- Secondary side (LV)	[40 KA]	[40 KA]
3	Direction of power flow	Uni-directional	Uni-directional
4	a) Transformer application	Station Transformer	Unit Transformer
	b) Applicable standards	IS: 2026	IS: 2026

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S N.	DESCRIPTION		STATION TRANSFORMER	UNIT TRANSFORMER
5	Transformer type			
	a)	Indoor/ outdoor	Outdoor	Outdoor
	b)	Dry type/Oil immersed	Oil Immersed	Oil Immersed
	c)	Core type/shell type	Core type	Core type
6	Auto wound / two winding/ three winding		Three winding	Two winding
7	Number of phases		Three	Three
8	Rated frequency		50 Hz \pm 5%	50 Hz \pm 5%
9	Rated no voltage			
	-	HV winding	<i>[220 kV or 400kV]</i>	<i>[-- kV] As per existing generator voltage</i>
	-	LV1 winding	<i>[6.9 kV]</i>	<i>[6.9kV]</i>
	-	LV2 winding	<i>[6.9kV]</i>	-
10	Cooling			
	a)	Method of cooling	ONAN/ONAF/OFAP	ONAN /ONAF
	b)	Cooling liquid	Mineral oil (IS: 335)	Mineral oil (IS: 335)
11	Rated MVA at no load voltage & principle tap (ONAN rating)			
	ONAN		-	-
	ONAF		-	-
	Tertiary winding (ONAF rating)		-	-
12	Overloading as per IS 6600		Required	Required
13	Design ambient temperature		50 °C	50 °C
14	Max. temp. rise at rated MVA & principal tap			

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S N.	DESCRIPTION		STATION TRANSFORMER	UNIT TRANSFORMER
	a)	Top oil by thermometer method over design ambient temp. of 50°C	50°C over 50 °C	50°C over 50 °C
	b)	Any winding (HV&LV) by resistance method over design ambient temp. of 50°C	55°C over 50 °C	55°C over 50 °C
	c)	Hot spot temp. based on the design ambient of 50°C	As per IS	As per IS
15	Percentage Impedance Voltage at rated current, frequency, principal tap and 75°C Between			
	HV-LV1		-	-
	HV-LV2		-	-
	LV1-LV2		-	-
16	Tappings		-	-
	a)	Off-circuit/ ON load	[On-load tap changer]	[On load tap changer]
	b)	Manual /automatic	Automatic	Manual
	c)	No. of steps	[16]	{16}
	d)	Percentage variation /step	[1.25 % -10% to + 10%]	[1.25% -10 to + 10%]
	e)	Winding in which tappings are required	HV	HV
17	External terminal Short circuit withstand capability of transformer on any tapping for 3 phase and line to ground faults across LV winding		Not less than 2 sec.	Not less than 2 sec

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S N.	DESCRIPTION		STATION TRANSFORMER			UNIT TRANSFORMER		
	a)	HV-uniform /Graded Insulated	Graded Insulated			Uniform		
	b)	LV-uniform/ Graded Insulated	Uniform			Uniform		
18		Insulation	PF withst and - KV (rms)	Impulse withst and KVP	Switching Impulse KVP	PF Voltage	Impulse voltage	SIV KVP
		HV winding	- [395]	[1300] [950]	[1050] -	Shall be decided based on existing generator voltage		
		LV winding	[20]	[60]	-	[20]	[60]	-
19		Winding insulation category						
	a	HV-uniform/Graded Insulated	Graded Insulated			Uniform		
	b	LV-uniform/ Graded Insulated	Uniform			Uniform		
20		Winding Data						
	a)	No. of windings	[Three]			[Two]		
	b)	Winding material	Copper			Copper		
	c)	Winding connection - (HV / LV winding)	Star /Star/Star			Delta / Star		
	d)	Vector groups - HV- LV	[YNyn0yn0]			[Dyn1]		
21		Core Laminations						
	-	Type	CRGO			CRGO		
	-	Material	Silicon Steel			Silicon Steel		
	-	Thickness mm (max. permissible)	0.3 mm			0.3 mm		

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S N.	DESCRIPTION	STATION TRANSFORMER	UNIT TRANSFORMER
22	Noise level in DB scale when measured 4 ft. from the transformer edge at a height of 5 ft. above the floor at rated voltage and load	As per NEMA Standard-TR-1	As per NEMA Standard-TR-1

For NGR

Table: 4.6

SI	Description	Station transformer NGR	Unit Transformer NGR
1	Service	Outdoor	Outdoor
2	Nature of Pollution	Heavily polluted	Heavily polluted
3	Design Ambient °C	50 °C	50 °C
4	Reference std.	IEEE std 32-1972	IEEE std 32-1972
5	Application	Power Transformer neutral earthing for [6.9] kV system	Power Transformer neutral earthing for [6.9] kV system
6	Rated value of resistance at design Ambient temperature	[16.6 Ohms (Without negative tolerance)]	[16.6 Ohms (Without negative tolerance)]
7	Rated voltage kV	[6.6] kV rms	[6.6] kV rms
8	Insulation class kV (RMS)	[7.2] kV	[7.2] kV
9	Rated current Amps	[300A]	[300A]
10	Rated frequency Hz	50Hz	50Hz
11	Rated time at rated current in Sec.	[30 Sec.]	[30 Sec.]
12	Material	Stainless steel Fecral punched sheet (AISI-406)	Stainless steel Fecral punched sheet (AISI-406)
13	Max. temp. rise over design ambient (°C)	300°C	300°C
14	1 min. PF withstand value kV (RMS)	[13.5] kV	[13.5]kV
15	Type of insulator supports	Porcelain	Porcelain

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SI	Description	Station transformer NGR	Unit Transformer NGR
16	Termination Incoming	HV Air insulated cable box with sealing kit suitable for [7.2] kV armoured Al conductor XLPE cable	HV Air insulated cable box with sealing kit suitable for [7.2] kV armoured Al conductor XLPE cable
	Outgoing (ground)	Earth strip	Earth strip
17	Enclosure class of protection	[IPW 55]	[IPW 55]
18	Max. limiting dimensions in mm length X Breadth X Height (excluding support structure if any)	Tender to specify	Tender to specify
19	Mounting arrangement	Structure	Structure
20	Painting of resistance enclosure	Epoxy after best painting procedures. Shade to be indicated during approval	Epoxy after best painting procedures. Shade to be indicated during approval

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4 ELECTRICAL TESTING LAB EQUIPMENTS

4.1 General

This specification is intended to cover *the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning]* of the minimum electrical laboratory and testing instruments that shall be provided complete with necessary hardware, software and other accessories such as main cables, calibration leads, clamps, connectors, operating manual, calibration certificates etc. for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

4.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC except where modified and/or supplemented by this specification.

equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

4.3 Design Criteria

- a) The electrical laboratory and testing instruments shall be installed in hot, humid and tropical atmosphere. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- b) All electrical laboratory and testing instruments shall be suited for uninterrupted operation under the following variations in voltage and frequency:
 - i. Voltage Variation : $\pm 10\%$
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency
- c) The test equipments shall be suitable for working on the following:
 - i. 3 phase, 4 wire, 415V, 50Hz solidly earthed.
 - ii. 1 phase, 240V, 50Hz solidly earthed system.
 - iii. 220V, 2 wire, DC system with following neutral and (+) 10% to (-) 15% variation.

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4.4 Specific Requirements

4.4.1 Portable 5 kV Digital Insulation Tester

Features

Complete with test leads, mains lead, carrying case, PC down load software, instruction manual, test/calibration certificate etc.

Measuring Ranges

- a) Purpose : For checking the insulation level and polarization index of electrical equipments.
- b) Resistance : < 100 kilo ohm -> 1 Terra ohm
- c) Current : < 100 pico A -> 5 mA
- d) Test Voltages : [500, 1000, 2500 and 5000V]
- e) Accuracy : Better than 2%
- f) Test Time : Adjustable < 15 Sec.-> 10 minute
- g) Display : LCD 3½ digit with analog bar graph for Resistance, test voltage, current, PI
- h) Data Storage Capacity : > 75 Values
- i) Power Supply : 240V, 50Hz and rechargeable DC battery
- j) MMI : Via RS232
- k) Printer/PC interface : Via RS232
- l) Safety Standard : IEC 1010-1
- m) EMC Standard : EN50081-1 and EN 50082-1

4.4.2 Portable HV Decade resistance box in Polystyrene case with lid and carrying handle.

It shall be used for testing and calibration of insulation testers.

- a) Overall range : 1 kilo ohms to 1 Terra ohms
- b) Resolution : 1k Ohms
- c) Accuracy : 0.1% - 2%
- d) Connection : Shielded Plugs with 1 Meter cable

4.4.3 Portable HV AC Test Set comprising

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- a) Shall be used for checking the high voltage with-stand level of electrical equipments viz, transformers, switchgears, cables, motors/ generators etc.
- b) An epoxy cast, single phase, 50-200kV/240V, 5kVA (continuous) and 10kVA (5minute) rated low discharge transformer with maximum discharge level of 1 PC mounted in a steel tank fitted with swivel cast or wheels, HV bushing.
- c) A control unit with microprocessor based automatic control, programming key pad LCD display analog ammeter and voltmeter with 2% accuracy trip push button, safety protections etc.
- d) A zero interlock circuit shall be provided to prevent energization of HV output on less voltage control is set to zero.
- e) Necessary power and metering cables, removable earth link fuses etc. shall be provided.

4.4.4 Automatic Capacitance And Tan-Delta Test Set (Schering Bridge) With Oil Resistivity Test Cell.

Equipment and material conforming to any other standard, which ensures Fully automatic, microprocessor-based, accurate AC Voltage Bridge. Shall be used for monitoring the condition of insulation of electrical instruments.

- a) Input : 120/240V, 50 Hz
- b) Output : 0-12kV, 100 mA (Cont.), 200mA (15 min) Extendible to 4A with resonating inductor
- c) Capacitance : 1.6 pF to 8 μ F (with 100pF std. capacitor)
- d) Measurement with $\pm 0.02\%$ to $\pm 0.05\%$ accuracy and 0.0001 pF resolution
- e) Tan-delta : 1×10^{-6} to 9.999 with accuracy $\pm 0.5\%$ and 1×10^{-6} resolution
- f) Capacitive current : 0-5A
- g) Measurement : 2.5 kV (RMS), 150°C, 100 cm³, 100 pF
- h) Display : Large graphic TFT (4-5 digit) Test voltage, frequency, capacitance, Tan-delta.
- i) Interface : RS232 for Printer 1 PC

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4.4.5 Portable Transformer Oil Breakdown Test Set

To test the dielectric strength of transformer oil.

- a) Test Voltage : 0-100kV (RMS)
- b) Accuracy : $\pm 2\%$ of reading
- c) Switch-off response : < 4 mA current.
- d) Switch-off response : < 6 mS time
- e) Rate of rise of : 0.5/1/2/3/5KV per sec.
- f) Test voltage : Manual/Auto adjustable
- g) Display : Alpha numeric LCD.
- h) Interface : RS 232, RS232C
- i) Standard : IEC 156, ASTM D877
ASTM D1816, BS 5874, IEC 1010-1

4.4.6 Portable Karl-Fischer Test Set

Coulometric test set for oils with specific gravity ranging from 0.6 to 1.4, with a built-in printer. It shall be used to measure the percentage of moisture contamination of transformer oil.

- a) Titration Method : Coulometric, Karl-Fischer
- b) Display : 40 character alpha numeric with backlit LCD
- c) Sample Volume : 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0 ml
- d) Sp. Gr. range : 0.6 to 1.4 in 0.01 steps
- e) Moisture range : 1 ppm – 100%
- f) Measuring range : 1 μ g – 10 mg water
- g) End point detection : ac polarization
- h) End point indication : Visual display/ printout/ acoustic beep
- i) Titration speed : 2 mg/ minute maximum
- j) Maximum current : 400 mA
- k) Drift compensation : Automatically controlled
- l) Start delay : 10 seconds
- m) Stirrer speed : Microprocessor-controlled
- n) Accuracy : $\pm 3 \mu$ g to $\pm 0.5\%$
- o) Calculation mode : Volume/ density or weight/ weight
- p) Printer : High Speed Thermal

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q) Power supply : 90-264V ac, 12V dc rechargeable Battery.

4.4.7 3- Phase Portable Transformer Turns Ratio and Vector Group Meter

Fully automatic, microprocessor based having automatic tap changer control with internal chip card reader and built-in keyboard. In a robust mobile case having following features:

- a) Ratio : [Range : 0.75 to 10000]
- b) Ratio accuracy : $\pm 0.1\%$ to $\pm 0.3\%$ ± 1 digit
- c) Measuring Voltage : Yes
- d) Frequency Range : Yes
- e) Phase angle range : $\pm 90^\circ$
- f) Phase angle accuracy : $\pm 0.1^\circ \pm$ digit
- g) Magnetizing Current : $< 1 \text{ mA} \rightarrow 500 \text{ mA}$
- h) Magnetising Current accuracy : Better than $\pm 2\%$
- i) Measuring time : 5-20 seconds
- j) Data Storage : 200 sets of measurement
- k) Display : Backlit LCD 256 x 128 pixels
- l) Data displayed : Vector group, phase, tap position, ratio, Ratio deviation, phase angle, phase angle deviation, mag. current, pass-fail result
- m) Interface : RS232C, printer port
- n) Accessories : Windows compatible software for control Via PC HV/LV, main lead, clamps, operating manual, guarantee certificate.

4.4.8 Digital Low Resistance Ohmmeter

Features

Dual channel , direct – reading ohm meter having a safe discharge circuitry and in built printer with date and time stamping, software for remote PC control heavy duty connecting cables, clamps, operating manual, test/calibration certificate and transportable case.

Shall be used for for simultaneous measurement of HV and LV winding resistance and check on OLTC operation.

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- | | | |
|-----------------------|---------------------------------------|--------------|
| a) Measuring ranges | Nominal range | Resolution |
| | 0-2m ohm | Micro Ohm |
| | 0-20m ohm | 1.0micro Ohm |
| | 0-200 Ohm | 1.0micro Ohm |
| | | milli Ohm |
| | 0-2 Ohm | milli Ohm |
| | 0-20 Ohm | 10 milli Ohm |
| | 0-2000ohm | |
| b) Accuracy | 0.1 % of reading over entire range | |
| c) Excitation Current | 0.1-25 A with compliance open circuit | |
| d) Display | 4 1/2 Digit backlit LCD | |
| e) Data Storage | Upto 700 measurement | |
| f) Interface with | RS232 | |
| | remote control | |

4.4.9 Portable High Current Digital Micro Ohm Meter

Suitable for carrying out measurements in charged EHV (>400kV). Supplied with built-in charger, mains lead, operating manual, test/calibration certificate, mounted in a light weight portable case with clip-on clamps and voltage leads for 4-wire measurement system having the following features:

- | | |
|----------------------------|-------------------------------------|
| a) Measurement ranges: | |
| i. 100 micro ohm | |
| ii. 600 micro ohm | |
| iii. 6000 micro ohm | |
| iv. 10.0 – 60000 micro ohm | |
| v. 600 m ohm | |
| vi. 1.0 – 6000 m ohm | |
| b) Resolution | : 0.01 micro ohm to 1.0 milli Ohm |
| c) Accuracy | : (±) 0.2% --- (±) 0.5% |
| d) Display | : with 4 digit LED or LCD (backlit) |
| e) Data Storage | : > 300 readings |

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- f) Interface : RS232
g) Test Current : Up to 200A

4.4.10 Portable Primary and Secondary Current Injection Test Kit with Separate Control and Loading Units

- a) Control Unit
- ii. Current Output : 0-25A/0-50A (cont.),
0-50A/0-100A (upto 5 min)
 - iii. Voltage Output : 0-230V
 - iv. Current and Voltage : By true RMS, 4 digit digital meters
With measurement $\pm 0.6\%$
accuracy (+ 6 digit)
 - v. Timing Units : For ON and OFF
 - vi. Range : 0 – 1000 Sec.
 - vii. Resolution : 1 m sec.
 - viii. Accuracy : $\pm 0.1\%$ + 2 digits
 - ix. Power supply : 230V $\pm 10\%$, 45-551/2, 1-phase
 - x. Display : LCD/ LED
- b) Loading Unit
- i. Ranges : 0-500A/0-1000A/0-2000A/0-3000A

4.4.11 Portable Automatic Earth Tester

Microprocessor-controlled, user-friendly, with self-diagnostic features and alphanumeric display, re-chargeable battery shall be used in this equipment. Mounted in a robust case and provided with hammer and 4 GI spikes and 50m long cable on a cable winder.

Shall be used for measuring earth electrode resistance and soil resistivity using Warner 4-terminal method.

- a) Earth resistance : 0-20 k Ohms(Auto ranging)
range with 1 M Ω resolution
and 60.5% 62 digit accuracy
- b) Test frequency : 100-160 Hz in 0.5 Hz steps
- c) Test current : 50 mA
- d) Max. output voltage : <50V (RMS)
- e) Max. Interference : 40V peak to peak (50 Hz)
- f) Display : 3½ digit Alpha numeric LCD
- g) Standards : IEC 1010-1, EN 50081-1, EN

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4.4.12 Portable three phase Universal Protective Relay Test Set

Microprocessor-based user-friendly with digital signal processing. Having large LCD display with programmable menu. Having programmable output current and voltage waveforms and phase angles. Having following additional features and specifications:

- a) Input power : 90-250V, 1 Ph, 50 Hz
- b) Outputs : One AC Current 0-100A
One AC Voltage 0-300V
One AC Voltage/Current, 0-240V/0-2.5A
- c) Output frequency : Selectable from 16.66 Hz – 300 Hz
- d) Output AC voltage : 0-360deg. independently controlled phase shift
- e) Reading accuracy : $\pm 1\%$ for AC/DC Volts, Current
 ± 0.5 deg. In phase angle
 $\pm 0.02\%$ in power factor
 $\pm 1.5\%$ in active/reactive power
 $\pm 0.005\%$ in time
- f) Memory : Non volatile RAM
- g) Interface : RS port for PC and parallel printer Port
- h) Capacitive measurement : Resolution : 1pF
Accuracy : $\pm 0.2\% + 20$ digits

4.4.13 Precision Digital Multimeter

7½digit precision multi-meter for calibration of voltage/ current sources, decade resistance boxes, frequency sources with a large 24-digit vacuum fluorescent display, a bar-graph function allowing user programming of high and low pass/ fail limits, audible and visual indication of component specification and Auto Dynamic Filter (ADF) to enable automatic selection of suitable filter.

- a) Input Power : 110/220/240V AC 50 Hz
- b) DC Voltage Measurement Range: 3 MV to 10 kV
Resolution : 10 nV
Accuracy : $\pm 12\text{ppm} + 6\text{digits}$
- c) DC Current Measurement Range: 3 μ A to 30A

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		Resolution	: 10 pA
		Accuracy	: $\pm 75\text{ppm} + 10\text{digits}$
d) Resistance Measurement	:	30 M ohm to 1 G ohms	
		Resolution	: 10 n Ohm
		Accuracy	: $\pm 200\text{ppm} + 6\text{digits}$
e) Frequency Measurement	:	1 Hz to 100 K Hz	
		Resolution	: 1Hz
		Accuracy	: $\pm 10\text{ ppm} + 1\text{digit}$
f) AC Voltage Measurement	:	3m V to 3 KV	
		Resolution	: 100 nV
		Accuracy	: $\pm 0.05\% + 40\text{digits}$
g) AC Current Measurement	:	3 Micro Amp to 30A	
		Resolution	: 100 pA
		Accuracy	: $\pm 0.1\% + 80\text{digits}$

4.4.14 Portable Digital Frequency Meter

Rugged, high accuracy portable frequency meter/calibrator in a dust tight, water resistant case.

Having LCD display complete with test leads, carrying case, 9V battery and instruction manual.

a) Ranges	:	0-100 KHZ / 0-1000 Hz
b) Resolution	:	1 KHZ / 0.1 Hz
c) Accuracy	:	$\pm 0.1\% \text{ FS } \pm 1 \text{ LSD}$
d) Step Size	:	10% of range
e) Scroll Size	:	0.1 % of range
f) Input	:	1V to 100V p-p
g) Output	:	5V p-p Square Wave
h) Maximum load	:	5 mA

4.4.15 Digital Sound Level Meter

Condenser type microphone, frequency and time weighting functions, AC and DC outputs supplied with 9V battery and calibration screw driver.

a) Range	:	[0-130dB] $\pm 1.5\%$ of reading
b) Battery operated	:	Yes
c) Portable, handheld, rugged	:	Yes

4.4.16 Digital Tachometer:

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Non-contact photoelectric optical type. Having features like reading hold, memory recall and low battery indication

- a) Display : 5 digit LCD
- b) Range : [0-10000 rpm or better]
+/-5 % of reading
- c) Resolution : 0.1 rpm to 1 rpm
- d) Accuracy : $\pm 0.1\%$ ± 1 digit to $\pm 0.15\%$
 ± 1 digit
- e) Optical Range : Up to minimum 300mm
- f) Non- Contact type : Yes
- g) Auto ranging : Yes
- h) Battery operated : Yes
- i) Portable, handheld, rugged : Yes

4.4.17 Cable Fault Locator

Working on pulse reflection (echo) technique. Capable of discriminating between inter-core and core to earth fault with facility to detect high resistance faults (>10 ohms) complete with surge generator, acoustic receiver, input filters, head phones etc.

- a) Input : 240V, 1 phase, 50 Hz
- b) Range : 10 nano sec. To 2000 ns
- c) Impedance range : 25 ohms to 100 ohms
- d) Surge Generator : 15kV, 100 mA, <512 joules,
capacity 10-20 pulses per minute
- e) Display : Backlit LCD

4.4.18 Portable Hand held SF6 Gas Leakage Detector

(With audio-visual indication)

- Sensitivity : 3 to 5 ppm

4.4.19 Portable Hand held Hydrogen Gas Leakage Detector

(with audio-visual indication)

- Sensitivity : 50 to 100 ppm`

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4.4.20 Portable Vacuum Tester

For testing the condition of vacuum in medium voltage switchgear with automatic discharging facility and high voltage screened cable and over load/over voltage protection

- a) Display : Digital display of applied voltage in kV and leakage current in mA. Red and green indications for defective and acceptable chambers.
- b) Resolution : 0.1 kV and 0.01 mA
- c) Input : 240V AC, 50 Hz
- d) Output : 0-60 kV DC Adjustable
0-9.99 mA Adjustable
- e) Loading time : Upto 30 seconds

4.4.21 Portable Light Intensity Meter

- a) With selenium photocell, 2 metres lead and filters.
- b) Ranges : 0-15/30/100/300/1000/3000 lux
- c) Accuracy : $\pm 4\%$ of full scale

4.4.22 Portable Circuit Breaker Motion Analyser

For analyzing performance of SF6/Vacuum/air circuit breakers upto 400kV Microprocessor-based capable of measuring, recording and printing opening/ closing times and velocity, coil currents, dynamic contact resistance of main/aux. and arcing contacts, pole discrepancy etc. The instrument shall have user-friendly menu driven software for easy operation and reduced set up time. It shall have communication ports for downloading of data from memory on to a PC. It should have a built-in DC battery and printer. Other specifications shall be as follows :

- a) Input Supply : 110-240V, 50Hz with built-in DC battery backup with charger
- b) Current injection : Up to 100A DC
- c) Timing Range : 0-9.99 S. with a resolution of 0.1mS and accuracy of $\pm 0.01\%$
- d) Number of channels : 12 analog, 24 digital
- e) Display : 16 character alphanumeric LCD

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4.4.23 Generator On-line Partial Discharge Real Time Monitoring System

To detect and monitor partial discharge activity in generator stator windings and vibrations in generator end windings by acoustic sensors. To generate alarms in case of excessive partial discharge or end winding vibrations. Should have the capability to acquire partial discharge patterns and determine PD quantities as apparent charge, quadratic rate and average discharge current for each phase. Standalone type with facility for storage of trend data and patterns. With facility to download patterns and trends on to PC or LAN; visualization software and automatic report generation shall be provided. Having noise suppression circuitry for input and signal transfer. The surge capacitors connected on the line Terminals of the generators shall be used as PD sensors. Necessary surge capacitor connection kit shall be included and the instrument shall be compatible with surge capacitors of 0.25 micro farads/ 24 kV supplied with the generators the instrument shall be in 19" rack-mounted design and shall be housed in a wall-mounted IP65 case. Other specifications as below:

- a) PD Input : 4 channels, 0-30 V rms
- b) Frequency Ranges : 0.3 MHz - About 10 M Hz
- c) Acquisition Software : Standalone C-based
- d) Evaluation Software : Standalone Java based
- e) Data Storage : Up to 48 values per channel 1
Pattern per day
- f) Visualization : Web server with standard web-Browser and Windows based internet capable software
- g) Communication : 100 M Bit Ethernet interface with TCP/ IP protocol and fiber-optic communication

4.4.24 Interfacial Tension Meter for Transformer Oil

Motorised operation using a Platinum Iridium Ring. In dust tight IPW55 enclosure

- a) Range : 0-90 Dynes/per cm.
- b) Zero Drift : < 0.1 Dynes/m in 24 Hours
- c) Resolution : 0.05 Dynes
- d) Accuracy : \pm 0.5 Dynes/cm

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4.4.25 Portable, Hand-held Thermal Imaging Camera

Having voice recording and alarm facility, double ocular view finder and clear CCD lens, multi-spot (Minimum 4) temperature measurement and High End image analysis software capable of generating wizard guided reports and trend analyses etc. Battery operated.

- a) Temperature Range : -10°C to 2000°C
- b) Detector Type : Un-cooled Focal Plane Array
- c) Thermal Sensitivity : 0.08°C @ 30°C
- d) Frame Rate : 50 Hz
- e) Field of View : 20° x 20°
- f) Spectral Response : 8 to 14 microns
- g) Battery Operation : For at least 2-hours

4.4.26 Portable High Voltage/Live Line Detector

Electronic type, giving audio-visual indication for presence of voltage/charge, having in-built self-diagnostic check feature.

- a) Insulating stick shall be class 'F' insulated.
- b) Range : Up to 300 kV

4.4.27 Tong Testers

Digital clamp-on volt-ammeters Ranges:

- a) 0-5/ 25A, 0-60/ 300/ 600V
- b) 0-1/ 5A, 0-60/ 300/ 600V
- c) 0-10/ 30/ 300/ 1000A, 0-60/ 300/ 600V

4.4.28 Portable Phase Sequence/Continuity Indicators

To indicate phase continuity and phase rotation sequence of 3-phase power circuits. Complete with colour-coded and insulated 1 Meter long fused leads with boot-protected alligator clips and carrying case. It shall have an impact resistant plastic body with encapsulated circuitry incorporating neon indicators for phase continuity and phase sequence.
Rated 100-600V, 40-60 Hz.

4.4.29 Relay Tool Kit

Comprising following minimum tools:

- a) Spring setting tool

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- b) Inspection mirror and torch
- c) Ring spanners
- d) Box spanners
- e) Burnishing tool
- f) Contact pressure gauge
- g) Factor gauges
- h) Test plugs with link plugs
- i) Screw drivers
- j) Nose pliers
- k) Scissors

4.4.30 HV Discharge Rod and Portable Earthing Equipment

Class 'F' insulated. Having non-linear carbon film resistor with negative temperature co-efficient. Non-hygroscopic

- a) Dimensions : ID : 25 mm
OD : 31 mm
Length : 1250 mm (main rod and each Extension)
Total Length: 6 meters
- b) Discharge hook : 100 mm (dia)
12.5 mm (dia) copper rod
- c) Earth lead : Flexible braided copper
- d) Voltage rating : Up to 400 kV

4.4.31 Hot Sticks (Live/ Dead Line Tester)

Class 'F' insulated, upto 400kV, extendible from 1.25 meter to 6.0 meters with inbuilt self-check feature. Contact or proximity type in a special carrying case.

4.5 Tests

a) Type Test

For each type & rating of equipment for [220 kV/400 kV] substation, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

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In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

b) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

c) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

d) Test Certificates

- iii. Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- iv. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

4.6 Drawings, Data and manuals

The engineering services scope and the documentation to be issued with the bid are described hereafter. The list shows the minimum requirements for the documentation, so that any additional documentation considered as necessary will be added to this.

a) Engineering, manufacturing, delivering and test schedule

b) Sub-Supplier lists.

c) General arrangement drawings(plan, elevation, section view) with dimensions

d) Foundation drawing including loading data.

e) Technical Data sheets.

f) Electrical and control wiring diagram.

g) Terminal arrangement drawing, interconnection wiring diagram.

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- h) Cross sectional drawing.*
- i) Inspection and test plan.*
- j) Manufacturing Quality Plan.*

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5 ENERGY MANAGEMENT SYSTEM

5.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Energy management system complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

5.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE standard.

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

5.3 Design Criteria

- a. The EMS shall acquire electrical parameters like 3 ph voltage, 3 ph current, KW, KVA, KVAR, PF, frequency, KWh and KVARh from numerical relays and energy meters of various feeders subject to availability of the above parameters on communication port of numerical relays & energy meters.
- b. The communication server shall poll the data concentrator and energy meters for data acquisition. The communication server shall act like Master and the data concentrator and energy meters as slaves in the communication network. The data so collected shall be stored in data base for further use.
- c. Energy parameters are displayed in workstation and viewer PCs for meters in various feeders in the form of single line diagram.
- d. Energy data shall be logged in the server and Energy consumption reports shall be generated for analysis. Reports shall be generated on daily, monthly or periodically basis. Facility to print reports on laser printer shall also be provided. The following reports shall be provided.

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- i. Power consumption report – Shift wise, Daily, Weekly, Monthly and Yearly basis. For each switchgear board, power consumption parameters of incoming / outgoing feeders shall be displayed.
 - ii. Single Line Diagram: For each switch board, presence of energy meter / numerical relay is indicated as bitmap. Instantaneous values like V, A, PF, KWH, KVAR, F shall be displayed below each feeder.
 - iii. Load flow: Direction of load (active & reactive power) flow along with the present value of load (active & reactive power) shall be indicated for each switch board.
- e. Numerical relays are being supplied as part of various station and unit switchgear boards for this project. Energy consumption parameters for various feeders located in the switchgear boards (KW, KVAR, KWH, KVARH etc) are acquired from these numerical relays through the communication port on suitable protocol by EMS system. All the numerical relays pertaining to a switchboard shall be looped and connected to a data concentrator. Data concentrator shall be interfaced to EMS system for acquiring energy data from numerical relays.
- f. Similarly for switchboards where energy meters are provided in place of numerical relays, the energy meters shall be interfaced to EMS system. Energy meters shall be looped to form RS485 network within that switchboard. Further energy meters shall be networked from switchboards to EMS system panel. For noise reduction RS485 signals shall be converted to TCP/IP or fiber optic communication depending upon distance.
- g. Alternately, the data, if available, can be realized from the PLCs of sub-package before giving input to DDCMIS. However, this acquisition of data should not affect or slow down the operation of DDCMIS and PLCs.
- h. In the unit control room location, Network panel of suitable dimension shall have to be provided. [Color of panel shall be RAL9002 powder coated with IP42 protection class.] At MCC/switchgear room, wall mounted network enclosures of suitable dimensions shall have to be supplied. These enclosures shall not pose any hindrance to the Electrical panels. Enclosures shall be of steel construction with holes for wall mounting brackets, Gland plate at bottom for cable entry, Ventilation

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slots and front tinted glass door. *[Color of enclosure shall be RAL7032 powder coated with IP20 protection class]*

- i. Network Panel and wall mounted enclosures installed in the power plant unit control room shall be powered from the control room UPS.
- j. For remaining wall mounted enclosures, 1 KVA online UPS with 30 min back up time shall be provided.
- k. Network panel and wall mount enclosures shall house TCP/IP based RS485 serial server devices, Ethernet to fiber converter, Light guide Interface Units (LIUs) for fiber termination as per requirements. Data concentrators and energy meters forming RS485 loops from one area shall be terminated at serial servers in the enclosures. Ethernet of serial server is the converted to fiber format by employing Ethernet to fiber converters for further connection to communication server (HMI) system at Unit Control Room.
- l. For interconnection of different locations (i.e. switchgear rooms) where cabling is running outdoor, optic fiber based network shall be deployed. Fiber optic network shall be single mode fiber based with 4 cores armored cable. Two cores of the fiber shall be utilized for interconnection between locations and balance cores shall be terminated on the LIUs.
- m. At the [Unit Control Room], workstation PCs shall be provided with Energy Management Software which work as communication servers. These workstations acquire online data from network of geographically distributed numerical relays and energy meters. Separate PCs shall be provided for data viewing purpose. For printing of reports,[network A3 size color laser printer] shall be provided.
- n. HMI system comprises of Workstation computers with TFT monitor, QWERTY keyboard and optical mouse in the Unit Control Room. Workstation computers shall be with following minimum specifications or higher versions.
 - i. *[Intel Quad Core processor, 2 GB RAM, 500 GB SATA Hard disk, DVD-ROM, 16x DVD +/-R/W Drive, 10/100/1000 Base-T PCIe Based Ethernet NIC's with RJ45 ports, supporting 1600 x 1280 resolution with true colors, 22" TFT MONITOR with resolution of 1280 x 1024. Microsoft Windows XP Professional with latest service pack.*

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ii. *Fiber optic cable specifications: 4 core, single mode fiber optic cable.*

iii. *RS485 cable specification: Low Capacitance Computer Cable for EIA RS232/485, 28AWG stranded tinned copper conductor, 2 pair twisted pair cable with 100-120 ohm characteristic impedance with a drain wire]*

- o. Furniture specification: Ergonomically designed computer table, computer chair & printer table shall be provided as per the requirement.
- p. For data acquisition, customized energy management software shall be loaded in these workstation computers (communication servers). The EMS software shall be programmed to generate reports for energy consumption per feeder and log reports.

5.4 Specific Requirements

5.4.1 The EMS system shall be supplied at following locations.

a. Electrical Control Room

Following equipments shall be supplied in Electrical control room.

- i. *[2 No of Desktop type Workstation for EMS Software.*
- ii. *2 No of Desktop type Workstation for viewing purpose.*
- iii. *1 No of A3 size network ready color Laser printer.*
- iv. *1 No of Network Panel housing Communication network accessories.*
- v. *4 No of Desktop type Tables for Work Stations.*
- vi. *1 No of Printer tables for the above printers.*
- vii. *4 No of chairs for operators.]*

b. MCC / Switchgear Rooms

Following equipment shall be supplied in MCC/Switchgear room

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- i. [1 set of wall mounted network enclosures housing serial servers, media converters and LIUs as per requirement in each switchgear room.]

c. Common Items

- i. [1 set of EMS software for various numerical relays and energy meters (approx. 500 Nos).
- ii. 1 set of serial cable for networking meters in switchgears in RS485 loop.
- iii. 1 set of Fiber optics, HDPE pipes with accessories for linking different locations.
- iv. 1 set of 1KVA, 30 min backup UPS for enclosures where UPS supply is not available.
- v. Any other items, to make the system complete].

d. Fiber Optical Cable Construction Specification

i. Secondary Protection

The primary coated fibers may be protected by loose packaging within a tube or tubes, filled with thyrotrophic jelly.

ii. Strength Member

Solid FRP non-metallic strength member / members in the cable core / sheath shall be provided. The strength member (s) in the cable shall be for strength and flexibility of the cable and shall have anti buckling properties. These shall also keep the fibre strain within permissible values.

The non-metallic strength member (s) may be in the cable core or embedded within the sheath.

iii. Cable Core Assembly

Primary coated fibres in loose tube / tubes and / or in groove stranded together around a central strength member using helical or reverse lay techniques shall form the cable core. Alternatively multiple units of fibres may be placed loosely in a single tube with the strength members in the sheath.

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iv. Core Wrapping

The main cable core containing fibres shall be wrapped by layer / layers of polyester foil tape. The nylon / polyester binder tape or thread shall be used to hold the tape, if required.

v. Moisture Barrier (Protection)

The main cable core (containing fibres & core wrapping) shall be protected by flooding compound (jelly) having properties of non-hygroscopic dielectric material and water swellable tape. The core wrapping shall not adhere to the secondary fibre coating.

vi. Filling Compound

The filling compound used in the loose tube and in the cable core shall be compatible to fibre, secondary protection of fibre, core wrapping etc. The drip point shall not be lower than +70°C. The fibre movement shall not be constrained by stickiness and shall be easily removable for splicing. Reference material test method to measure drop point shall be as per ASTM D 556. The filling and the flooding jelly compound shall be as per the GR No.G/ORM-01/02 MAR 99 and the subsequent amendments if any.

vii. Inner Sheath

A non-metallic moisture barrier sheath may be applied over and above the cable core. The core shall be covered with tough weather resistant High Density Polyethylene (HDPE) sheath black in colour (UV Stabilized) and the colour shall conform to Munsell Colour Standards. Thickness of the sheath shall be uniform and shall not be less than 1.8 mm including the strength members used in the sheath. The sheath shall be circular, smooth, and free from pinholes, joints, mended pieces and other defects. Reference test method to measure thickness shall be as per IEC 189 Para 2.2.1 and Para 2.2.2.

viii. Reinforcement

The aerial optical fiber cable shall be reinforced with Aramid Yarn in the periphery over the inner sheath. The Aramid Yarn shall be uniformly and equally distributed on the entire periphery (circumference) of the cable. The quantity of the Aramid Yarn used per kilometre length of the cable with its D-Tex value shall be indicated by the manufacturer.

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ix. Outer Jacket

A circular and uniform tough weather resistant polyethylene compound HDPE material. Sheath/Jacket black in colour shall be provided over and above the reinforcement of aramid yarn. The thickness of the outer sheath/jacket shall not be less than 2.0 mm. The sheath shall be free from pinholes, joints, scratches, mended pieces and other defects etc. and it shall have smooth finish.

x. Cable Diameter

The manufacturer shall define the cable diameter. The finished cable diameter shall be within + 0.5 mm from the defined cable diameter.

xi. Rip Cord

The two suitable (minimum) ripcords shall be provided which shall be used to open the inner and outer (HDPE) sheath of the cable. It shall be capable of consistently slitting the sheath without breaking for a length of 1 meter at the installation temperature. The rip cord (s) shall be properly waxed to avoid wicking action and shall not work as a water carrier.

The ripcord used in the cable shall be readily distinguishable from any other components (e.g. Aramid Yarn etc.) utilized in the cable construction.

e. Component Specification

Details of the various components used in the system along with quantity are given in the attached table. The items and quantity shall include but not limited to the followings:

Table: 1

SL. NO.	ITEM	Details
1	RS 485 to TCP/IP converter (RTC) with accessories	N port, multi client, isolated with automatic direction control, 10/100 MBPS, two port RS 485, two wire, ESD protection 15 KV, power supply 12 to 30V DC, operating temperature 0 to 55°C with installation and configuration software.

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SL. NO.	ITEM	Details
2	TCP/IP to Fiber Optics Converter with one Fiber Optics output (TFCO) with accessories	Un-managed Ethernet / Fiber Optics Switch, one Fiber Optics Interface, one Single Mode 100 Base Fx Port, six TCP/IP Ports, operating temperature 0 to 60°C.
3	TCP/IP to Fiber Optics Converter with two Fiber Optics outputs (TFCT)	Un-managed Ethernet / Fiber Optics Switch, two Fiber Optics Interface, two Single Mode 100 Base Fx Ports, six TCP/IP Ports, operating temperature 0 to 60°C.
4	Light Interface Unit (LIU)	LIU for Fiber Optics connection, Patch Cords, required connectors, etc.
5	Fiber Optics Cable (OFC) along with HDPE Pipe and Hardware & fittings	Six core, armored detailed specification mentioned below

5.5

Tests

a. Factory Acceptance Test (Fat)

The EMS system shall be tested in phased manner. First phase shall include testing of the EMS hardware and second phase shall be testing of the EMS software. During FAT of EMS at EDN works, Panel and enclosures shall be offered for inspection for visual, dimensional, BOQ and verification data collection from sample energy meters (1 No of each type) shall be demonstrated and same shall be verified on configured displays and reports.

b. Site Acceptance (SAT)

During SAT of EMS software, data collection from all energy meters / numerical relays through data concentrators shall be demonstrated and it shall be verified on configured displays and reports.

c. Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder.]

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d. Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

5.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below

- a) [System Interface diagram.
- b) Bill of materials.
- c) Technical Data sheet and Catalogue of different items.
- d) General arrangement drawing, panel fixing drawings for network panel and wall mounted panels.
- e) Descriptive write-ups and literature for Energy management system.
- f) Wiring diagram.
- g) Inspection and Test Plan (ITP).
- h) Transport/shipping dimensions and weights].

5.7 Ratings & Requirements

Energy management system shall comply with the particulars indicated in the following tables.

Table- 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		[By bidder]
1.2	Place & Country of manufacture		[By bidder]
1.3	Specifications and Standards		[By bidder]
2.0	Main network panel/wall mounted network panel		
2.1	Name of the devices located in the network panel		[By bidder]
2.2	Degree of Protection		[IP42]
2.3	Paint Shade		[RAL7032]

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S. No.	DESCRIPTION	UNIT	DATA
2.4	Operating Temperature		[By bidder]
3.0	Media converter		
3.1	Maker's name		[By Bidder]
3.2	Technical details		[By Bidder]
4.0	Serial server device		
4.1	Maker's name		[By Bidder]
4.2	Technical details		[By Bidder]
5.0	Light guide interface unit		
5.1	Maker's name		[By Bidder]
5.2	Technical details		[By Bidder]
6.0	Terminal Block		
6.1	Maker's name		[By Bidder]
6.2	Type		[By Bidder]
7.0	UPS (optional)		
7.1	Maker's name		[By bidder]
7.2	Input Voltage, frequency		[By bidder]
7.3	Output voltage, frequency		[By bidder]
7.4	Type of battery		[By bidder]
7.5	Back up time		[30 min]
7.6	Degree of protection		[IP42]
8.0	Data concentrator		
8.1	Maker's name		[By bidder]
8.2	Dimension		[By bidder]
8.3	Power supply requirement		[By bidder]
8.4	Operating temperature		[By bidder]
9.0	Workstation details		
9.1	Make		[By Bidder]
9.2	Power supply		[By Bidder]
9.3	Processor		[Intel quad core]

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S. No.	DESCRIPTION	UNIT	DATA
9.4	RAM		[2 GB]
9.5	HDD		[500 GB SATA]
9.6	Connecting ports		[By Bidder]
9.7	Operating system		[By Bidder]
9.8	Operating temperature		[By Bidder]
10.0	Workstation monitor		
10.1	Make		[By Bidder]
10.2	Type		[TFT]
10.3	Power supply		[By Bidder]
10.4	Screen size		[22"]
10.5	Connecting port		[By Bidder]
11.0	Fiber Optical cable		
11.1	Make		[By Bidder]
11.2	Technical details		[By Bidder]

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6 LIST OF ATTACHMENTS

The following List of attachments is enclosed along with this specification.

[Note: List of attachments is depends on specific project scope of work. R & M consultant may attach the attachments as per project specific scope of work. For reference all attachments are considered in this package as per scope of work considered]

Legend: O: USE, X: NOT USE

Sl.No	Attachment Number	Description	Rev No	Application
1	E1	Motor	R1	O
2	E2	Motorized Actuators	R1	O
3	E3	LV Transformers(Dry type/Oil type)	R1	O
4	E4	415V Switchgear, MCC and DBs	R1	O
5	E5	415V Non Segregated Bus Duct	R1	O
6	E6	220V DC system	R1	O
7	E7	HV Cables	R1	O
8	E8	LV Cables	R1	O
9	E9	Illumination system	R1	O
10	E10	Cable Carrier System	R1	O
11	E11	Earthing and Lightning Protection system	R1	O
12	E12	6.6kV Switchgear	R1	X
13	E13	Variable Frequency Drives	R1	X
14	E14	6.6kV Segregated Phase Bus Duct	R1	X

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-II, PART-B, ANNEXURE-E1
TECHNICAL SPECIFICATION FOR MOTORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E1

1.0 MOTOR

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Electric Motor complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS : 325	:	Specification for three phase induction motor.
IS : 900	:	Code of Practice for installation and maintenance of induction motors
IS : 996	:	Single phase AC motors
IS : 1231	:	Dimensions of three-phase foot-mounted induction motors
IS : 1271	:	Thermal evaluation and classification of electrical insulation.
IS : 2223	:	Dimensions of flange mounted ac induction motors.
IS : 2254	:	Dimensions of vertical shaft motors for pumps
IS : 3177	:	Crane duty motors
IS : 4029	:	Guide for testing three phase induction motors.
IS : 4691	:	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	:	Specification for rotating electrical machinery.

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IS : 4728	:	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	:	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	:	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	:	Designation of Method of Cooling of Rotating electrical machines.
IS : 8223	:	Dimensions and output ratings for foot mounted rotating electrical machines with frame numbers 355 to 1000.
IS : 8789	:	Values of performance characteristics for three phase induction motors.
IS : 12065	:	Noise level of motors.
IS : 12075	:	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	:	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	:	Temperature rise measurement of rotating electrical machines
IS : 12824	:	Type of duty and classes of rating assigned.
IS : 14222	:	Requirements and method of Impulse withstand test
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IEC: 60034	:	Rotating electrical machines.
NEMA, MG-1	:	Motors and Generators
ISO : 1940-1	:	Mechanical vibration – Determination of permissible residual unbalance

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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All motors shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The motors shall be suitable for operation in a highly polluted environment.
- b. AC Motors shall be of [constant speed, squirrel cage, three/ single phase, induction type.] Motors shall be rated for [continuous duty/intermittent duty]. They shall also be suitable for long period of inactivity. They shall also be suitable for direct online starting (DOL starting).
- c. DC motors provided for emergency service shall be shunt / compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.
- d. Power supply for AC motors shall be as follows:

Table: 2.0

1.	[Below 0.22 kW]	:	240V, 1 Phase, 50Hz
2.	[From 0.22 kW up to & including 160 kW]	:	415V, 3 Phase, 50Hz
3.	[Above 160 kW]	:	6.6kV, 3 Phase, 50Hz

- e. All AC motors shall be suited for the following range of frequency and voltage variations:
 - i. Voltage Variation : +/-10%
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)
- f. DC motors shall be rated for 220V DC supply with voltage variation of -15% to +10%.
- g. The motor characteristics shall match the requirements of the driven equipment so that adequate starting, accelerating, pull up, break down and full load torques are available for the intended service.

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- h. Moreover, motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
- i. Motors shall be capable of developing the rated full load torque even if the supply drops to 70% of the rated voltage.
- j. For 6.6kV motors, locked rotor current not to exceed [600%] of full load current, including positive tolerance, except for BFP. For BFP the starting current shall be [450%] of FLC. For 415 V motors Locked rotor current not to exceed [600%] of full load current with IS tolerance.]
- k. For DC motors, the starters shall be provided to limit the starting current to [2] times of the full load current.
- l. Maximum continuous motor ratings shall be at least [10%] above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.
- m. Accelerating torque at any speed with the lowest permissible starting voltage shall be at least [10%] motor full load torque. Pull out torque at rated voltage shall not be less than 205% of full load torque. It shall be 275% for crane duty motors.
- n. The motors shall be suitable for bus transfer schemes provided on the 6.6kV and 415V systems without any injurious effect on its life. If motors are connected to an automatic bus transfer system, they may be subjected to 150% of the nominal voltage during changeover of buses due to the phase difference between the incoming voltage and motor residual voltage. In such cases, motors shall be capable of restarting under full load after momentary loss of voltage.
- o. Motors shall be of [energy efficient of type Eff-2] as per IS: 12615/equivalent IEC/ International Standards.
- p. Motor shall be designed to keep torsional and rotational natural frequencies of vibration of the motor and driven equipment at least 25% above the motor operating speed range.

1.3.1 System Grounding

Table: 3.0

(a)	6.6 kV	:	Low Resistance Grounded to limit the earth fault current to [300 Amps]
(b)	415 V	:	Solidly Grounded
(c)	220V DC	:	Ungrounded

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1.3.2 Fault Level

Table: 4.0

(a)	6.6 kV	:	[40 kA for 1 second]
(b)	415 V	:	[50 kA for 1 second]
(c)	220V DC	:	[25 kA for 1 second]

1.3.3 Degree of Protection

Table: 5.0

(a)	Indoor Motors	:	[IP 54]
(b)	Outdoor Motors	:	[IPW 55]
(c)	Cable Box located in Indoor Area	:	[IP 54]
(d)	Cable Box located in Outdoor Area	:	[IPW 55]

1.3.4 Winding Insulation

Table: 6.0

(a)	For 6.6 kV AC Motors	:	[Class – F]
(b)	For 415V AC Motors	:	[Class – B]
(c)	For 220V DC Motors	:	[Class – B]

1.3.5 Winding Conductor Material

Table: 7.0

(a)	For 6.6 kV AC Motors	:	Copper
(b)	For 415V AC Motors	:	Copper
(c)	For 220V DC Motors	:	Copper

1.3.6 Bearing

Table: 8.0

(a)	For Drive End	:	[Roller]
(b)	For Non Drive End	:	[Roller / Ball]

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1.3.7 Temperature Rise

Table: 9.0

(a)	For Air Cooled Motors	:	[70 °C] over ambient temperature [Class B]
(b)	For Water Cooled Motors	:	[80 °C] over inlet cooling water temperature [Class B]

1.3.8 Motor Earthing

Table: 10.0

(a)	Motors above 90 kW	:	[50 x 6 mm GI Flat]
(b)	Motors above 30 kW and up to 90 kW	:	[25 x 6 mm GI Flat]
(c)	Motors above 5 kW and up to 30 kW	:	[25 x 3 mm GI Flat]
(d)	Motors up to 5 kW	:	[8 SWG GI Wire]
(e)	Terminal Box	:	[8 SWG GI Wire]

1.3.9 Space Heater

Table: 11

(a)	For Motors 30 kW rating and above	:	Space heater suitable for 1Phase, 240V AC, 50 Hz supply
(b)	For Motors below 30 kW rating	:	No Space heater provided.

1.3.10 Painting

Table: 12

a)	Paint Type	:	Epoxy based with approved class
b)	Paint Thickness	:	[Within 100 to 150 micron.]
c)	Paint Shade	:	[RAL5012 BLUE]

1.4 Specific Requirements

1.4.1 Locked Rotor Withstand Time

- The starting time of the motor shall be at the minimum permissible voltage.
- For motors with starting time up to 20 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot

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condition at highest voltage limit shall be at least 2.5 second more than starting time.

- c) For motors with starting time more than 20 second and up to 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 second more than starting time.
- d) For motors with starting time more than 45 seconds at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
- e) Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.

1.4.2 Starting Voltage Requirement

I.	All motors (except mill motors):
a)	[85% of rated voltage for motors up to 4000 kW]
b)	[75% of voltage for motors above 4000 kW]

II.	For mill motors:
a)	[85% of rated voltage for motors above 1000 kW]
b)	[90% of rated voltage for motors below 1000 kW]

The motor shall be capable of withstanding the stresses imposed if started at 110% rated voltage.

Pump motor subject to reverse rotation shall be designed to withstand the stresses encountered when starting with non-energized shaft rotating at [125%] rated speed in reverse direction.

The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage.

1.4.3 Winding and Insulation

a)	6.6 kV AC motors	:	Winding material shall be of copper. Insulation shall be of [Class F with winding temperature rise limited to Class B]. They shall withstand 1.2/50 microsecond switching surges of "4U + 5 KV" (U = Line voltage in KV). The coil inter-turn insulation shall be suitable for 0.3/3 micro second surge of 32 / 12 KV followed by 1 min
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			power frequency high voltage test of appropriate voltage on inter turn insulation.
b)	415V AC & 220V DC motors	:	Winding material shall be of copper. Insulation shall be of [Class B with temperature rise limited to Class B.]
c)	Conveyor motors		Short circuit rings of conveyor motors shall be either joint less or welded type. Brazed joint is not acceptable.

1.4.4 Motor Control

a) For HV Motors

- i. Motors of rating above [160 kW] shall be suitable for 6.6 KV voltage
- ii. Frequent starting motors of rating above [160 kW] shall be suitable to be controlled by vacuum contactors

(b) For LV Motors

- i. Motors of rating less than [132 kW] shall be operated by Contactor from respective MCCs. Motors of rating up to [18.5 kW] shall be provided with MPCBs and Electronic overload relays. Motors of rating above [18.5 kW] and below [45 kW] shall be provided with MCCBs and Electronic overload relays. Motors of rating [45 kW] and above but less than [132 kW] shall be provided with MCCBs and CT operated Electronic over load relays.
- ii. Motors of rating [132 kW] and up to [160 kW] shall be suitable to be controlled by Air circuit breakers from switchgear, PMCCs and shall be provided with comprehensive numerical motor protection relays.
- iii. Only for firefighting system, motor rated [upto 200kW] shall be fed from 415V switch board.

1.4.5 Starting duty

Motors shall be suitable for [3 nos. consecutive Cold starts ups and 2 nos. consecutive Hot starts ups.] Motors shall be suitable for three equally spread starts per hour when the motor is under normal service condition.

1.4.6 Bearings

- a) Anti-friction type radial and thrust bearings (ball, roller) and sleeve bearing shall be rated for minimum standard life of 40,000 hours taking bearing and driven equipment loads (in case the drive is not having

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separate thrust bearing) into account. If bearings are lubricated, loss of grease shall be scarce and it shall not creep along shaft into motor housing. Facility of removal of excess grease shall also be provided for grease lubricated bearings.

- b) Vertical shaft motors shall be provided with thrust and guide bearings. Thrust bearing of tilting pad type is preferred. However, if Anti-friction bearings can take vertical thrust, thrust & guide bearings are not required.
- c) Bearing shall be effectively sealed against dust ingress and shall be pressure grease gun lubricated. The bearing and housing shall be so designed that greasing shall be possible while the motor is running, without removal of covers.
- d) Where bearing supports are attached to the motor casing, adequate bracing shall be provided on these supports to reduce vibrations and ensure life of bearings.
- e) If the bearings are oil lubricated, a drain plug shall be provided for draining residual oil and oil level gauge shall be provided to show precisely oil level required under standstill and running conditions.
- f) Unless otherwise approved, bearing lubricating system shall be such that no external forced oil or water is necessary to maintain required oil supply to keep bearing temperature within design limits.
- g) Lubricants shall be selected for prolonged storage and normal use of motors in tropical climate and shall contain corrosion and oxidation inhibitors. Greases shall have suitable bleeding characteristics to minimize setting. The selected lubricants shall be indigenously available.
- h) Motors rated above 1000 kW shall have insulated bearings to prevent flow of shaft currents.

1.4.7 Temperature Rise

- a) For Air Cooled Motors, temperature rise of insulation should be limited to [70 °C] over ambient temperature by resistance method.
- b) For Water Cooled Motors, temperature rise of insulation should be limited to [80 °C] over inlet cooling water temperature mentioned elsewhere, by resistance method.

1.4.8 Cooling

[All motors shall be either Totally Enclosed Fan Cooled (TEFC) or Totally Enclosed Tube Ventilated (TETV) or Closed Air Circuit Air Cooled (CACA) type. However, motors rated 3000 kW or above can be Closed Air Circuit Water Cooled (CACW)]

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1.4.9 Enclosure

- a) All motor enclosures shall conform to the degree of protection of [IP54] for indoor and IPW-55 for outdoor installation unless otherwise specified. Motor for outdoor or semi outdoor service shall be of weather proof construction. Motors of large output rating located indoor could have screen protected drip proof (SPDP) enclosure conforming to [IP-23.]
- b) For motors located in outdoor & corrosive locations, FRP canopy shall be provided. In case steel canopy is provided, the same shall be epoxy painted to meet the surrounding atmosphere. Motors located in hazardous areas such as Hydrogen plant shall have flame proof enclosures of Group – IIB conforming to IS: 2148.
- c) For hazardous locations such as fuel oil facilities area, the enclosure of motor shall have flame proof construction conforming to IS 2148.

1.4.10 Noise Level and Vibration

Noise level shall be limited to 85 dB (A) at 1.5 meters from the motor. However the same shall be as per IS: 12065 unless otherwise specified. The peak amplitude of vibration shall be within the specified limits laid down in IS: 12075. Motors shall withstand vibrations produced by driven equipment. HV motor bearing housings shall have flats in both X and Y directions suitable for mounting 80mmX80mm vibration pads. Vibration pads with screwed holes for mounting vibration probes shall be provided at both DE and NDE.

1.4.11 Temperature Monitoring

[In HV motors, at least four numbers simplex/ two numbers duplex platinum resistance type temperature detectors shall be provided for each phase of stator winding]. Each bearing shall be provided with dial type thermometer with adjustable alarm contact and two numbers duplex Platinum resistance type temperature detector (3 wire, 100 ohm at zero °C). In case of CACA and CACW motors dial type temperature indicator shall be provided (one each for hot and cold air temperature monitoring for CACA and CACW and one each for inlet and outlet water temperature monitoring for CACW). If alarm and trip are required for cooling air temperature, temperature switch shall be provided. The contact rating shall be minimum 0.5A at 220V DC and 5A at 240V AC. Flow switches shall be provided for monitoring cooling water flow of CACW motor and oil flow of forced lubrication bearing. Low voltage motors rated 100 kW and above shall be provided with two PT100 RTDs per phase of winding.

1.4.12 Earthing

Motor body shall have two earthing points on opposite sides. Motor terminal boxes shall also have separate grounding terminals.

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1.4.13 Termination

- a) HV motors can be offered with either Elastimold termination or dust tight phase segregated double walled (metallic as well as with insulated barrier) cable boxes. In case Elastimold terminations are offered, then protective cover and trifurcating sleeves shall also be provided. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material for single core cables) shall be provided in case of cable boxes. The main cable box / terminal box shall withstand *[a fault current up to 40 kA for 0.25 seconds for HV motors and 50 kA for 0.25 seconds for LV motors]*. Separate terminal boxes shall be provided for space heaters and RTDs and NCT (if applicable).
- b) *[All terminal boxes shall be capable of being turned through 360 degrees in steps of 90 degrees unless otherwise specified.]*
- c) For HV motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

1.4.14 Differential Protection

For motors rated 6.6kV, *[2000 KW & above,]* neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box for differential protection.

1.4.15 Tropical Protection

- (a) All motors shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
- (b) All fittings and hardware shall be corrosion resistant.
- (c) Space Heater
- (d) Suitable single phase space heaters operated at 240V, 50Hz, 1Phase AC supply shall be provided on motors rated for 30KW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided.
- (e) The space heater shall be sized to maintain the motor internal temperature above dew point when the motor is in idle condition.

1.4.16 Rating Plate

Motor shall have Stainless steel nameplate(s) showing diagram of connections, all particulars as per IS: 325 / NEMA-MG-1 and following additional information:

- (a) Type of bearing and recommended lubricants along with location of insulated bearing.
- (b) Temperature rise under normal/abnormal conditions.

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(c) In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.

(d) Year of Manufacture

1.4.17 Drain Plug

Motor shall have drain plugs so located that they shall drain the water, resulting from the condensation or other causes from all pockets of the motor casing.

1.4.18 Dowel Pins

Motor shall be designed to permit easy access for drilling holes through motor feet or mounting flange for installation of dowel pins after assembling the motor and driven equipment.

1.4.19 Painting

The complete motor assembly including fan shall be painted with corrosion proof paints of approved class.

1.4.20 Lifting provision

Motor weighing 25 Kg or more shall be provided with eyebolt or other adequate provision of lifting.

1.4.21 Local Push Button Station (LPBS)

- a) Each motor shall be provided with push button station as per process requirement i.e. Start/Stop or Emergency Stop.
- b) The degree of protection of LPBs shall be IPW 55 for outdoor and IP 54 for indoor applications.
- c) All Push Buttons shall be push to actuate type and stop Push Button shall be lockable in off position as per the scheme requirement.
- d) The Emergency local stop push button of Stay put type shall be provided with Press to lock & turn to release keyless mechanism.
- e) All PBs shall be provided with 2 numbers NO and 2 numbers NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to switchgear module for direct tripping and another contact to control system.
- f) Terminals to be suitable for 2 cores of 2.5 Sq.mm. cable with 20% spare terminals.
- g) All LPBS shall be of Poly Carbonate /FRP / Die Cast Aluminium material.

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I) TestsType Test

For each type & rating of HV and LV motors of rating above [50 kW], the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last[five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- (a) Visual and dimensional check
- (b) Winding resistance measurement
- (c) No load test
- (d) Mechanical vibration
- (e) Direction of rotation versus phase sequence
- (f) Insulation resistance measurement
- (g) High potential test
- (h) Locked rotor test
- (i) Speed/torque test
- (j) Over speed test
- (k) Temperature rise test
- (l) Determination of characteristic
- (m) Degree of protection test for the enclosure.
- (n) Noise level
- (o) Shaft current and bearing insulation test (Applicable for HV motors)

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

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IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.5 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

Dimensional General Arrangement drawing

- a) [Motor sizing calculation
- b) Foundation Plan & Loading
- c) Cable end box details
- d) Space requirement for rotor removal
- e) Thermal withstand curves hot & cold
- f) Starting and speed torque characteristics at 80% & 100% voltage
- g) Complete motor data
- h) Erection & Maintenance Manual
- i) Test reports
- j) QAP]

1.6 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	Technical Particulars	Unit	Parameters	Remarks
1	Motor application		[As per requirement]	
2	Rated Output, kW	kW	[As per requirement]	
3	Maximum continuous kW obtainable without exceeding specified temperature rise	kW	[By Bidder]	
4	Motor type		Squirrel cage induction motor	
5	Duty Cycle (IEC 60034-1)		[S1]	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
6	Rated voltage	kV	6.6 kV for HV motors 415 V for LV motors 220V DC for DC motors	
7	Phase/frequency	Hz	50	
8	Allowable variation in supply conditions			
a)	Voltage		6.6 kV	
b)	Frequency		50	
c)	Combined			
9	Method of starting		DOL	
10	CT details for differential protection	Yes/No	For motors of rating > 2000kW	
11	Full load amperes	A	[By Bidder]	
12	Locked rotor current amperes	A	HV(Except BFP): 6 times without tolerance BFP: 4.5 times without tolerance LV: 6 times with IS specified tolerance DC : 2 times with no positive tolerance at rated terminal voltage.	
13	Method of Cooling (IC code)		[As per requirement]	
14	Enclosure (IP Code)		Indoor : IP54 Outdoor : IPW55	
15	Construction (horizontal or vertical)		[As per requirement]	
16	Max. temperature, by resistance method	Deg C	120 deg (Class B)	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
17	Insulation class		HV: Class F LV: Class B	
18	Motor insulation system (describe material used)		[By Bidder]	
19	Bearings		[By Bidder]	
a)	Type			
b)	Quantity			
c)	Lubrication system pressure and flow			
20	Temperature detector (type & quantity)			
a)	Winding		[As per requirement]	
b)	Bearing		[As per requirement]	
21	Space heaters		30 kW and above	
a	Watts (Rating/Operating)	W	[By Bidder]	
b	Volts (Rating/Operating)	V	[By Bidder]	
22	GD ² of motor		[By Bidder]	
23	Power factor		[By Bidder]	
a)	Full load	p.u		
b)	3/4 load	p.u		
c)	1/2 load	p.u		
d)	No load	p.u		
24	Efficiency		[By Bidder]	
a)	Full load	%		
b)	3/4 load	%		
c)	1/2 load	%		
25	Impedance data		[By Bidder]	
a)	locked rotor reactance per phase	Ohm		
b)	Rotor resistance per phase	Ohm		

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S. No.	Technical Particulars	Unit	Parameters	Remarks
c)	stator resistance per phase	Ohm		
26	Net motor weight	Kg	[By Bidder]	
27	Terminal box dimensions H/W/D	Mm	[By Bidder]	
28	Rotor removal clearance	mm	[By Bidder]	
29	Winding connection (star or delta)		HV: Star LV: Delta	
30	Noise Level	dB(A)	[As per requirement]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E2

**TECHNICAL SPECIFICATION FOR MOTORIZED
ACTUATORS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E2

1.0 MOTORIZED ACTUATORS

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Motor Operated Actuator complete with all accessories for efficient and trouble-free operation of valves, dampers and gates for R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes & Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS : 325	Specification for three phase induction motor.
IS : 900	Code of Practice for installation and maintenance of induction motors
IS : 996	Single phase AC motors
IS : 1271	Thermal evaluation and classification of electrical insulation.
IS : 2223	Dimensions of flange mounted ac induction motors.
IS : 4029	Guide for testing three phase induction motors.
IS : 4691	Degree of protection for enclosures of rotating electrical machinery.
IS : 4722	Specification for rotating electrical machinery.
IS : 4728	Terminal marking and direction of rotation for rotating electrical machinery.
IS : 4889	Methods of determination of efficiency of rotating electrical machines.
IS : 5571	Guide for selection of electrical equipment for hazardous areas.
IS : 6362	Designation of Method of Cooling of Rotating electrical machines.

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IS : 8789	Values of performance characteristics for three phase induction motors.
IS : 9334	Electrical Motor Operated Actuators.
IS : 12065	Noise level of motors.
IS : 12075	Measurement and evaluation of vibration of rotating electrical machines.
IS : 12615	Induction motors - Energy efficient, three-phase, squirrel cage - Specification
IS : 12802	Temperature rise measurement of rotating electrical machines
IS : 12824	Type of duty and classes of rating assigned.
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package
IEC: 60034-1	Rotating electrical machines.
NEMA, MG-1	Motors and Generators

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All motor operated actuators shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%.
- Depending on the required type of services, the rating of motor operated actuators shall be selected. For isolating service, the actuator shall be [rated for three successive open-close operations of the valve/ damper or 15 minutes continuous operation whichever is higher.] Whereas for regulating service, the actuator shall be suitably [time rated for required number of duty cycle or 150 start per hour whichever is higher].
- The actuator shall be accompanied with constant speed, squirrel cage, three/ single phase, induction motor. The motor shall be designed for high

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torque and reversing service. They shall also be suitable for direct online starting (DOL starting).

- d. Motors of actuators shall be suited for the following range of frequency and voltage variations:

- i. Voltage Variation : +/-10%
- ii. Frequency Variation : 50Hz (+)3% to (-)5%
- iii. Combined Variation of : 10% (absolute sum)
Voltage & Frequency

- e. The motor operated actuator shall be sized for performing open / close operation at rated speed against designed differential pressure at [90%] of rated voltage. The motor shall have [10%] design margin on the shaft design power.

The actuator shall meet the following performance requirements:

- i. Open & Close the valve completely and make leak tight valve closure without jamming.
- ii. Attain full speed of operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- iii. The motor reduction gearing shall be sufficient to lock the shaft when the motor gets de energized and prevent drift from torque switch spring pressure.
- iv. The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.
- v. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

1.4 Specific Requirements

1.4.1 Construction

- a) The actuator shall essentially comprise of drive motor, limit switches, gear train, clutch, hand wheel, position indicator/ transmitter, space heater and internal wiring.
- b) The actuator enclosure shall be totally enclosed, dust tight, weather proof with [IPW 55] degree of protection.
- c) All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.

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- d) Gear train shall be made of metal (fiber gears are not acceptable). Self locking feature shall be provided to prevent drift under torque switch (wherever applicable) spring pressure when motor is de energized.
- e) Manual wheel shall disengage automatically during motor operation.

1.4.2 Type

- a) The actuators shall have integral starters along with overload relays with built-in single phase preventer.
- b) A 415 V, 3 phase, 3 wire, 50 Hz power supply will be provided from power plant 415 V switchgear through MCCB. Control voltage of the starter circuit shall be 110 V AC or depending on manufacturer's practice. But the same shall be derived from incoming 415 V, 3 phase, 3 wire supply.

1.4.3 Motors

- a) Type: The drive motor shall be three phase, squirrel cage induction motor suitable for direct on line starting with starting current limited to six times the rated current
- b) Enclosure: The motor shall be totally enclosed, self ventilated with [IPW 65] degree of protection.
- c) Insulation: The motor winding shall be insulated with [Class – B] insulation having temperature rise limited to [Class – B].
- d) Bearing: The motor bearing shall be [double shielded, grease lubricated and antifriction type].
- e) Earthing: At least two earthing terminals shall be provided for the motor body. Separate earthing terminal should be provided for terminal box.
- f) Protection: The following electrical protections should be provided for the motor:
 - i. Single Phasing Protection
 - ii. Overload Protection
 - iii. Overheating Protection through thermostat
 - iv. Wrong Phase Sequence Protection
- g) Limit Switches: Each actuator shall be accompanied with following switches:
 - i. Four nos. positional limit switches (2 for open & 2 for close), each adjustable at any position from fully open to fully closed positions of the valve / damper.
 - ii. Two torque limit switches, one for each direction of travel, self blocking & adjustable torque type.

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- iii. Four nos. end travel limit switches, two for each direction of travel.
 - iv. A single shaft shall actuate all contacts of limit switches at each position.
- h) Interface: Open/close command termination logic with position and torque limit switches, positioned circuit shall be suitably built in the PCB inside the actuator.
- i. For binary drive, open/close command and status thereof and disturbance monitoring signal (common contact for overload, thermostat, control supply failure, L/R selector switch at local, other protections operated) shall be provided. Interface with the control system shall be through hardwired signal only. Interposing relays provided (with coil burden 2.5 VA) in the DCS shall be energized to initiate opening and closing, by 24V DC signal from the external control system. Potential free contact provided by the IPR shall be utilized in the control circuit of the contactor of motorized actuators.
 - ii. For modulating drive, the command to actuator shall be in form of 4- 20mA signal. The necessary positioning circuit and motor protection shall be provided.
 - iii. Open/close command termination logic shall be suitably built inside actuator.
- i) Hand Wheel: Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall disengage automatically when the motor is energized.
- j) Position Indicator / Transmitter: The actuator shall have
- i. One built in local position indicator for 0 – 100% travel.
 - ii. One position transmitter of modulating / inching type for remote indication suitable to stabilize 4-20mA signal and operated with [24V DC].
- k) Space Heater: Space heater of suitable rating shall be provided. The power supply shall be derived from main power supply available in the actuator.

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- l) Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be done with [2.5 sqmm] copper wires. All wiring shall be well identified at both ends with ferrules.
- m) Terminal Box:
- i. The terminal box shall be weather proof with removable front cover and cable glands suitable for cable connection. The terminals shall be suitable for connection of [2.5 sq.mm copper conductor].
 - ii. Necessary double compression cable glands with nickel coating and tinned copper lugs for cables shall be provided.
 - iii. The terminal block shall be suitable for 650V grade power cable.
- .
- n) Rating Plate : Motor and actuator shall have Stainless steel nameplate(s) showing all particulars as per relevant IS/ IEC and following additional information:
- i. Type of bearing and recommended lubricants.
 - ii. Temperature rise under normal/abnormal conditions.
 - iii. Degree of Protection
 - iv. In addition to above, an arrow block shall be screwed on to the body of motor on the non-driving end to indicate normal direction of rotation of motor.
 - v. Year of Manufacture

1.5 Tests

The actuator and all components thereof shall be subject to routine factory tests as per relevant IS standards. In addition, if any special test is called for in equipment specification, the same shall be performed.

1.5.1 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum [7] days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc.]

1.5.2 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished with requisite no. of copies for approval of the Owner.

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- b) The equipment shall be dispatched from works only after receipt of owner's written approval of shop test reports.

1.6 Drawings Data and Manuals

The drawings, data & manuals for the motorized actuators shall be submitted as indicated below:

1. [Actuator Data Sheet]
2. General arrangement drawing
3. Internal wiring Diagram and Control Schematic.
4. Torque switch and Limit switch contacts development.
5. QAP for Test Reports
6. Manufacturer's Catalogue.
7. Instruction manuals on Installation methods.]

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		Integral
2.	Application		[As per project specific]
3.	Motor type		Squirrel Cage
4.	Supply voltage	V	415 V, 3 ph, 3 wire.
5.	Phase, frequency	Hz	3ph, 50 Hz
6.	Motor rated voltage	V	415V/230 V
7.	Control Voltage	V	[110 V AC]
8.	Voltage and its variation	V	± 10%
9.	Frequency and its variation	Hz	+ 3 to -5%
10.	Combined V & f variation	%	10%

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S. NO.	DESCRIPTION	UNIT	DATA
11.	Degree of Protection		IPW 65
12.	Winding Insulation		Class B
13.	Temperature Rise (over ambient temperature)	°C	Class B
14.	Painting		[RAL 5012]
15.	Motor Starting		
a)	Method		DOL
b)	Starting Current		6 times

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E3

TECHNICAL SPECIFICATION FOR LV TRANSFORMERS

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E3

1.0 LV TRANSFORMER (DRY TYPE/OIL TYPE)

1.1 General

This specification is intended to cover [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV Transformers (Dry type/Oil type) complete with all accessories for efficient and trouble free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

CODE	NAME OF STANDARD
IS:334	Dimensions for porcelain Transformer bushing
IS:335	New insulating oil for transformers and switchgears
IS:1271	Classification of insulating materials for Electrical Machinery and apparatus in relation to their stability in service.
IS 2026	Specification for power Transformer (all parts)
IS:2071	Method of high voltage testing
IS:2099	High voltage porcelain bushings
IS:2147	Degree of protection.
IS:2705	Current transformers
IS:3202	Code of practice for Climate proofing of electrical equipment
IS:3637	Gas operated relays
IS:3639	Fittings and accessories for power Transformers
IS:5561	Electric Power connectors
IS:6600	Guide for loading of oil immersed transformers

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CODE	NAME OF STANDARD
IS: 11171	Dry type transformers
IS:10028	Code of practice for selection, Installation and maintenance of transformers Part I, II and III
CBIP	Manual on transformers
IEC60076	Power Transformer
IEC 60214	Tappings
IEC 60726	Dry-type power transformers
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and / or Resin-Encapsulated Windings
ANSI C57.12.51	Requirements for Ventilated Dry-Type Power Transformers, 501 KVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low Voltage 208Y/120 to 4160 Volts
ANSI C57.12.55	Dry-Type Transformers in Unit Installations, Including Unit Substations –Conformance Standard
ANSI/IEEE C57.98	Impulse Tests, Guide for Transformer (Appendix to ANSI/IEEE C57.12.90)
ANSI/NFPA 70	National Electrical Code
IEEE C57.12.91	Test Code for Dry-Type Distribution and Power Transformers
IEEE C57.94	Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry-Type Distribution and Power Transformers

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CODE	NAME OF STANDARD
NEMA ST 20	Dry Type Transformers for General Applications
CEA	CEA Regulations
CEA	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The transformers shall be dry type (AN) for indoor location and shall be oil type (ONAN) for outdoor location.
- b) The oil type transformer shall be installed in hot, humid and tropical atmosphere with ambient temperature equal to 50°C. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- c) The transformer shall be capable of continuous operation at specified rating under the following condition:
 - i) Voltage variation - $\pm 10\%$
 - ii) Frequency variation - $[+3\%, -5\%]$
 - iii) Combined voltage and frequency variation (absolute sum) - $[10\%]$
- d) The transformer shall be capable of withstanding the short circuit stresses due to a terminal fault on one winding with full voltage maintained on the other winding for minimum period of two (2) seconds.
- e) The noise level shall be limited to the value specified by NEMA Standard Publication No. TR-1-1993 when measured in accordance with conditions outlines in ANSI/IEEE C57.12.90-1999/IS13964/CBIP publication.
- f) The design shall be such as not to cause any undesirable interference with radio or communication circuits.
- g) Transformers shall accept without injurious heating, combined voltage and frequency variation which produce an over fluxing condition of 120% for one (1) minute.

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- h) Each transformer shall be sized based on actual load with 10% margin and considering voltage regulation factor. It shall be sized by considering 100% load connected on the bus considering other transformer outage. An appropriate load factor of 0.9 for continuous and 0.2 for intermittent shall be considered.
- i) The impedance of the transformers shall be chosen such that the fault level on the LV switchgear does not exceed 50kA including the motor contributions and also voltage dip while starting the motor does not exceed 15% at motor terminal.

1.4 Specific Requirements of Transformers

1.4.1 Enclosure (for dry type)

- a) The encapsulated cast resin transformer shall be housed in naturally ventilated floor mounted cold rolled sheet steel cubicle with louvers backed by fine brass wire mesh. The enclosure shall be of bolted type fabrication and degree of protection shall be at least IP32. The minimum sheet steel thickness shall be 2 mm.
- b) Enclosure shall be provided with lifting lugs and grounding terminals at both ends. Further the enclosure door shall have pad locking provision.
- c) The enclosure door shall be interlocked with service transformer incoming breaker such that.
 - The door can be opened only when the service transformer HV side circuit breaker is in Test/Isolated position.
 - [6.6] kV side circuit breaker can be closed only when the doors are closed.
- d) Necessary illumination with controls shall be provided in the enclosure.
- e) Thermostatically controlled space heater inside the enclosure of suitable rating shall be provided if necessary.

1.4.2 Tank (for oil type)

- a) For LV transformers, the tank shall be of conventional type.
- b) Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.
- c) Tank shall be designed to permit lifting, by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.
- d) Tank together with radiators, coolers, conservator, bushings vessel and other fittings, shall be designed to withstand full vacuum without permanent distortion.
- e) The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

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- f) The material used for gaskets shall be cork-neoprene or approved equivalent. Gasketed joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather. Spare gaskets shall be provided for all openings as shipping gaskets will not be reused.
- g) Tank shall be provided with all necessary valves.
- h) Tank shall be provided with a pressure release device which shall operate at a pressure below the test pressure for the tank and radiators. This device shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment. The device shall be rain proof after blowing and shall be provided with a device visible from ground to indicate operation. An equaliser pipe connecting the pressure relief device to the conservator shall be supplied. This device shall be provided for all transformers. Pressure relief device shall be equipped with remote monitoring/alarm contacts

1.4.3 Core

- a) The transformers shall be three phase core type. The core shall be built up with high grade, non-ageing, low loss, high permeability grain oriented cold rolled silicon steel laminations especially suitable for core material. Laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.
- b) CRGO sheets shall be coated with insulation varnish. Insulation shall be able to withstand the curing temperature and shall reduce eddy current to minimum. The core shall be protected from corrosion with a rust-resistant coating.
- c) The core clamping brackets shall be designed to provide an even distribution of clamping forces to the core, yokes and legs and shall be rigidly braced to reduce sound levels and losses.

1.4.4 Winding

- a) The coils shall be manufactured from electrolytic copper conductor with sufficient number of radial supports and fully insulated for rated voltage.
- b) The insulating material shall conform to Class F. Coils shall be so insulated that impulse and power frequency voltage stresses are minimum and shall withstand even the severest of temperature fluctuations.
- c) Coil assembly shall be suitably supported between adjacent sections by insulating spacers and barriers. The windings shall be arranged to ensure a free circulation of the air and to reduce the hot spots in the winding.

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- d) All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used where practicable.
- e) The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer, under short circuit stresses, switching or other transients.
- f) All coils rated 1200V or higher shall be subjected to partial discharge tests to ensure a properly cured and void free casting.

1.4.5 Encapsulation (for dry type)

- a) HV and LV coils shall be separately cast under vacuum in fibre glass reinforced epoxy resin compound. The insulation shall be fire resistant, non-inflammable, non-hygroscopic and resistant to temperature fluctuations.
- b) The epoxy shall contain filler material providing characteristics superior to unfilled epoxy including higher temperature rating, better heat conductivity, better arc resistance and adhesion to the conductor, plus a coefficient of expansion closer to that of the conductor material. The epoxy resin shall be self extinguishing.
- c) Encapsulated winding shall be free of internal voids, surface irregularities, etc. No surface finishing of encapsulated winding shall be undertaken after the process of encapsulation.

1.4.6 Insulating Oil (for oil type)

- a) The transformer shall be filled with mineral insulating oil suitably inhibited to prevent sludging.
- b) The quality of oil to be supplied for the transformer shall conform to the parameter specified in IS: 335 with latest amendments. No inhibitors shall be used in oil. Prior to filling oil shall be tested as per IS: 335 for tan delta, specific resistivity, breakdown voltage, moisture content etc.
- c) Transformer shall be dispatched oil filled. 10% excess oil for topping up shall be supplied in non-returnable container suitable for outdoor storage.
- d) Oil preservation shall be by means of conservator tank complete with silica gel breather and oil seal.
- e) Oil preservation shall be by means of bellows/ diaphragm sealed conservator tank with silica gel breather to avoid direct connection between atmosphere and transformer oil. It shall be complete with level gauges, pipes , drain valve etc. The level gauges shall be so placed that same can be readable standing from ground.
- f) Necessary device shall be kept to provide annunciation in the event of rupturing of bellow.

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1.4.7 Tappings (OCTC)

- a) Off-circuit taps as specified shall be provided on the high voltage winding.
- b) The transformer shall be capable of operation at its rated KVA on any tap provided the voltage does not vary by more than $\pm 10\%$ of the rated voltage corresponding to the tap.
- c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.
- d) A warning plate indicating that switch shall be operated only when the transformer is de-energized shall be provided.
- e) Off circuit tap changer switch where provided shall be 3 phase, hand operated, by an external handle with position markings and pad locking facility and mechanical stops to prevent over cranking beyond extreme positions.
- f) Arrangement shall be such that switch can be operated at standing height from ground level.
- g) The operating handle can be padlocked at any tap position. The design shall be such that the lock cannot be inserted unless the contacts are correctly engaged. The mechanism shall be provided with a mechanical tap position indicator with pad locking facility.

1.4.8 Fittings and Accessories:

The following fittings and accessories shall be provided :

- a) Earthing pads: Two earthing pads of copper or other non-corrodible material shall be welded at the bottom corners of the transformer tank and supplied with clamp type terminals suitable for the purchaser's earthing conductors. Suitable earthing terminals on cable boxes shall also be provided.
- b) Terminal marking and rating plates shall be as per the specified standard.
- c) In case of oil type, the conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of -5°C up to an oil temperature of 100°C , with oil level varying within the minimum and maximum visible levels with necessary accessories.
- d) In case of oil filled type, Valves shall be supplied on the transformer tank and radiators.
- e) Pressure relief device: Pressure relief device shall be provided for transformers rated 2 MVA and above which shall be of sufficient size for rapid release of any pressure that may be generated within the tank and which may result in damage of the equipment
- f) Gas and Oil Actuated Relay (Magnetic Reed Type Gas & Oil Relay):

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A double float type magnetic reed type gas and oil relay as per applicable standard shall be provided for all oil filled transformers. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure. These contacts shall be wired up to the transformer marshalling box. The relay shall be provided with shut off valves on the conservator side as well as the tank side.

g) Temperature Indicators

i Oil temperature indicator (OTI)

All oil type transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent ungrounded alarm and trip contacts, maximum reading pointer and resetting device. The contacts shall be rated minimum 0.5A making and 0.2A breaking at 220V DC.

ii Winding Temperature Indicator (WTI):

A device for measuring the hot spot temperature of the winding shall be provided. The accuracy class of winding temperature indicator shall be $\pm 20^{\circ}\text{C}$ or better.

iii Oil Level Indicator:

A magnetic type oil level indicator shall be provided to indicate oil level in the tank.

iv RTD/transducers for remote annunciation:

In addition to the above mentioned indicators, the Oil and winding temperature measurement, RTDs / transducers shall be provided for remote indication in the DCS. RTDs shall be duplex platinum type with nominal resistance of 100 ohms at zero degree centigrade.

h) Bushing Current Transformers for stand by earth fault protection shall be provided in the neutral bushing and lead shall be brought to Marshalling box.

i) Radiator (oil filled type): Tank mounted radiators banks shall have bolted flanged connections and pipe extensions to permit withdrawal of

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transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes (unless otherwise approved) to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. The interconnecting pipes shall be provided with drain plug and air release vents.

- j) Conservator (For oil filled type): The transformers rated below 7.5MVA shall be provided with conventional single compartment conservator with dry air filling the space above the oil.

1.4.9 Bushings

- a) The bushing shall conform to the requirements of IS:2099 and IS:3347.
- b) All transformer bushings shall be of porcelain (for oil filled)/ epoxy (for dry type).
- c) The neutral terminal of 433V winding shall be brought out on a bushing along with the 433V phase terminal to form a 4 wire system for the 433V. Neutral CTs shall be located in the lead coming out of the winding and location of these CTs shall not be inside the tank.
- d) The neutral terminal of secondary shall be brought out through an outdoor. Further this neutral terminal shall be connected by a copper flat of size [50 mm x 6] mm, which shall be brought down upto 100 mm above ground. The copper flat shall be insulated and supported from the tank body.

1.4.10 Terminal arrangement

- a) Cable boxes
- Wherever cable connections are specified, suitable cable boxes shall be provided and shall be air insulated.
 - Cable boxes shall have drilled gland plate of adequate size to receive cables and to allow easy termination.
 - Removable drilled gland planes shall be provided in the cable boxes.
 - The additional supports for the cable boxes shall be galvanised iron.
 - The contractor shall provide earthing terminals on the cable box, to suit [50mmx6] mm GI flat.
- b) Bus duct
- Wherever Bus duct termination is specified a flanged throat or equivalent connection shall be provided for termination of bus duct enclosure. The winding termination shall be outdoor type bushing. The material of the bus duct termination arrangement of the transformer shall be nonmagnetic. The bus duct may be either phase-segregated or non-segregated.

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- ii. Tolerance permissible for the height of terminals and bus duct flange location specified for bus duct termination over ground level is $\pm 5\text{mm}$. Contractor has to ensure that radiator, conservator and explosion vent do not obstruct the path of the bus-ducts.

1.4.11 Marshalling box

- a) A sheet steel weather, vermin and dust proof marshalling box shall be furnished. The sheet steel used shall be at least 2.0 mm (CRCA) thick. The box shall be free standing floor mounted/tank mounted type and have a sloping roof. The degree of protection shall be IP-55 in accordance with IS:2147.
- b) The marshalling box shall have a glazed door of suitable size for convenience of temperature indicators reading.
- c) All incoming cables shall enter the marshalling box from the bottom.

1.4.12 Wiring

- a) All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.
- b) Wiring shall be done with 650V PVC wires in conduit or PVC armored cable. *[Minimum wire size shall be 1.5 sq.mm stranded copper. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.]*
- c) Multi-way terminal block complete with mounting channel, binding screws and washers for wire connections and marking strip for circuit identification shall be provided for terminating the panel wiring. *[Terminals shall be stud type, suitable for terminating 2 nos. 2.5 mm2 stranded copper conductor and provided with acrylic insulating cover.]*
- d) All devices and terminal blocks shall be identified by symbols corresponding to those used in applicable schematic or wiring diagram. Each wire shall be identified, at both ends, with interlocking type permanent markers bearing wire numbers as per Bidder's Wiring Diagrams. AC / DC wiring shall have separate colour-coding.
- e) Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

1.4.13 Painting

- a) All steel surfaces shall be thoroughly cleaned by sand blasting and / or by chemical agents, as required to produce a smooth surface free of scales, grease and rust.
- b) The external surfaces, after cleaning, shall be given a coat of high quality red oxide or yellow chromate primer followed by filler coats.
- c) The transformer finished with two coats of epoxy based powder coated paint. The paints shall be carefully selected to withstand tropical heat,

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rain etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

- d) Painting shade shall be subject to owner's approval.
- e) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.14 Name Plate

Nameplates of approved design shall be furnished at each cubicle (one no. each at front as well as at backside of cubicle) and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black background. Self-tapping screws shall hold the nameplate. *[Nameplate size shall be minimum 20 x 75mm for instrument/device and 40 x 150mm for panels. Caution notice on suitable metal plate shall be affixed at the back of terminal Box.]*

1.5 Tests

1.5.1 Type Tests

For each type & rating of LV Transformers, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within *[last five]* years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within *[last five]* years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The following shall constitute the type tests:

- a) Temperature rise test
- b) Dielectric test

1.5.2 Routine Tests

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The following tests shall be performed on each transformer as a minimum:

- a) After assembly, each core shall be pressure tested for one minute at 2KV (r.m.s.) A.C. between all bolts, side plates, structural steel works and the core.

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- b) The wiring for auxiliary power and control circuitry shall be subjected to withstand one minute power frequency test with 2.0KV (r.m.s.) to earth
- c) Measurement of winding resistance
- d) Measurement of voltage ratio and check of phase displacement
- e) Measurement of short circuit impedance and load loss
- f) Measurement of no load loss and current
- g) Dielectric routine tests
- h) Excitation loss and current measurements shall be made at 90%, 100% and 110% of the rated voltage as routine test.
- i) Partial discharge test
- j) Tan delta test

1.5.3 Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

1.5.4 Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings/ Data and Manuals

Drawings, data, and manuals for the transformers shall be submitted as indicated below:

- a) *[General Arrangement Drawing]*
- b) *Dimensioned general arrangement drawing showing enclosure, core coil assembly, terminal arrangement, marshalling box and various fittings.*
- c) *Transport/shipping dimensions with weights, wheel base detail etc.*
- d) *Foundation plan & loading.*
- e) *Bus duct/cable termination arrangement.*
- f) *Control schematics and wiring diagrams.*
- g) *Test reports and QAP*
- h) *Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.*
- i) *Instruction manuals on Transformer and its various fittings The manual shall clearly indicate method of installation, checkups and tests to be carried out before commissioning of the equipment.]*

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Note: The drawings, data and manuals listed are minimum requirement only. The Bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted.

1.7 Ratings and Requirements

Table 2.0

6.6/0.420 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Application	[As per project requirement]	[As per project requirement]
2.	Location	Indoor	Outdoor
3.	Type	[Dry Type: epoxy cast resin transformer]	[Oil type transformer]
4.	Reference standard	IS 11171	IS 2026
5.	Rated power (indicative)	[As per project requirement]	[As per project requirement]
6.	Rated winding voltage ratio (line to line)	6.6/0.433 kV	6.6/0.433 kV
7.	Number of phases	3	3
8.	Winding	2	2
9.	Rated frequency	50 Hz	50 Hz
10.	Type of cooling	AN	ONAN
11.	Insulation Class	Class F or Better	Class F or Better
12.	Temperature rise Over ambient temperature of 50°C		
a.	For Winding by	90°C or lower as permissible for class	55°C

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	resistance method	of insulation offered	
b.	For Oil by Thermometer method	Not Applicable	50 °C
13.	Insulation level (LI/AC)		
a.	HV- (LI/AC)	60 KVp/20 kVrms	60 KVp/20 kVrms
b.	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
14.	Vector group	[Dyn11]	[Dyn11]
15.	Short-circuit impedance on principal tap	[As per project requirement]	[As per project requirement]
16.	Parallel operation of transformer	Momentarily	Momentarily
17.	Type of taps provided	OCTC, full capacity	OCTC, full capacity
18.	Taps provided on	H.V. winding	H.V. winding
19.	Range of taps	[+/- 5 % in steps of 2.5%]	[+/- 5 % in steps of 2.5%]
20.	Method of Tap charge control-		
a.	Manual local	Yes	Yes
b.	Electrical local	No	No
c.	Electrical remote	No	No
d.	Automatic	No	No
21.	System earthing		

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a.	H.V.	Non-effectively earthed			Non-effectively earthed
b.	L.V.	Effectively earthed			Effectively earthed
22.	Terminal arrangement				
a.	H.V.	6.6kV(UE) Cable/ busduct			6.6kV(UE) Cable/ busduct
b.	L.V.	Non-segregated phase bus duct			Non-segregated phase bus duct
23.	Neutral for earthing	GS flat connector			GS flat connector
24.	Transformer bushing	HV	LV	LV - N	Same as Dry type transformer
25.	Voltage class KV(r.m.s.)	7.2	1.1	1.1	
26.	Creepage distance mm	[As 25mm/kV]			[As 25mm/kV]
27.	Min. Ph-Ph/ Ph-E clearance mm	As per Standard			As per standard
28.	System fault Level				
a.	HV Side	40 KA (r.m.s.)			40 KA (r.m.s.)
b.	LV Side	50KA (r.m.s.)			50KA (r.m.s.)
29.	Max. Noise level	As per NEMA std. TR-1			As per NEMA std. TR-1
30.	Auxiliary supply	415 V, 3 ph, 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)			415 V, 3 ph 3 wire AC, 50 Hz 220V + 10%, -15% 2 wire DC(if required)
31.	LV neutral side	[As per project]			[As per project]

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	current transformer for standby earth fault protection	requirement]	requirement]
32.	Guaranteed no load loss (kW)	[By Bidder]	[By Bidder]
33.	Guaranteed load loss (kW)	[By Bidder]	[By Bidder]
34.	Efficiency		
a	At full load	[By Bidder]	[By Bidder]
b	At 75% load	[By Bidder]	[By Bidder]
c	At 50% load	[By Bidder]	[By Bidder]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E4

**TECHNICAL SPECIFICATION FOR 415V SWITCHGEAR,
MCC & DBs**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E4

1.0 415V SWITCHGEAR, MCC AND DB

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Switchgear MCC and DBs, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

Codes	Name of Standard
IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2551	Danger notice plates
IS :2705	Current transformers-specification
IS :3156	Voltage transformer specification
IS :3231	Specification for electrical relays for power system protection
IS: 8084	Specification for interconnection busbars for AC voltages above 1kV up to and including 36kV.
IS :8623	Specification for low-voltage switchgear and control gear assemblies
IS :8686	Specification for static protective relays
IS :10118	Code-of practice for selection installation and maintenance of switchgear and control gear
IS :12021	Specification for control transformers for switchgear and control gear for voltages not exceeding 1000 v ac
IS : 13947 (Part 1)	Specification for low-voltage switchgear and control gear
IS : 13947 (Part 2)	Specification for low-voltage switchgear and control gear –part 2: circuit breakers
IS : 13947 (Part 4)	Specification for low-voltage switchgear and control gear -part 4 : contactors and motor feeders

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Codes	Name of Standard
IS : 13947 (Part 5)	Low-voltage switchgear and control gear specification Part 5 : control circuit devices and switching elements
IEC 61439	Low voltage switchgear and control gear assemblies.
CEA	CEA regulations for installation and operation of meters 2006.
CEA	Standard technical specifications for main plant package

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- All 415V Switchgear, MCC and DB shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The Switchgear shall be suitable for operation in a highly polluted environment.
- All 415V Switchgear, MCC and DB shall be suitable for following voltage & frequency variations as follows:

Voltage Variation	:	(±) 10%
Frequency Variation	:	(+) 3% to (-) 5%
Combined Variation of Voltage & Frequency	:	10% (absolute sum)
For DC system	:	-15% to +10%

- 415 V switchgear & MCCs shall be of indoor /outdoor, double front/single front [Preferably single front] and fully draw out type. ACB feeder may be of single tier/two tier configuration depending upon rating. DBs (ACDB / DCDB) shall be of single / double front [Preferably single front] and fixed type. These shall be CRCA sheet metal enclosed and assembled to form a rigid, free-standing floor mounted structure. Vertical units shall be assembled to form a continuous line up of panels. Compartmentalized multi-tier configuration shall be provided.
- All AC motor starters shall be suitable for Direct on Line (DOL) starting. Motors rated below [132]kW shall be provided with combination starters consists of MCCB/MPCB, contactors and electronic over load relay and

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the motor starter shall comply with Type – 2 coordination conforming to relevant code and standards. Motors rated [132] kW and above shall be breaker controlled and shall be provided with comprehensive motor protection relay. Motors rated above [160]kW shall be fed from MV Switchgear [Only for firefighting system Motor rated up to 200kW shall be fed from 415V switch board].

- e) For 415 V switchgear & MCCs Feeders rated [630A] and above shall be equipped with Air Circuit Breaker (ACB). Outgoing/Incoming feeders rating below [630] A shall be MCCBs.
- f) For DBs Incomer rated 630A and above shall be ACB. Incomer below 630A shall be MCCB. Outgoing feeder may be MCCB/MCB depending upon the bus fault level.
- g) All ACB shall be draw out type & should have Service, test and disconnected positions with positive indications for service & test positions. It shall be possible to charge the springs manually, if, required
- h) Local/remote selection shall be provided for all incoming/Outgoing ACB module. Incoming/Outgoing breaker shall be closed at service position from remote (DCS) and at test position from Local(Switchgear).
- i) Two out of three breaker logic shall be considered for switchgear/MCC. However mechanical interlock shall be considered for income of MCCB operated DBs.
- j) Also, Local/remote selection switch shall be provided for all motor modules for control from Remote(DCS). Also for breaker operated motor, breaker shall be closed in Test position from local(Switchgear).
- k) All motors shall be provided with Emergency stop push button.
- l) Control circuits shall operate at suitable voltage of 110V AC or 220V DC. Necessary control supply transformers having primary and secondary MCCB/MCB shall be provided for each MCC, 2 x 100% per section. However breaker shall operate on 220V DC. The auxiliary bus bars for control supply shall be segregated from bus bars. This control supplies shall be monitored.
- m) All the numerical relays shall have communication on two ports, local front port communication to laptop and a second port with [IEC 61850 protocol] to communicate with DCS.

1.4 Specific Requirements

1.4.1 Construction

All 415V switchgear, MCC and DBs shall have following minimum features.

- a) All 415V switchgear, MCC and DBs shall be metal enclosed, indoor, floor mounted and free standing type. The panels shall be suitable for cable entry at bottom and busduct connection at top.

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- b) Between 415V Switchgear and dry type transformers, non segregated phase bus duct is considered. Hence switchgear shall be suitable for this connection and necessary flange connection and co ordination with busduct manufacturer in this regards is covered in this specification.
- c) All frames and load bearing members shall be fabricated using mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2 mm.
- d) Frame shall be enclosed in cold rolled sheet steel of thickness not less than 2 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Removable gland plates of thickness 3mm (hot/cold rolled sheet steel) or 4 mm (non magnetic material)shall be provided for all panels. Suitable removable type lifting hooks and / or jacking pad shall be provided on each panel or shipping section for ease of lifting of switchgear. These hooks when removed shall not leave any opening in the panels
- e) Each breaker shall be housed in a separate cubicle, complete with an individual front access door. Each vertical section shall have a removable back cover.
- f) The switchgear enclosure shall confirm to the degree of protection IP-54 (for outdoor). For indoor, enclosure shall confirm to IP52, however for Busbar chamber of switchboards rated above 1600A, degree of protection shall be IP-42.
- g) Paint shade for complete panels excluding end covers shall be [RAL 9002] and [RAL 5012] for extreme end covers for all board.
- h) The switchgear assembly shall comprise a continuous, line-up of single / multi tier cubicles. The installations of circuit breakers however shall be limited to the bottom two tiers only. Working height shall be limited to [250 mm to 1800 mm] from the floor level.
- i) Metallic barriers shall be provided between vertical sections and also between adjacent modules to ensure prevention of accidental contact with live parts during routine inspection/maintenance of functional units or cable terminations of one or more functional units when working on those of adjacent units. These barriers shall have insulating inserts as necessary for taking the interconnections etc
- j) A nameplate with switchgear designation shall be fixed at the top of the central panel. A separate nameplate giving feeder details shall be provided for each compartment. A separate nameplate giving details of bus section shall also be provided for switchgears having more than one bus section.
- k) Name plate shall be provided for each equipment (lamps, push buttons, switches, relays, auxiliary contactor, etc) mounted on the switchboard. Special warning plates one each on each feeder of a shipping section shall be provided on removable covers of doors giving access to cable

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terminals and busbars. Name plate size shall be minimum of 20x75 mm for Instruments/devices and 40x50 mm for panels. Thickness shall be minimum 3 mm.

- l) For MCC/DB a full height vertical cable chamber with cable supports shall be provided in each section to facilitate unit wiring.
- m) 2x100%, 415V/110V AC control transformer shall be provided for control, Indication and annunciation supply for contactor operated motor feeder. All the necessary auxiliary and main contactor shall be provided suitable for this control supply.
- n) Two 220V DC feeders shall be provided for control, Indication and annunciation of breaker operated module.
- o) Compartment door shall be interlocked with main power isolating device for safety with provision for defeating it by authorized person.
- p) Supplier shall provide total 20% or minimum one (1) no. spare feeder of each type & rating with respect to total requirement of the switchgear.
- q) Motors of rating 30 kW and above shall be provided with anti-condensation heaters. Necessary provision for supply of motor space heating shall be considered in the switchgear.
- r) The incoming connection to transformer of more than 1000kVA and inter-connecting sections between switchboards shall preferably be of bus ducts.
- s) It should be possible to carryout maintenance on a feeder with adjacent feeders alive.

1.4.2

Bus and Bus taps

- a) The main buses and connections shall be of high [conductivity Aluminum / Copper] alloy sized for specified current ratings with temperature rise limited [to 40°C over ambient temperature of 50°C].
- b) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminum contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance. Adequate contact pressure shall be ensured by means of two bolts connection with plain & spring washers and locknuts. Temperature rise shall not exceed 105 degree for silver plated joints over an ambient temperature of 50 degree.
- c) Bus bars and connections shall be fully insulated for working voltage with adequate phase / ground clearances. Insulating sleeves for bus bars and shrouds for joints shall be provided.
- d) Bus insulators shall be flame-retardant, track resistant type with high creepage surface. All buses and connections shall be supported and braced to withstand the stresses due to maximum short-circuit current and also to take care of thermal expansion.

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- e) Bus bars shall be color coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from the front to switchgear assembly.
- f) Power shall be distributed to each module or compartment by a set of vertical bus bars. The vertical bus bars shall run behind the modules. Necessary tee off connectors shall be used for distributing auxiliary supply to each vertical panel. Rubber grommets shall be used for all wire entries to make the entries dust and vermin proof.
- g) The clearance between the individual bare phase power bus bars and between the phase and earth bus bars in air shall be not less than [25.4] mm.
- h) Three phase, neutral (with at least [50] % rating of main Bus bar and continuous earth bus shall be provided. Bus bar and tapping shall be provided with color coded PVC sleeves.

1.4.3

Air Circuit Breaker

- a) All Circuit Breakers for incoming feeders and Bus couplers shall be [four] poles; single throw, motor operated and air break type. Circuit breaker for outgoing feeders shall be triple pole, single throw and air break type. However for supply feeders it shall be [four] pole.
- b) Circuit Breakers shall be [draw out type] having Service, Test & Disconnected positions with positive indication for each position.
- c) Circuit breakers of identical rating shall be physically and electrically interchangeable.
- d) Bolted disconnected links shall be provided for all outgoing feeders for isolation of neutral, if necessary.
- e) For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open – close – open operation of the circuit breaker shall be possible after failure of power supply to the motor when the spring is charged after a closing operation.
- f) Mechanical safety interlock shall be provided to prevent the circuit breaker from being racked in or out of the service position when the breaker is closed.
- g) Automatic safety shutters shall be provided to fully cover the female primary disconnects when the breaker is withdrawn.
- h) Each breaker shall be provided with an emergency manual trip, mechanical ON-OFF indicator, an operational counter and mechanism to indicate spring charge / discharge condition.
- i) In addition to the auxiliary contacts required for normal breaker operation and indication, each breaker shall be provided with followings for interlocking purpose:-
 - i. Position / cell switch with 4 No + 4 NC contacts.

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- ii. Limit / auxiliary switches shall be convertible type that is facility for changing N.O. contact to N.C. and vice-versa.
- iii. Mechanical stopper to prevent accidental falling while withdrawing.
- j) Breaker cannot be racked in from 'isolated' to 'test' position with the door open together with provision for defeat of this interlocking, however, the door can be closed only when the breaker is brought back to 'isolated' position. Insertion of breaker into 'Service' position not possible if the shutters are not free.
- k) Door can be opened only when breaker is OFF and is in 'Isolated' position. Remote closing of breaker not permitted with door open.
- l) Anti pumping relay / device to ensure that there can be only one closing operation for each closing command.
- m) Suitable trolley arrangement shall be provided for breaker/starter modules. Two trolleys per switchgear room shall be provided so that top most breaker module of all types, sizes and rating can be withdrawn on trolley and lowered for maintenance purpose.
- n) Closing and tripping coil shall operate satisfactorily under the following conditions.
 - i. Closing Coil: 85% to 110% of rated voltage.
 - ii. Tripping Coil : 70% to 110% of rated voltage.

1.4.4 Contactors, MCCB and MPCB

- a) Incomers for MCCs and DBs rated below 630A shall be MCCB.
- b) Incomer and bus coupler rated below 630A shall be mechanically Interlocked.
- c) Motor starter contactors shall be of air break, electromagnetic type. Suitable for DOL starting of motor, and shall be of utilization category AC-3 for ordinary and AC-4 for reversing starters. DC contactor shall be of DC-3 utilization category.
- d) The contactors shall be three pole, air break type designed for [duty class III category A.C. –3 with non-bouncing silver / silver alloy.]
- e) Each contactor shall be provided with two (2) normally open and two (2) normally closed auxiliary contacts unless otherwise specifically stated. Rating shall be decided by the bidder.
- f) Reversing contacts shall be electrically and mechanically interlocked.
- g) Contactors with delayed dropout feature shall be provided for some essential auxiliaries. These contactors shall not dropout on power failure if the voltage is restored within 3 seconds.

1.4.5 Electronic over load relays

- a) Electronic overload relays shall conform to IEC:292-1 and shall be triple pole, ambient temperature compensated with adjustable setting, inverse time lag, built in single phase preventer and hand/auto reset type

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provided as per requirement along with necessary command, feedback cable, coupling relays etc.

- b) Provided with 1 NO and 1NC contact of rating same as the auxiliary contact of the contactors.
- c) The relay shall be able to withstand prospective short circuit current without damage or injurious heating till the motor protection MCCB/MPCB clears the fault.
- d) Relays may be direct acting or CT operated, depending on current rating. CTs shall be included in the scope of supply.

1.4.6 Bus Transfer scheme:

Each switchgear of two incomer and bus coupler shall be provided with the following provisions.

- i) Dead bus closing.
- ii) Manual live change over (Momentary paralleling)
- iii) Automatic bus transfer scheme.

1.4.7 Current Transformer

- a) Current Transformers shall be cast-resin type. All secondary connections shall be brought out to terminal blocks where wye or delta connection shall be made.
- b) CTs shall have polarity makings indelibly marked on each transformer at the lead terminations and at the associated terminal block. Facility shall be provided for short circuiting and grounding the CT secondary at the terminal blocks. Secondary terminals shall be provided with protective cap.
- c) CT terminal block shall be disconnecting type and suitable for round type lugs with facility for testing and short circuiting of individual CT.
- d) All CTs shall be provided with supports independent of busbars / busbar supports. The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shutdown of adjacent feeders.
- e) CTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.8 Voltage Transformer

- a) Voltage transformers(VT) shall be cast-resin type with an accuracy class of 1.0 for metering and 3P for protection.
- b) VTs shall be of the single-phase type. VTs shall be protected on their primary side by MCCBs with interrupting ratings corresponding to breaker rating and by MCB (with auxiliary contacts) on the secondary sides.

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- c) VTs shall have continuous over voltage factor of 1.2 and short time over voltage factor of 1.5 for 30 seconds for effectively earthed system
- d) It shall be possible to replace VTs without having to de-energise the main busbars.
- e) VTs shall be provided with disconnected type test links in both secondary leads for carrying out current and phase angle measurement.

1.4.9 Transducer

For all the incoming and the outgoing of 415V Switchgear / MCC/ DB Feeders requiring remote metering and/or current monitoring shall be provided with multi-functional transducers. The output shall be 4-20 mA DC which shall correspond to the normal range.

1.4.10 Secondary Wiring

- a) The switchgear shall be fully wired at the factory to ensure proper functioning of control, protection and interlocking schemes.
- b) Fuse /MCB and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks.
- c) Secondary wiring within the switchgear shall be carried out in a neat and systematic manner and securely held in position (either loomed or run in conduit / trunking). Wherever wiring passes through compartment, it shall be run in conduit / trunking, if metallic shall be bonded to the main earth busbar.
- d) Wiring shall be done with flexible, 1.1/0.650kV grade, PVC insulated switchboard wires with [stranded copper conductors of 2.5 mm² for CT & PT circuits and 1.5mm² for control circuit wiring.]
- e) Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per bidder's wiring diagrams. Wire terminations shall be made with crimping type connectors with insulating sleeves, wire shall not be spliced between terminals.

1.4.11 Terminal Blocks

- a) Terminal blocks shall be 660V grade box-clamp type with marking strips, similar to 10 mm² or equal. Terminals for C.T. secondary leads shall have provision for shorting.
- b) Not more than two wires shall be connected to any terminal. If more than two wires at one terminal are required, separate terminals with function wise shorting links shall be provided. [Spare terminal equal in number to 20% of active terminals shall be furnished.]
- c) Terminal blocks shall be located to allow easy access. Wiring shall be so arranged so that individual wires of an external cable can be connected to consecutive terminals.

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1.4.12 Ground bus

- a) A ground bus, rated to carry maximum fault current, shall extend full length of the switchgear. The ground bus shall be provided with two-bolt drilling with G.I. bolts and nuts at each end to for connection to the grounding conductor / flat.
- b) Each unit shall be connected directly to the ground bus. The frame of each circuit breaker and draw out V.T. unit shall be grounded through heavy multiple contacts at all times except when the primary disconnecting devices are separated by a safe distance.
- c) C.T. & V.T. secondary neutrals shall be earthed through removable links so that earth of one circuit may be removed without disturbing others. All hinged doors shall be earthed by flexible copper bride.

1.4.13 Space Heater

- a) Each vertical section shall be provided with thermostat controlled space heater 5A, 3 pin socket plug.
- b) In addition, motor feeders rated [30 KW and above] shall be wired up for feeding the motor space heater through suitably rated breaker auxiliary NC contact and/or contactor.
- c) Cubicle heater, Motor heater, and Plug socket circuit shall have individual switch fuse units/MCB.

1.4.14 AC Distribution Boards (ACDBs)

- a) AC Distribution Boards shall have MCCB/MCB at incomer depending upon the short circuit rating. Distribution Boards may be fed from switchgear and shall have two incomers. AC distribution Boards shall be of two types - one with 415V, 4-wire, triple pole and neutral (TPN) outgoing feeders and the other with 240V, 2-wire, single pole and neutral (SPN) outgoing feeders.
- b) For small loads, MCB boards with TPN MCB as incomer and TPN/SP MCBs for outgoing may be considered. The feeder rating and quantity shall be as per requirement.
- c) Board shall be single/double front [preferably single front], metal clad, front matched, dust and vermin proof, fixed type, compartmentalized and extensible on both sides.
- d) Bus bars shall have same cross section throughout the length. Rating of the neutral bus bar shall be 50% of the main bus bar. Earth bus bar shall run in bottom chamber throughout the length of the Board.

1.4.15 DC Distribution Boards

DCDBs shall have two incomers and a bus coupler. Incomers and outgoing feeders of DCDBs shall be MCB/MCCB modules. They shall be fixed type and floor mounted. Other constructional features shall be similar to ACDB.

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The feeder rating and quantity shall be as per requirement.

1.4.16 Control & Indication

The circuit breaker shall be wired up for local & remote operation. Each breaker cubicle shall be equipped with following:

- a) Remote selector switch with pistol grip handle and key interlock for breakers with motor wound spring charging mechanism. In Remote position, the breaker can be operated in service position with all interlock and protections. In switchgear position, the breaker shall be operated from switchgear only in test position with only protection (no interlock).
- b) Two (2) heavy duty, oil-tight, push buttons for Trip & Close.
- c) Circuit breaker shall be indicated electrically. The following indication colour shall be used.

Breaker open - GREEN

Breaker closed - RED

Spring Charged - WHITE

Breaker Auto Trip- AMBER

- d) However, any other indication shall be provided as per owner's requirement.
- e) Lamps shall be LED type with resistance for voltage protection. Lamp and lens shall be replaceable from the front.
- f) For all MCCB feeders, trip indication lamp shall be provided on front of the compartment.
- g) For all starters, ON, OFF and trip indication lamps shall be provided on front of the compartment.

1.4.17 Relays, Protection & Metering

- a) The hardware design for protection and associated equipment shall use latest state-of-the-art technology and shall generally be integrated numerical/digital, modular in nature. Where design is based on numerical technology, adequate self testing/monitoring/diagnostic facilities shall be provided.
- b) All numerical relays, auxiliary relays and devices shall be of types, proven for the application; satisfying requirements specified elsewhere and shall be subject to Purchaser's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity to the satisfaction of the Owner.
- c) All protective relays shall be in draw out or plug-in type / modular cases with proper testing facilities. Necessary test plugs / test handles shall be supplied loose and shall be included in supplier's scope of supply.

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- d) All AC operated relays shall be suitable for operation at 50 Hz. AC voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for [1 or 5] amp CT secondary. All relays and timers shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.
- e) Energy meters shall be provided for incomer of 415V Switchgear and MCC and shall be able to communicate with DCS. These meters shall be as per CEA regulation 2006 "Installation and operation of meters". Accuracy class shall not be less than 1.0S.
- f) Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.
- g) All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.
- h) The relay shall be designed to perform satisfactorily under highly noisy electrical environment. Sufficient degree of high frequency disturbance immunity and impulse voltage withstand capacity shall be built into electronic designs as stipulated in relevant standards.
- i) All protections shall be furnished complete with necessary auxiliary, supervisory, lock out relays. Suitably separate sets of single phase auxiliary C.T with multiple taps shall be provided with relay whenever required.
- j) Visual and audible alarm annunciation shall be initiated in the event of operation of protective/supervisory relay.
- k) D.C supply shall be supervised by DC supervision relays.
- l) Trip circuit shall be supervised by Trip circuit supervision.
- m) Tripping shall be done through high speed lock out relays.
- n) All meters/ instrument shall be flush mounted on front panel, at least 96mm² size with 90° linear scales and accuracy class of 2.0.
- o) Interposing relays for ON/OFF command or any other command shall be as per system requirement.
- p) For alarm and Indication at DCS end necessary contacts shall be provided at switchgear end.
- q) Metering and protection shall be as per below table

a)	Incomers	
	Protections	Metering
i	Time graded short circuit protection	Local Current (single phase) indication and remote indication through transducer.

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ii	Over current protection	Voltage Measurement for all three phases and remote indication through transducer.
iii	Earth fault protection	KW, Kwhr
b)	Bus coupler	
	Protections	Metering
i	Over current protection(51)	Local Current (single phase) indication.
ii	IDMT Earth fault protection(51N)	
c)	Contactor controlled motor feeders [90kW and above motor only]	
	Protections	Metering
i	Time graded short circuit protection	Local Current indication and remote indication through transducer.
ii	Over current protection	
c)	[Motor Feeders [of 132KW and above only]]	
	Protections	Metering
	Composite motor protection to cover a minimum of protections such as over current, short circuit, earth fault, locked rotor, Negative phase sequence, thermal overload etc.	Local Current indication and remote indication through transducer.
[Other feeders]		
a)	Bus PT / Line PT Modules	
	Protections	Metering
	Under voltage protection	[Voltage – phase to phase,]
	Fuse failure protection	
b)	Motor feeders (MPCB/MCCB with Contractors)	
	Protections	Metering
	Electronic Overload relay (with single phase preventor), short circuit protection (through fuse/MCCB/MPCB as specified)	
c)	Incoming feeders for ACDB/DCDB	
	Protections	Metering

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	Short circuit protection (if MCCB)	[Voltage (single phase and, Phase Current (1 Phase))] Local indication only.
d)	Outgoing feeders of ACDB/DCDB	
	Protections	Metering
	Short circuit protection (through fuse/MCCB)	

1.5

Tests

I) Type Test

For each type & rating of 415V Switchgear, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the switchgear similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant /purchaser or his representative.

The minimum tests shall be conducted are as follows:

- Measurement of insulation resistance of Circuit Breaker in closed and open positions.
- Measurement of milli-volt drop across Circuit Breaker main contacts and other joints.
- Measurement of Circuit Breaker/Contactor operating time for close & open at nominal voltage and 80% of rated voltage.
- Measurement of resistance, IR value and drop-off/pick-up voltage of close and trip coils.
- Healthiness of limit switch contacts.
- Spring charging motor functional checks.
- Verification of phase sequence and checking of clearances of busbars between phase to phase and phase to earth.
- Measurement of milli-volt drop across busbar joints

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- i) Torque tightness test.
- j) High voltage test on busbar.
- k) Measurement of CT/PT polarity, ratio and knee point voltage.
- l) Electrical and mechanical interlock checks.
- m) Secondary injection of all protection relays by using service settings and simulation of all protection functions.
- n) Secondary injection of all metering circuits.
- o) Functional tests to demonstrate the specified control and interlocks

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates:

Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner. The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawing & Documents

Drawings, data & manuals for the motors shall be submitted as indicated below

- a) [General Arrangement drawings and cross-section showing constructional features & cable entry with bottom view with opening.
- b) Bill of Materials.
- c) Technical Data sheet and Catalogue.
- d) Foundation drawing details with bottom view of switchgear.
- e) Descriptive write-ups and literature for the main equipment offered including relays, meters, etc.
- f) Control Schematics & Wiring diagram.
- g) Inspection and Test Plan (ITP).
- h) Suggestive list of protective relays.
- i) Transport/shipping dimensions and weights].

1.7 Ratings & Requirements

415V switchgears, MCC and DB shall comply with the particulars indicated in the following tables.

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Table- 2.0

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		415 Volts, 3 Phase, 4 wire 50 Hz.
2.2	System neutral earthing		Solidly earthed
2.3	Voltage & frequency variation	%	+/-10%, -5%to +3% Hz.
2.4	Rated frequency	Hz	50Hz
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		a) 2.5kV b) 1.5kV
2.5	Continuous current rating of busbars under site reference ambient temp.		[As per Project requirement]
2.6	Reference ambient temperature		50°C
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		90°C for busbars having non-silver plated joints 105°C for busbars having silver plated joints
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	50
b	Dynamic Rating	kA (peak)	105
2.9	Whether busbars have been insulated	Yes	Required
2.10	Type of insulation		[By Bidder]
2.11	Material of bus bar supports		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
2.12	Switchgear designation		[As per project specific]
2.13	Bus bar material		Cu/Al
2.14	Fully draw out (FD)/ Fixed (F)		FD for Switchgear/MCC; F for DBs.
2.15	Entry –Top (T)/Bottom (B)		Top for busduct, bottom for cables
2.16	Degree of protection		IP 52
2.17	Colour finish shade	Interior Exterior	[Glossy white] [RAL 5012]
2.18	Earthing bus	Material	GS
2.19	Minimum clearances in air of live parts	mm	As per standard
3.0	Starters		
3.1	Type	DOL	DOL
3.2	Contactor rated duty		AC3 for DOL
3.3	Single phasing preventer required.	Yes / no	Yes
3.4	Thermal overload relay reset	Manual / Auto	Settable for either to Manual or Auto
4.0	Circuit breakers		
4.1	Maker's name		[By bidder]
4.2	Voltage, frequency & no.of phases , poles		415 V, 50 Hz, 3 Ph, 4 Pole
4.3	Rated operating duty		O-3min-CO- 3min -CO
4.4	Circuit breakers type		ACB
4.5	Short circuit withstand current for 1 sec. Duration	kA	50
4.6	Rated making current	kAp	105
4.7	Rated current at site reference ambient temp	A °C	[By bidder]

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S. No.	DESCRIPTION	UNIT	DATA
4.8	Type of operating mechanism		Spring charged motor and manual
4.9	Minimum no. of auxiliary Contacts for purchaser's use		6 NO, 6 NC
4.10	Control voltage		
a	Spring charging motor	V AC/DC	[220V DC/240V AC]
b	For closing/tripping	V AC/DC	220V DC
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	As per IS
b	Closing at normal voltage	%	As per IS
c	Trip coil	%	As per IS
4.12	Power required for closing at normal voltage	W	[By bidder]
4.13	Power required for tripping at normal voltage	W	[By bidder]
4.14	Spring charging motor details:		
a	Rating	kW	[By bidder]
b	Rated voltage	V, AC/DC	[By bidder]
c	Spring charging	Sec.	[By bidder]
	Electrical and mechanical anti-pumping features been provided	Yes/No	Required
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		415 V, 50 Hz & 3 P for outgoing, 4P for incoming and supply feeders
5.2	Rated operating duty		As per IS
5.3	Rated breaking capacity	kA (rms)	50

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S. No.	DESCRIPTION	UNIT	DATA
5.4	Rated making current	kA (Peak)	105
5.5	On/off operation		
5.6	Manual	Yes/No	Yes
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	Yes
5.8	Auxiliary contacts required	Yes/No	[As per project specific]
6.0	Contactors		
6.1	Make		[By Bidder]
6.2	Rated duty	AC3/A C4	AC3 for DOL AC4 for RDOL
6.3	No of poles		3
6.4	Utilization category		[By Bidder]
6.5	Rated voltage of auxiliary contacts	V	[By Bidder]
6.6	Rated voltage of coil	V	[By Bidder]
6.7	Rated breaking capacity	Factor of rated current	[By Bidder]
6.8	Rated making capacity	Factor of rated current	[By Bidder]
6.9	Limits of operation		As per IS/IEC
a	Supply voltage variation		[By Bidder]
b	Supply frequency variation for closing		[By Bidder]
c	Drop out voltage		[By Bidder]
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		

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S. No.	DESCRIPTION	UNIT	DATA
7.1	Voltage Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
7.2	CT Ratio		Primary current/1A or 5A
7.3	Measuring CTs		CI - 1.0 instrument safety factor 5.0
7.4	Protection CTs		CI 5P20
7.5	Measuring VTs		(min)/phase CI1.0
7.6	Protection VTs		CI 3P
8.0	Control transformers		
8.1	Make		[By Bidder]
8.2	Type		Dry Type
8.3	Applicable standards		As specified in the specification
8.4	Ratio		$[415/\sqrt{3})/110/\sqrt{3})]$
8.5	Class of insulation		Class-B or Better
8.6	Rated output	VA	[As per project specific]
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		[By Bidder]
10.2	Make		[By Bidder]
10.3	Type designation		[By Bidder]
10.4	Setting range		[By Bidder]
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		[By Bidder]
11.2	Make		[By Bidder]
11.3	Type		[By Bidder]
11.4	Current setting range		[By Bidder]

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	[By Bidder]
12.0	Under voltage relay		
12.1	Make		[By Bidder]
12.2	Type		[By Bidder]
12.3	Voltage rating	V	[By Bidder]
12.4	Setting range	V	[By Bidder]
13.0	Auxiliary relays and timers		
13.1	Make		[By Bidder]
13.2	Type		[By Bidder]
13.3	Coil voltage	V	[By Bidder]
14.0	Control/selector switch		
14.1	Make		[By Bidder]
14.2	Type designation		[By Bidder]
15.0	Meters		
15.1	Applicable Standards		As specified in the specification.
15.3	Accuracy Class		Class 1.0 or Better
15.4	Make		[By Bidder]
15.5	Type		Multi function with RS 485 connectivity
16.0	Voltmeter		
16.1	Make		*[By Bidder]
16.2	Type		Moving coil
16.3	Applicable standards		As specified in the specification.
16.4	Accuracy class		Class 1.0
17.0	Ammeter		

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S. No.	DESCRIPTION	UNIT	DATA
17.1	Make		As specified in the specification.
17.2	Type		Moving coil
17.3	Applicable standards		As specified in the specification.
17.4	Accuracy class		Class 1.0
18.0	Indicating lamps		
18.1	Make		As specified in the specification.
18.2	Type		Clustered Led
18.3	Voltage	V	As specified in the specification.
18.4	Wattage of lamp	W	As specified in the specification.
19.0	Push buttons		
19.1	Make		As specified in the specification.
19.2	Type designation		As specified in the specification.
19.3	Contact rating	A	As specified in the specification.
20.0	Space heater		
20.1	Make		As specified in the specification.
20.2	Type		As specified in the specification.
20.3	Rated voltage	V	As specified in the specification.
21.0	Wiring and terminal blocks		
21.1	Voltage grade		1.1 kV
21.2	Insulation		[By Bidder]
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	2.5 for CT & PT 1.5 for Others
b	Control wiring	Sq.mm	1.5 for Others

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S. No.	DESCRIPTION	UNIT	DATA
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		Sliding type
	II) For Fixed Type		Stud & nut type
21.5	Minimum current rating of terminal blocks	A	10

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E5

**TECHNICAL SPECIFICATION FOR 415V NON
SEGREGATED PHASE BUS DUCTS**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E5**1.0 415V NON SEGREGATED PHASE BUS DUCT****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of 415V Non Segregated Phase Busduct, complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

IS 8084	Interconnecting Bus bar for AC Voltage above 1KV up to and Including 36kV
IEC 60947	Low Voltage Switchgear and Control gear
ANSI/IEEE C37.20	Metal-Clad and Station-Type Cubicle Switchgear
ANSI/IEEE C37.24	Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal Enclosed Switchgear
IEC 60439	Low-voltage switchgear and control gear assemblies.
BS 159:1957	Bus bar and Bus bar connection
CEA	CEA regulations and standards

Equipment and material conforming to any other standard which ensures equal or better quality may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3 Design Criteria

- a) The 415V Non-segregated phase bus duct shall serve as an interconnection between the 415V Switchgear and 11/0.433kV LV Transformer. The Non-segregated phase bus duct shall be installed

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indoor/Outdoor in a hot, humid and tropical atmosphere. All panels associated with Non-segregated phase bus duct shall be located indoors/Outdoors.

- b) Bus duct, associated equipment and wiring shall be provided with tropical finish to prevent fungus growth. All ventilation openings shall be screened and drains shall be filtered to prevent entrance of dust and insects.
- c) For continuous operation at specified ratings, temperature rise of the bus duct and auxiliary equipment shall be as specified in Clause 1.7 Rating and requirements.
- d) Bus duct and auxiliary equipment shall be capable of withstanding the mechanical forces and thermal stresses of the required short-circuit currents.
- e) The bus ducts and supporting structures shall be designed & constructed so as to withstand without damage the horizontal / vertical ground accelerations due to earthquake.
- f) The bus ducts shall be self cooled and shall not be equipped with blower or any other type of forced ventilation.
- g) The equipment rating shall be based on an ambient temperature. Same phase disposition shall be maintained throughout the run of the bus duct. Phase crossover units, if required, shall also be provided inside the Busduct itself.
- h) Bus ducts shall be suitable for continuous operation at maximum system voltage and shall be adequately sized to withstand short circuit current.

1.4 Specific Requirements

1.4.1 General

- a) 415V Non Segregated Phase Busduct is provided for connection between low voltage side of 11/0.433kV cast resin dry type /oil type transformers and associated 415V Switchgears shall be of TPN (3 phase and neutral) along with necessary bends, flexible at both transformer & switchgear ends, flanges, phase crossover chambers (if required), support structures & accessories including terminations at the equipment ends.
- b) The 415V bus duct shall be metal enclosed, non-phase segregated enclosure type, self cooled and insulated for 1.1kV voltage. The cooling medium inside the duct shall be air.

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- c) All parts and accessories shall have appropriate match mark and part numbers for easy identification and installation at site.
- d) The 415V non-segregated phase bus duct will be installed indoor or partially indoor & outdoor depending upon the location of equipment being interconnected in a hot, humid and tropical atmosphere. All panels associated with LV non-segregated phase bus duct will be located indoors.
- e) The continuous current rating and momentary peak withstand current rating of the Busduct between transformers & their associated switchgears shall be same as that of the associated switchgears and as indicated in the specification.
- f) All supporting steel structures shall be hot dip galvanized.
- g) The bus ducts shall be provided with space heaters to control moisture. Slicagel breather if required same shall be provided.

1.4.2 Enclosures

- a) The enclosure shall be rectangular and shall be made of [aluminium alloy/Mild steel] of grade [19000H2] as per IS-5082. The entire bus duct shall be designed with dust, weather and vermin-proof construction. The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- b) *[Phases shall be enclosed in a weather-proof, dust-tight, non-magnetic metal (aluminum alloy) of 3mm for bus rating including and above 3000A whereas enclosures for normal bus current rating (<3000 A) shall be sheet steel fabricated type of 2.5mm thick].*
- c) Enclosures shall be provided with flange ends with drilled dimensions to suit the flanges at the switchgear and transformer ends.
- d) Circumferential neoprene rubber gaskets shall be provided for dust tight joints with adjacent enclosure section.
- h) The bus enclosure shall have extended bellows or equivalent means to allow for temperature changes and vibrations. Flexible joints shall be provided in enclosures at all points where the bus duct terminates at equipment to withstand vibration, expansion / contraction and at suitable intervals in any straight run of the bus duct where expansion and contraction would otherwise result in stresses in the supporting structures.

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- i) All outdoor bus-enclosures shall be so designed & constructed as to prevent accumulation of rain water on top sheet. Similarly all Gasketed flanged joints shall be suitably protected against direct splashing of rain water in case of outdoor runs. The connection flanges shall be sufficiently stiffened so as not to bend while tightening the bolts.
- j) Outdoor portions of the bus duct, if any, shall have continuous rain hood of non magnetic material or with suitable arrangement for rainwater prevention.
- k) Suitable inspection openings shall be provided for access to support insulators, bus joints, transformer terminals, switch gear terminals etc. All inspection openings shall have reliable sealing arrangement with neoprene gaskets.
- l) Seal-off bushings complete with wall-frame and support plates shall be provided where the bus duct penetrates the building wall. The seal is to prevent free exchange of air between indoor and outdoor portions of the bus duct.
- m) In case, the bus duct penetrates the firewall, the wall frame assembly and the seal shall be designed for the same fire rating as the firewall.
- n) Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct. Space Heaters shall be provided in the bus duct.
- o) Filtered drains for drainage of condensate shall be provided at the lowest points and at such locations where accumulation of condensate can be expected.
- p) Shipping length of the Busduct shall be not more than three (3) meters in length.
- q) Minimum Degree of protection of Busduct enclosure shall be IP-52 for indoor and IPW-55 for outdoor section of the Busduct.

1.4.3

Bus Conductor

- a) The bus conductor shall be of high conductivity, [Aluminium alloy / Aluminium].
- b) The bus conductors shall be given a coat of matt black paint to facilitate heat dissipation. However the sizing of the bus conductor shall consider the conductor as bare.
- c) The bus conductor shall be designed for bolted connections throughout the run.
- d) Flexible connection shall ensure an efficient and trouble-free connection.

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- e) Silver plating shall be done on copper bar wherever copper to copper and copper to aluminium contacts are envisaged. All connection hardware shall be non-magnetic and shall have high corrosion resistance.
- f) The bus conductors and their support insulators shall be designed to withstand, without damage, the forces developed while carrying the short circuit current.
- g) The bus bar shall be sleeved with FRLS heat shrinkable, colour coded PVC sleeves at intermittent points for phase identification.
- h) The material of the conductor shall be aluminium alloy of grade [63401WP] as per IS: 5082. The temperature rise of conductor shall be 40 degree over design ambient temperature of 50 degree. Also, the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.

1.4.4 Disconnect Link

- a) Removable bolted disconnected link shall be provided in the bus for the purpose of isolation.
- b) Disconnect link shall consist of a removable section of conductor and shall be so constructed as to permit easy removal or reinsertion without alignment difficulties.
- c) The bus on both sides of the link shall be rigidly supported so that the disconnect link is equal in mechanical strength to any other section of the bus.
- d) A minimum clearance of [300 mm. (12")] shall be provided between the disconnected bus sections with the link removed.

1.4.5 Insulators

- a) The bus conductor supporting insulators shall be flame retardant, non-hygroscopic, high impact and high dielectric strength material with an anti tracking contour.
- b) Material of insulator shall be [Epoxy SMC moulded /FRP].
- c) Spacing of the bus support insulators shall be considered by giving due factor of safety to withstand the forces due to the short circuit current assigned to the bus duct.
- d) Bus support insulators shall be interchangeable, high creepage, high strength, wet process, fine glazed porcelain. Alternatively good quality cast resin insulators may be offered.

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- e) Insulator shall be mounted in such a way so as to permit easy removal or replacement without disassembly of the bus. The insulator mounting plate shall be designed for cantilever loading to withstand the short circuit.
- f) The conductor shall be fastened on the insulator through fixed and slip joints so as to allow conductor expansion or contraction without straining the insulator.
- g) Space heater shall be provided preferably located near to each insulator to avoid moisture condensation within bus duct.

1.4.6 Connections & Terminations

- a) All matching flanges, seal-off bushings, gaskets, fittings, hardware and supports required for termination of the Busduct at the switchgear, transformers and other equipment shall be furnished.
- b) In this connection the bidder is required to coordinate with the switchgear and auxiliary transformers manufacturer with regard to connection details, mechanical and thermal stresses.
- c) Flexible connections both for conductor and enclosure shall be furnished at all equipment termination to provide for misalignment up to 25 mm in all directions.
- d) The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation of equipment during testing.

1.4.7 Supporting Structures

- a) All supporting structures required for hanging and/or supporting the complete bus duct shall be furnished. These include all members, indoor/outdoor posts, bolts, shims, base plates, beams, hangers, brackets, bracings and hardware.
- b) All buses shall be adequately supported and braced to successfully withstand normal operation, vibration, thermal expansion, short circuit forces and all specified design loads including wind & earthquake forces.
- c) Support shall be designed to provide tolerance of ± 12 mm in the horizontal and vertical directions.
- d) All steel members shall be hot-dip galvanized after fabrication. All hardware shall be of high strength steel with weather resistant finish.
- e) The mounting arrangement of Busduct on the supporting structure shall be designed to allow movement of the Busduct during expansion and contraction.

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- f) All structure shall be self supporting and in no case rely for support on equipment to which the busbars are connected.

1.4.8 Ground bus

- a) The ground bus of two numbers of separately run [50x10 mm] minimum GS flat shall be provided along the run of the bus duct. All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to above ground bus.
- b) Ground bus shall be finally to connected to power plant earth grid at one end.

1.4.9 Wiring

All wiring for space heaters shall be done with insulated stranded copper conductor of not less than [2.5 mm² cross-section]. Each wire shall be identified at both ends with wire designation as per bidder's wiring diagram and shall be brought out to a terminal box outside the bus duct.

Terminal blocks shall be box-clamp type minimum 10 mm² with marking strips.

At [least 20% spare terminals] shall be furnished in the terminal block.

1.4.10 Name Plate

Suitable name plate shall be furnished with each piece of equipment.

[Materials for name plate shall be plastic / lamicaid, 3 mm thick, using white letters on black background.]

1.4.11 Space Heater

Thermostatically controlled Space heaters shall be provided in the bus ducts, wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation. At least one number space heater with thermostat shall be provided at each transformer and switchgear end.

The space heaters shall be suitable for continuous operation on single phase supply, and shall be automatically controlled by thermostats. Necessary wiring up to junction boxes mounted on bus duct and from junction boxes to switchboards shall be provided.

1.4.12 Painting and Finish

- a) All surfaces to be painted including interior and enclosures and other metal parts shall be shot or sand blasted or chemically treated to remove all rust, scale, grease and other adhering foreign matters as far as

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possible shall be painted with not less than two (2) coats of Acid and corrosion resistant paint

- b) Steel surfaces, exposed to weather shall be given two (2) coats of zinc chromate and two (2) coats of an 'approved' Manufacturer's paint of 'approved' colour.
- c) All metal parts not accessible for painting shall be made of corrosion resistant materials. All machine finished or bright surfaces shall be coated with a suitable rust preventive compound and wrapped or otherwise protected.
- d) Inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The shade of exterior surface finish shall be [RAL 5012].
- e) The interior surface finish shall be as per manufacturer's standard.
- f) Pretreatment consisting of degreasing, de-rusting etc. shall be done on all fabricated parts before painting or galvanizing.
- g) Paints shall be carefully selected to withstand heat and weather conditions. The paint shall not scale-off or crinkle or get removed by abrasion due to normal handling.
- h) Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished.
- i) The paint shade shall be subject to owner's approval.

1.5 Tests

l) Type Test

For each type & rating of 415V Non segregated phase bus duct, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the Busduct similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

Some of the specific tests required are listed below.

- a) Visual inspection and verification of dimensions
- b) Dry power frequency voltage withstand for 1-minute
- c) Milli-volt drop test & Water tightness test

1.6 Drawings and Documents

Drawings, data & manuals for the 415V Non segregated phase bus duct shall be submitted as indicated below:

- a) [Dimensional GA drawing]
- b) Data sheets
- c) Typical calculation for arriving at the size of conductor and the insulator spacing.
- d) Type test report (short circuit, temperature rise test) for similar bus duct manufactured by the proposed manufacturer.
- e) Foundation layout and requirements
- f) The bidder may note that the drawings, data and manuals listed are minimum requirement only. The bidder shall ensure that all other necessary write-ups, curves and information required to fully describe the equipment offered are submitted with his bid.]

1.7 Ratings and Requirements

Major technical parameters of 415V non segregated Bus Duct are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

Table: 2.0

S. No.	Technical Particulars	Unit	Parameters	Remarks
1.	Type of bus duct		Non segregated phase bus duct	
2.	Rated voltage and No. of phase	V	415V, Triple Pole , Neutral(3Phase & 4 Wire)	
3.	Applicable standard		IS 8084	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
4.	System Frequency	Hz	50	
5.	Design ambient temperature	Degree	50	
6.	Rated Current	A	[As per project Requirement]	
7.	Designation (from & to)		[As per project Requirement]	
8.	Type of cooling (NSPBD)		Natural air	
9.	Maximum temperature rise of conductor over 50°C ambient	°C	[40]	
10.	Maximum temperature rise of enclosure over 50°C ambient	°C	[30]	
11.	One minute power frequency voltage withstand	KV (RMS)	2.5	
12.	Continuous current rating at 50°C design ambient air temperature	A	[As per project Requirement]	
13.	Material a) Bus bar b) Enclosure		a) [Aluminum] b) [Aluminum alloy/MS]	
14.	One second short circuit withstand rating	KA (RMS)	50	
15.	Momentary short circuit withstand current	KA (Peak)	105	
16.	Bus bar Support		[FRP/ SMC]	
17.	Degree of protection		IP 52 for indoor IP W55 for outdoor	
18.	Earthing Conductor Material		GS	

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S. No.	Technical Particulars	Unit	Parameters	Remarks
19.	Heating		Thermostat controlled space heater	
20.	Fittings of silica gel breather and drain plug		Required	
21.	Finish of Bus Enclosure		a) Inside: Matt Black b) Outside [RAL 5012]	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E6

TECHNICAL SPECIFICATION FOR 220V DC SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E6

1.0 220 V DC SYSTEM

1.1 General

This specification is intended to cover the [design, engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, erection, site testing and commissioning] of 220V DC system with its all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS- 266	:	Specification for Sulfuric Acid
IS- 1069	:	Specification for Water for Storage battery
IS- 1146	:	Specification for rubber and Plastic Containers for Lead Acid Storage Batteries
IS-1652-1991	:	Stationary Cells and Batteries, lead acid type (with Plante positive plates) – Specification
IS- 3116	:	Specification for Sealing Compound For Lead Acid Batteries
IS- 8320	:	General requirements and methods of tests for lead acid storage batteries.
IS- 6071	:	Specification for synthetic separators of lead acid storage batteries.
IS-10918-1984	:	Specification For Vented Type Nickel-Cadmium Batteries.
IS-14782-2000	:	Code of Practice for maintenance and testing of large Lead Acid Batteries in Generating Station and Substation.
ANSI-C-	:	Guide for surge withstand capability test.

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37.90a		
IEC - 60623	:	Secondary Cells and Batteries Containing Other Non-Acid Electrolytes – Vented Nickel- Cadmium Prismatic Rechargeable Single Cells.
IEEE-1115-2000	:	Recommended Practice For Sizing Nickel-Cadmium Battery For Stationary Application.
IEEE-485-1997	:	Recommended Practice For Lead Acid Battery For Stationary Application.
IEEE-946-1992	:	Recommended Practice For The Design Of DC Auxiliary Power Systems For Generating Station.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package
IS:5	:	Colours for ready mix paints.
IS : 694	:	PVC Insulated Cable for working voltages upto and including 1100V
IS : 1248	:	Specification for Direct acting indicating analogue electrical measuring instruments.
IS:13947 Pt-1	:	Degree of protection provided by enclosures for low voltage switchgear and control gear.
IS : 13947	:	Specification for low voltage switch gear and control gear
IS : 3231	:	Electrical relays for power system protection.
IS : 3842	:	Application guide for Electrical relays for AC System
IS : 3895	:	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	:	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	:	Code of practice for phosphating of Iron and Steel
IS:6619	:	Safety Code for Semi-conductor Rectifier Equipment.
IS:6875	:	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 VAC or 1200VDC

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IS : 9000	:	Basic environmental testing procedures for electronic and electrical items.
IS:13703	:	Low voltage fuses for voltages not exceeding 1000 V AC, 1500VDC.
EEUA-45D	:	Performance requirements for electrical Alarm Annunciation system

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity (IE) Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- 220 V DC Systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The system shall be suitable for operation in a highly polluted environment.
- The permissible voltage variation for 220V battery shall be from -15% to +10%.
- The battery shall be of storage type [Lead Acid Plante Positive Plate/Ni-Cd] Type. The Battery shall be of high discharge performance type. The plates shall be designed for maximum durability during all service conditions including high rate of discharge & rapid fluctuation of load.
- While estimating the battery size, temperature correction factor [based on lowest expected temperature 5 Deg C], margin on capacity [10%] and aging factor [1.0 for Lead Acid Plante and 1.2 for Ni-Cd] shall be considered.
- Cell Voltages for Lead Acid batteries:

i.	Nominal Discharge Voltage/cell	2.0 V
ii.	Float Voltage/cell	2.2 V
iii.	Boost Voltage/cell	2.7 V
iv.	Capacity for ten(10) hour rate at 27°C any time during the entire duty	1.85 V/Cell

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	cycle	
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f) Cell Voltages for Ni-Cd Batteries

i.	Nominal Discharge Voltage/cell	1.2 V
ii.	Float Voltage/cell	1.42 V
iii.	Boost Voltage/cell	1.7 V
iv.	Capacity for five(5) hour rate at 27°C any time during the entire duty cycle	1.14 V/ Cell

- g) 2x100% sets, 220V of either Lead-Acid Plante Type or Nickel-Cadmium battery banks with 2 x100% float cum boost charger catering to 100% of unit as well as station loads shall be provided.
- h) Permissible voltage variation for 220V battery shall be from 190V to 240V.
- i) The Ampere-Hour capacity of DC Storage Battery shall be based on [Three] hours' continuous DC supply at rated voltage to essential auxiliaries.
- j) Batteries shall be suitable for being boost charged to fully charged condition from fully discharged condition within 10 hours.
- k) Lead acid batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.2V/cell.
- l) Ni-Cd batteries shall be boost charged at about 1.54 to 1.7 volts per cell maximum and float charged at about 1.42V/cell.
- m) The float-cum-boost charger shall be rated to cater to the following:
- Trickle charging current of the battery
 - Equalizing charging of the Battery
 - Boost charging of the Battery
 - Continuous load on the DC system
 - 25% spare capacity over above loads.

1.4 Specific Requirements

1.4.1 Constructional requirements of battery

a) Containers

Container shall be made of transparent glass for lead acid and polypropylene for Ni-Cd batteries. It shall be robust, heat resistance, leak

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proof, non-absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container. The marking for the electrolyte level should be for the upper and lower limits. Container shall be closed / sealed lid type.

The pole sealing arrangement should be such that no acid particle gets entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

b) Vent Plugs

Vent plug shall be provided in each cell. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the spring type hydrometer can be inserted into the vent to take electrolyte sample.

c) Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuation of load. The construction of plates shall conform to latest revisions of standards as applicable for type of battery.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative posts shall be clearly marked.

The plante positive plates shall be supported from the ledges of the SAN container. They should not be supported at the bottom of container. Sufficient space shall allowed to allow the creepage of the plates.

d) Sediment Space

Sufficient sediment space shall be provided so that the cells shall not have to be cleaned out during normal life and prevent shorts within the cells.

e) Cell Insulators

Each cell shall be separately supported on PVC / Porcelain / Hard rubber insulators fixed on the racks with adequate clearances between adjacent cells. Minimum distance between adjacent cell shall be more than the bulge allowed for two cells in accordance with relevant IS standard.

f) Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS: 266 and distilled water conforming to IS: 1069 for lead

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acid batteries and battery grade potassium hydroxide for Ni-Cd batteries. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately in a separate non-returnable container. 10% extra electrolyte shall be furnished to cover spillage in transit or during erection.

g) Connectors and Fasteners

Lead or Lead coated copper connectors (For Lead acid Plante Type batteries) and Nickel coated copper connectors (for Ni-Cd batteries) shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated/Nickel coated to prevent corrosion. The thickness of lead coating of connectors should not be less than 0.025 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulated shrouds. End take-off connections from positive and negative poles of battery shall be made by single core cables having stranded aluminum conductors and XLPE insulation. Necessary supports and lugs for termination of these cables on battery shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 30 minutes discharge current of the respective battery and through fault short circuit current which the battery can produce and withstand for the period declared. Suitable number of inter rack connectors shall be supplied by the bidder to suit the battery room layout during the detail engineering.

h) Battery Racks

Steel racks with anti-corrosive epoxy paint for all the battery shall be provided. They shall be free standing type mounted on porcelain / hard rubber / PVC pads insulators. Battery shall be located in the single tier arrangement. However battery having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The battery rack and support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.

i) Manufacturer's Identification Systems

The following information shall be indelibly marked on outside of each cell:

- i. Manufacturer's name and trade marks
- ii. Country and year of manufacture
- iii. Manufacturer type of designation
- iv. AH capacity at 10 hour discharge rate
- v. Serial number

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1.4.2 Constructional Requirements of battery charger

- a) The Charger shall be indoor, floor mounted, self supporting sheet metal enclosed cubicle type. All necessary base frames, anchor bolts and hardware shall be supplied. The charger shall be fabricated using cold rolled sheet steel shall not less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied. The lugs for cables shall be made of electrolytic copper with tin coat. The chargers shall be tropicalised and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The chargers shall have hinged double leaf doors provided on front / or backside for adequate access to the charger internals. All the charger cubicle doors shall be properly earthed. The degree of protection of charger enclosure shall be at least IP-42.
- b) All indicating instruments, control and selector switches and indicating lamps shall be mounted on the front side of the charger.
- c) Electronic equipments shall be of modular design consisting of plug in modules in standard 19 inches metallic racks with metallic card guides. The cards should be provided with proper handles. Card to card wiring should be preferably through a motherboard. Unplanned jumpering and track modifications are not permitted and track modifications are not permitted. Mechanical interlocks to prevent wrong insertion of cards should be provided. Each card shall have its junction and test points identified. Maintenance aids such as extension printed wiring boards and jumper leads shall be provided.
- d) The layout of charger equipment shall be such that their heat losses do not give rise to excessive temperature within the charger panel surface. Location of the electronic modules shall be such that temperature rises of the location, in no case, shall exceed 10°C over ambient air temperature outside the charger.
- e) Printed Circuit Boards (PCB)
PCB shall be made of glass epoxy of 1.6 mm thick, fire resistant, bonded with 99.8% pure copper foil, free of wrinkles, blisters, scratches and pinholes. The contact surface of the edge connectors of the PCBs shall be plated with hard gold to a minimum thickness of 5 microns. Component identification shall be printed on PCB by silk screen method. All PCBs shall be tropicalised and masked.
- f) Contactors

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All battery chargers shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. The operating coil shall be rated for 415 Volts AC.

g) Thermal Overload Relay

A thermal overload relay incorporating a distinct single phase protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

h) Rectifier-Transformer and Chokes

The rectifier-transformer and chokes shall be dry and air cooled (AN) type. The rating of the rectifier transformers and chokes shall correspond to the rating of the associated rectifier assembly. The rectifier-transformers and chokes shall have class-B insulation with temperature rise limited to class A insulation value.

i) Rectifier Assembly

The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective charger. The rectifier cells shall be provided with their own heat dissipation arrangement with natural air cooling. The rectifier shall utilize diodes / thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink shall not be permitted to exceed 85 °C absolute duly considering the maximum charger panel inside temperature. Calculations to show what maximum junction temperature shall be and what the heat sink temperature shall be when operating at 200% and 100% load current continuously duly considering the maximum surrounding air temperature of 50°C outside the panel have to be submitted. Necessary surge protection devices and rectifier type fast acting fuses shall be provided in each arm of the rectifier connections.

1.4.3 System Concept for 220 V DC system

- a) First float cum boost charger shall be normally ON in float mode, supplying the D.C. load and at the same time trickle charging the battery and shall (a) provide occasional equalizing charge (b) boost charge the battery up to 2.7/1.7 Volts per cell as required.
- b) The characteristics shall be such that if load is high and exceeds the charger capacity, the excess load shall be supplied by the battery.
- c) The second float-cum-boost charger shall be normally in stand-by (auto float/charge) mode and shall come into the circuit automatically (a) to take over the functions of first float cum boost charger in case of its failure (b) to provide occasional equalizing charge as required, (c) boosting charge the battery up to 2.7/1.7 Volts per cell.

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- d) The float-cum-boost charger shall also have provision for float, equalizing, and boost charging the battery through manual selection. On failure of station A.C. supply, float-cum-boost charger shall go out of service and battery shall take over to supply emergency loads.

1.4.4 Operational requirements of charger

- a) The float-cum-boost charger shall be sized to restore the fully discharged battery to full charge condition in ten (10) hours with 10% margin over maximum charging rate and also to operate as a float charger.
- b) The batteries & chargers shall be so designed that the maximum fault level on DC DB is limited to 15KA (Indicative only; the actual value shall be decided by the contractor after substantiating the same by calculation.)
- c) The battery shall be trickle charged at 2.15 to 2.25 V per cell and 1.4 to 1.42V per cell for lead acid and Ni-Cd battery respectively. All chargers shall also be capable of boost charging the associated battery at 2.0 to 2.7 V per cell for lead acid and 1.53 to 1.7V for Ni Cd at the desired rate. The chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50 °C.
- d) Necessary interlocks shall also be provided to avoid accidental boost mode operation when loads are connected to the bus.
- e) The battery chargers as well as their automatic regulators shall be of static type. Battery chargers shall be capable of continuous operation at the respective rated load in trickle mode i.e. trickle charging the associated lead acid battery/Ni-Cd battery while supplying the DC loads.
- f) Battery chargers shall have a selector switch for selecting the battery charging mode i.e. whether trickle / float or Boost charging.
- g) All battery chargers shall be provided with facility both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage / current control, whether automatic or manual. Means shall be provided to avoid current / voltage surges of harmful magnitude/ nature which may arise during changeover from Auto to Manual mode or vice versa under normal operating condition.
- h) Soft start feature shall be provided to build up the voltage to the set value slowly within fifteen (15) seconds. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the DC load current exceeds the load limiter setting of the charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the charger nor shall it cause blowing of

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any of the charger fuses. The charger shall not trip on overload or external short circuit. After clearance of fault, the charger voltage shall build up automatically when working in automatic mode.

- i) When on automatic control mode, during trickle / float charging, the charger output voltage shall remain within (\pm) 1% of the set value for AC input voltage variation of (\pm) 10%, frequency variation of (+) 3 / (-) 5%, a combined voltage and frequency variation of 10% (absolute sum) and a continuous DC load variation from zero to full load. Uniform and step less adjustment of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire trickle / float charging output range specified. Step less adjustment of the load limiter setting shall be possible from 80% to 100% of the rated output current for trickle / float charging mode.
- j) During boost charging, the battery chargers shall operate on constant current mode (when automatic voltage regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50% to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be vernier type.
- k) Energizing the chargers with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere shall be less than fifteen (15) seconds.
- l) Momentary output voltage of the charger, with the battery connected shall be within 94% to 106% of the voltage setting during sudden load change from 100% to 20% of full load or vice versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above mentioned change.
- m) The charger manufacturer may offer an arrangement in which the voltage setting device for trickle/ float charging mode is also used as output voltage limit setting device for Boost charging mode, and the load limiter of the trickle / float charging mode is also used as Boost charging current setting device.
- n) Suitable filter circuits shall be provided in all the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.

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1.4.5 Auxiliary Equipment

- a) DC Voltmeter, DC ammeter and AC voltmeter in 96 mm square shall be provided for each charger. The instruments shall be 240 scale, antiglare glass, flush mounted type, dust proof and moisture resistant. The instrument shall have easily accessible means from zero adjustments. The instruments shall be of 1.5 accuracy class.
- b) In addition to above, following metering provision shall be given for remote metering / recording at PLC/DCS
 - i. Battery Voltage
 - ii. DC voltage of float & Boost charger
 - iii. DC current of float & Boost charger
 - iv. DC load voltage
 - v. DC load current
 - vi. DC Voltage and Current at FCBC
 - vii. Centre Zero Ammeter with Shunt to read Discharge/Charge current
 - viii. Ammeter for Battery Trickle Charge current
 - ix. DC Bus Voltmeter indicating - +ve to Earth, -ve to Earth and +ve to -ve with Selector switch.

The following indications shall be provided

- i. AC Supply – R,Y,B Healthy
- ii. DC supply – Available
- iii. Charger in Float Mode
- iv. Charger in Equalising mode
- v. Charger in Boost mode
- vi. Charger tripped on fault
- vii. D.C Earth fault sensing & alarm

Suitable soft link to be provided for interfacing with DDCMIS.

c) Air Break Switches

All chargers shall have AC input and DC output switches of air break, single throw, load break and fault make type. The contacts of the switches shall open and close with a snap action. Switches shall be rated for 120% of maximum continuous load. 'ON' and 'OFF' position of the switch shall be clearly indicated.

d) Control and Selector Switches

Control and selector switches shall be rotary, stay put type with escutcheon plates showing the functions and positions. The switches shall be of sturdy construction and suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred. The contact ratings shall be at least the following:

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- i. Make and carry continuously - 10 Amps
- ii. Breaking current at 220V DC - 0.5 Amp (inductive)
- iii. Breaking current at 240V AC - 5 Amp. at 0.3 p.f.

e) Fuses

Fuses shall be of HRC cartridge fuse link type. Fuses shall be mounted on fuse carriers which are mounted on fuse bases. Wherever it is not possible to mount fuses on fuse carriers, fuses shall be directly mounted on plug in type bases. In such cases one insulated fuse pulling handle shall be supplied for each charger. Kick-off fuses (trip fuses) with alarm contacts shall be provided for all DC fuses.

f) Indicating Lamps

Three (3) indicating lamps shall be provided to indicate AC supply availability. The indicating lamp shall be of panel mounting, LEDs and capable of clear status indication under the normal room illumination. The lamps shall be replaceable from front. The lamp covers shall be preferably screwed type, unbreakable and moulded from heat resistant material.

g) Blocking Diode

Blocking diode shall be provided in the output circuit of each charger to prevent current flow from the Battery into the charger.

h) Annunciation System

Following annunciation shall be provided for local and remote indications in all chargers(List is indicative only)

- i. AC supply failure
- ii. Rectifier fuse failure
- iii. Surge circuit fuse failure
- iv. Filter capacitor fuse failure
- v. Load limiter operated
- vi. Charger fail / trip
- vii. Battery on Boost
- viii. Battery on Trickle
- ix. DC output fuse failure
- x. Positive grounded
- xi. Negative grounded
- xii. Battery fully discharged
- xiii. AC input under voltage
- xiv. DC voltage low
- xv. DC voltage high
- xvi. DC system earth fault

The annunciation system shall have audio-visual arrangement and shall incorporate acknowledge, reset and test push buttons. On occurrence of fault, the corresponding window lights up and shall stay in lighted

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condition till the fault is cleared and the reset push button is pressed. At least 20% spare annunciation windows with accessories shall be provided.

i) Lamp / Space Heaters / Receptacles

The charger panels shall be provided with:

- i. Internal illumination lamp with door switch.
- ii. Space heater with thermostat control.
- iii. 3-pin 5A receptacle with plug.
- iv. Lamp, heater and receptacle circuits shall have individual switch fuse units/MCB.

1.4.6 Battery Accessories

Each battery shall be furnished complete with following:

- a) First charge of electrolyte plus 10% extra.
- b) Teak wood racks with 3 coats of anti-acid paints.
- c) Stand insulators 5% extra.
- d) Cell inter-connectors 5% extra and one extra end take-off.
- e) Lead-coated connection hardware 5% extra
- f) Cell numbering tag with fixing arrangements
- g) Insulated cable clamps with hardware
- h) Six (6) extra cell with all accessories but without acid
- i) In addition to the above each battery shall be furnished with a set of following accessories.
- j) One (1) Interconnector bolt wrench
- k) One (1) Hydrometer syringe
- l) One (1) Thermometer with specific gravity correction scale.
- m) One (1) Cell testing voltmeter with leads.
- n) One (1) Pocket thermometer
- o) One (1) set of Acid resisting funnels
- p) One (1) set of Acid resisting jugs of adequate capacity
- q) One (1) set of Rubber aprons
- r) One (1) set of Rubber gloves
- s) PVC spill trays under the battery cells
- t) Spanner for cells

Catalogues and Instruction manuals of battery and battery charger to be furnished.

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1.4.7 Painting

- a) All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.
- b) After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality lead oxide primer and stoved after each coat.
- c) The equipment shall be finished in Siemens Gray RAL: 9002 color with two coats of epoxy based powder coated paint except end covers and RAL 5012 for end covers. The coating shall be done electro statically followed by stoving.
- d) Sufficient quantity of touch-up paint shall be furnished for application at site.

1.4.8 Installation

- a) The battery room floor shall be acid resistant type and walls shall have acid resistant tiles up to a suitable height. Alternatively acid resistant paints are also acceptable. Adequate ventilation shall be provided in the battery room for the removal of hydrogen.
- b) The Battery charger along with D.C. distribution board shall be located in separate rooms.
- c) After erection and connection of the Battery Charger, the contractor shall complete the charging discharging cycles recommended by the manufacturer. The contractor shall rig up a suitable discharge resistor for this purpose.
- d) Connection from Battery terminals shall be made by means of cables. Lead coated terminal connector shall be furnished for this purpose.

1.5 Tests

1) Type Test

For each type of Battery and battery charger, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

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II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works in the presence of consultant / purchaser or his representative.

All Battery, Battery chargers, Inverters and its components thereof shall be subject to shop tests as per relevant IS/IEC standards. The tests on Battery chargers shall include but not limited to the following:

- a) Voltage regulation check from 0 to 100% loads with $\pm 10\%$ input voltage variation.
- b) Ripple content measurement.
- c) D.C short circuit test to prove ability of current limit.
- d) Measurements of transient overshoot/undershoot during switching ON/load throw-off.
- e) Current limiter operation.
- f) Special tests for electrical equipment, when specified in relevant Indian / International standard shall be carried out on at least one item of each rating.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports. Drawings, Data & Manuals:

1.6

Drawings, Data & Manuals

1. Following drawings/ data and Manuals to be submitted for approval:

- a) [Dimensional battery layout diagram and plan & section.
- b) Connection details of take-off terminals.
- c) Dimensional general arrangement drawings of battery charger clearly showing device dispositions, cable entry, space requirement, etc.

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- d) Sectional views of battery charger.
- e) Charger foundation plan and loading.
- f) Charger schematics and wiring diagrams.
- g) Test reports
- h) Detailed bill of materials
- i) Any other relevant drawing or data necessary for satisfactory installation, operation and maintenance.
- j) Instruction manuals of battery and battery Charger. The manual shall clearly indicate method of installation, check-ups, and tests to be carried out before commissioning of the equipment.
- k) Bidders shall note that the drawings, data and manuals listed herein are minimum requirements only. The Bidders shall ensure that other necessary write-ups, curves and information required to fully describe the equipment are submitted with their bids].

1.7 Rating and Requirement

S.No	Technical Particulars	Unit	Parameters	Remarks
1.0	General			
1.1	Bidder's Name			
1.2	Make			
1.3	Application		[For Main plant/BOP]	
2.0	Battery			
2.1	Make and country	:	[By bidder]	
2.2	Type	:	Lead acid(Plante)/Ni Cd	
2.3	Reference standard		As specified in specification	
2.4	Rated system voltage	: (Volts)	220V DC	
2.5	Rated capacity for one hour discharge at 27°C	: (Ah)	[As per project specific]	
2.6	Rated capacity for 10 hour discharge rate at 27°C	: (Ah)	[As per project specific]	
2.7	Nominal voltage per cell	: (V)	2.2V /1.42V	
2.8	End cell voltage	: (V)	1.85/1.14V	
2.9	Number of cells per battery	:	Based on type of battery.	
2.10	Short circuit current	: (kA)	[By bidder]	
2.11	Mounting type	:	[By bidder]	

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S.No	Technical Particulars	Unit	Parameters	Remarks
2.12	AH efficiency at rated load	: (%)	[By bidder]	
2.13	Watt hour efficiency	: (%)	[By bidder]	
3.0	Constructional details		[By bidder]	
3.1	Container			
a	Material			
b	Thickness	Mm		
3.2	Separator			
a	Type			
b	Material			
c	Thickness	Mm		
3.3	Electrolyte			
3.4	Quantity for first filling plus 10% extra			
3.5	Specific gravity at twenty seven (27) degree Centigrade			
a	With all cells fully charged			
b	At the end of discharge			
3.6	Method of supporting elements		[By bidder]	
a	Edges of plates and Inner surfaces of container	Mm		
b	Bottom of negative plates	Mm		
c	Top of plates	Mm		
d	Sediment space	Mm		
3.7	Weather explosion-proof cent plugs are provided		[By bidder]	
3.8	Distance between centre's of cells when erected	mm	[By bidder]	
3.9	Expected life span of battery	Year	[By bidder]	
3.10	Proposed Layout (attach layout)		[By bidder]	
4.0	Battery Charger			
4.1	Number of rectifiers	:	[By bidder]	
4.2	Reference standard	:		
4.3	Make and country			
4.4	Type	:		

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S.No	Technical Particulars	Unit	Parameters	Remarks
4.5	Rectifiers with thyristors Y/N	:	[By bidder]	
4.6	Rated input AC voltage	: (V)	415V, 3ph, 4 wire	
4.7	Frequency	: (Hz)	50	
4.8	Output DC current	: (A)	[By bidder]	
4.9	Rectifier efficiency	: (%)	[By bidder]	
4.10	DC voltage setting adjustment of AVR for float charging		[By bidder]	
4.11	Boost mode:		[By bidder]	
a	Starting rate	: (V)		
b	Finishing rate	: (V)		
4.12	Protection class of cubicles	:		
4.13	Residual ripple	: (%)	[By bidder]	
4.14	Current limiting feather provided	: (Yes/No)	[By bidder]	
4.15	Soft starting feather provided	: (Yes/No)	[By bidder]	
4.17	Voltage and current setter in different mode provided	: (Yes/No)	[By bidder]	
4.18	Type of cooling	:	Natural	
4.19	Paint shade: Indoor and outdoor		[RAL 5012]	
5.0	Constructional details		[By bidder]	
5.1	List of major accessories			
5.2	Diode			
a	Make			
b	Type			
c	Rating			
d	Voltage	V		
e	Current	A		
5.3	Rectifier Transformer			
a	Make			
b	Rating	kVA		
c	Connection			
	Primary Winding			
	Secondary Winding			

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S.No	Technical Particulars	Unit	Parameters	Remarks
d	Voltage			
	Primary Winding	V		
	Secondary Winding	V		
e	Percentage of tap provided			
	Primary Winding	%		
	Secondary Winding	%		
5.4	Control/ Selector switch			
a	Make			
b	Type designation			
c	Voltage Grade	V		
d	Current rating	A		
e	Make and carry			
f	Brake			
g	Spring return or stay out			
h	Type of handle			
i	No. of positions			
j	No. of poles/ ways			
k	Angular Movement			
m	Special features if any			
5.5	Indicating Lamp			
a	Make			
b	Type			
c	Voltage	V		
d	Series resistor value	Ohm		
6	Thickness of battery charger panel sheet steel;	Mm		
5.6	Weight & dimensions		[By bidder]	
a	Length	Mm		
b	Depth	Mm		
c	Height	Mm		
d	Weight	Kg		

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E7

TECHNICAL SPECIFICATION FOR HV CABLES

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E7

1.0 HV CABLEs

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of HV cables complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part II)	:	XLPE insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques
IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the

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		cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
ASTM-D-2843	:	Standard test method for density of smoke from burning/decomposition of plastics.
ASTM-D-2863	:	Test for determination of oxygen index.
CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All HV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The HV power cables shall be 6600V unearthed grade, single/multi core stranded Aluminum conductor, extruded XLPE insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-2). These cables shall conform to IS 7098 (Part II).
- d) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- e) HV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- f) HV cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)
 - v. Installation conditions.
 - vi. Voltage drop under normal running and starting condition
 - vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
 - viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
 - ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.

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1.4 Specific Requirements

1.4.1 Type of Cable

- a) HV cables shall be 6600V unearthed grade, heavy duty, stranded aluminium conductor, XLPE insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-2) cables conforming to IS: 7098 part II.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum to form compact conductor having a resistance within the limits specified.

1.4.3 Conductor Shield

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be provided over the conductor by applying non metallic semi conducting tape or by extrusion of semi conducting tape or by extrusion of semi-conducting compound or a combination of the two. The semi conducting polymer shall be cross linked for XLPE cables.

1.4.4 Insulation

The insulation of the HV cables shall be XLPE type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

1.4.5 Insulation Shield

A non magnetic semi conducting shield shall be put over the insulation to confine electrical field to the insulation. The XLPE cable insulation shield shall be strippable.

The metallic layer of the insulation shield shall be grounded at least at one location in the cable's run. In the case of single conductor cable, care should be taken with regard to ampacity when grounding at more than one point.

For all the cables having insulation shield, it shall have some form of stress relief measure at every splice at termination. This can be stress cones, moulded devices, heat shrink or cold shrink kits. All kits must be suitable for the voltage class and cable size.

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1.4.6 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.7 Armour

HV cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.8 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.9 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than 500m or as per required length.

1.4.10 Identification of cores:

HV power cables shall be identified by color code.

1.4.11 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers

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shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.

b) Workmanship shall be neat, clean and of the highest grade.

c) Special Properties:

All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:

- i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
- ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
- iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
- iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
- v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
- vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
- vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.12 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.13 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]
- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.

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- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.4.14 Fire Proof sealing system

- i) General
 - a) Fire proof sealing system shall consist of Fire-stops/fire-seals for sealing of cable/cable tray and conduit/pipe penetrations, both horizontal and vertical, through brick or RCC walls/floors, to prevent the spread of fire from one area, which is separated from others by fire-resistant barriers.
 - b) 'Fire-breaks' provided on long runs of cable racks/trays to prevent the propagation of fire along the cable rack, within a single fire-area or fire- zone.
 - c) The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop/fire-break.
 - d) The FPS system shall comply in all respects with the requirements of the codes and standards listed below

IEEE-634 ASTM-E-814

ANSI-IEEE-383 IEC-331 IEC-332

ii) Fire stop/ seal

The FPS system adopted for cables or cable trays penetrating through walls and floor constitute a openings, or cables passing through embedded conduits / pipes / pipe- sleeves, fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

iii) Fire Break

The fire proofing system, other than fire-stops, adopted to retard flame propagation long runs of horizontal or vertical cable trays in the same fire zone or area, in an event of a fire, shall constitute a `fire-break' and shall be provided by applying a suitable fire –resistance coating on cables and cable trays for the required length, with or without a fire resistant panel, at the point of the fire break to obtain the fire-rating specified.

iv) Application of fire proof sealing system

Fire stops shall be provided for cable penetration openings listed below

The passage of cables/cable trays pipe sleeves/embedded conduits through walls / floors.

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Vertical raceways, which carry cables between successive floors, through openings provided in the RCC floor slab, shall be sealed by fire stops at each floor level.

Cable entry through openings in floor slabs below HT/LT switchgear, MCCs, various Control and relay panels and other bottom entry panels, shall be effectively sealed by fire stop

Location of fire breaks

Firebreaks shall be provided on both cable rack and trenches at all cable tray Intersections and tee-offs.

On linear runs of cable trays between fire stops or fire breaks, fire breaks shall be provided at intervals of 15 metres on horizontal cable runs and 5 m on vertical cable runs.

Fire breaks in linear runs of cable trenches between intersections and tee-offs shall be provided at intervals of 30 metres.

Bidder shall furnish the test certificates for the fire stops and fire breaks after award of contract for Owner/Owner's Representative review. If the certificates are not satisfactory all the tests shall be conducted free of cost. The offered system i.e. fire stops and fire breaks shall be identical (or better) with the system which is successfully type tested for the specified rating i.e. the composition density of the material, thickness of coating in case of fire breaks and any other properties of the material / system offered shall be identical or better than the tested system and shall be subject to Owner / Owner's Representative.

v) Test on fire stops

The fire stops shall be subjected to the following type tests:

- a. Fire Rating Test
- b. Hose Stream Test

Type tests shall be conducted on different fire stop test specimens described above as per IEEE-634. The sizes of the fire stop test specimens shall be similar to the largest of the sizes being used in the plant.

Preconditioning of fire stop test specimens before conducting the fire rating and hose stream tests, each test specimen shall be preconditioned for thermal ageing, water immersion and vibration.

Test on Fire Stops

During the fire rating test, the transmission of heat through the cable penetration fire stop shall not raise the temperature on its unexposed surface above the self ignition temperature of the outer cable covering, the cable penetration fire stop material, or material in contact with the cable

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penetration fire stop, with a maximum temperature limit on the unexposed surface of 200°C.

Tests on fire breaks

Firebreaks shall undergo the following tests as per ANSI-IEEE-383:

- Ampacity test
- Flame test

1.5 Tests

1.5.1 Type Test

For each type & rating of HV cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- Tests on conductor:
 - Annealing test (for copper)
 - Tensile test (for aluminum)
 - Wrapping test (for aluminum)
 - Conductor resistance test.
- Test for armouring wires/strips
- Test for thickness of insulation and sheath
- Physical tests for insulation and outer sheath:
 - Tensile strength and elongation at break
 - Ageing in air oven
 - Shrinkage test
 - Hot deformation
 - Loss of mass in air oven
 - Heat shock test
 - Thermal Stability
- Insulation resistance test
- High voltage test (water immersion test)
- High voltage test at room temperature
- Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 H.V. Power cable, 6600V unearthed grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		6.6 V	
2.	Voltage Grade		6.6/6.6kV Unearthed	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE cables		90°C	
5.	Maximum conductor temperature for		250°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE cables			
6.	Conductor		Aluminum	
7.	Insulation		XLPE	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		Armoured	
11.	System Grounding		Resistance Grounded	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		40 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E8

TECHNICAL SPECIFICATION FOR LV CABLES

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E8

1.0 LV CABLES

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of LV cables for power & control applications complete with all accessories for efficient and trouble-free operation for of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client]..

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified or supplemented by this specification.

Table: 1.0

IS:1554(Part I)	:	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100V
IS: 2982	:	Copper conductor in insulated cables and cords.
IS: 3961	:	Recommended current ratings for cables.
IS: 3975	:	Mild steel wires, strips and tapes for armouring cables
IS: 5609	:	Specification for low frequency wirers and cables with PVC insulation and PVC sheath
IS:5831	:	PVC insulation and sheath of electric cables
IS: 6380	:	Specification of elastomeric insulation of sheath of electric cables.
IS:7098(Part I)	:	XLPE insulated PVC sheathed cables for working voltage up to 1.1kV
IS: 8130	:	Conductors for insulated electric cables and flexible cords
IEC: 60	:	High voltage test techniques

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IEC: 230	:	Impulse tests on cables and their accessories
IEC: 287	:	Calculation of the continuous current rating of the cables(100% load factor).
IEC: 288	:	Nominal cross sectional area and composition of conductor of insulated cables.
IEC-331	:	Fire resisting characteristics of electric cables
IEC: 332-1	:	Test on electric cables under fire conditions.
IEEE: 383	:	Standard for type test for class IE electric cables, filled splices and connection for nuclear power generation station.
IEC: 502	:	Extruded solid dielectric insulated power cables for rated voltages from 1kV upto 30kV.
IEC: 540	:	The methods for insulations and sheath of electric cables and cords(elastomeric and thermoplastic compounds)
IEC-754-I	:	Test method for acid gas generation
NEMA-WC-5	:	Thermoplastic insulated wires and cables for transmission and distribution of electrical energy.
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CEA	:	CEA Regulations
CEA	:	Standard Technical Specifications For Main Plant Package

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

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The electrical installation shall meet the requirements of Indian Electricity Rules as amended upto date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a) The cables shall be installed in hot, humid tropical atmosphere with ambient temperature of 50°C.
- b) All LV cables shall be suitable for operation under the following voltage & frequency variations:

Voltage Variation : (±) 10%

Frequency Variation : (+) 3% to (-)5%

Combined Variation of Voltage & Frequency : 10% (absolute sum)

- c) The LV power cables shall be 1100V grade, single/multi core stranded Aluminum conductor, extruded XLPE/PVC insulated with extruded PVC inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1). These cables shall conform to IS 7098 (Part I) for XLPE and 1554(part 1) for PVC insulation.
- d) The control cables shall be 1100 V grade, multi core, stranded annealed high conductivity copper with extruded PVC insulated inner sheath, armoured and overall sheath with extruded Flame Retardant Low Smoke (FRLS) PVC compound (Type ST-1).
- e) The continuous and short time current carrying capacity of XLPE insulated cables shall be based on maximum operating temperature of 90°C and 250°C respectively.
- f) The continuous and short time current carrying capacity of PVC insulated cables shall be based on maximum operating temperature of 70°C and 160°C respectively.
- g) LV power cables shall be sized taking into account the following derating factors:
 - i. Max Ambient air temperature
 - ii. Max Ambient ground temperature
 - iii. Grouping of cables/Method of laying
 - iv. Depth of laying for cable buried in ground.
 - v. Soil thermal resistivity for cable buried in ground.
- h) Power cables shall be chosen taking into account the following factors:
 - i. System Fault level.
 - ii. Maximum time for fault clearance (i.e, operating time of the backup protection relays plus the time of operation of the circuit breakers).
 - iii. Full load current of the circuit.
 - iv. Short circuit current and duration (for breaker protected cables)

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- v. Installation conditions.
- vi. Voltage drop under normal running and starting condition
- vii. Voltage drop at motor terminals shall be within permissible limit during starting & normal running. i.e 5% during steady state and 15% during transient or starting at motor terminal.
- viii. The cable should withstand the maximum fault current corresponding to the particular voltage level for the minimum time before the fault is cleared.
- ix. Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many types.
- x. The minimum size of cables to be used shall be as follow :
 - Aluminium conductor : 6 Sq. mm.
 - Copper conductor : 2.5 Sq. mm

1.4 Specific Requirements

1.4.1 Type of Cable

- a) LV power cables shall be 1100V grade, heavy duty, stranded aluminium conductor, XLPE/ PVC insulated, extruded black FRLS PVC inner sheathed, armoured and overall FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS: 1554(Part 1) for PVC insulation and IS 7098(Part 1) for XLPE insulation.
- b) Control Cables shall be 1100 V grade, heavy duty with annealed high conductivity stranded copper conductor, PVC insulated, FRLS PVC inner sheathed, armoured and FRLS extruded black PVC outer sheathed (Type ST-1) cables conforming to IS : 1554.
- c) LV power cables of size above 35 sq. mm may be provided with XLPE insulation. Bidder shall clearly indicate the type of insulation provided in the technical bid.

1.4.2 Conductor

The cable conductor shall be made from standard Aluminum for LV Power cables and Copper for control cables to form compact conductor having a resistance within the limits specified. All the cables of size 25mm² and above shall have sector shaped conductors.

1.4.3 Insulation

The insulation of the LV power and control cables shall be [XLPE/PVC] type. It shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give a very smooth interface between semi conducting screen and insulation. The insulation of the cables shall be of high standard quality.

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1.4.4 Inner Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded with FRLS properties.

1.4.5 Armour

LV power and control cables shall be provided with galvanized steel wire/strip armouring. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS-8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

1.4.6 Outer sheath

Outer sheath shall be extruded layer of FRLS PVC compound (ST-1). Sheath shall be resistant to water, Ultra Violet radiations, fungus, termites and rodent attacks. The color of the sheath shall be black.

1.4.7 Packing

[Cables shall be supplied in non-returnable drums]. Drum lengths shall be such so that cable joints are totally avoided. The drums shall be of heavy construction. *[All wooden parts shall be manufactured from seasoned wood.]* All ferrous parts used shall be treated with suitable rust preventive finish or coating to avoid rusting during transit or storage. *[Wooden cable drum shall be treated by immersing in copper-nitrate solution.]*

The ends of each cable length shall be sealed before shipment. Heat shrinkable cable cap shall be used for this purpose.

[A label shall be securely attached to each end of the reel indicating the Purchaser's order number, Owner's identification mark, length, type, voltage grade, conductor size and number of cores of the cable.] A tag containing the same information shall be attached to the leadings end of the cable inside. An arrow and necessary instructions shall be marked on the drum indicating the direction in which it should be rolled. Drum numbers are to be indicated on the cable drums. Drum length shall not be less than the following:

- a) Power cables: 500m
- b) Control cables: 1000m

1.4.8 Identification of cores and spares:

LV power cables shall be identified by color code. However LV control cables shall be identified by the number of its cores.

[Multi-core control cables shall have 20% spare core, minimum one spare.]

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1.4.9 Constructional Requirements

- a) Cable shall have suitable filters laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality.
- b) Workmanship shall be neat, clean and of the highest grade.
- c) Special Properties:
All the above cables shall be conforming to the relevant Indian/IEC standard in general, with the following special properties:
 - i. Oxygen Index of the outer sheath shall not be less than 29, when tested as per ASTM-D-2863.
 - ii. Temperature Index of the outer sheath shall not be less than 250 °C, when tested as per ASTM-D-2863.
 - iii. Halogen acid contents in outer sheath shall not be more than 20%, when tested as per IEC-60754.
 - iv. The maximum smoke density in percent light absorption should not exceed 60% in case of PVC compound and 20% in case of fire survival cables, when tested as per ASTM-D-2843.
 - v. Swedish chimney test as per SS-4241475 class F3 and ladder test for flammability as per IEEE-383.
 - vi. The cables shall be tested for resistance to Ultraviolet radiation. The retention values of tensile strength and ultimate elongation after test shall be minimum 60% of tensile strength.
 - vii. Outer sheath of cable shall be subject to tests for water absorption. The methodology shall be as per IS 10810 part 33.

1.4.10 Joints and Terminations

Materials of construction for a joint/termination shall perfectly match with the dielectric chemical and physical characteristics of the associated cables. The material and design concepts shall incorporate a high degree of operating compatibility between the cable and joints. The protective outer covering (jacket) used on the joints/terminations shall have the same qualities as that of the cable outer sheath in terms of ambient/operating temperature withstand capability and resistance to hazardous environments and corrosive elements. No joints shall be allowed unless the cable drawn length is exceeded.

1.4.11 Cable Identification

Cable identification shall be provided by embossing the following on the outer sheath:

- a. [Manufacturer's name or trade mark]

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- b. Voltage grade
- c. Year of manufacture
- d. Type of insulation.
- e. Type of outer sheath e.g. "FRLS" etc.
- f. ISI marks
- g. Nominal cross sectional area of the conductor & no of cores
- h. Sequential marking
- i. Owner's identification mark]

1.5 Tests

1.5.1 Type Test

For each type & rating of LV power and control cables, the Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within [last five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

The list of type tests are as follows:

- a) Tests on conductor:
 - i. Annealing test (for copper)
 - ii. Tensile test (for aluminum)
 - iii. Wrapping test (for aluminum)
 - iv. Conductor resistance test.
- b) Test for armouring wires/strips
- c) Test for thickness of insulation and sheath
- d) Physical tests for insulation and outer sheath:
 - i. Tensile strength and elongation at break
 - ii. Ageing in air oven
 - iii. Shrinkage test
 - iv. Hot deformation
 - v. Loss of mass in air oven
 - vi. Heat shock test
 - vii. Thermal Stability
- e) Insulation resistance test
- f) High voltage test (water immersion test)
- g) High voltage test at room temperature
- h) Flammability test

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1.5.2 Routine Test

Cables shall be subject to acceptance and routine tests as per IS codes. Acceptance tests and FRLS test as specified earlier shall be conducted on cables and the same shall be witnessed by purchaser.

The FRLS test shall be carried out on one cable of each batch of compound used. Other acceptance tests shall be carried out on drums selected as per sampling plan as indicated in IS. Test certificates for routine acceptance and special tests shall be furnished by the Bidder for review and approval of purchaser.

1.6 Drawings, Data and Manuals

The following drawings/documents and calculation as listed below but not limited to shall be furnished along with the bid for review

- [Cable datasheets and cross sectional drawings]
- [Cable sizing calculation]
- [QAPs & Test Reports]
- [Relevant catalogues]
- [Estimated weight of cable and cable drum]

1.7 Ratings and Requirements

1.7.1 L.V. Power and control cables, 1100 V grade

Table: 2.0

S.No.	Technical Particulars	Unit	Parameters	Remarks
1.	System voltage		415 V	
2.	Voltage Grade		1.1 kV	
3.	Ambient Temperature		50°C	
4.	Maximum conductor temperature for continuous operation for XLPE/PVC cables		For XLPE: 90°C For PVC: 70°C	
5.	Maximum conductor temperature for		For XLPE: 250°C For PVC: 160°C	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
	short time operation for XLPE/PVC cables			
6.	Conductor		For power cable: Aluminum	
			For Control Cable: Copper	
7.	Insulation		For power cable: XLPE/PVC	
			For Control Cable: PVC	
8.	Inner Sheath		Extruded PVC (ST-1)	
9.	Outer sheath		Extruded PVC (ST-1) with FRLS characteristic	
10.	Armored/ Un-armored		For power cable: Armoured	
			For Control Cable: Armoured	

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S.No.	Technical Particulars	Unit	Parameters	Remarks
11.	System Grounding		415 V system is solidly grounded.	
12.	Whether cores identifications numbers provided		To be provided	
13.	Whether incremental running lengths are marked on cable.		By Bidder	
14.	Short circuit capability for 1 sec		50 kA	
15.	Maximum overall diameter of cables		By Bidder	
16.	Min. Bending Radius		By Bidder	
17.	Drum Details:		By Bidder	
a)	Length of cables in Drums and Volume + Tolerance		By Bidder	
b)	Weight of cable drum with cables		By Bidder	
c)	Weight of cable drum without cables		By Bidder	
d)	Type of end sealing		By Bidder	
e)	Marking on cable drums as per IS required		By Bidder	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E9

TECHNICAL SPECIFICATION FOR ILLUMINATION SYSTEM

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E9

1.0 ILLUMINATION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Illumination System complete with luminaries and all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table: 1.0

Code		Name of Standard
IS 1913	:	Electrical lighting fittings- General and safety requirements
IS 2418 - Part I	:	Tubular fluorescent Lamp
IS 3480	:	Flexible steel conduits for electrical wiring
IS 3646 (Part I to III)	:	Code of Practice For Interior Illumination
IS 4012	:	Dust proof electric lighting fittings
IS4013	:	Flame proof enclosure
IS 6665	:	Code of practice for industrial lighting
IS 5077	:	Decorative light fittings
IS 9537 - Part II	:	Rigid steel conduits for electrical installations

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IS 9583	:	Emergency lighting units
IS 9900	:	High pressure mercury vapor lamp
IS 9974	:	High pressure sodium vapor lamp
IS 10322	:	Luminaries for street lighting
CBIP Manual	:	Substation Equipment, Illumination and Layouts
IES (Illuminating Engineering Society of North America)	:	Application and Reference Volume
IEC 60598	:	Luminaries
CEA	:	CEA regulations and standard technical specification.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

1.3

Design Criteria

- a. All illumination systems shall be suitable for an ambient temperature of 50 °C and relative humidity of 95%. The illumination systems shall be suitable for operation in a highly polluted environment.
- b. Lighting fixtures shall be suited for the following range of frequency and voltage variations:
 - i. Voltage Variation : $\pm 10\%$
 - ii. Frequency Variation : 50Hz (+)3% to (-)5%
 - iii. Combined Variation of Voltage & Frequency : 10% (absolute sum)

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- c. All emergency DC lighting systems shall be suited for voltage variation from -15% to + 10% of rated voltage.
- d. The design of the lighting systems shall be such that it shall ensure average lux levels specified for different areas.
- e. The illumination system shall comprise of the following:
 - i. Normal AC lighting
 - ii. Normal cum emergency lighting system
 - iii. 220V DC Emergency lighting system
 - iv. Maintenance 24V AC lighting system
 - v. Portable emergency lights with self contained battery packs.

1.4 Specific Requirements

1.4.1 Scope of work

The scope of work shall include design, preparation of Lighting design and manufacture, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with Lighting system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Switchgear room and cable gallery.
- iv) All roads within battery limit.
- v) Perimeter and boundary illumination of the above premises.
- vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room and cable gallery.
- v) FOPH area.
- vi) Transfer towers & Conveyor galleries.
- vii) All roads within battery limit.
- viii) Perimeter and boundary illumination of the above premises.

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- ix) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- c) Balance of plant Area:
 - i) Lighting system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- e) AHP Area:
 - i) Switchgear rooms.
 - ii) All roads within battery limit.
 - iii) Perimeter and boundary illumination of the above premises.
 - iv) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard control room
 - ii) GIS building (if applicable)
 - iii) Transformer area
 - iv) All roads within battery limit.
 - v) Perimeter and boundary illumination of the above premises.
 - vi) Any other area/premises not specifically mentioned here, but which fall under the battery limit of this package is included in the scope.

1.4.2 Illumination System Description

The plant illumination system shall comprise of the following categories:

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a. Normal AC lighting

In this system, the lighting circuits shall be fed by the 3 phase, 4 wire normal AC supply from the normal lighting distribution boards (LDB). All the lighting fixtures connected to this system shall be available as long as the 415V station / unit auxiliary service supply is available.

b. Normal cum emergency lighting system

Certain lighting fixtures considered essential shall be connected to this system. In this system the lighting circuits shall be fed from lighting distribution board connected to 415V Normal cum Emergency Switchgear. The lighting fixtures connected to this system shall be available whenever normal supply is available in the plant and also whenever DG set supplies the power to 415V Normal emergency switchgear.

These lighting fixtures will go off for a few seconds when normal supply fails but will be automatically restored when the emergency AC bus is re-energized by automatic transfer to standby DG supply.

[20% of the total fittings shall be fed from Emergency lighting for areas such as Switchgear room and control rooms etc.]

c. Emergency 220 V D.C. Lighting

The Emergency DC Lighting System shall be located strategically in critical operating areas and at emergency exits. Emergency DC lighting shall also be provided in the Control rooms, Switchgear/ MCC rooms and other strategically important areas. These fixtures shall be fed from respective Emergency DC Lighting Panels. The Emergency DC Lighting Panels (DC ELLP) shall be fed from 220V DC Distribution Boards (DCDB).

These lights shall remain normally OFF but on failure of AC supply these lights shall be automatically ON. Tube lights with Electronic choke suitable for 230 V, AC / DC operation or other Energy Efficient Lamps may be used for DC emergency lighting.

d. Maintenance 24 V AC Lighting System

For lighting facilities comprising portable hand lamps and/or connection of portable hand tools etc., required during the routine maintenance work, 24V single phase 3 pin sockets with switches shall be provided at selected points in the areas listed below. Such sockets for routine maintenance shall be clearly identified by colour coding in order to distinguish them from the normal 240V power outlets. Necessary outlets shall be made on the inside walls of the building near equipments.

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- i. Boiler area: Near inspection manholes on the boiler platforms and near boiler drum at different levels on all four sides.
- ii. TG building: Near HP & LP heaters, turbine flash tank, blow down tank, near condenser water box and near bus duct termination of generator end.
- iii. ESP columns: Near inspection manholes
- iv. Near de-aerator.
- v. Cable galleries.

Any other areas considered necessary identified during detailed engineering.

e. Portable Emergency Lights

This system shall be provided by portable self-contained battery / automatic charger / inverter fed compact fluorescent lamps in isolated buildings / areas where station D.C. supply is not available. These portable emergency light units shall be switched on automatically on loss of normal AC supply. *[Battery packs for portable emergency lights shall be rated for minimum 3 hours duty and the battery shall be of Ni-Cd.]*

f. Exit lights

Emergency escape signs shall be provided at the exit doors, escape routes, intersection corridors, at different floor levels/directions, windowless rooms, toilets, firefighting equipment, lifts, control rooms, switchgear rooms and the areas considered necessary by bidder. *[9W CFL]* lamp shall be used for exit lamps.

The contractor shall design emergency exit lighting system based on plant layouts and install escape lights at suitable locations considering the various escape routes. Emergency exit lights will be fed from normal-cum-emergency lighting panel, wherever available, *[and will be with in-built battery (Ni-Cd) back up of 3 hours operation.]*

1.4.3

Illumination Calculation

- a. Standard Lumen method shall be adopted for interior and exterior lighting in order to determine the number of lighting fixtures for obtaining the desired average level of illumination.
- b. The coefficient of utilization shall be considered to take care of Lumen loss due to:

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- i. Effect of room dimensions.
 - ii. Absorption of light in luminaries.
 - iii. Absorption of light at various room surfaces i.e. ceiling wall etc.
 - iv. Floor cavity, ceiling cavity.
 - v. Mounting height.
- c. Moreover a maintenance factor shall also be considered to account for the fall of illumination due to aging, pollution like dust deposits etc.
 - d. Voltage drop at the fixture terminals from the MLDB shall [not exceed 3%]. Circuit loading of each lighting Panel shall be done in such a way that almost balanced loading in all the phases i.e. R, Y and B is achieved. At least two sub circuits shall be used for illumination of a particular area. Sub circuit loading of each lighting panel shall be restricted to 2000 Watts.
 - e. Design of lighting system shall be such that the average lux level as specified is achieved. The Bidder shall submit illumination calculation/layout for the purchaser's review.

1.4.4 Lighting Distribution System

- a. Separate lighting transformers shall be provided inside the lighting distribution boards located at required location. Lighting distribution system shall be distinct and separate from the LV main distribution. Lighting transformers shall be encapsulated cast resin dry type.
- b. AC lighting panels shall have 240V single-phase, 2 wire incomer controlled by earth leakage circuit breaker and number of single phase outgoing circuits controlled by MCBs. The lights connected to a circuit or few circuits shall be 'ON' automatically through photocell for outdoor lighting. Provision shall be made for switching 'ON' the rest of the lights. Lighting fixtures in indoor areas shall be controlled from the respective lighting panels
- c. Normal 240 V AC Lighting System
For this system, lighting points shall be supplied at 240 V AC through 415 V, 3-phase, 4-wire, 50 Hz, LDB. The supply shall be derived from 415 V, 3-phase, 4-wire, 50 Hz switchgear through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant. Different circuits shall be used from different source. The whole lighting network shall be balanced as far as possible.
- d. Normal/Emergency 240V AC System
For these systems, the distribution shall be by 415V, 3-phase, 4-wire, 50 Hz supply. This supply shall be derived from 415 V, 3-phase, 4-wire, 50

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Hz normal emergency switchgear for NE & lighting through delta/star lighting transformer. The secondary of lighting transformer shall be connected to respective 415 V, 3-phase, 4-wire AC lighting distribution board (LDB). The LDBs shall be provided with number of outgoing circuits controlled by double pole MCBs to feed the lighting panels distributed in and around the plant.

e. Emergency 220 V DC Lighting System

The power supply shall be obtained from the nearest 220 V DC switchboard. DC lighting panel will have one (1) incomer controlled by double pole MCB, Outgoing circuits will be controlled by DP MCB. Upon failure of the normal-cum-emergency AC supply, emergency DC lighting fixtures will be made automatically ON. The change over in the reverse direction shall also be automatic.

f. Maintenance 24V AC Lighting System

24 V AC supply for maintenance purposes (for hand lamps and/or hand operated tools) shall be supplied from 24 V AC distribution panel, which receives 240 V power supply from 415 V/240V transformer modules of N/E switchgear. 24 V AC distribution panel consists of one incomer controlled by MCB, one 240/26.5 V dry type transformer of adequate rating and number of outgoing circuits controlled by MCB.

1.4.5 Illumination levels and choice of lighting fixtures

The area-wise distribution of average illumination levels and type of luminaries shall be as indicated below:

[Note: These are indicative only. However as per specific Existing project, Bidder may refer section I of this specification for exact details of type of fixtures.]

Table 2.0

Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
A - TURBINE GENERATOR BUILDING				
1.1	General (auxiliary equipment areas)	200	Industrial well glass fixture, dust & jet proof, die cast aluminium body, stove enamel finish, vitreous enamel reflector integral mounted control gear/industrial bulk head with integral mounted control gear.	1x70 W/ 1x150 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.2	Cable vault	100	Industrial type FTL with vitreous enamel reflector	Energy Efficient FTL
1.3	All switchgear room area (including off-site building control room)	250	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.4	TG Building operating floor	250	Industrial high bay with anodized aluminium reflector with all accessories including control gear	1x400 W Metal Halide lamp
1.5	Unit control room and Switchyard control room	400	Decorative recessed with wide angle mirror optic antiglare type	Energy Efficient FTL
1.6	Battery rooms	150	Corrosion-proof	Energy Efficient FTL
1.7	TG building ground, mezzanine floor and misc. floors	200	Industrial well glass with integral control gear	1x150 W/ 1x250W Metal Halide lamp
1.8	Air washer room and A/C plant room	200	Totally enclosed vapor proof with clear acrylic cover	Energy Efficient FTL
1.9	Unloading and maintenance bay	300	Industrial high bay with anodised aluminium reflector	250 W HPSV lamp (for mounting height > 9m)

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.10	Electrical laboratory, chemical laboratory etc. (air-conditioned)	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
B -	BOILER AREA			
1.1	Boiler area and platforms, ESP area and platforms	100	Dust proof / dust tight well glass fixture	70 W Metal Halide lamp
1.2	Feeder floor areas	150	Dust proof / dust tight increased safety well glass	70 W Metal Halide lamp
1.3	ESP control room	300	Decorative recessed with wide angle mirror optic anti-glare type	Energy Efficient FTL
C -	VARIOUS OFF-SITE BUILDING			
1.1	Equipment room (pump house)	200	Industrial type with vitreous enamel reflector upto mounting height of 8 M	150 / 250 W HPSV lamp
1.2	Switchgear room	250	Industrial high bay for mounting heights above 8M	Energy Efficient FTL
1.3	Outside working areas	70	Flood light medium beam	250 W HPSV lamp
1.4	Stores	100	Industrial type with vitreous enamel reflector	Energy Efficient FTL
1.5	Fuel Oil Tank Farm	50	General Purpose flood light with weatherproof fixture	250 W HPSV lamp

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.6	Fuel oil decanting pump house, Hydrogen storage area, Coal conveyor areas	150	Flame-proof well glass	1 x 70 W HPMV lamp
D -	GENERAL			
1.1	Corridors, walkways, staircase, etc.	100	Industrial type with vitreous enamel reflectors/channel mounted box type	Energy Efficient FTL/1 x 70 W HPMV lamp
1.2	Lockers, toilets, wash rooms, etc.	100	Channel mounted box type	Energy Efficient FTL
1.3	Elevator well	50	Industrial bulk head	1 x 100 W incandescent lamp
1.4	Building periphery lighting	50	Industrial well glass with integral mounted control gear/industrial bulk head with integral mounted control gear/flood light fittings with timer control	70 W HPSV lamp / 400 W HPSV lamp
1.5	Office Rooms	300	Decorative recessed type FTL	Energy Efficient FTL
1.6	Transformer yard and Switchyard	50 on equipment, 20 general	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
1.7	Street lighting	20	Street weatherproof fixture with timer control	150 / 250 W HPSV lamp
1.8	Parking area	70	Flood light with weatherproof fixture with timer control	400 / 250 W HPSV lamp
E	DC LIGHT FITTINGS			

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Sl. No.	Area/Structure	Average Illumination Level in Lux	Type of Fixture	Type of Luminaries
1.1	Control room	400	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp
1.2	Other areas	250	Energy Efficient 2x40W FTL industrial type of vitreous enamel finish and with Electronic choke suitable for 220V DC operation	CFL lamp

1.4.6 Area wise distribution of Lighting system in plant

Area wise lighting distribution shall be as below:

Table: 3.0

Area/building	Percentage Distribution of Lighting		
	Normal	Normal & Emergency	220V DC
Turbine Generator Building (all the bays)	80%	20%	10%
Control rooms	80%	20%	10%
Boiler Area (Grade level & Platforms)	80%	20%	5%
Service building	90%	10%	5%
Various pump houses and electrical switchgear rooms such as AHP, CHP, FOPH switchgear room, etc.	90%	10%	5%
Electro static precipitator	90%	10%	5%
Switchyard and Transformer yard	80%	20%	5%

1.4.7 Lighting System Design

The lighting system design shall comply with the acceptable norms and the best engineering practices. The system design shall consider principles of

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lighting specified in following paragraph. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

a. Indoor Lighting

The recommended values of illumination level for various areas in the plant are indicated in the table above. Lighting layouts shall be designed such that the ratio of minimum to average illumination shall not be less than [0.6]. Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/buildings in the plant.

i. Maintenance Factor:

- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Air conditioned clean interiors like office rooms, Laboratories, Auditoriums : 0.8
- Industrial areas with normal interiors such as workshops, stores : 0.7
- Industrial areas with dusty interiors : 0.6
- Industrial areas with very dusty interiors such a crusher house and junction towers : 0.5

ii. Reflection factor for wall/ceiling

- White and very light colors : 0.7
- Light colors : 0.5
- Middle tints : 0.3
- Dark colors : 0.1

iii. The working plane shall be considered at 0.85 m from the floor level.

iv. The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination. The suspension height for suspended fixtures shall not exceed 1 meter.

b. Outdoor Lighting

- i) The recommended illumination levels for outdoor areas are indicated in the above table.
- ii) Mounting height, spacing of flood lights shall be based on lamp wattage, uniformity of illumination and vertical angles. Ratio of minimum to average illumination shall not be less than 0.3 and for minimum to maximum shall not be less than 0.05.

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- iii) Maintenance factor shall be generally 0.6 under average conditions.
- iv) Flood lights for area lighting shall be mounted on building structures. For outdoor lighting i.e. around the power plant building and transformer yard provision to be made with 400W outdoor type lamps mounted on wall/structures.
- v) Automatic switching ON/OFF shall be shall be provided through timers/photo cells.
- vi) For road illumination inside the boundary limit lighting poles shall be provided and the distance between the poles shall not exceed 30m.
- vii) Aviation obstruction lights shall be provided on tall installations (Chimney, Cooling Towers etc) as per Airports Authority and international standards. Aviation warning lights shall be high intensity type-A flashing LED type with varying intensity for day and night.
- viii) In an area, the lighting fixtures shall be arranged in different phase / LPs such that even in case one lighting panel is faulty complete lighting is not affected. In any location the lighting shall be arranged from two phases.
- c. The circuit loading on each circuit shall be restricted to 80% of the MCB rating.
- d. The voltage drop from LDB and any fixture shall not exceed 3%.
- e. All lighting design calculations, layouts, conduit wiring diagrams, LDBs and LPs drawings and technical data sheets etc shall be furnished for Owner/ Owner's consultant's approval.

1.4.8 Lighting system equipment

- a. Lighting Distribution Boards (LDB) & Lighting Panels (LP)
 - i. The Lighting Distribution board shall be fed through 415V/433V lighting transformers with off circuit taps $\pm 5\%$ in steps of 2.5%. The lighting transformer shall be cast resin dry type , vector group of [Dy1], class F insulation with temperature rise limited to class F and shall be housed in a suitable enclosure. In general, the transformers shall conform to the specification covered under 'Service transformers. The lighting distribution boards shall consist of MCCB incomer and required number of double pole MCB controlled out going feeders to LPs. The LDB shall be designed for the required short circuit level of [20] kA. All the distribution boards shall be sheet steel clad, dust and vermin proof, cubicle type with degree of protection conforming to IP-52. Outdoor panels shall be weather proof type with IPW-55 protection. The

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thickness of sheet steel enclosures shall be CRCA, 2 mm minimum for load bearing and 1.6 mm for other members.

- ii. Number of outgoing feeders in each LDB shall be provided as per requirement including the minimum 3 nos spare feeders for "Purchaser use". Each outgoing MCB in LDB's shall be of 15 A, but load to be limited to 2 kW or maximum 10 nos. fittings to be connected to one MCB
- iii. Individual control in office buildings shall be through single pole flush type switches/MCBs. In those areas where group controls are required, rotary switches shall be provided
- iv. External area lighting shall be fed from separate boards located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers/photo cell.
- v. In high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder / platform / approach shall be provided for maintaining / replacement of light fittings.
- vi. Each of the LDBs shall be provided with voltmeter and ammeter along with selector switches, "SUPPLY ON" indicating lamps, etc. The switch boxes, receptacle boxes etc. shall be made up of 18 SWG sheet steel.
- vii. Two ground pads with bolts and nuts shall be provided on each board for connection to 50x6/25x3 mm GS flat.

b. Lighting Fixtures and Lamps

- i) Fluorescent fixtures with electronic ballast shall be generally provided for a room height upto 5m. Type of fixture shall be industrial type with gasket, clear acrylic cover and enamelled reflector or decorative type to suit the aesthetics. For areas with false ceiling, recessed mounted decorative fixtures with mirror optic louvres shall be used. In control room / computer rooms, decorative mirror optic fluorescent light fittings with antiglare features shall be provided. The surface finish shall be smooth, unobtrusive and scratch resistant.
- ii) Reflector shall be of sheet steel or aluminium, minimum 20 SWG thick and securely fixed by fastening device of captive type.
- iii) Fixture shall be suitable for 19 mm conduit entry and 16 SWG GI earth wire connection.
- iv) Fixture shall be furnished complete with lamps and integrally mounted accessories. These shall include holders, ballast, capacitor, starter, ignitors (separate type) etc.

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- v) For corrosive areas, corrosion proof lighting fixture shall be provided. For hazardous areas, light fittings, conduits, junction boxes etc. shall have to meet the corresponding area classification requirement.
- vi) Medium bay or high bay type of lighting fixtures with HPMV/HPSV lamps shall be used depending on the mounting heights for indoor areas having room height more than 5m. Medium/ High bay fixtures shall be provided with vibration damper wherever required.
- vii) For areas like boiler and outdoor areas such as roads, street, transformer areas and open yards, weatherproof HPSV flood/ street lighting fixtures shall be used. For areas like boiler platforms, weatherproof well glass type HPSV fixtures with wire guards shall be used.
- viii) All type of fluorescent lamps including Compact Fluorescent Lamp (CFL) shall be bi-pin rotary type and either cool daylight or white.
- ix) Mercury / Sodium vapour lamp shall be colour corrected type with screwed cap.
- x) Lamps shall be suitable for use in position and capable of withstanding small vibrations.
- xi) Ballasts shall be of heavy duty, low loss and polyester-filled type with copper winding.
- xii) Ballasts for Mercury / Sodium vapour lamps shall be provided with suitable tappings to set the voltage within range specified.
- xiii) Ballasts shall be free from hum. Ballasts which produce humming sound shall be replaced, free of cost.
- xiv) In multi-lamp fixture, each lamp shall be provided with individual ballast.

c. Switches, Receptacles

- i. In the plant areas, the lighting circuits shall be controlled directly from the MCBs in the lighting panels. Wherever the lighting panel is not in the same area, separate switches shall be provided. For cabins, rooms, etc., separate switches shall be provided for each point. Similarly for entrances, building periphery lighting separate switches shall be provided
- ii. 240V, 50 Hz, 3 pin Power Receptacles (5A, 15A) shall be provided in all building/areas of the plant. Inside a building, receptacles shall be provided at interval of 30m or part thereof for hand tools, water coolers, exhaust fans etc. Inside each cabins at

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least two receptacles shall be provided and the same shall be indoor/outdoor/flameproof as per the location. Minimum 2 nos of 5A and 1 no 15A receptacles shall be provided in each room. Receptacles shall be heavy duty, complete with individual plug and switch as described below:

Table: 4.0

S.No.	Type	Description
1	RA	5A, 240V, 2 Pole, 3 Pin with third pin earthed - Suitable for flush mounting in office areas and control room. The switch shall also be flush mounting piano type.
2	RB	15A, 240V, 2 Pole, 3 Pin with third pin earthed - Wall/column mounted, metal clad gasketed construction, suitable for 19 mm conduit entry, screwed metal cover tied with metal chain, weatherproof construction suitable for indoor/outdoor installation. This shall be provided at an interval of 30m, or minimum one in each room.
3	RC	63A, 415V, 3 Phase, 5 pin interlocked plug and switch with fifth pin earthed. Wall/column mounted, metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 4 Core 35 sq.mm AYWY cable. These receptacles shall be provided at an interval of 50m throughout the Plant Area.
4	RD	100A, 415V, 3 phase, 5 Pin interlocked plug and switch with fifth pin earthed Wall/column mounted metal clad gasketed construction weather proof, suitable for loop in/ loop out connection of 3.5 Core, 95 sq.mm AYWY cable.

d. Cables and Wiring

- i. Wiring from lighting DBs/panels to individual fixtures, plug points, fans, etc. shall be of single core, 2.5sq.mm, 1100 V grade PVC stranded copper conductors through surface mounted or concealed medium duty GI conduits confirming to IS 1239 with earth wire. The wires in the conduits shall not exceed 60% of the conduit area.
- ii. 1100V grade stranded copper conductor, PVC insulated, colour coded, wires laid in GI conduits shall be used for lighting in non-hazardous area. In the hazardous area, outdoor areas like transformer yard and road lighting, cabling shall be adopted. The

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specification of cable shall conform to the details indicated in "Cabling System" section.

- iii. Minimum size of wires in case of conduit wiring shall be 2.5sq.mm copper in case of lighting and 4sq.mm copper in case of receptacle wiring
- iv. Wires of different phases shall be run in separate conduits. However, wires of same phase but having different circuit nos. can be run in same conduit. Wires of lighting and power receptacles shall be carried out in separate conduits and on separate circuits. Wires of AC and DC lighting system shall be carried out in separate conduits
- v. For outdoor lighting, the cable shall be buried at a minimum depth of 750 mm from ground level or run in cable trays. The buried cables shall have suitable bedding, protective covers and markers
- vi. Material used for saddles, clamps, JBs, etc. shall be galvanized
- vii. Office buildings, laboratory buildings shall have concealed wiring with 2.5sq.mm wires using PVC conduits. In heat zones, i.e. in the areas where ambient temperature is 600 C and above, heat resistant control cables shall be used in hot dip galvanised rigid steel surface mounted conduits

e. Fans and Regulators

- i. The fans shall have three well balanced blades, double ball bearings and shall be reasonably free from noise. Fan motor shall be totally enclosed type with copper winding and class-E insulation. Sweep shall be given as 1200 /1400 mm.
- ii. Regulators shall have minimum five steps. Electronic Regulators with smooth control shall be provided.

f. Flame-Proof Equipment

- i. The enclosure of all flameproof equipment for use in hazardous areas where gases/vapors of Group I, IIA, IIB are present, shall be of cast iron/cast aluminum, stove enamel finished. Chemical corrosion resistant epoxy finish shall be provided in corrosive areas. The construction shall comply with relevant applicable standards
- ii. If the enclosures are additionally required to be weather proof, neoprene gaskets shall be provided to make the enclosure dust and weather proof providing a degree of protection of IPW 55.
- iii. All ferrous parts, exposed to atmosphere shall be suitably plated/galvanized

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- iv. All internal wiring shall be connected to terminal blocks provided in terminal enclosure on incoming side.
- v. Flameproof cable gland entries shall be provided suitable for the cable sizes. The number of required cable entries for junction/terminal boxes as required for branching, terminating of cables for lighting distribution shall be provided. All unused cable entries shall be closed by flameproof plugs.
- vi. Flameproof receptacle unit (socket with associated switch/MCB and plug) shall have interlocking feature such that plug cannot be inserted or taken out with switch/MCB in "ON" position.
- vii. Adequate mounting lugs with necessary hardware shall be provided for mounting the equipment on wall/structure.
- viii. These enclosures shall have inscription warning against opening the enclosure unless the circuit is isolated. Equipment rating and ON/OFF positions of switches/MCBs shall also be designated.
- ix. The BIDDER shall indicate that the enclosures have been tested and certified by relevant statutory authorities for use in hazardous areas.

g. Lighting poles and towers

- i. Lighting poles for street lights and flood lights shall be of swaged and welded steel, pole of height 9M/11M and shall conform to relevant standard. Poles shall be hot dip galvanized internally and externally after fabrication as per IS 2629 / IS 2633 / IS 4759 standards. The Poles shall be designed to withstand the maximum wind speed as per IS 875. The steel sheet used to manufacture steel poles shall be of minimum thickness of 3 mm and shall conform to relevant standard . Junction boxes shall be provided with weather proof flush doors and locking facility. Bidder shall design and furnish the foundation drawings for the poles to withstand basic wind speed of minimum [50]meter/sec.
- ii. The supply of poles/Towers shall be complete with base plate, foundation bolts, hot dip galvanized brackets / necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes.
- iii. Towers for mounting flood lights shall be e of continuously tapered poly gonol cross section and shall be supplied with all acesssories. Steel structure for towers shall be made of hot dip galvanized steel. A steel ladder and platform at the top shall be provided. The length of each step of the ladder shall be at least

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300 mm and spacing between two adjacent steps not more than 300 mm. The structure shall be suitable for mounting the required number of flood lights, weights of maintenance crew and specified wind pressure. The factor of safety shall be [2] for each part and section. The Contractor's structural design drawings shall be approved by the Purchaser before fabrication.

1.4.9 Name Plate

Name plates shall be furnished for identification of devices and circuits. All switches, controls and indications shall be permanently and legibly marked in English regarding the functions.

1.4.10 Painting

All surfaces shall be sand blasted, pickled and grounded as required to produce a smooth, clean surface free of scale, grease and rust.

After cleaning, the surfaces shall be given a phosphate coating followed by 2 coats of high quality primer and stoved after each coat.

The equipment shall be finished in approved color shade by owner with two coats of epoxy based powder coated paint. The coating shall be done electro statically followed by stoving.

Sufficient quantity of touch-up paint shall be furnished for application at site.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

Tests on Lighting Distribution Boards / Panels shall include:

- a. Wiring continuity tests.

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- b. High voltage and insulation tests.
- c. Operational tests.

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *Lighting panels & distribution boards.*
- b) *Receptacles & Junction boxes.*
- c) *Street light poles & towers.*
- d) *Lighting fixture complete with lamps and accessories.*
- e) *Non-integral/separate type control gear box for lighting fixtures, as applicable.*
- f) *Lux level calculations for each area.*
- g) *Data sheets for lighting fixture, lamps, accessories with light distribution curves, co-efficient of utilization charts etc. Type and routine test certificates of transformer and cables.*
- h) *Control schematic and wiring diagram of 415V AC/220V DC lighting panel with automatic changeover from AC to DC and vice-versa, 415V normal AC Street/area lighting panel with automatic ON/OFF feature.*
- i) *Technical leaflets and data sheet on each piece of equipment/ device such as MCB, switch, fuse, receptacle etc. Type and routine test certificates of transformer and cables.*
- j) *QAP and relevant test certificates*

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- k) Lighting layouts showing the disposition of fixtures, lighting panels/boards, circuit distributions, conduit & wire routing.
- l) Key Single Line Diagram for lighting distribution, board wise single line diagram with feeder loading, cable schedule and interconnection chart, design calculation for lighting.]

1.7

Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC DC	240V, 1Ph, 50Hz 220V DC
1.2	Variation in Supply		
	a) Voltage	%	±10
	b) Frequency	%	±5
	c) Combined voltage & frequency	%	10
1.3	Design Ambient Air Temperature	°C	50
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	50KA for 1 sec
	b) At 220V DC (For DC LP)	kA(DC)	[10] kA for 1 sec
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		G.I
b	Conductor size	SWG	12
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		[By bidder]
2.2	Rated Voltage, phase and Frequency	AC	415V, 3phase, 4 wire, 50Hz
2.3	One Minute Withstand Voltage	V	2500
2.4	Mounting Type		

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S. No.	DESCRIPTION	UNIT	DATA
	a) LDBs		Floor Mounted
	b) Single Phase LP		Wall/Structure mounted
2.5	Type and no of circuits & feeder rating		[As per project requirement]
2.6	Colour shade		[RAL 5012]
2.7	Lighting Transformer		
	a) Type		Epoxy cast resin dry type
	b) Voltage Ratio	V	415/415V
	c) Taps	%	+/-5%
	d) Vector Group		[Dyn1]
	e) Impedance	%	[5%]
	f) Rating	KVA	[As per project requirement]
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		[By Bidder]
3.2	Luminaries		[By Bidder]
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		[By bidder]
	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		[By bidder]
	a) Luminaires		
	b) Accessories		

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S. No.	DESCRIPTION	UNIT	DATA
4.0	Schedule of fitting and Accessories		[As per project requirement]
5.0	Technical details of luminaries		[By bidder]
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
i)	After 100 burning hours	Lumen s	
ii)	After 1000 burning hours	Lumen s	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		[By bidder]
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
i)	Ballast	Hrs.	
ii)	Starters	Hrs.	
5.3	Capacitors		[By bidder]
a	Power factor		
5.4	Luminaries		[By bidder]
a	Weight of luminaries	Kgs	
b	Earthing terminal		
i)	Material		G.I
ii)	Suitable upto conductor size	SWG	12
c	Internal wiring size	Sq.mm	

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S. No.	DESCRIPTION	UNIT	DATA
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		[By bidder]
6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		[By bidder]
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		CTs VTs
8.1	Make		[By bidder]
8.2	Type		[By bidder]
8.3	Output	VA	[By bidder]
8.4	Accuracy Class		[By bidder]
8.5	Literature enclosed	Yes/No	[By bidder]
9.0	Meters		VOLTMETER AMMETER WATTMETER
9.1	Make		[By bidder]
9.2	Type		[By bidder]
9.3	Accuracy Class		[By bidder]
9.4	Literature enclosed	Yes/No	[By bidder]
10.0	Relays (if any provided)		[By bidder]
10.1	Make		

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S. No.	DESCRIPTION	UNIT	DATA
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a) Normally open		
	b) Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		[By bidder]
11.2	Suitable for use in hazardous area		
	a) Area classification		[Fuel oil pump house, Main oil tank area]
	b) Gases/Vapor group		[By bidder]
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	[By bidder]
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	[By bidder]
12.0	Lighting Control Switches		[By Bidder]
12.1	Make		
12.2	Decorative		
12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		[By Bidder]
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	

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S. No.	DESCRIPTION	UNIT	DATA
14.0	Lighting wires		[By Bidder]
14.1	Make		[Point wiring with respect to different length shall be furnished]
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	Conduits		[By bidder]
15.1	Make		
15.2	Rigid Steel		Galvanized
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		[By bidder]
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		Yes
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		[By bidder]
17.1	Make		
17.2	Type of Poles/Towers		

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S. No.	DESCRIPTION	UNIT	DATA
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		[By bidder]
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E10

**TECHNICAL SPECIFICATION FOR CABLE CARRIER
SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E10**1.0 CABLE CARRIER SYSTEM****1.1 General**

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Cable Carrier system complete with all accessories for efficient and trouble free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS 800	Code of Practice for structural Steel
IS 1646	Code of Practice for Fire Safety of buildings
IS2667	Fittings for Rigid steel Conduits
IS 3419	Fittings for Rigid Non – Metallic Conduits
IS 3837	Accessories for Rigid Steel Conduits
IS 4649	Adaptors for Flexible Steel Conduits
IS 5216	Guide for Safety Procedures and Practices in electrical Work

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Cable and cable trays shall be installed in an ambient temperature of 50 °C and relative humidity of 95%.
- b) The cable carrier system shall be designed considering the following:
 1. Facility for easy laying of cables.
 2. Access to maintenance.
 3. Neat and aesthetic appearance.
 4. Safety of equipment & personnel.
 5. Ground water seepage.
- c) Cables shall be laid in prefabricated ladder/perforated type trays and in conduits. Direct burial of cable shall be mostly avoided.
- d) Upper cable trays and all vertical cable trays shall be provided with tray covers.
- e) Cable filling in the trays or racks shall not exceed 80%. Conduits if used, the wires in the conduits shall not exceed 40% of the conduit area.
- f) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V cables shall be laid in top trays and cables of subsequent voltage grade in lower tier of trays. Instrumentation cables shall be laid at bottom most tray.
- g) At least 300mm clearance shall be provided between HV and LV cables & LV and control/Instrumentation cables.
- h) Support system for cables shall be prefabricated type.
- i) Single core cables shall be laid in trefoil touching formation. Trefoil clamp shall be provided in a staggered manner.
- j) 1100V grade power cables of [120] mm² size and above shall normally be laid in single layer in trays/on racks.
- k) 1100V grade power cables below [120] mm² may be run in double layers in case of space restrictions.
- l) Control and instrumentation cables can be laid up to a maximum of three layers in each tray/rack.

1.4 Specific Requirements

1.4.1 Scope of work:

The scope of work shall include Design, Preparation of Cable Tray, Trench/Duct bank/Conduit Layout, supply of Cable tray and its Accessories, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the Cable Carrier System

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for following package. The below list indicates area where cable carrier system to be provided but not limited to:

[Note: With reference to particular package, scope of work shall be modified.]

a) TG Area:

- i) TG Platforms.
- ii) TG area Grade Levels Maintenance area.
- iii) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- iv) Laying and Termination of power & control cables for all the equipments of TG package.

b) Boiler Area:

- i) Boiler Platforms
- ii) Boiler Grade Levels covering coal mill and Maintenance area.
- iii) ESP Platforms
- iv) ESP/FOPH switchgear room.
- v) FOPH area.
- vi) Preparation of Cable schedules and Inter Connection schedules/Diagram.
- vii) Laying and Termination of power & control cables for all the equipments of Boiler package.

c) Balance of Plant Area:

- i) Cable Carrier System for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
- ii) Laying and Termination of power & control cables for all the equipments of BOP package.

d) CHP Area:

- i) CHP Switchgear room
- ii) Conveyor.
- iii) Crusher House
- iv) Stacker and Reclaimer
- v) Any other area covered in this package.
- vi) Laying and Termination of power & control cables for all the equipments of CHP package.

e) AHP Area:

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- i) AHP Switchgear room.
- ii) Silo Area.
- iii) Any other area covered in this package.
- iv) Laying and Termination of power & control cables for all the equipments of AHP package.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard
 - ii) Transformer yard
 - iii) Inter plant cabling.
 - iv) Any other area covered in this package.
 - v) Laying and Termination of power & control cables for all the equipments of eBOP package.
- g) All civil and structural works necessary for successful installation and commercial operation of all electrical equipment to be erected under this specification. Supply of cement, sand, stone etc. required for the execution of the contract shall be the responsibility of the Bidder.
- h) All other ancillary works in connection with the items of work described above which are not specifically mentioned but are necessary to complete the work.
- i) For Terminal Points and Exclusions of Cable Carrier system and Specific scope of work Bidder may refer section I of this specification.

1.4.2 General Installation Requirements:

- a) Cable trays shall be fabricated from 14 gauge mild steel sheets. Cable trays shall be of hot dip galvanized Steel of ladder/perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings to be submitted by Bidder. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be hot dip galvanized.
- b) Constructional details, supporting arrangement and installation details for cable trays shall be furnished by Bidder.
- c) Each 2.5 meter section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.
- d) Cable tray covers shall be fabricated from 16 gauge MS sheets. Cable tray covers shall be hot dip galvanized and same shall be provided for all outdoor cable trays and vertical raceways/trays. Covers for vertical raceways shall be in individual, easily removable sections to facilitate cable maintenance.

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- e) Cable Tray of Standard width of 600mm shall be followed. However, trays with 450, and 300, 150 mm width may be used in some places considering the requirement and space restrictions. For instrumentation and control purpose, some perforated type cable trays of width 150 mm may be used particularly in Boiler Platform area, and 600, 450, 300 mm perforated trays may be used depending on site requirement.
- f) Cable trays shall be ladder type with maximum rung spacing 250 mm depth 100 mm and rung width not less than 50 mm.
- g) Cable trays in areas subjected to excessive coal dust, or mechanical damage shall have hot-dip galvanized sheet metal tray cover installed on front tray in vertical run and inverted 'V' type on upper tray in horizontal run. Where covers are used on trays containing power cables, consideration should be given to ventilation requirements. Areas where corrosive chemicals are likely to be handled, cable tray and covers shall be epoxy painted.
- h) Suitable embedded steel inserts shall be provided on wall/floor/ ceiling surfaces for welding of cable tray bracket in order to make the cable tray system withstand horizontal / vertical accelerations due to seismic forces for indoor trays and also wind load for outdoor trays such as on Boiler platforms in addition to normal tray cable loadings.
- i) Cable installation work shall mean erection of cable trays/racks, supports, hangers, junction boxes, conduits, laying of cables either in ground or on trays inside trenches tunnels/overhead trays in conduits etc. dressing and clamping, jointing and termination inclusive of supply of necessary jointing/termination kits, lugs, glands, ferrules, tapes etc. and other accessories, grounding of cable armor. In case of direct laying in ground, all excavation work, necessary back-filling, supply of bricks and protective concrete slabs, removal of excess earth shall be part of the installation work.
- j) Erection of cabling work shall be executed keeping in view all necessities and requirements of fire fighting codes for Generating Stations having an adverse industrial environment.

1.4.3 Cable Routing/Laying

- a) Cables shall generally be laid on ladder type cable trays either in trenches or overhead supported from building steel/structures except in some

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cases cables may have to be laid underground and for short runs in conduits for protection while crossing roads and other facilities.

- b) For interplant connections, the cables may be routed through an overhead cable bridge or cable trenches/tunnels selection being dependent on site constraints.
- c) For underground crossing of railways, roads etc. hume pipes shall be used and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged.
- d) In boiler area, trench shall be avoided as far as practicable. The cable racks shall be supported from Boiler structure in vertical configuration with suitable cover to avoid deposition of coal dust as far as practicable.
- e) Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. Power cables shall be on top trays and Control/Instrumentation cables on bottom trays, and it is recommended that trays for cables of different voltage levels be stacked in descending order with higher voltage level above.
- f) Cables for redundant equipment/system shall be run in separate trays in separate route.
- g) Cables from two different services viz. supply from station board and supply from unit board shall be fully segregated to prevent simultaneous damage due to fire in one of the services.
- h) Low level signal cables and other special Instrumentation and Control cables shall run in separate trays. In general, a minimum of 1500 mm clearance shall be maintained between these cables and noise generating equipment (large motors, generators, transformers etc.).
- i) The cable spreaders of each unit shall be compartmentalized by provision of fire proof partition wall and fire proof doors.
- j) The floor of the cable spreader rooms shall have to be made water proof so that water does not percolate to lower levels in the event of fire fighting operations. Adequate arrangement for efficient drainage of water shall be provided. The cable raceways should also be suitably planned to avoid water entry through this place.
- k) Cables shall generally be laid on cable trays either in concrete trenches or overhead supported from building steel/structures. Cables shall be run in concrete trenches in those electrical rooms at ground level, which are without any spreader room below. In mechanical equipment areas (Indoor), overhead cable trays shall generally be used.

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- l) For inter plant connections, the cables shall be routed through an overhead cable bridge pipe cum Cable Bridge. For isolated but long outdoor cable route with very few cables of 3/4 nos., the cables may be directly buried with prior permission from the purchaser.

1.4.4 Installation of Cables

- a) The Bidder shall install, terminate and connect up all cables and conduits with supporting arrangements as per drawings, cable schedules and interconnection chart/drawings.
- b) The HV power cables of 6.6kV shall be laid in trays or racks as follows:
- In single layer only.
 - 3 core cables to be laid in touching formation.
 - Cables in trefoil groups of the same circuit shall be laid as indicated below so as to ensure balanced current distribution:

Y Y Y Y

R B B R R B B R and so on.

- c) 1100V grade power cables shall be laid in single layer in trays depends on size of cables. Cable of up to 120 sqmm shall be laid in two layers. Beyond this size single layer will be followed.
- d) Control and Instrumentation cables can be laid up to a maximum of three layers in each tray.
- e) The trays shall be run with a vertical spacing of 300 mm for overhead cable trays as well as inside cable trenches. A minimum of 225 mm clearance shall be provided between the top of tray and beams, cold piping, 500 mm clearance for hot piping/object to facilitate installation of cables in tray.
- f) Adequate pull boxes shall be provided in conduit run to facilitate cable pulling in long runs and also to ensure that there shall not be more than 2 nos. 90 Deg. Bends between pull points.
- g) Cable tray/conduit system shall be installed to accommodate cable manufacturer's recommended maximum pulling tension, minimum bending radius and no. of bends.

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- h) All openings in the floor and wall for cable access shall be sealed after installation of the cable system with non-inflammable materials, as follows :
- Fire stop/Penetration seal shall be installed in the cable spreaders and cable raceways.
 - Similarly in the trenches fire stop/penetration seals shall be provided at suitable interval to avoid spread of fire.
 - For all HV, LV, Relay and Control panels, Control desk, instrumentation panels, battery charger, D.C. Dist. boards and other miscellaneous panels, fire-stops should be provided below base plate.
- i) All floor/wall openings for cable entry to the electrical equipment and accessories shall be sealed with non-inflammable materials, after completion of cable installation. Thickness of such materials shall be equal to the thickness of floor/wall unless specified otherwise.
- j) The portion of galvanized steel, which, if required, undergoes any welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.

1.4.5 Cable Termination and Joints (if applicable and not covered in cable specification)

- a) The Bidder shall supply cable termination and jointing kits in requisite quantity for HV. Power Cables, LV. Power, Control Cables, etc. along with all accessories & consumables required for making termination and joints complete . All the materials and components of the termination/joints shall be suitable and compatible with the type of cables for which the terminals/joints are intended.
- b) The straight through joints of HV. cables shall be heat shrinkable and pre moulded push on type. The end termination kits for HV. cables shall be of {Raychem/3M/Elastimold} type. Cable joint or end terminations on Electrical equipment shall be suitable for Indoor & Outdoor use, as the case may be.
- c) Glands and lugs required for termination of HV, LV. shall be supplied by the Bidder in required quantity.
- d) Cable glands shall be tinned brass gland, double compression type complete with necessary armour clamp and tapered washer etc. Cable glands shall match with the sizes of different HV/LV/Control cables.

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- e) Cable lugs shall be suitable for termination of different cross-sections of L.V./Control cables and shall be of following types:
 - i. Aluminium tubular terminal end for solderless crimping to aluminium conductors.
 - ii. Copper tubular terminal end for solderless crimping to copper conductors.
 - iii. Solderless crimping of terminals shall be done by using corrosion inhibiting compound. The cable lugs shall suit the type of terminals provided on the equipment. Lugs for control/instrumentation cables shall be PVC insulated/sleeved type.
 - iv. Cable lugs for control cable termination shall be insulated. These lugs shall be pin type/flat type/ring type/U type to suit the terminals provided in the panels.
 - v. The terminations shall with tinned copper only.
 - vi. For mill area, the cable shall be routed through GI pipes embedded in Ground.
 - vii. In heat zone areas as far as possible the cables shall be taken away from the area to avoid heat. If cabling in the heat zones can not be avoided, the cables shall be terminated in junction box of IP 67 protection class away from the heat zones and small length of cables may be laid from junction box to the respective equipment to facilitate easier replacement in case of fire. Bunching of cables in the heat zones and boiler areas shall be avoided and laid in separate groups.

1.4.6 Identification

- a) The complete cabling system shall be properly identified. Methods for identification of cabling system will be furnished to the Bidder and the Bidder shall strictly adhere to the said methods.
- b) Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- c) Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanized iron plate, projected above ground level.
- d) Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, at each bend and at every thirty (30) meters in cable tray/trench runs. Cable tags shall also be provided

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inside the switchgear, MCC, control & relay panels etc. wherever required for cable identification, such as where a number of cables enter together through a gland plate.

1.5 Tests

I) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

- a) Checking of continuity / phasing and IR values for all the cables before and after HV test
- b) Checking of continuity / phasing and IR values for all the cables before and after HV test.
- c) HV test and measurement of leakage current after termination of cable kits (for HT cables).
- d) Checking of earth continuity for armour.
- e) Check for mechanical protection of cables.
- f) Check for identification (tag number system) distance placement of cable marker, cable joint etc. as per the cable layout drawing.
- g) Check earthing of cable structures.
- h) Check safe head room in gallery area
- i) Check clearance from ventilation duct and light fittings for cable structures.
- j) Check proper fixing of cable structures.
- k) Check for proper drainage and removal of water (if any).

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall

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obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6 Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[General arrangement drawing Cable Tray]*
- b) *[Cable Tray Accessories like Tee, Cross, Bends, Coupler, Reducer etc]*
- c) *[Cable Tray support materials]*
- d) *[Technical Data sheets for cable carrier system].*

1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		[By bidder]
2.	Size of Tray	mm	[600/450/300/150]
3.	Material		Galvanised Steel
4.	Application		[As per project requirement]
5.	Type of Tray		[Ladder/Prerforated]
6.	Thickness of Tray	mm	2mm
7.	Thickness of Galvanization		[100 microns]
8.	Tray Cover Size	mm	[As per project requirement]
9.	Cable Tray Accessories		[By bidder]

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SL NO.	DESCRIPTION	UNIT	DATA
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	a) [100] b) [50x 50 x 6]

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

VOLUME-II

SECTION-II, PART-B, ANNEXURE-E11

**TECHNICAL SPECIFICATION FOR EARTHING AND
LIGHTNING SYSTEM**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

ANNEXURES-E11

1.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of Earthing and Lightning Protection System complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [...] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC as given below except where modified and/or supplemented by this specification.

Table 1.0

IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanizing of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles.
IS:3043	Code of practice for Earthing
IS:9537	Conduits for electrical installation.
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
CEA	CEA Regulations and standard technical specification for main plant package.

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the standard adopted shall be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Code of Practice. In addition, other rules and regulations applicable to the work shall be followed.

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1.3 Design Criteria

- a) Earthing system design shall consist of earth grids and electrodes buried in soil in the whole plant area, embedded in concrete inside all the buildings to which all the electrical equipment, metallic structures are connected to have earth continuity for safety reasons.
- b) The main objectives of earthing system is to:
 1. Provide safety to personnel from contact of dangerous potential caused by ground fault.
 2. Ensure sufficient grounding current for effective relaying.
 3. Stabilize circuit potential with respect to ground.
- c) The earthing conductor shall be designed for fault current of [50 kA] for duration of 1 second.
- d) It is the responsibility of the Bidder to undertake the soil resistivity measurements at site and select suitable size of conductor based on the soil resistivity.
- e) Ground conductor shall be of galvanized steel for above ground and mild steel for embedded and below ground earthing.
- f) Main earth grid conductor shall be mild steel (MS) of [40] mm dia.
- g) Suitable corrosion allowance shall be considered over ground conductor size depends upon soil resistivity.
- h) The main purposes of lightning protection system are to :
 1. Provide protection to structures from lightning strokes.
 2. Provide a low resistance-conducting path to lightning discharge.
 3. Lightning protection shall be provided as per IS: 2309 for Boiler area and other tall structures within the battery limit.

1.4 Specific requirements

1.4.1 Scope of Work

The scope of work shall include Design, Preparation of Earthing and Lightning Layout, supply, unloading at site, storing, laying, fixing, jointing/termination, erection, testing and commissioning of equipment associated with the safety earthing and Lightning Protection system for following areas Listed below but not limited to the following:

[Note: With reference to particular package, scope of work shall be modified.]

- a) TG Area:
 - i) TG Platforms.

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- ii) TG area Grade Levels Maintenance area.
- iii) All equipments, structures etc of TG package.
- iv) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- b) Boiler Area:
 - i) Boiler Platforms
 - ii) Boiler Grade Levels covering coal mill and Maintenance area.
 - iii) ESP Platforms
 - iv) ESP/FOPH switchgear room.
 - v) FOPH area.
 - vi) All equipments, structures etc of Boiler package.
 - vii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- c) Balance of plant Area:
 - i) Earthing and lightning protection system for Mechanical BOP package like Raw water, Water pre-treatment, Fuel oil, CW / ACW System and Cooling Towers, AC and ventilation Vacuum Pump House, Silo Area, Compressor House, Guard Pond, Effluent Treatment Plant, Chimney, Fire water pump house, Cable galleries, Transformer area, all Switchgear Rooms, Control rooms, all roads within battery limit etc.
 - ii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- d) CHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- e) AHP Area:
 - i) Switchgear rooms
 - ii) All equipments, structures etc of Boiler package.
 - iii) For all above areas, above ground Earthing and Lightning protection system shall be provided.
- f) Electrical Balance of Plant(Switchyard) Area:
 - i) Switchyard, Transformer yard and BTG area are provided with earth mat of [40] mm dia MS Rod conductor buried below 600mm from ground level. Areas like AHP, CHP, Boiler and TG, and all other

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BOP area below grounding system are covered in this eBOP package and above ground earthing for AHP, CHP, Boiler, TG and Mechanical BOP are covered in respective package itself. System Neutrals are earthed through Treated Earth Pit. All areas of power plant are interconnected to form an integrated single earthing system. Lightning system for above ground are covered in respective packages and below ground is covered in this eBOP package in same way as earthing system.

1.4.2 Earthing system

- a) Earthing system shall be designed in accordance with IS 3043 and Indian Electricity Rules and Acts.
- b) Fault current for the earthing system shall be designed for [50] KA for duration of 1 sec.
- c) All electrical equipment, non-current carrying metal parts, structures, building steel, lightning protection system, transformer neutrals shall be connected to station ground grid.
- d) Treated earth pits including riser shall be provided for transformer neutral earthing.
- e) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- f) Entire erection of grounding work shall be carried out in such a way as to be capable of withstanding the intended services of carrying full short circuit level currents to ground mat without any damage/deformation.
- g) All off site area of AHP , CHP etc shall be provide with peripheral earthing with at least two connection to main station earth grid through treated earth pit.

1.4.3 Ground Grid Conductor

- a) Ground grid conductor of mild steel rod shall be used.
- b) *[The minimum conductor section is determined on the basis of ground fault current. This section is then increased by an allowance to account for the soil corrosion loss of 0.12 mm (on diameter of conductor) per year over the design life of 40 years.]*
- c) However bidder shall consider as per CBIP norms “ Manual on Earth mat design” the corrosion allowance as below:
 - For soil resistivity greater than 100 ohm-meter: No allowance.

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- For soil resistivity greater than 25- 100 ohm-meter: 15% allowance.
- For soil resistivity less than 25 ohm-meter: 30% allowance.

1.4.4 Underground Grid

- The ground grid mesh is designed to keep the touch and step voltages within safe limits as per recommendation of IEEE 80.
- [The ground grid conductors shall be buried in earth at a depth of 600 mm]. The length of ground conductors below earth shall be sufficient to ensure a ground resistance less than one (1) ohm.
- The ground grid conductor shall be so laid as to provide short and direct connection to building steel and major electrical equipment.
- Ground rods shall be provided at the points where system neutrals/lightning protections are connected to the ground grid.
- All ground grid conductor connections shall be welded type.
- Ground grid shall be interconnected with the ground grid of neighboring areas at least at two (2) points for further reducing the ground grid resistance.
- Suitable pigtailed shall be provided and shown in the [layout drawing] for connection with ground grid of neighboring areas.
- A minimum earth coverage of [300] mm shall be provided between the ground grid conductor and the bottom of trenches, tunnels, underground pipes, foundations, railway tracks etc. The ground grid conductor shall be re-routed in case it fouls with equipment foundations.
- In some cases, it may happen that the construction work of cable trench, foundation and laying of underground pipes are being taken up after the grounding mat has been laid. It may be required to cut a portion of grounding conductor to avoid fouling with cable trench, equipment foundations, underground pipes etc. In this case, the ground conductor shall be properly rerouted and rejoined/reconnected with the main grounding mat during the construction/laying of above underground objects and good electrical continuity of grounding conductor shall be ensured.
- Grounding conductors crossing the road may have to be laid at greater depth to suit the site conditions.
- Grounding conductor around the building shall be buried in earth at a minimum distance of [1200] mm from the outer boundary of the building.
- The Bidder shall carryout the grounding of all electrical equipments and connection to main earth grid.

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1.4.5 Ground Electrode

Ground electrodes shall be [40] mm dia. and [3] metre long M.S. rod. These are to be fabricated and driven into the ground by the side of mat conductors. All connections to the conductors shall be done by arc welding process.

1.4.6 Above Ground Connections

- Galvanized steel flats shall be used for all connections above earth.
- Inside building, ground conductors shall be run for each floor supported on building steel and/or cable trays. These ground conductors in turn shall be connected to the station ground grid through riser (at least two) coming up along building columns/cable shafts.
- Two separate and distinct ground connections shall be provided for each electrical equipment in compliance with I.E. Rules.
- All steel columns and structures shall be connected to the earth mat through earth leads.

All connections above ground shall be welded type except connection to equipment/structures which shall be bolted type.

1.4.7 Risers

Risers are required for connecting the equipment and structures with the ground mat. Risers are to be provided from underground mat to above ground levels where the ends shall be left free for connecting to the equipment. Each riser shall be 1 No. [40] mm dia. M.S. rod and shall project above grade level/concrete floor level by minimum 300 mm. They are to be clamped or supported along the outer edge of the concrete foundation. Connection to the ground mat shall be done by arc welding.

1.4.8 Equipment Ground Lead

- Equipment ground connections shall be sized to carry the ground fault current. Considerations shall also be given to mechanical ruggedness of the connections and to limit the number of sizes.
- The minimum ground conductor sizes for various equipment and structures are given in below.

Table 2.0

DESCRIPTION	SIZE	MATERIAL
a) Main Grounding Grid Conductor	[40] mm dia Rod	Mild Steel
b) Riser/Pigtail From Grounding Grid/Mat	[40] 40 mm dia Rod	- Do -

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DESCRIPTION	SIZE	MATERIAL
c) Electrode	[40] mm dia, [3000] mm long Rod	- Do -
d) Conductor used for connection of various equipment/structures as listed below		
HV motors, Earthing ring, Earthing lead to earth pits etc.	[50 x 10] mm	Galvanised steel
Structures, Control Panels, Cable Trays etc.	[50 x 10] mm Flat	- Do -
415V Power Control Centres, Motor Control Centres, Distribution Boards etc.	[50 x 10] mm Flat	- Do -
Local Panels, Lighting Panels	[25 x 6] mm Flat	- Do -
Motors :		
Above 90 kW	[50 x 10] mm Flat	Galvanised steel
Above 30 kW Upto 90 kW	[25 x 6] mm Flat	- Do -
Above 5 kW Upto 30 kW	[25 x 3] mm Flat	- Do -
Upto 5 kW	[8] SWG	- Do -
Miscellaneous Items, viz. Push Button Station, Junction Boxes etc	[8] SWG	- Do -

{The Above size of Earth flat is indicative only. Bidder shall refer Volume II Section I for size of earth flat used for existing plant or as per design.}

1.4.9

Jointing and Connection

- All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode. The contact surfaces shall be thoroughly cleaned to provide good electrical continuity.
- The bending of the large diameter ground conductor where necessary shall be done by gas heating.
- The projected portion of riser/pigtail above ground shall be coated with two coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- The connections between the riser/pigtail and earthing conductors

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(galvanized steel flats) and between the earthing conductors above ground level shall be made by electric arc welding.

- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The earthing connections to equipment grounding pads/terminals and some removable structures shall be bolted type with GI bolts and nuts. The contact surfaces shall be thoroughly cleaned (to free from scale, paint, enamel, grease, rust) before connection to ensure good electrical contact.
- g) Equipment/structures ground connections shall be coated with weather resistant paints/cold galvanizing paints after proper checking / testing.
- h) Whether specifically shown or not, all conduits, trays, cable armour and cable end box, electrical equipment such as motors, switchboards, panels, cabinets, junction boxes, lockout switches, fittings, fixtures, etc. shall be effectively grounded.

1.4.10 Earthing system installation

- a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
- b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750 mm.
- c) The earthing conductor crossing the road / track shall be laid in hume pipe or laid at a greater depth to avoid damage.
- d) When earth conductor passes through floors, walls, etc suitable pipe sleeves shall be provided and the same shall be sealed after installation.
- e) The connection between earthing pads / terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
- f) Metallic conduits and pipes shall not be used as earth continuity conductor.
- g) Street lighting poles, flood light poles & towers, their junction boxes shall be connected to the earthing conductor to be run along with supply cable. This earth conductor shall be in turn connected to earth grid at two extreme points.
- h) The steel columns, metallic stairs, hand-rail etc. of the building where electrical equipment are located shall be connected to the nearby ground mat by earthing conductor. Electrical continuity shall be ensured by bonding the different sections of handrails and metallic stairs.
- i) Fence within the ground grid shall be bonded to the plant ground system at regular interval not exceeding ten [10] metres. Fence gate shall be separately grounded with flexible connection to permit movement.

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- j) [50 x 10] mm galvanized steel flats(minimum size) shall be run as main earthing conductors above ground along building columns, walls, steel structure, etc. for equipment and other structures earthing. These earthing conductors shall be interconnected between them and to the main ground grid through risers/pigtail. The connection between earthing conductor and riser shall be made above ground. Earthing conductors can be embedded in concrete floor of the building wherever necessary without having direct contact with the reinforcement rods. At the crossing of building walls, floors etc. the earthing conductor shall be passed through galvanised conduit sleeves. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.
- k) All indoor and outdoor electrical equipment and associated non-current carrying metal works, supporting structures, building/ boiler columns, fence, system neutrals, lightning masts/arresters shall be connected to the plant ground system.
- l) Miscellaneous devices such as junction boxes, pull boxes, pushbutton stations, lockout switches, cable end boxes, lighting fixtures, receptacles, switches etc. shall be effectively grounded whether specifically shown or not.
- m) Metallic conduits and pipes shall not be used as earth continuity conductor. These shall be grounded at both ends.
- n) A continuous [50 x 10] mm (minimum size) G.S. flat earthing conductor shall run along the cable trays and supporting structure of all cable routes. This earthing conductor shall be attached to each section of cable tray/trays through [50 x 10] mm G.S. flats. The earthing conductor shall be securely connected to the earth mat at both ends.
- o) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
- p) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint / compound.
- q) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- r) The cable sheaths, screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.
- s) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- t) Main plant earth grid and switchyard earth grid shall be interconnected each other by minimum two numbers of leads.

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1.4.11 Lightning Protection System Design

- a) Lightning protection design and installation work shall be provided on the basis of IS 2309 Code of Practice.
- b) Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down conductors and pipe electrodes.
- c) The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than value specified in IS shall be provided with lightning protection. However, Boiler areas, station building, switchyard building shall be provided with lightning protection irrespective of the arrived risk index.
- d) Shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 Degrees.
- e) Down conductors shall run along the outer surfaces of the building and shall have a test joint about 1500 mm above ground.
- f) A Lightning electrode shall be provided at the connection point of the down conductor with the station ground.
- g) Galvanized steel rods and flats shall be generally used for air termination and connections. All connections shall be welded type.

1.4.12 Air Terminations

- a) The vertical air terminal rods shall be installed at the roof of Turbo generator building, Boiler and chimney etc to protect these objects from lightning strokes.
- b) The projected length of the Air termination rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.
- c) The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building, the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.
- d) All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size [50 x 6] mm galvanized steel flats.
- e) For chimney air termination, rods interconnected by circumferential conductors will be provided at the apex of flue and also upon outer shell of the chimney. The air termination system will be formed by lead coated copper conductors to prevent melting and corrosion of conductors due to flue gas.
- f) For cooling towers, air termination system will comprise of horizontal

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circumferential conductors at the top

1.4.13 Down Conductors

- a) Galvanized steel down conductors of suitable size [25 x 6] shall be connected with air terminal rod/horizontal conductor at the top of roof/structure and other end connected to the nearest 40 mm dia. mild steel rod riser from ground electrode.
- b) Each down conductor shall have an independent earth termination. In no case conductors of the lightning protection system shall be connected with the conductor of grounding system above ground level.
- c) The connection between each down conductor and rod electrode (by means of 40 mm mild steel rod riser) shall be made by others. However Bringing down comer with test link at a level of 1500mm approximately from above ground level shall be boiler contractor scope of work.
- d) The down conductor shall be laid straight and sharp bends shall be avoided as far as practicable. These shall be cleared on outside of the building wall and column/structure at about 750 mm intervals unless stated otherwise in the drawing.
- e) At all supports for down conductor along the column/wall of the buildings etc. the portion embedded inside the building concrete should not touch the reinforcement bars.
- f) All exposed metallic parts of the buildings shall be bonded to the down conductors. Such parts shall include ladders, balconies, conduits etc.
- g) The down conductors shall be protected at the ground level against mechanical injury by means of non-metallic pipes, viz. PVC pipes filled with bituminous compound.

1.4.14 Switchyard Lightning protection

- a) For switchyard lightning protection shall be provided by lightning masts and/or shield wires.
- b) In case of lightning protection by shield wire, the shield wires provided shall be of GS wire strung across the pinnacles of the gantry tower structures. The size of shield wire shall be based on the lightning impulse current expected and the time duration for which it is likely to flow. Allowance shall be given in the final size to account for corrosion of the shield wire during service at rate of [0.03] mm per annum. However, minimum size of the shield wire shall not be less than [70]sq.mm. The zone of coverage for the shield wire shall be considered as 60 deg between the two shield wires and 45 deg for end shield wires. The down conductors from shield wires shall be run along the towers and

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connected to rod/pipe electrodes.

- c) In case of lightning protection by lightning protection masts, the down conductors from the masts/peaks/shield wires shall be run along the tower and connected to the test links mounted on the towers at 1500m from the ground level. Conductors from the test links shall be connected to the rod/pipe electrodes which in turn are connected to the main earth grid in the switchyard. Calculations for sizing and determining topography and number of lightning masts shall be furnished for approval.

1.4.15 Electrodes (for Lightning Protection)

The electrodes shall be [40 mm] diameter [3000 mm] long mild steel rod. These shall be driven into the ground.

All the electrodes shall be interconnected by means of one (1) [40 mm] dia mild steel rod which shall be laid under ground at a minimum depth of [600 mm] below finished grade level unless stated otherwise. This ground mats/electrode in turn shall be connected to main grounding grid.

1.4.16 Riser (for Lightning Protection)

All risers connected to grounding mat shall be [40 mm] mild steel rods and shall be projected 300 mm above grade level unless stated otherwise.

1.4.17 Jointing & Connection

- a) All ground conductor connections below ground level shall be done by electric arc welding with low hydrogen content electrode.
- b) The projected portion of riser above ground shall be coated with two (2) coats of bitumen paints (anti-corrosive paints) with a minimum thickness of 1 mm after connection.
- c) The joints in the lightning conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors.
- d) All the joints shall be done by arc welding process overlapping of the conductors at straight joints shall not be less than 150 mm. The contact surfaces shall be cleaned properly before jointing.
- e) The portion of galvanized steel flats, which undergoes welding at site, shall be coated with two (2) coats of cold galvanizing anti-corrosive paint after welding.
- f) The bolted joint of the test link shall be covered with thick coating of bitumen paint after successful testing.
- g) The air terminal rods and shielding mast shall be coated with weather resistant anti-corrosive paint (zinc chromate followed by two coats of aluminium paint).
- h) The steel to copper connection shall be brazed type.

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- i) The lightning protection of inflammable liquid storage tanks wherever required, shall be provided with horizontal conductors strung between tall poles covering the entire zones or with air terminal rods mounted on top of poles/structure. These horizontal conductors/vertical air terminal rods shall be connected to rod electrodes, which in turn shall be connected to station ground mat.
- j) The sizes and materials of earthing conductors to be used in lightning protection system are listed below :
- k) Note: The above sizes are indicative only. Actual size shall be as per Bidder design or as per existing plant details as provided in Section I in case of replacement work as called for.

Table 3.0

DESCRIPTION	SIZE	MATERIAL
a) Vertical Air Termination	[20] mm dia Rod	Galvanised steel
b) Horizontal Conductor	[50 x 6] mm flat [25 x 6] mm Flat	-----do-----
c) Down Conductors	[25 x 6] mm Flat	-----do-----
d) Ground electrode / riser	[40] mm dia Rod	Mild Steel
e) Interconnection with earth mat	[40] mm dia Rod	Mild Steel

1.5

Tests

1) Type Test

The Bidder shall submit for Owner's approval the reports of all the type tests as per relevant standards and carried out within last [five] years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been conducted at an independent laboratory.

In case the Bidder is not able to submit report of the type test(s) conducted within last [five] years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the

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Bidder shall conduct all such tests under this contract free of cost to the Owner and submit the reports for approval.

II) Routine Test

All equipment shall be completely assembled, wired, adjusted and routine tested as per relevant IS / IEC Standards at manufacturer's works/site in the presence of consultant /purchaser or his representative.

The following test shall be conducted:

- a) Measurement of earth resistance for each electrode.
- b) Measurement of total earth resistance.
- c) Measurement of earth loop resistance for E/F path of biggest LV drive.
- d) Check tightness of all earth connections
- e) Check earthing of all metallic equipments, cable trays, bus bar supporting structures, building column (if steel all elect equipments, pipe lines etc. as per the drawing / specification)

III) Test Witness

[The tests shall be carried out in presence of the Owner's representative, for which a minimum 7 days notice shall be given by the Bidder. The Bidder shall obtain the Owner's approval for the type test procedure before conducting the type test. The test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.]

IV) Test Certificates

- a) Certified copies of all tests carried out at works and at site shall be furnished in requisite no. of copies for approval of the Owner.
- b) The equipment shall be dispatched from works only after receipt of Owner's written approval of shop test reports.

1.6

Drawings, Data & Manuals

Drawings, data & manuals for the motors shall be submitted as indicated below:

- a) *[Earthing Material like conductor , flat , welding description etc]*
- b) *[Air termination rod and its accessories etc]*
- c) *[Technical Data sheets for Earthing and Lightning system].*

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1.7 Rating and Requirements

Major technical parameters of motor are listed below. However, Bidder may also refer to Volume-III, technical schedule in order to submit technical data of equipment along with their technical proposal.

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-II, PART-C
DETAILED TECHNICAL SPECIFICATION-C&I**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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2. Instruction to Bidder
3. General Project Information
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1. Intent of Specification
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SECTION-II: DETAILED TECHNICAL SPECIFICATION

- A. Not used.
- B. Detailed Technical Specification-Electrical
- C. Detailed Technical Specification-C&I
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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

- A. Not used
- B. Technical Schedules - Electricals
- C. Technical Schedules – C&I
- D. Not used

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1 COMMUNICATION SYSTEM

1.1 General

This specification is intended to cover the [design, Engineering, manufacture, assembly, testing at manufacturer's works, supply in properly packed condition for transport to site, Erection, site testing and commissioning] of communication system complete with all accessories for efficient and trouble-free operation of R&M of Unit No. [..] of [Name of the Power Plant] at [District], [State] for [Name of the Client].

1.2 Codes and Standards

All equipment and materials shall be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / IEC / IEEE as given below except where modified and/or supplemented by this specification.

- IS 1881-1998 : Code of Practice for Indoor Installation of Public Address System.
- IS 1882-1993 : Code of Practice for outdoor Installation of Public Address System.
- IS 9302-Part 1to 10 : Characteristics and Methods of Measurements for Sound System Equipments.
- IS 7714-Part 1 to 4 : Specification for Loudspeakers.
- IS 2147-1962 : Degrees of protection provided by Telecommunication Equipment.
- IS 11414-1986 : Basic mode control procedures for Data Communication system.
- IS 13176-1991 : PVC Insulation and Sheath of Telecommunication Cables-Specification.
- IS 14438-1997 : Audio cords and cordages for Telecommunication specification.
- IS 14450-1997-Part 1 : Conductors for Electronics and Telecommunication Applications Specification - Part 1: Bare Copper Wire (Round). Etc.,
- IS 1554-1988 : PVC insulated (heavy duty) electric Cables
- IEC 60268-Part 1 to 17 : Sound System Equipment
- ANSI C37.90A/IEEE-472:Surge withstands capacity.
- Indian Electricity Act 2003
- Central Electricity Authority – Regulations
- Indian Electricity Rule (IE) as amended up to date

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Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Owner. In such case, copies of the English version of the standards adopted shall have to be submitted along with the bid.

The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed

1.3

Design Criteria

The Plant Communication System shall consist of the following:

1. Communication System for the entire power plant includes either IP PABX Exchange complete with Telephone system and telephone handsets in the Power Plant and associated administration buildings.
2. Loud Speaker Talk Back System
3. General Announcement system
4. UHF Wireless System
5. Audio Conferencing system
6. DC Power supply system, cables and other accessories.

[Co-ordination with WPC wing for getting Frequency allocation and License from the Ministry of Communication, Govt. of India is in Bidders scope.]

1.3.1

Design Basis

The System/Equipment shall work efficiently in an adverse industrial environment with hot, humid and tropical atmosphere. Equipment in some areas shall withstand vibration, coal dust, fly ash, oil/water vapors as prevalent in a Thermal Power Generating Plant.

1. The system shall have to provide quick and reliable communication between plant personnel located in different areas.
2. Telephone System including telephone exchange (EPABX), maintenance console, MDF provided with Krone terminals, float cum boost charger, battery sets, telephone Instruments etc. complete with cable network, Krone junction boxes and all other accessories.
3. Provision of necessary software and hardware required at this Exchange end shall be under the scope of the Bidder.
4. Loudspeaker talk-back system complete with power and signal cable network and all other accessories.
5. General announcement system consisting of provision to play the announcement/Music from central system with distributed Amplifiers and volume control for each speaker, complete cable network and all other accessories.
6. Audio conferencing system for Conference hall consisting of Controller, Mics amplifier, speakers LCD projection system, collar, cordless mike etc.
7. Bidder shall supply a minimum of quantity of Telephones, loud speakers, walkie-talkies and other items as per the Schedule of Quantities.

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8. Supply, Laying, termination, testing of all communication cables and power supply cable required for facilitating the communication systems in the plant.
9. The offered systems shall be complete in all respects and any device, component, materials and accessories, etc. which have not been specifically mentioned in this specification but are required for smooth, trouble free, safe and successful operation of the system is included in the scope of work of the Bidder.
10. The Exchange shall be provided with necessary paging cards so that it can be interfaced with Loud Speaker Talk Back System and the General announcement System.
11. In hazard areas like oil storage, wall telephone sets with explosion proof and corrosion resistant metal cases shall be provided.

1.4 **Telephone System**

1.4.1 General Requirements

1. The telephone exchange covered in this specification shall be IP digital electronic type, initially equipped for [400] extensions and expandable up to [500] extensions in future.
2. The telephone exchange shall be complete with central processing unit, control cards, extension line cards, junction line cards, conference facility card, switching circuits, interfacing modules and devices, required for processing and interconnection of speech, data line and service circuits. The exchange shall also have power supply modules, PC based maintenance console, Operator console, printer, interconnecting cables, wires, connectors and other auxiliary equipment.
3. To meet the functional reliability the hardware for the exchanges shall use redundant CPU, redundant memory and memory control, redundant data bus, high speed RAM backed by non volatile memory, redundant storage devices and system control.
4. Telephone exchange shall be of approved technology of Department of Telecommunications. A copy of the 'DOT' approval letter shall have to be enclosed along with the bid. The exchange shall have facility to connect P&T (D.O.T/Trunk) lines. The exchange shall also have facility for interconnection/ tieup with other telephone exchanges. The bidder shall submit TEC approval certificate for quoted model of Telephone exchange along with the bid.
5. In the Telephone Exchange Room all incoming and outgoing voice communications to and from the operators at any telephone sets (Fixed-Phone, IP-Phone, WLAN-Phone and DECT-Phone) or within the IP-PABX and the Hotline telephone sets must be recorded online. Suitable voice recording equipment, external to or integrated within the IP-PABX, must be provided and connected to the IP-PABX.

1.4.2 Design Requirements

1. The IP digital exchange shall be designed and built to offer utmost reliability and efficiency in operation, ensuring instant communication by suitable configuration of functional units and use of reliable components.
2. All components used in the telephone exchange shall be rated for round the clock continuous operation.

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3. The telephone exchange shall employ latest state-of-the art digital switching technology and VoIP enabled.
4. The telephone exchange shall be microprocessor based, stored program controlled, employing Time Division Multiplexing (TDM) and Pulse Code Modulation (PCM) technique.
5. Sufficient redundancy shall be provided in the exchange central processor control unit & other critical components to ensure uninterrupted operation of the exchange functions even in case of failure of these units / components.
6. All the common processing and control cards required for functioning of the IP digital exchange shall be duplicated to a 1+1 configuration. The standby cards shall perform the entire functions of the exchange when the main CPU and control cards fail without affecting the functioning of the exchange. Any failure of cards shall be brought to the notice by audio - visual alarm.
7. The exchange shall be provided with EVM interface cards, Paging cards, E&M cards, IP DECT cards, Interfacing PRI cards etc. as per requirement.
8. The exchange shall be provided with modular construction, dispersal of power modules, ringers and interface cards to the respective extension line racks thus helping to localize faults.
9. The exchange shall have the facility for expandability or system up-gradation to meet future requirements without extensive hardware / software modifications. The telephone exchange shall be wired for the expandable capacity and be expanded in small steps by plugging in appropriate cards.
10. The exchange shall adopt universal port architecture so as to install any peripheral cards in any slot.
11. The exchange design shall have flexibility for interchanging same type cards viz. extension cards, tie-line cards, and trunk cards etc without making any modification in hardware as well as the software.
12. The exchange shall be suitable for connecting electronic push button telephones with CLI facility, IP telephone, DECT handsets.
13. The exchange shall be capable of simultaneously accepting, processing and delivering information in various forms such as voice, data and text in a wholly integrated manner.
14. The exchange shall be designed for simultaneous transmission of voice/data at the transmission speed of 64 Kbps in synchronous mode and 19.2 Kbps in asynchronous mode through telephone cable.
15. The insertion of voice / data cards for simultaneous transmission shall not reduce the availability of total number of voice and data extension lines at any instant.
16. Insulation resistance between components and exchange panel shall be more than 20 K ohms.
17. Speech attenuation shall be less than 1 db. Cross talk attenuation between speech circuits shall be more than 70 db.
18. The exchange shall have all familiar distinct tones, such as dial tone, busy tone, NU tone, ring back tone etc.

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19. Adequate protection of exchange shall be provided against electrical short circuits and heavy current flow as a result of induced or conducted lightning or power systems faults. The exchange shall also be protected against electromagnetic and electrostatic interferences of the power plant complex.
20. The exchange shall have a PC based maintenance console. Provision shall be kept for all routine tests, measurements and checks of exchange equipment and subscriber lines. The system shall be capable of monitoring its own performance to detect, analyze, locate and report faults whenever they occur. The console shall also indicate exchange parameters and card level faults.
21. The system shall be provided with audio and visual alarms for continuous indication of system status.
22. The offered telephone exchange shall have remote maintenance facility to test; executing programmes and monitor the functioning of the telephone exchange from a far off remote location.
23. The exchange shall be compatible to ISDN networking.
24. The exchange equipment shall be provided with interface equipment for interconnection with Loudspeaker Talk-back system, UHF Radio trunking system of the plant complex.
25. The exchange equipment shall be capable of working without sacrificing the quality of performance during prolonged absence of air-conditioning.

1.4.3

Equipment Design Requirements

1. All equipment shall be housed in an elegant floor mounted cabinet. The cabinet shall be designed for ease of transportation and facilitate easy assembly at site. Doors shall be provided at both front and back of the cabinet for easy maintenance.
2. The metallic parts of the cabinet shall be rugged in construction and shall be treated with anti-corrosive paints to withstand the tropical conditions & corrosive atmosphere.
3. Test access points and indications shall be located in the front of the panel.
4. All incoming cables for entry bay connection shall be plug-in type.
5. All component units shall be mounted on plug-in type PCBs to facilitate easy replacement.
6. Cards of identical functions shall be interchangeable.
7. All cards and sub assemblies shall be suitably marked for identification on respective locations.
8. Components mounted on cards shall be designated according to the nomenclature used in the circuit diagram.
9. Bus bars / cables for various supply voltages and signals shall be identified by adopting suitable colour scheme throughout the system.
10. Fuses, keys are to be located for easy access at a convenient level.

1.4.4

Functional Requirements

The IP digital exchange shall have the following minimum features:

1. Non-blocking speech path network employing TDM-PCM technique with no restriction on number of simultaneous calls.

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2. Redundancy in all critical units such as call processing unit / critical control units, memory modules / data buses / hard disk storage unit and other critical components.
3. Modular expansion capability for future expansion possible by simply plugging in additional cards, modules, sub racks and racks.
4. In-built, on line diagnostic features with print out facility. Display of faults through maintenance console.
5. Flexible extension numbering without changing cabling.
6. Distinct ringing for internal calls and trunk calls.
7. Silent operation.
8. Easy and minimum maintenance.
9. High reliability.
10. Interfacing facility with other exchanges of the plant through PRI/CO trunk cards.
11. Compatibility with VOIP digital national network.
12. Extension to extension dialing.
13. Direct outward dialing access to other exchanges.
14. Direct inward dialing.
15. Caller Line Identification facility
16. Changing the subscriber facility through the maintenance console.
17. Facility of connecting up computer terminals etc.
18. Facility for connecting Public address system.
19. Facility for connecting Radio Communication (UHF) system.
20. Remote maintenance facility.

1.4.5

Subscriber Facilities

The following minimum facilities shall be provided for subscribers of telephone exchange.

1. Calling between subscriber
2. Conference facility (4 party)
3. Call transfer
4. Internal consultation
5. Executive/secretary facility with visual indication for line busy identification.
6. Call forwarding
7. Automatic call back
8. Priority interrupt
9. Call pick up
10. Paging access
11. Emergency reporting
12. Last number re-dial
13. Hotline facility
14. Music on hold

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15. Other common features of the latest IP digital exchanges.

1.4.6 Equipment details

The Telephone exchange system shall broadly comprise of the following:

1. Telephone exchange equipment and peripherals such as PC based maintenance console, printer etc.
2. Main distribution frame with protection devices on the exchange side.
3. Power supply equipment, including rectifier - cum - charger, back up battery set and interconnecting cables & wires.
4. Auto-telephone instruments.
5. Telephone cable network comprising cables, wires, distribution & termination devices and associated erection accessories required for connecting the telephone instruments to the telephone exchange.

1.4.7 Main Distribution Frame

1. Separate main distribution frame (MDF) shall be considered for the telephone exchange.
2. MDF shall serve as a common terminating point of the telephone cable network. The MDF shall be compact with systematic wiring and termination, following a numbering scheme facilitating easy maintenance.
3. KRONE type MDF complete with protection devices shall be considered. The 400 extension lines on exchange side shall be provided with IPM for over voltage/current protection.
4. The MDF at present shall be capable of terminating 400 pair cable in exchange side and 500 pairs cable in the extension side (outgoing - field side). Spare capacity to the tune of 10% shall be provided for terminating additional cables on both the sides of the MDF.
5. The MDF equipment shall be installed in the exchange room. Suitable jumper wires and hardware required to connect the equipment and MDF shall be supplied and installed by the Bidder.

1.4.8 Power supply equipment

1. Linear Power supply cum Boost charger to the telephone exchange's power supply equipment and it's associated devices shall be provided from 230V, 50Hz, single phase, AC supply
2. The power supply unit for exchange shall comprise of the following :
 - Rectifier-cum-Boost charger
 - 48 volt battery set
3. The exchange shall work on - 48 V DC obtained through the rectifier cum chargers.
4. The complete power supply unit shall be designed to support the full load condition of a 500 line telephone exchange.
5. The rectifier cum float charger shall feed the exchange equipment and back up battery set in parallel float working principle.
6. The battery set shall work as a backup for providing un-interrupted power supply to the exchange equipment and its PC based maintenance console in case of AC mains

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failure. The backup battery set shall be of lead-acid type with 300 AH capacity sufficient to supply continuous power to the exchange (at its full load capacity) and the PC based maintenance console and printer in case of AC mains failure.

7. Each battery set shall consist of 24 numbers high performance cells of 2 volts each. Each cell shall have vent plugs, buffers, inter cell connectors etc confirming to IS 1652. The 24 cells shall be connected in series to have 48 volts.
8. The rectifier cum charger shall be suitable for operation to trickle charge as well as boost charge the battery set. The power supply unit shall be designed so as to facilitate charging from "Float" to "Full charge" operation by simple switching in auto as well as manual mode.
9. The rectifier-cum-float charger set shall be capable of taking the full load of the exchange while float / boost charging the backup battery set as per the requirement.
10. A switching circuit shall be provided in the rectifier- cum-charger for automatic change-over from rectifier to battery supply in case of AC mains power supply failure.
11. Necessary protection for overload, short circuit, under voltage and over voltage shall be provided.
12. The DC output generated by the rectifier-cum-charger shall be adequately filtered before going to the exchange equipment.
13. Audio - visual alarm shall be provided to indicate any malfunction / failure in power supply system. Audio and visual indications for charging / discharging mode, AC/ DC ON indications shall be provided.
14. The rectifier-cum-charger and all other necessary equipment and protective devices shall be housed in sheet steel cabinet.
15. The charger units shall be provided with ammeters and voltmeters to indicate charging / discharging mode, AC / DC "ON" indication.
16. Necessary accessories required to install the battery sets and charger shall also be provided.
17. The battery sets shall be installed on a suitable platform in a separate room with acid proof floor. The Bidder shall provide the necessary platform.

1.4.9

Telephone Set

1. All IP-PABX switches and subscriber locations shall be equipped with Dual Tone Multiple Frequency (DTMF) standard telephone sets and mobile DECT handsets.
2. For the selected persons at the power station digital telephone sets allowing for all exchange features shall be supplied. Switchboard extensions attached to these telephone sets shall contain a single push-button facility for important contacts. Pressing a button shall automatically establish a call with the relevant attendant.
3. All telephones and associated equipment installed in the process area or in outdoor locations shall have IP 65 weather protection in accordance to IEC 60529. All telephones and associated equipment installed in hazardous areas shall be certified explosion proof type in accordance with IEC 60079.
4. Suitable telephone booths have to be provided for plant rooms/areas with a high noise level (e.g. STG hall).

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- 1.4.9.1 Desk telephone set
Desk telephone sets shall be used only in air-conditioned rooms and offices, and shall have high impact, dust-tight and temperature-resistant plastic cases.
- 1.4.9.2 Wall telephone sets
Wall telephone sets for use in rooms that are not air-conditioned shall have water- and dust-tight (degree of protection at least IP 65) temperature-resistant plastic cases or to be contained in weatherproof container.
- 1.4.9.3 Wall telephone set, Explosion-proof type
In hazard areas such as fuel oil pump house, etc. wall telephone sets with explosion-proof and corrosion resistant metal cases shall be provided.
- 1.4.9.4 Telephone booth
The telephone booths for wall-mounting are to consist of high impact and corrosion-proof steel or aluminium material (resistant to UV radiation) and are to be equipped with the following:
- One internal roof light, type IP 65 enclosure, fully wired with switch
 - One external call light, type IP 65 enclosure, marked on three sides (mounted on roof of telephone booth)
 - IP 65 enclosure, for telephone connection cable and cable connection
 - Telephone relay for auxiliary bell.
- For installing telephone booths in hazardous areas all equipment used shall be exclusively of the explosion-proof type.
- 1.4.9.5 IP DECT (IP based Digital Enhanced Cordless Telephone) Systems
DECT based telephone system shall also be provided in the plant at a number of locations for limited mobility. Outline of the System is indicated below:
- Central Voice Switch or EPABX, as indicated above.
 - DECT controller, a module that can be interfaced with the EPABX and shall connect to a number of radio base stations.
 - Radio Base Station (RBS) Compact units, located strategically at various points over the desired coverage area and connected to controller over air.
 - User Handsets shall be similar to GSM handsets and shall have the provision to work with GSM SIM Cards and shall communicate on regular cellular networks also simultaneously.
- The distance between base station and handset shall be 300 meters. The distance of Base station to Controller shall be 2 km.
- Handset users shall be able to call each other and also wired subscribers. The users shall also have access to various features of the EPABX as well as features of modern cordless devices. The system shall work on IP/cellular technology with seamless roaming and handover between cells. Multiple redundant over the air path shall be available between the base stations to provide reliable and seam less

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communication. Failure of one Base station should not affect the communication from the handsets and the handsets should take automatic alternate shortest route for linking up with the controller. There should not be any limitation to the number of handsets that can work with one base station.

1.4.10

Cable network

1.4.10.1

Cable network for Telephone exchange

1. For facilitating plant telephone connection at various locations within the plant complex a separate cable network is to be provided. The telephone cable network shall facilitate a total of 400 telephones.
2. The telephone exchange and its associated devices shall be provided.
3. The telephone cable network can be divided in the following categories :
 - Main & Tie cable network
 - Distribution telephone cable network
 - Indoor telephone network
4. The main telephone cable network shall comprise of cabling between the MDF of the telephone exchange and the telephone distribution cabinets in various areas / units of the plant complex.
5. To strengthen the reliability of the cable network the distribution cabinets of various areas in the plant complex shall be interconnected through tie cables of adequate capacity.
6. The distribution telephone cable network shall comprise of the cables and termination devices for facilitating telephone connections in various areas of the plant. The distribution cables shall be laid from the above cabinets to various areas & terminated in telephone distribution cabinets / CT boxes / Distribution boxes.
7. Indoor telephone cable network shall comprise of cabling from cable terminal boxes / distribution boxes up to ceiling rose / tag block for further connection to various subscribers. Single & multi-pair un-armoured PVC telephone cables in concealed conduits / surface conduits / PVC casings shall be used for indoor wiring.
8. Cable route for the interplant cable network shall be prepared based on the plant general layout drawing.

1.4.10.2

Cables for Telephone System

1. All telephone cables shall have copper conductor. Each conductor shall consist of a 0.51 mm dia. solid wire of annealed high conductivity copper.
2. The cables shall conform to the latest edition of the following Standard specifications.
 - ITD Spec. no. S/WT-143 B for Petroleum jelly filled armoured telephone cables.
 - ITD Spec. no. S/WS-113 C for PVC insulated, PVC sheathed telephone cables.
 - IS:1554, Part -I & II for armouring & outer sheath of PVC cables.
3. All PVC armoured and unarmoured telephone cables shall be Fire retardant low smoke type (FRLS Type) having protective system of inner and outer sheath specially designed with thermoplastic or thermosetting materials having superior

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resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics. The cable will conform to the following standards -

- IEC -332 (Part 1)
- BS -4066
- IEC -332 (Part 3)
- IEEE -383

1.4.11 Cable Distribution Cabinets

1. The cabinet shall consist of a framework on which cable terminal boxes are mounted. The outer case of the cabinet shall be of hot dip galvanised mild steel sheet.
2. The distribution cabinets shall be suitable for both installations by road side in open air as well inside a building on walls / floors.
3. The doors provided shall be strongly secured to the case of the cabinet with a locking system. Each door shall be provided with hinges, suitably spaced and welded or riveted to the case and the door. The case shall be designed to prevent entry of water into the cabinet during rainy conditions.
4. The MS sheets used for making the cabinet body shall be of 2 mm thickness.
5. Angles, channels & flat iron bars used shall be hot dip galvanised. The iron racks, bolts, nuts & other accessories shall be hot dip galvanised before they are fitted on to the cabinet. Screws, fly nuts etc shall be nickel plated mild steel.
6. Words - "TELEPHONE DISTRIBUTION CABINET" shall be embossed on the external top side of the cabinet.
7. A 100 pair distribution cabinet shall have the facility of termination of 100 pair 0.51 mm dia. conductors in the exchange side & 100 pair's 0.51 mm dia. conductors in the extension line side.

1.4.12 Cable Distribution Boxes (DBs)

1. The Distribution Box (DB) shall consist of a hot dip galvanised mild steel sheet cabinet suitable for both indoor and outdoor mounting, wall mounted with a hinged cover and locking arrangement to prevent unauthorised access. The DB shall be dust & vermin proof and protected from weather.
2. The MS sheets used for making the body shall be of 2mm thickness.
3. The Distribution Boxes shall be provided with suitable mountings to fit tag blocks. The tag blocks shall be Phenolic moulded each having 10 pairs (20 brass inserts) soldered on the brass plate. The brass plate carrying the tag block shall be fitted on the cast aluminium cubicle with 4 brass screws.
4. A 10 pair distribution box shall have the facility of termination of 10 pair cables in the exchange side & 10 pairs of cables in the extension line side.
5. The cubicles will be fitted with two brass or plastic nozzle inlet glands for leading in cables.
6. Words - "TELEPHONE DISTRIBUTION BOX" shall be embossed on the external top side of the box.

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1.4.12.1 Telephone socket

1. Two pin socket along with plugs (specially designed for telephone connections) shall be provided at the subscriber locations for plugging in telephones.
2. The incoming cables from the distribution boxes in each block / unit / building shall be terminated in these sockets.

1.4.12.2 Maintenance Facilities

1. The exchange shall provide automatic monitoring of its own performance and to detect, analyze, locate and report faults whenever they occur.
2. The system shall verify the proper execution of call handling and exchange software or hardware malfunctions and report on the condition of interfaces and exchange resources such as memory occupation, CPU utilization etc.
3. The maintenance console shall be PC based having bulk software loading facility. The PC based maintenance console shall have CDD and HDD and shall work on 48 volt exchange supply. All the programming required to provide various facilities shall be possible from this unit. Facility shall be available to ensure automatic print outs of all important events and faults.
4. Provision shall be kept for all routine tests, measurements and checks of all exchange devices and subscriber lines. The console shall also indicate all exchange parameters and card level faults.
5. Malfunctioning in any part/ control unit/ power supply units of the system shall initiate the audio visual alarms. The equipment shall be provided with audio visual alarms in case of failures with facility for cutting off the audible alarm when required.
6. Automatic line testing equipment shall form part of the maintenance facility for telephone exchange. It shall be capable of testing the network without physically disconnecting the telephone cable.
7. It shall be used to test the open loop and closed loop condition of each subscriber, insulation value of telephone cable pair, capacitance, impedance, resistance and foreign potential (AC & DC) for each extension lines. The above values shall be displayed on the automatic line testing equipment.
8. The telephone exchange equipment design shall be such that any special care on the part of maintenance personnel is absolute minimum and no preventive maintenance is required.

1.5 UHF Band Wireless System

[Supply, Installation and commissioning of Multi-channel, Multi user trunked radio, analog type, and systems equipped for 4 channels in 403-470 MHz band]

The supply shall be complete with all details of equipments illustrating and describing drawings with complete literatures. The supplier shall include all minor accessories though not specifically mentioned in this specification but essential for the completeness of the equipment. The required quantity of equipment/ component/items/cables essential for completeness of Trunked Radio System for satisfactory operation shall be supplied.

The Wireless System shall consist below listed items:

- Radio site controller with telephone inter connect

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- Repeater base station sets
- Antenna system consisting of Omni-directional antenna
- Transmitter combiner
- Receiver Multi coupler
- Low loss RF cable to connect antenna to the system
- System Management Terminal
- Portable type programming kit for field use
- Portable subscriber radio (Walkie Talkie set)
- Fixed radio (main set/mobile set)
- Suitable self supported tower of height 45 meters
- Suitable capacity UPS for min. 4 hours backup
- Co-ordination with WPC wing for getting Frequency allocation and License from the Ministry of Communication, Govt. of India is in Bidders scope.

1.5.1

System Design

The 5 channel single site UHF Radio System shall comprise of the following.

- Radio site Controller
- Repeater-Base Stations
- Omni-directional Antenna
- Transmitter Combiner
- Receiver Multi-coupler
- Low Loss RF cable
- Accessories & Cable Connectors
- System Management Terminals (SMT)
- Subscribers:
- Portable –Analog type
- Fixed – Analog type
- UPS for UHF Wireless systems backup

The Radio site Controller, which is the heart of the system, shall be responsible for passing call requests to and from subscriber terminals. The microprocessor based controller boards shall control the UHF systems and its operation. The controller shall be compatible for Hybrid mode of operation.

Each Repeater station, Comprises of Transceivers tuned at different frequencies shall boost the RF signals for required coverage. Each Repeater shall consist of one Transmitter and one Receiver capable to operate at any RF channel. Each Repeater can be programmed for different power options.

Transmitter combiner and Receiver Multi-coupler shall have one transmitting and one receiving antenna and shall be used for the whole repeater system operation.

The antenna shall be minimum 5 dB high gain Omni-directional antenna.

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The system shall support 100 or more subscribers with all possible groups and or subgroups. The system shall be of modular construction providing options for both sub equipping and system expansion. Additional sites or radio channels may be added if required for future expansion. The system design shall allow the users to communicate during system failure. During system failure, the system shall switch over to conventional radio repeater operation to pre assigned groups.

One of the RF channels shall be used as control channel. This control channel shall be responsible for all control data transmission. This system feature shall allow any RF channel to act as a control channel in case of control channel failure without disturbing the system operation.

The system shall support wide/Narrow band (25kHz/12.5kHz) operation as applicable. Besides that, the system shall be equipped with a system management terminal (SMT). This SMT shall take care of the system Management & Configuration.

1.5.2 Features

The UHF radio system shall have the following general and system features.

1. It shall also support all the radio features.
2. All equipment (except R/T terminals) shall be supplied rack mounted and shall be compact, solid state construction.
3. The equipment shall be plug in type modular in construction with suitable protection to facilitate removal/insertion of plug in units with power on.
4. Any incoming or outgoing call shall not land on faulty channel. System shall have the facility to lock out the faulty RF channel.
5. It shall be possible to select any RF channel for servicing without affecting the working of other channels.
6. The equipment shall have easy access for servicing and maintenance.
7. The equipment shall be designed for round the clock operation.

1.5.3 Area of Coverage

The Radio System shall provide out-door reliable coverage from the main site as well as in-building RF coverage for the entire plant area.

1.5.4 Traffic Channel

Out of the available 5 channels, the system shall use 4 as traffic or voice channels and one as control channels. These channels shall be used as pool of RF channels from which the UHF Radio system controller utilizes either or all channels simultaneously.

1.5.5 Control Channel

The wireless system shall use one RF channel as control channel. All the units turned on within the coverage area shall monitor this channel. In case of failure of control channel, any of the other RF channels shall take over automatically the role of control channel. There shall be a min of 4-control channel.

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- 1.5.6 Channel Assignment
- The system site controller shall assign all RF channels so that any or all system users shall have access to all traffic channels via a system priority protocol.
- 1.5.7 Call Types
- 1.5.7.1 Group call:
- Every member of a group shall be able to talk to each other.
- 1.5.7.2 Individual Call:
- It shall allow one-to –one conversation through radio units and that shall not be heard by other radios.
- The system shall allow a free channel immediately, to an emergency call and in case one is not available, it shall be placed at the top of the queue.
- 1.5.7.3 Normal calls:
- The calls from radio unit shall be kept in queue when no channels are available and shall call back when channels become free.
- 1.5.8 Out of Contact Indication
- Any field unit attempting to connect to the system from out of coverage area shall get a visual alert which is different from other audible alert. This shall enable the user to determine that the unit is out of contact with the system.
- 1.5.9 Reporting
- The system manager terminal shall be able to configure the system and manage the users.
- 1.5.10 Call Limit Timers
- This shall allow configuring to impose different time limits for communications to the system as per requirement. It shall be possible to configure separately for normal and peak periods for voice calls.
- 1.5.11 Telephone Interconnect
- The radio users shall be able to initiate and receive telephone calls from the subscriber radio & should be part of controller.
- 1.5.12 Addition of Radios with Channel Expansion
- It shall be possible to add radios in to the system during channel expansion without requirements for recalling radios already being used on the system or reprogramming of radios already in use.
- 1.5.13 Site Controller
- The microprocessor-based site controller shall be the heart of system and responsible for all the controlling functions of the system. It shall monitor the integrity and service ability of the system. It shall generate alarm/report as soon as it diagnosis a fault. The site controller shall be of hybrid type to support analog type and digital type subscribers.

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The controller shall be provided with suitable surge suppressor protection devices to withstand variation in line input voltage and any surge current.

A system management terminal (SMT) shall be provided for the UHF wireless system.

1.5.14 Repeater System

The repeater system shall be comprised of 5 repeaters and linked with the system controller. Out of which four shall be used as voice channels and one shall be used as standby channel. However in case of failure of one repeater standby of the repeater stations shall be used without disturbing the operation.

Each repeater station shall have the following features:

1. Each Repeater shall be linked to the system controller and shall have one transmitter and one receiver respectively. However any or all transmitters and receivers shall be able to operate independently and simultaneously with any or all repeaters of the system. Each repeater shall be capable to operate at any of the 403-470 MHz band and shall be tuned for a particular pair of frequencies.
2. Each repeater station shall be microprocessor based & suitable for different power options. Any further up gradation and expansion shall be possible through software. This shall ensure flexibility, simplified set-up, easy field up gradation & easy tuning of each repeater.
3. Each repeater shall be provided with suitable surge suppressor protection to withstand variation in voltages and any surge current.
4. Each repeater design shall ensure of 24 Hrs. of unattended operation.
5. The repeater system shall be redundant, so the failure of one repeater shall not affect the whole operation. Also the hardware redundancy shall ensure the conventional operation of repeaters for pre-selected groups in case of failure of Site controller.

1.5.15 Antenna Sub-System

Each repeater site shall require high gain omni-directional antennas with combiner for each Transmitter/Receiver. Similarly for reception one receiver antenna with one multi-coupler shall be used. Both the Transmitter combiner and Receiver multi-coupler shall be expandable type.

1.5.16 Antenna for the Repeater

Omni-directional co-linear antennas with 5 dB or better gain shall be used for repeater station.

The antenna shall be centre fed co-liner antenna to ensure consistent gain and impedance across the operating band. It shall be properly designed to meet various requirements of mobile radio service.

Copper alloy radiating element shall be encased in a weatherproof fiberglass low loss housing to protect the radiating element from extreme environmental hazard.

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1.5.17 Antenna Tower

Suitable antenna tower, as per requirement for the selected UHF system, is to be installed, to support the two Omni-directional antennas and tower top amplifier shall be provided. The necessary accessories like lightning arrestor, civil aviation lights etc, are to be provided. The antenna and tower design shall support to withstand wind velocity of 180 KM/Hr.

1.5.18 Transmitter Combiner

The Transmitter combiner shall be designed to maximize the use of tower space in to one antenna. It shall be highly compact, modular and accommodate closed channel spacing with very high isolation.

The combiner can be expanded one cavity, or more at a time up to 4 channels or more. Temperature compensation devices shall build in to all passive components to help, insure, trouble free, service over, long term, heavy-duty communication system usage

1.5.19 Receiver Multi-Coupler

Receiver Multi coupler shall be used to combine a minimum of 4 receivers onto a single antenna. The device shall have a plug in power supply, and bipolar, low noise RF amplifiers. Channel capacity shall depend on the arrangements, within the multi-coupler. External high performance pre-selector filter shall determine the band-pass response. Any attenuation shall be offset by the RF amplifiers.

1.5.20 Accessories

All the accessories used shall be designed to be compatible with RF cable, to have a long lasting and effective transmissions line system. The following shall be the key accessories for transmission line system:

1.5.20.1 Grounding Straps

The transmission tower system shall be grounded, with grounding straps at three points, the Top, the middle and the bottom of the tower.

1.5.20.2 Hangers

Hangers in the tower shall be used at intervals of no more than three feet to provide maximum support and security for the transmission tower. These hangers shall provide quick and easy attachment in all weather conditions.

1.5.21 Radio Subscribers

Following Type of radios shall be considered-

- Hand held portable radios.
- Fixed station radio

All the radios shall be analog type. All the radios shall be programmable for its ID and other features through radio interfacing unit. All the hand held radios shall have keypad. All the radios shall have its own electronic serial number for its programming to protect unauthorized entry of new radios.

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Radio handheld sets shall be battery operated, mobile sets shall be operated from vehicle battery and fixed stations shall be operated from 230 Volt AC power points.

All the system programming shall be done through USB/ RS- 232 port via. PC. All the features and operational instructions shall be incorporated through this PC. Similarly, radios shall be programmed through the PC with the help of Radio interface kit.

The following minimum controls are required for radios:

- On/Off switch
- Multi-group and Talk –group select switch.
- Volume control
- LED indication for transmission

1.5.22 Hand Held Portable Radio

1. The walkie Talkie sets shall be hand held and shall be tough, lightweight, compact design. It shall be dirt, dust and moisture proof.
2. [The walkie-talkie sets shall be of frequency-synthesized version in 403-470 MHz band and shall be tuned to the respective spot frequencies.]
3. All the operation controls are to be located preferably on the topside of the walkie-talkie sets.
4. [Each channel of the Walkie-talkie set shall be able to programmable to deliver RF power from 1W / 4W by the user end.]
5. The walkie-talkie set shall be field programmable type for any radio frequency in the specified band and also shall be able to program the individual characteristic such as PL on unit ID number etc.
6. Each Walkie-talkie set shall be compatible to connect external speaker and microphone assembly to hear or send the messages. Necessary provision to connect the external mic/speaker assembly should be available.
7. The walkie-talkie set shall have battery saver feature to avoid idle current consumption and also should have low battery indication.
8. The Ni-MH batteries of the walkie-talkie sets should be packed in a separate battery box. The battery box shall be able to charge the batteries in the charger separately without need of walkie-talkie sets.
9. Each walkie-talkie set shall be supplied with necessary helical antenna, battery (min 1800 mAH), carrying case, regular battery charger, user manual etc.
10. Walkie-talkie sets shall have a time-out timer facility to limit the transmission time of the radio.

The hand held portable radios shall have the following features and as per the detailed specification:

Radios shall support following call types:

- Individual to Individual.
- Individual to Group call.
- Private Conversation.

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- The feature shall allow the radio unit to selectively enter into one – to – one call with another radio. The target user can view the ID of the initiating radio. No one can overhear this conversation.
- 1.5.22.1 Multiple system/Talk-group capabilities
Radio unit operation of 5-system/4 talk – groups or more shall be possible. This shall allow the user to access many user groups.
- 1.5.22.2 Incoming call information storage
The radio unit shall give a series of audio and visual indications when received an incoming call.
- 1.5.22.3 LCD Display
User-friendly LCD screen shall be available with radios with keypads. This gives the user instant talk identification.
- 1.5.22.4 Talk Group Scan:
In case the radio is part of multiple talk groups, the user can scan the selected talk groups of which he is part and can switch over to one particular talk group.
Programming software:
Software shall simplify the computer programming and customization of features of radio as per requirement.
- 1.5.23 Fixed Radio
The fixed radios shall have the following features and as per the detailed specifications:
1. The fixed station radio shall be operated from both 12V battery and 230V AC. Necessary power supply unit for the above should be supplied.
 2. The Fixed station radio shall have audio and PTT connection to connect amplifier.
 3. All controls required for operation and external microphone shall be provided. The microphone shall have high impact, resistance plastic housing, a coil cord and connectors
 4. Each set shall have one 3dB gain Omni-directional antenna for both transmission and reception.
- 1.5.23.1 Call Type
Radio shall support following call types
- Individual to individual
 - Individual to group call
- This feature shall allow the radio units selectively enter into one to one call with another radio user.
- 1.5.23.2 Multiple system/talk group capability
Radio unit operation of 5 systems/4 talk groups or more shall be possible. This shall allow the user to access many user groups.

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- 1.5.23.3 Incoming call information storage:
The radio unit shall give a series of audio and/or visual indications when receiving an incoming call. This is useful in the noisy environment or the user is away from the radio.
- 1.5.23.4 LCD Display:
A user-friendly LCD screen and keypad shall be available with radios. This gives the user instant talk identification.
- 1.5.23.5 Talk Group Scan:
In case the radio is a part of multiple talk groups the user can scan the selected talk groups of which he is part and can be switched over to one particular talk groups.
- 1.5.23.6 Programming Software:
The software shall simplify the computer programming and customization features of a radio as per requirement
- 1.5.24 System Management Terminal (SMT)
The system management terminal (SMT) shall be used for system configuration, control and monitoring of the whole system and same shall be of latest Make.
The bidder shall supply all necessary connectors, cable with connectors for testing the repeater/fixed/portable radios. The testing cable shall be provided with BNC/UHF/N connector.
A suitable UPS shall be provided to give backup for the UHF wireless system for at least 4hours during power failure.
- 1.5.25 Circuit Diagram and Manuals
The bidder shall supply 6 sets of as built relevant operation and maintenance manuals comprising of block diagram, interconnecting diagram, neat circuit diagrams, circuit description, test voltages, spare parts list, trouble shooting guide, tuning with procedures, list of testing equipment required along with supply. The firm should also supply the programming kit and the required software.
- 1.5.26 Testing Equipments
The firm should recommend the necessary testing equipment's for the maintenance trouble shooting of repeater stations, portable radios and fixed station radios and should quote for the same separately.
- 1.5.27 Specification for Antenna Tower
The self-supporting towers shall be similar to the design adopted by Posts and Telegraphs Department for their Microwave/UHF Towers.
The supply of tower materials should be complete in all respects including all the accessories such as ladders, antenna fixtures, rest platforms, antenna platforms, lightning arrester, base plates, anchor bolts and templates, bolts-nuts, aviation lights, twilight switches and electrical fittings like conduits etc.

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Galvanized steel ladder should be provided form 4.5m from the ground level to the highest point of each tower. Guard loops should be provided to the ladder to protect the climber from falling. No structural members shall intrude into the guard loop.

1.5.27.1 Design Considerations

The tower must be designed for self-weight and wind velocity of [180 KM/Hr.]

The wind pressure on the wind- ward should be taken as 100% of the designed pressure.

The wind pressure for the diagonal case should be taken as 1.18 times those in the normal case. The tower should be designed to support 4 -repeater station antennas and shall be mounted as per the requirement.

The top width of the tower shall be 1.8m.

1.5.27.2 Galvanization

All steel members off the tower shall be hot dip galvanized in accordance with IS 4759-1968 (or as revised).

1.5.27.3 Lightning Arrester

Lightning Arrester shall generally conform to IS – 2309-1969 (or as revised).

1.5.27.4 Earthing System

The maximum value of earth resistance should be of the order 1 ohm.

1.5.28 Material to be used for Fabrication:

Tested steel as per specification given in to be checked (or as revised) shall be used for bolted work. All steel section used shall be cleared rolled to the dimensions, sizes and weights specified for required subject to permissible tolerances as given in IS-802-1995 (or as revised). It shall be free from cracks, surface flaws, laminations, rough and imperfect edges and other visible defects etc.

1.6 Loudspeaker Talk Back System (LSTB)

Loud speaker Talk back system shall be used to issue instructions, calling and conversing with key operating and maintenance personnel.

Master station for the common facilities shall be located in central control room within BTG area. Between the groups, communication shall be permitted between Master to Master only. Power supply to communication system shall be fed from UPS. Loud speaker Talk back system and General Announcement System shall also be hooked up to telephone system.

Loud speaker Talk back system shall have the following features:

1. The system shall provide two independent channel of communication namely page channel and party channel.
2. The page channel shall be used to make any announcement over the system loud speakers. A call attention gong tone shall automatically precede all paging announcements.

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3. The party channel shall provide for highly intelligible voice communication between two or more stations without being heard over the loud speakers.
4. Selection between page and party mode shall be through a “Press to Page “switch located at the handset.
5. Master Control Station shall have facility for generating and introducing the siren tone in the page channel.
6. Loud speaker Talk back system and General Announcement System shall be of distributed amplifier type. Number of handsets and loud speakers are to be provided at all locations to cover the respective area for efficient operation of the system.
7. The design of loud speaker Talk back system and General Announcement System shall be such so as to provide highly intelligible two channel voice communication even in areas of high background noise (50 db to 100 db) with the following features:
 - The System characteristic shall be such so as to cover the entire audio range and the speech band, particularly over frequency range of 500 Hz to 5000Hz and dynamic range of 40 to 80 db.
 - The system shall be distributed amplifier type with provision for easy future extension. Each station shall be complete with its own pre-amplifier, signal processing and power amplifier.
 - Equipment shall be self protecting against transients in the input A.C. supply and against failure of any component or cable in the entire communication system.

i) Communication within a group

- To originate a call, the caller shall lift the hand set off the cradle at his station and press the page button.
- The associated loudspeaker shall get muted to prevent acoustic feedback. A call gong shall be heard over all other loudspeakers.
- The caller shall then make his announcement and release the page button. The announcement shall be heard over all loudspeakers except those muted.
- On hearing the announcement, the called party like-wise shall lift the handset off the cradle at his station and establish two-way communication over party channel.
- Party channel busy lamp shall be lit up at other stations as soon as the channel is in use.
- Loudspeaker associated with any station engaged in party channel conversation shall be free to receive any paging announcement.
- In addition, switch shall be provided at each handset to mute the associated loudspeaker, if required, when engaged in party channel.

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- The system shall have provision to ensure that any number of stations can join in conference on party channel.

ii) Communication between Masters

- To initiate a call, the calling station shall operate the selector switch corresponding to the desired station.
- At the called station, a buzzer shall sound and a lamp corresponding to calling station shall glow.
- The buzzer can be muted but the lamp stays lighted till the calling party reset his switch.
- To attend a call, the called party shall also operate the relevant selector switch at his station.
- The call is now established and communication can now proceed in duplex mode over the handsets.
- After the call is over, the selector switch at both stations shall be reset to terminate the call.
- It shall also be possible to have conference facility, if required by calling other stations through relevant switches.

1.6.1 System Features

1. The system shall be of distributed amplifier type using latest state of the art technology.
2. The system shall be designed for perfectly clear and intelligible speech communication and shall have high operational reliability under adverse environmental conditions including high noise level (90 to 110 db)
3. The system shall be designed for two channels of communication i.e. in paging and private modes. In paging mode the announcement from any station shall be heard at all other stations in the respective system through respective loudspeakers while in private mode close-talk communication shall be possible between two or more stations.
4. The proposed system shall be configured as an open line system.
5. The system shall be provided with call attention tone facility preceding all paging / announcement calls.
6. Each loud speaker talk back station shall be provided with indication such as power ON, channel busy, paging control, private control etc.
7. The system shall have provision for automatic muting of the associated loudspeaker in the paging / announcement mode to avoid acoustic feedback.
8. The system shall have the facility to have interconnection with the telephone exchange for speech communication in private mode and paging mode.
9. The system shall be of modular construction for easy expansion of subscriber stations as and when required without affecting the installed equipment.

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10. The system shall be designed for continuous reliable operation and of rugged construction to withstand shock and vibration

11. The system shall be suitable for operation from a centralized 240 V +/- 10%, 50Hz +/- 5%, single phase AC mains power supply. Power supply cable shall be drawn to each subscriber location from this centralized source for each system.

1.6.1.1 Establishment of a call

1. Any person calling to communicate with another person has to go to the nearest subscriber station, lift the handset, press the “page” switch and call for the desired person.
2. A call attention gong automatically precedes the paging announcement. The paging announcement is heard on all the loudspeakers of the system except that of the calling station. After the announcement the calling person releases the “page” switch and waits for the response of the called person.
3. The called person can go to the nearest station and communicate with the calling person directly in private mode by simply lifting the handset.
4. A third person can join the conversation in conference mode. During the private mode the associated loudspeakers are free to receive paging announcement generated by other stations.

1.6.2 Equipment Details

Each system shall be distributed amplifier type and broadly consist of (but not limited to) the following:

1. Subscriber station of both desk and outdoor (pole/wall/structure mounted) type complete with built-in amplifiers, additional extension amplifiers (if required), microphones etc. as per the requirements.
2. Industrial horn type / box type loudspeakers.
3. Power supply unit.
4. Interconnecting cable networks comprising power supply cable, signal cable, loudspeaker cables, junction boxes, cable termination devices, mounting accessories & other erection accessories for the system.

1.6.3 Subscriber Stations

The subscriber stations shall be indoor desk or outdoor wall / pole mounted type as per the requirement. Desk mounted subscriber stations conforming to IP 52 shall be used in control rooms, offices, etc. while outdoor stations conforming to IP 55 shall be used for shop floor areas and outdoor applications.

The desk mounted subscriber station shall broadly comprise a desk top hand set station, an extension amplifier and false ceiling type box type loudspeaker. The desktop hand set station shall consist of line amplifier, signal processing unit, function switches, indicating lamps, etc. all housed in polystyrene case. The wall mounting type extension amplifier shall consist of a power supply unit and a plug in type power amplifier electronic module.

The pole / wall / column mounting subscriber station shall have die cast aluminum alloy (LM6) housing conforming to IP 55 and shall broadly comprise line amplifier,

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page / private channels and other functions, noise canceling microphone and receiver hand set, etc. all housed in the above mentioned housing. In addition the outdoor subscriber station shall be provided with dust, weatherproof protection cover suitable for outdoor installation. The re-entrant horn type loud speaker shall be used in conjunction with these stations.

Pilfer proof subscriber stations shall be considered for all outdoor locations where there is scope of pilferage. The subscriber station shall also have provision for direct plugging in additional higher wattage amplifier to raise the power output wherever required.

The press to talk (PTT) micro switch shall be provided in the handset itself. It shall be designed in such a manner that only when this micro-switch is pressed the microphone shall be ON. The PTT micro switch in the handset shall disconnect the line amplifier power supply to cutoff idle current in addition to cutting of microphone.

1.6.4 Amplifiers

The amplifiers shall be fully solid state using integrated circuits/ semiconductor devices and shall generally have a frequency response characteristic of +/- 3 dB between 60 Hz to 10 KHz and the response shall drop off sharply beyond the speech frequency zone to achieve maximum intelligibility under higher noise level conditions.

The design of the amplifiers shall be such as to limit the effects of external interference. It shall essentially be free from hum and have a total harmonic distortion of not more than 5% at full output.

The amplifier dynamic characteristic shall accommodate the entire dynamic range of sound signal and shall provide optimum fidelity ensuring faithful sound reproduction.

The amplifier shall be of suitable wattage and impedance to match with the speakers connected to it. The amplifiers shall be designed to operate from power supply with voltage variation of +/- 10% without much variation in output or gain. The amplifier PCB card shall be of modular construction for easy replacement.

1.6.5 Microphone

Microphone shall be of robust construction matching with amplifier input. It shall be of noise canceling type with proper directional response pattern to suppress ambient noise.

It shall be designed to limit the non-linear effects caused by external interference due to magnetic fields, mechanical vibration and wind. The microphone shall be immune to the stray magnetic fields and mechanical vibration.

It shall be provided with a gooseneck / suitable mounting / fist type for the indoor stations and shall be in built in the handset for outdoor stations.

1.6.6 Loudspeakers

The loudspeaker shall have uniform sensitivity and low frequency cutoff having suitable directional response pattern for efficient and high quality speech reproduction.

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It shall match the output of the amplifier. Necessary line matching transformer shall be provided for each loudspeaker. The loudspeaker shall be either industrial re-entrant horn type [(conforming to IP 55) or box type (conforming to IP 52)] depending upon the location where the station shall be used. The indoor box type loudspeaker shall be housed in sheet steel enclosure suitable for wall mounting.

The industrial horn type loudspeaker shall be weather proof version of die cast aluminum body with sturdy mounting bracket suitable for mounting on pole / wall /column. The driver unit shall be concealed in the horn to prevent damage due to environmental conditions and pilferage.

Peak output power shall be 10 watts for indoor box loudspeaker and 15 watts for outdoor industrial re-entrant horn type loudspeaker. Indoor false ceiling speakers shall be provided in control rooms, meeting halls etc wherever required.

1.6.7 Power Supply

The equipment shall be suitable for operation from a centralized power supply. Contractor has to tap the supply for his equipments with necessary cabling.

The power supply equipment shall be provided with protections against short circuit, over voltage, under voltage and transients.

1.6.8 Wireless Full Duplex Public Address System

The radios for the wireless duplex public address stations shall comprise of two way wireless Radio, with suitable Power supply and High gain Omni Directional Antenna, with a Industrial type, Heavy duty amplifier and a suitable Duplex filter to interface both the radios and the wireless public address stations shall be installed at suitable number of locations.

All the wireless public address system stations shall be provided in different places like machines, junction towers etc. The equipments shall be integrated with an Industrial type Horn for clear and loud communication. All the equipments except the horn shall be mounted in a suitable MS enclosure.

The stations shall be equipped for talk back facility with Press to Talk Fist Mike. The radios used shall be of MIL grade type to withstand the Industrial exposure. Individual announcement shall be possible by selective dialing of any station. All call announcements shall be possible.

The Antenna shall be of weatherproof type to avoid Electrical interferences and Lightning problems.

Features

- The Wireless PAS shall cover about 3 kms talk back range.
- Talk back shall be possible.
- It shall be possible to interface with the existing wireless units in the similar frequency band.
- The stations shall be portable and hence shifting shall be easy.
- All calls shall be in full Duplex mode.

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1.6.9 Cables for the LSTB Systems

The signal cables shall be separated from wiring of any other circuit of high voltage. When the cables are to be laid in the existing electrical cable trays of the conveyor galleries, sufficient space shall be maintained from the cables of the high voltage circuits.

Each subscriber station shall be connected to the power supply unit through a separate cable network using 3 core power supply cables. The loudspeaker cable shall be twisted pair.

Armored FRLS PVC cable shall be used when the cable is to be laid in the existing trays in cable tunnels / overhead cable galleries / overhead cable trays.

The contractor shall furnish the specification of the signal cable, power supply cable and loudspeaker cable proposed to be used in the system.

All cables used shall be made up of annealed high conductivity multi strand solid copper conductor.

All PVC armored cables shall be fire retardant low smoke type (FRLS Type) having protective system of inner and outer sheath specially designed with thermoplastic or thermosetting materials having superior resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics. The cable shall conform or corrosive characteristics.

The cable shall conform to the following stands:

- IEC –332 (Part 1)
- IEEE – 383
- IEC – 332 (Part 3)
- BS – 4066
- Swedish chimney test as per SS 4241417.

1.7 General Announcement System

The general announcement system shall facilitate for announcement / paging over 100 number of loudspeaker distributed all over the plant complex. All the *[100 nos. of speakers]* shall be provided in different places at TG hall, mill area, boiler floors, switchgear rooms, and common facility area.

The system shall be central amplifier type. The amplifiers shall be located in the telephone exchange premises and the amplifier shall be integrated with telephone exchange to make announcement from any of telephone line& should be interconnected with wireless base station for Walky-talky announcement. An announcement point shall be installed in the Main Plant control room if required.

The amplifier shall have the capacity of suitable output power inclusive of 100% stand-by capacity.

The announcement / paging shall normally be made from the main plant control room with provision of a second announcement point in the shop in charge's office.

The loudspeaker shall be operated group wise or all at a time depending upon the requirement.

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Two such systems, each having the requisite number of loudspeakers shall be provided for Unit I and Unit II for announcement of instructions and smooth flow of information between process points.

1.7.1 System Feature

General Announcement System shall have the following features:

1. The general announcement system shall ensure quality performance using the latest technology in design and manufacture of audio equipment.
2. The system shall facilitate near total reproduction of original speech or music and shall guarantee trouble free operation.
3. The system shall adopt modular construction. The amplifier rack shall be provided with input and output terminals. All connectors shall be of ELMAX type.
4. The system shall be switched on through press-to-talk (PTT) switch provided on microphone assembly, which has to be provided in main control room.
5. Suitable protection of the system against accidental wrong connection, over loading, short circuit etc. shall be provided.
6. The equipment shall be of rugged construction to withstand shock and vibration. The system shall be capable of withstanding extreme conditions of temperature and humidity.
7. The equipment shall be suitable for operation from 240 V +/- 10%, 50 Hz +/- 5%, Single phase, AC main power supply. The power supply equipment shall be provided with protections against short circuit, over voltage, under voltage & transients.

1.7.2 System Equipment

Each of the system shall broadly consist of Amplifier rack housing preamplifier, power amplifier including working and standby capacity of **[1000 W]** each with changeover facility, monitoring facilities etc.

1.7.3 Microphone Assembly

Loudspeakers (re entrant horn type / indoor box /False ceiling type) complete with mounting accessories such as poles, mounting brackets.

Cable network comprising cables, wires, junction boxes, cable termination devices, GI pipes/conduits, and all other cable laying accessories.

1.7.4 Power Amplifier

The amplifier shall be fully solid-state modular type using semiconductor devices.

The amplifier dynamic characteristics shall accommodate the entire dynamic range of the sound signal and shall provide optimum fidelity ensuring faithful reproduction of speech and music.

The stability of gain shall be fairly high. Reliable and quality components shall be used in its construction to prevent drift in their characteristics.

The amplifier shall be provided with easy to operate filter type volume and tone controls and potentiometer adjustment facility to regulate its input sensitivity.

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The amplifier shall be provided with variable high frequency boost for increased clarity of speech and music.

Power Amplifier Shall Have the Following Features-

- *[No. of channels – min. 4]*
- User adjustable input sensitivity for each channel.
- Low distortion, wide bandwidth.
- Electronic protection against overloads.
- Multiple output taps.
- *[Transformer coupled output 70V, 100V.]*
- Individual speech filters for each channel.

1.7.5 Thermal Protection

The amplifier shall be cascaded to have call facility for calling all speakers using selector switches.

1.8 Audio and Video Conference Equipments

1.8.1 General

Supply and installation of Public Address Audio and video conference microphones units in built with monitor amplifier and speaker (corded and cordless type), AF Power controller unit, Power amplifiers, hand held wireless mic, collar type wireless mic, speakers, mic cables, LCD Projector, PA Microphone, DVD Player, LED TV Set with all other accessories to conduct meetings/ seminars/ presentation.

1.8.2 Chairman and Delegate Mic (Cord Type) Units In Built With Monitor Amplifier and Speaker

The chairman and delegate mic units shall be suitable for indoor Conference / meetings / seminars and shall have the following features:

1. The mics shall be indoor desktop type to place freely on the conference table.
2. It shall have ON / OFF and indicator button and also it shall have LED to indicate Mic is ON.
3. The chairman mic shall be prior than delegate mics. It shall have power to cut delegate member's speaking.
4. The mics shall have inbuilt speaker inside with monitor amplifier and echo – control function.
5. When the Mike is being used, the inbuilt speaker shall automatically become silent in order to prevent echo.
6. The required signal cables to connect all the chairman mic and delegates mic with connect boxes shall also be supplied.
7. The mics units shall be supplied with required all other accessories to connect for complete conference.

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1.8.3 Chairman And Delegate Mic (Cordless Type) Units In Built With Monitor Amplifier And Speaker

The chairman and delegate wireless type microphones shall be ideal for Boardroom & meeting hall. It shall be possible to operate minimum 4 nos. of mics simultaneously without any frequency interference among the mics. It shall have crisp and clear sound.

The chairman and delegate mic units shall be suitable for indoor Conference/meetings/seminars and shall have the following features:

1. The mics shall be indoor desktop type to place freely on the conference table.
2. It shall have ON / OFF and indicator button and also it shall have LED to indicate Mic is ON.
3. The chairman mic shall be prior than delegate mics. It shall have power to cut delegate member's speaking.
4. The mics shall have inbuilt speaker inside with monitor amplifier and echo – control function.
5. When the Mic is being used, the inbuilt speaker shall automatically become silent in order to prevent echo.
6. The mics shall be supplied with required Receiver, Power control unit and all other accessories to connect for complete conference.

1.8.4 AF Power Control Unit

1. The power control unit, which has to be, connected to the above chairman and delegate mics shall be latest state of art, solid-state amplifier unit and shall have the following functions.
2. It shall have multi – conferences power source provider and signal enlarger system.
3. It shall have connectivity to connect one chairman microphone, and 20Nos delegate member's microphones.
4. It shall have 4-balanced mic input signals and 2 sets of Aux. output for recording or amplification.
5. It shall be possible to control chairman and delegate member's monitor speaker volume.
6. Aux volume button, mics Volume button, treble tone control button, Bass tone control button.
7. It shall be possible to combine pre amplifier and power amplifier function and connect other speakers directly.
8. It shall have voice control feature when all microphones have no input signal then member mics shall automatically turn off after 30 – 45 sec. or adopt open system.

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1.8.5 Power Amplifier (500 W)

The Power amplifier shall be highly versatile, extremely efficient, high power low distortion, solid-state amplifier. It shall be designed for continuous service and high performances reliability for sound reinforcement. The amplifier also isolate low current, low voltage circuits from high voltage elements. It enhances sonic purity and provides demonstrably superior performance. It shall deliver 500 watts (RMS) at less than 1% distortion and is ideal for use where high power and reliability are required. The unit shall operate from 230V AC (50Hz). The audio power supply capacity is designed to deal with most awkward dynamic load usually associated with real life loudspeakers and these contribute to the amplifiers excellent transient handling capability.

Features

- 500W continuous RMS output.
- Quasi-complimentary, high speed, capacitor coupled output stages.
- Fully protected against accidental short circuits, DC offsets.
- Generous convection cooled heat sinking.
- All heavy-duty chassis.
- Immunity of RF interference.
- Ideally suited for public address and quality sound reinforcement application.
- Protection from short circuit and overload.

1.8.6 VHF FM Wireless Hand Held Mic With Receiver Base Unit.

The excellent response and inbuilt protection against breath and wind noise with capability to capture sound from long distance and wide area ideal microphone for speech in the frequency range of VHF FM operation. Ideal for indoor / outdoor stages, Lecture Halls, Entertainers, TV, Interviewers etc.

- Frequency stability shall be better than +/- 5PPM.
- R F Power output shall be better than 20 milli watts.
- Effective in a range 50-100 feet.
- Standard Battery operation.
- LED indication for correct turning.
- Receiver audio output level shall be better than unbalanced 0-30 mV.
- Receiver unit shall work on 230 volt 50 Hz ac supply.]
- Telescopic Antenna in the receiver for clear and distortion free reception.

The wireless hand held type microphone shall be supplied with necessary wireless receiver/base unit, AC power supply unit, antennas, connect cables etc.

1.8.7 VHF-FM Wireless Coller Type Mic with Receiver Base Unit.

The excellent response and inbuilt protection against breath and wind noise with capability to capture sound from long distance and wide area ideal microphone for speech in the frequency range of VHF FM operations.

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- [Effective in a range 50-100 feet.]
- Ideal for stage, Lecture Halls, Entertainers, TV Interviewers etc.
- Standard Battery operation.
- LED indication for correct turning.
- Telescopic Antenna in the receiver for clear & distortion free reception.

The wireless collar type microphone shall be supplied with necessary wireless receiver/base unit, AC power supply unit, antennas, connect cables etc.

1.8.8 PA Microphones:

The excellent response and inbuilt protection against breath and wind noise with capability to capture sound from long distance and wide area ideal microphone for speech & Music.

1.8.9 Microphone Stand

The mic stand shall be floor mounting; self support type functional and resistant to superior quality to hold the above PA mics. The bottom of the stand shall be round type plate to hold the stand. The height of the stand shall be adjustable type. The stand shall be supplied with necessary holders to hold the above PA mics.

1.8.10 Column Speakers

The column speakers shall be with well-defined sound beaming pattern, and shall be ideally suited for Auditorium sound system to reduce unwanted reflection & acoustic feedback. It shall offer improved speech clarity even under different acoustic condition.

Necessary clamp shall also be supplied to fix the column speaker on wall / column.

1.8.11 False Ceiling Speaker

The ceiling speaker to meet the requirement for indoor public address or background music system installation. The unit combines a highly efficient cone speaker with an ABS plastic cover attractive design to suit any décor.

1.8.12 Horn Type Loud Speakers

[Horn type outdoor use where noise level is high. 30 Watts, 70V/100V VFT driver unit for use with a Re-entrant Reflex Horn].

1.8.13 Mic Cables and Signal Cables

The mic and signal cables shall be flexible, multistrand, shielded type for connecting the above mics.

1.8.14 LCD Projector

The LCD projector shall be state of art equipment and the quality shall support standards of RJ 45 network, TCP/IP protocols. The LCD projector shall be of high-resolution data with more than 3000 ANSI using micro lens array. It shall withstand vibrant, and shall be rich audio in focus quality video. The data projector shall be easily portable and compact size to give presentation for conference programmes.

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The projector shall support USB and PS/2 for mouse control, HDCP and digital video, wireless remote control mouse, RAM memory stick, laser pointer and backlit function for perfect presentation. A screen shall be supplied along with self supporting stand.

The LCD Projector Shall Have The Following Feature:

- IBM, VGA, S.VGA, XGA, S.XGA compatibility.
- HDTV, NTSC, PAL, SECAM standard video compatibility.
- High performance metal halide DC lamp.
- Simple setup and easy operation.
- Digital zoom function.
- Contrast brightness over lamp life time.
- Perfect picture quality in video and data.
- High resolution.
- Automatic keystone correction.

1.8.15 Specification for Portable DVD/VCD Player

1. The audio and video CD player shall be of portable type with play back control and remote control model.
2. The CD player shall function for NTSC,PAL video signals. The DVD/VCD player shall have the following features and controls:
3. Menu button, display, play, pause, stop, head phone jack, audio output terminal, video output terminal, microphone jack etc.
4. The remote control unit shall have the following features and controls:
5. On screen Display button, repeat, voice, stop, recall, program, clear, selection forward, selection previous, pause buttons, numeric buttons etc.
6. The VCD player shall work on 230 Volt.50Hz A/C supply.
7. The DVD/VCD player shall be supplied with all accessories like power cord, AC to DC converter, remote control unit, carrying case etc.

1.8.16 Technical Specification for LED Television Set

1. The LED TV set shall have been the latest band and screen. The size of the screen shall be 48 inches. A remote control unit shall control the TV set. The remote control unit shall have all functions like, band selection, auto tune, memory, timer, on screen display of commands etc.
2. The LED screen shall have input terminals of serial, parallel ports, USB ports, and shall have TV tuners, audio in, audio out, video in, video out terminals / jacks etc.
3. The LED TV set shall be supplied with necessary power cable, audio, video cables, remote unit, operational manual etc.

1.9 Cable Laying Specification

1.9.1 General

Cable shall be laid on the cable tray/racks of concrete cable trench / cable channels / cable tunnels. Wherever such facilities are not available the cable has to be buried directly in underground trench by the contractor. PVC casings shall be used for all

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indoor cables and clamped along structure or buildings as per the site conditions and requirements.

For interplant cabling communication cables shall be generally be laid in the manner as follows:

- Laid on the racks of the interplant concrete cable trench
- Directly buried in underground trench
- On the racks of the underground cable tunnels
- On racks / trays of the overhead cable galleries
- In concrete ducts / pipes buried in ground where direct burial are not possible due to presence of other service lines
- Directly on the walls / structures by clamping the cable on to the walls / structures.

Armored PVC cable shall be used when the cable is to be laid in concrete cable trench / cable tunnels / overhead cable galleries / directly clamped on the walls or structures.

For internal distribution purposes the cables from the distribution box to the individual subscriber, the cables shall be laid in the following manner:

- In office buildings for unarmored communication cables shall generally be laid through PVC casing / concealed conduits embedded in walls.
- In shop floors, sub stations, control rooms etc. communication cables shall generally be taken either through surface conduits along wall / structure or through concealed conduits embedded in wall. The conduit shall be hard PVC
- Joint markers shall be provided at every joint on the cable.
- Where cables are required to cross under roads, surface drains and pipelines, they shall be taken through GI pipes/Hume pipes.
- Whenever cables are entering inside the buildings, they shall be specially protected by means of GI pipe. After cable laying these shall be sealed with bitumen or epoxy compound to make them fully watertight and vermin proof.

1.9.2 Laying Of Cables on Walls & Structures

Perforated aluminum tray with angle iron support shall be provided (wherever required) for cable laying.

[Smaller size cables shall be clamped onto the walls / structures. Clamps shall be provided at 1 meter interval.

Plastic / aluminum cable ties shall be provided at one meter interval.

Cable identification tags on fiber glass / aluminum with nylon cord shall be provided at every 15 M interval.]

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1.9.3 Laying Of Cables in GI Pipes

Only one cable shall be taken in on pipe in the case of laying cables through GI pipes / conduits. When it is found desirable to install several cables in one pipe total section of cable shall not exceed 40% of the GI pipe internal cross section.

1.9.4 Laying Of Pipes / Conduits

1. All conduits / pipes shall be neatly run and evenly placed.
2. Jointing of conduits / pipes shall be done only in straight portions the contractor shall have at site bending facility for conduits / pipes and dies for threading of conduits / pipes.
3. Junction boxes shall be provided after every 10M run of conduits / pipes, at every bend, at every location where the telephone provision is envisaged.
4. Ends of conduits shall be provided with threads so that DBs / CTBs / conduits / accessories can be attached at a later date.
5. No separate bend pieces shall be used, pipes / conduits shall be bent wherever required.
6. The bending diameter shall not be less than six times the diameter of the conduit / pipes.
7. Exposed portion of the thread shall be painted with non-corrosive paint.
8. The end threads of conduits which shall be left for extension / mounting of accessories shall be protected with grease or any other lubricant to prevent rust / corrosion.
9. 16 SWG steel wires shall be provided inside each conduit for pulling cables.
10. Conduit shall be laid concealed in wall / column at a height of 200 mm from finished floor level.

1.9.5 Installation of Distribution Boxes:

Grouting of the support / welding to iron structures, with frames, shall be done wherever necessary. Cables shall be tested at both the ends after termination.

Junction Boxes

Junction Box shall have ELMEX type connectors. Necessary holes for cable entry for power and signal cable to be provided at the bottom of the Junction Box.

1.10 Installation of Equipment and Commissioning

1. The contractor shall be fully responsible for the satisfactory erection, testing, commissioning, start-up and trial operation of the communication system's equipment and its associated cable network.
2. All erection, testing & commissioning work shall be carried out in accordance with the requirement specified in this tender document, the standard recommended practices and best workmanship. All work shall also comply with standard norms and practices adopted by the purchaser and respective State / Central Government authorities.
3. For complete erection, testing and commissioning, the contractor shall bring all installation aids/ material, consumables, tools, test equipment and qualified and experienced personnel, in order to carry out the job successfully. A list of the same shall be furnished to the purchaser for review.

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4. All technical personnel assigned to the site by the contractor must be fully conversant with the system hardware and software.
5. The contractor shall provide and maintain an office at the site during installation, testing and commissioning stage for his staff.
6. The contractor shall make his own arrangement at his own cost for the transport of his own staff and labour to and from the site of works.
7. Appropriate storage of the materials to be supplied shall be arranged by the contractor at the site. The contractor's responsibility shall also include safety and security of the equipment at site.
8. On completion of erection and installation of all equipment, and before start up, each item of the system shall be jointly inspected by the purchaser and the contractor for correctness and completeness of the installation and acceptability to start up leading to commissioning tests.
9. The list of commissioning tests to be performed shall be mutually agreed upon and included in the contractor's quality assurance plan.
10. The commissioning spares for all items / equipment shall be included along with the commissioning services. The consumables required during the commissioning of the system shall be included as part of the commissioning spares.
11. Requisite factory and site test reports shall be supplied by the contractor.

The contractor's scope for testing and commissioning shall also include.

- Preparation for commissioning including time and personnel planning.
- Provision of all necessary measuring instrument / test equipment and qualified personnel.
- Preparation of final commissioning report.
- Demonstration of satisfactory working of the offered systems and cable networks.
- Dissolution of commissioning site and handing over of balance materials at owner store.

1.11

Schedule of Quantities

S. No	Description	Unit	Qty
I.	Telephone system		
A	Telephone Exchange		[...]
1.	A 400 line digital electronic private automatic branch telephone a with all switching, cards, modules and interface units equipped for : • 400 extension lines	System	[...]

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S. No	Description	Unit	Qty
	<ul style="list-style-type: none"> IP trunking licensed conference facility VOIP card Provision of EVM interface cards, Paging cards, VOIP cards, DECT cards, Interfacing PRI cards etc. as per requirement. PC based maintenance console with a PC and required software and other associated devices. Operator console Printer A4 colour Laser Jet one no.(HP) 		
2.	Telephone instruments (DP/DTMF type)		[...]
	a) Standard table top model /Analog phones	No.	[...]
	b) IP Phones	No	[...]
	c) Digital Phones	No.	[...]
	d) Cordless telephone sets (DECT)	No.	[...]
	e) 2 line cordless phones	No	[...]
3.	<p>Main distribution frame (Krone type) complete with protection & safety devices for termination of.</p> <ul style="list-style-type: none"> 500 pair cable on the Exchange side 1000 pair cable on the Extension side Protection for the 500 pairs on the Exchange side 	Set	[...]
4.	DECT base station	Set	[...]
5.	Float cum Boost charger suitable for taking the full load the 500 line telephone exchange with auto changeover facility from working charger to standby charger.	Set	[...]

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S. No	Description	Unit	Qty
6.	48 V battery set of suitable AH capacity (min 300AH) suitable for taking the full load of the 500 line telephone exchange for at least 8 hours in case of AC mains failure.	Set	[...]
7.	Sound Proof Telephone Booths	Nos	[...]
II	UHF Wireless system		[...]
1	Radio Site controller	No.	[...]
2	Repeater base station	No.	[...]
3	Antenna system consisting of Omni-directional Antenna	No.	[...]
4	Transmitter combiner	No.	[...]
5	Receiver Multi coupler	No.	[...]
6	Low loss RF cable to connect antenna to the system	Mtrs.	[...]
7	System Management Terminal	Set	[...]
8	Portable type programming kit for field use	No.	[...]
9	Portable subscriber radio (Walkie Talkie Sets)	No.	[...]
10	Fixed Radio	No.	[...]
11	Telephones to interconnect unit to connect 3 telephone lines	Set	[...]
12	Suitable self supported tower of height 45 meters.	No.	[...]
13	4 hrs. back up UPS for UHF Communication system	No.	[...]
III.	Loudspeaker talk-back system		[...]

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S. No	Description	Unit	Qty
A.	Supply of main equipment and cable		[...]
1	Desk mounted subscriber station	No.	[...]
2	Wall / column mounted subscriber station complete with weather proof and pilfer proof housing.	No.	[...]
3	Station junction box.	No.	[...]
4	Box type loudspeaker (6 watt) with JB	No.	[...]
5	Horn type loudspeaker (15 watt) with JB	No.	[...]
6	Power supply unit including UPS for one hour for the complete system	Set	[...]
7	Wireless Full Duplex Public Address system	set	[...]
IV.	General Announcement system		[...]
1	Microphone assembly with Amplifier (including Main and Standby)	set	[...]
2	Box type speaker	set	[...]
3	Horn type speaker	set	[...]
4	False ceiling type speaker	set	[...]
5	Power supply unit including UPS for one hour for the complete system	Set	[...]
V	Audio Conference Equipments (one set consists of the following equipment)	Set	[...]

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S. No	Description	Unit	Qty
1	Chairman Mic (corded type)	No	[...]
2	Deligate mic (corded type)	No	[...]
3	AF Power Control Unit	No	[...]
4	Power Amplifier (500 watts)	No	[...]
5	Hand held type wireless VHF FM Mic set	No	[...]
6	PA microphone with stand	Nos	[...]
7	Portable 3-way loudspeaker with stand	Nos	[...]
8	Signal cables	mtrs	[...]
9	LCD projector and its accessories	No	[...]
10	DVD player	No	[...]
11	LED TV set	No	[...]
VI	Cable and accessories communication system	Lot	[...]

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2

COMMUNICATION CABLES

2.1

Loudspeaker Talk Back System (LSTB) Cable Specification

Table: 2.1

LSTB Signal Cable Specification

S.No.	Property	Specific Requirement
1	GENERAL	
	CABLE TYPE	PVC insulated, Overall Screened, extruded, PVC inner sheathed, armoured and overall FRLS PVC sheathed Signal cable
	APPLICABLE STANDARDS	BS:5308-II/86, IS:1554-I/88, IS:8130/84, IS:5831/84, IS:3975/88 and this data sheet
	NOS. OF PAIRS	5 PAIR
2	CONDUCTOR	
	Material	Stranded Annealed Tinned Copper
	Grade	Electrolytic
	Size	0.5 sq.mm
	No. of strands/appx. strand size	16 Nos./0.2 mm
	Shape of conductor	Stranded circular
3	INSULATION	
	Material	PVC Type-A of IS:5831/84
	Type	Extruded
	Thickness(Min.)	0.6 mm
	Pair Identification	Pairs shall be colour coded White + Blue, White + Orange , White + Green
	No. Of Twists (for pair)	Min. 10 Twists/Mtr
4	OVERALL SCREEN	
	Material	Al-Mylar Type
	Type	Helical
	Thickness (Min.)	0.040 mm
	Overlap/coverage	25/100%
5	DRAIN WIRE	
	Material	Stranded annealed tinned copper
	Size of drain wire	0.75 Sq.mm
	No.of Strands/appx.strand size	24 Nos./0.2mm

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**Table: 2.2
Loudspeaker Signal Cable Specification**

S.No.	Property	Specific Requirement
1	General	
	CABLE TYPE	PVC insulated, extruded, PVC inner sheathed, armoured and overall FRLS PVC sheathed Loud Speaker cable
	APPLICABLE STANDARDS	IS:694/90, IS:8130/84, IS:1554-I/88, BS:5308-II/86,IS:5831/84, IS:3975/88, and this data sheet
	NOS. OF CORES	4 Cores
	NO. OF TWISTS	Min.10 twists /Mtr
2	CONDUCTOR	
	Material	Stranded Annealed Tinned Copper
	Grade	Electrolytic
	Size	0.75 sq.mm
	No. of strands/appx. strand size	24 Nos./0.2 MM
	Shape of conductor	Stranded circular
3	INSULATION	
	Material	PVC Type-A of IS:5831/84
	Type	Extruded
	Thickness(Min.)	0.6 mm
	Colour Scheme	Red,and Black
4	INNER SHEATH	
	Material	PVC Type-ST1 of IS:5831/84
	Type	Extruded
	Thickness (Min.)	0.3mm
	Colour	Black
5	ARMOUR	
	Material	Galvanized steel round wire
	Type	Single layer
	Size of armour (Nom.)	0.9 mm

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Table: 2.3
LSTB Power Cable Specification

S.No.	Property	Specific Requirement
1	General	
	CABLE TYPE	PVC insulated, extruded, PVC inner sheathed, armoured and overall FRLS PVC sheathed cable
	APPLICABLE STANDARDS	IS:1554-I/88, IS:8130/84,,IS:5831/84, IS:3975/88 and this data sheet
	NOS. OF CORES	3 Core
2	CONDUCTOR	
		Stranded annealed bare copper
	Grade	Electrolytic
	Size	2.5 sq.mm
	No. of strands/appx. strand size	7 No.
	Shape of conductor	Stranded circular
3	INSULATION	
	Material	PVC Type-A of IS:5831/84
	Type	Extruded
	Thickness(Min.)	0.8 mm
	Colour Scheme	Red, Black and Green
4	INNER SHEATH	
	Material	PVC Type-ST1 of IS:5831/84
	Type	Extruded
	Thickness (Min.)	0.3mm
	Colour	Black
5	ARMOUR	
	Material	Galvanized steel round wire
	Type	Single layer
	Size of armour (Nom.)	0.9 mm

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2.2 Telecommunication Cable Specification

2.2.1 Telecommunication Cables (Voice & Data)

**Table: 2.4
STP Outside Plant Cable (Copper)**

S.No.	Property	Specific Requirement
1	Conductor	Solid annealed copper; 22 AWG (0.64mm)
2	Insulation	High density polyethylene
3	Pairs	Twisted Pairs
4	Shielding System	ASPIC-F/CASPIC-F
5	Cable Assembly	25 Pair binder; North American Color coding; PMP filling compound.
6	Core Covering	Non-hygroscopic dielectric tape.
7	Jacket	Virgin, black, high molecular weight low density polyethylene.
8	High Voltage Test (dc Voltage for 3 seconds)	
	a) Conductor to Conductor	5000 Vdc
	b) Conductor to Shield	15000Vdc
9	Capacitance Unbalance (pF/km)	
	a) Pair to Pair (less than 12 Pairs)	181(pF/km)
	b) Pair to Pair (larger than12 Pairs)	45.3(pF/km)
	c) Pair to Ground (less than 12 Pairs)	2655(pF/km)
	d) Pair to Ground (larger than12 Pairs)	656(pF/km)

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S.No.	Property	Specific Requirement
10	d-c Cond. Res. @20°C	58(Ω/Km)
11	Resistance Unbalance (Max. Ave.)	1.50%
12	Mutual Capacitance Deviation, Max.rms	3%
13	Ave. Mutual Capacitance:	
	a) less than 18 Pairs	52±4 nF/Km
	b) larger than 18 Pairs	52±4 nF/Km
14	Far end Cross Talk loss:150KHz@20°C dB/Km.	
	a) rms minimum	67.8 dB/Km.
	b) Minimum Individual	57.8 dB/Km.
15	Insulation Resistance@20°C/Megohm-Km	16000 Megohm-Km

2.2.2 UTP Distribution Cable (Voice and Data)

- a) Distribution Cable (for voice)
- Unshielded Twisted Pair (UTP)
 - 100 ohms; solid conductor
 - 4-pair x 23 AWG
 - Shall meet Category 6 cable specification
- b) Distribution Cable (for data/indoor type)
- Unshielded Twisted Pair (UTP)
 - 100 ohms; solid conductor
 - 4-pair x 23 AWG
 - Shall meet Category 6 cable specification
 - Ratings shall be in accordance with specific area classifications
- c) Distribution Cable (for data/outdoor type)
- Unshielded Twisted Pair (UTP)
 - 100 ohms; solid conductor
 - 4-pair x 23 AWG
 - Shall meet Category 6 cable specification for outdoor application.
 - Ratings shall be in accordance with specific area classifications

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Table: 2.5
UTP Distribution Cable (Voice and Data)

S.No.	Property	Specific Requirement
1	Conductor	Solid annealed copper; 24 AWG (0.50mm)
2	Insulation	High density polyethylene
3	Pairs	Twisted Pairs
4	Shielding System	Category 3-CMR/CMP
5	Cable Assembly	25 Pair binder; North American Color coding
6	Core Covering	Non-hygroscopic dielectric tape.
7	Jacket	CMR-Flame Retardant PVC (Polyvinyl Chloride); CMP-Low Smoke FR-PVC (Polyvinyl Chloride).

2.2.3

Specifications of Optical Fiber Cables (OFC)

- OFC shall be installed on cable tray, duct bank, cable trench installation as necessary. For outdoor applications the cable shall be armoured with Poly Ethylene sheathing. In all cases cable shall be routed through suitable grade HDPE permanently lubricated protection pipe as per IS-4984, IS-12235 & TEC.G/CDS-08/01 of suitable size @ 53% fill factor.
- The optical fiber core shall be of ultrapure fused silica glass coated with UV cured acrylate suitable to withstand temperature of about 80 deg. Centigrade continuously.
- OFC shall be 4 / 8 / 12 core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor / indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multi-mode fibers on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties & to be identified with the manufacturer's name, year of manufacture, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
- The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. steel central member, Loose buffer tube design, 4 fibers per buffer tube (minimum), Interstices and buffer tubes duly filled with

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Thixotropic jelly or better material etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile 1000 N minimum. The compressive strength of cable shall be 3000N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 DegC to 70 DegC.

5. The splicing loss of any two fibers in any case shall not exceed 0.10db/splice.
6. The total additional attenuation above the nominal attenuation due to regular splices, repair splices, connectors, temperature variation, ageing etc. shall be indicated.
7. Fiber coloring shall conform to EIA/TIA-598. The color-coding shall be permanent thus withstanding normal handling; e.g., during termination, testing, or cable relocation. Refer to EIA – 359 for color identification and coding.
8. Cables shall be designed & tested in accordance with ISO 11801, TIA-568 & ICEA 596 and Performance specifications shall be measured in accordance with the Fiber Optic test procedures(EIA/TIA -455 documents) test procedures of IEC-60793 & IEC-60794
9. The OFC shall generally conform to the following specifications:

Table 2.6
Specifications for Single Mode Optical Fiber

S.No	Feature		Minimum Requirement
1	Maximum Un-cabled Attenuation Coefficient	@ 1310 nm	0.4 dB/km
		@ 1550 nm	0.3 dB/km
2	Mode field Diameter	@ 1310 nm	9.2±0.4 µm
		@ 1550 nm	10.4±0.8 µm
3	Maximum Cable Cut-off Wavelength		1260 nm
4	Maximum Zero Dispersion Wavelength		1321.5 nm
5	Minimum Zero Dispersion Wavelength		1301.5 nm
6	Maximum Zero Dispersion Slope		0.092 ps/nm ² ·km
7	Maximum Polarization Mode Dispersion		0.2 ps/√ km
8	Gigabit Ethernet Length 1000BASE-LX		2-5000 mtrs.
9	Ten Gigabit Ethernet Length	10GBASE-LX	2-10000 mtrs.
		10GBASE-LX4	2-10000 mtrs.

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S.No	Feature	Minimum Requirement
10	Maximum Core/cladding Concentricity Error	0.5 μ m
11	Cladding Diameter	125.0 \pm 1.0 μ m
12	Cladding Non-circularity	1 %
13	Coating Diameter	245 \pm 5 μ m
14	Maximum Coating Concentricity Error	12.5 μ m
15	Temperature Dependence (-60 to +85C)	0.05 dB/km
16	Temperature & Humidity Cycling (-10 to + 85C, 4 to 90% RH)	0.05 dB/km
17	Minimum Proof Test	100 kpsi
18	Bending Induced Attenuation (100 turns, 75mm diameter)	0.5 dB

Table 2.7
Specifications for Multi Mode Optical Fiber

S.No.	Feature	Minimum Requirement
1	Maximum Un-cabled Attenuation Coefficient	@850 nm 3 dB/km
		@1300 nm 0.7 dB/km
2	Overfilled Launch Bandwidth	@850 nm 200 MHz.km
		@1300 nm 500 MHz.km
3	Gigabit Ethernet Length	1000BASE-SX 2-300 mtrs.
		1000BASE-LX 2-550 mtrs.
4	Ten Gigabit Ethernet Length	10GBASE-SR 2-33 mtrs.
		10GBASE-LX4 2-300 mtrs.
5	Numerical Aperture	0.275 \pm 0.015
6	Core Diameter	62.5 \pm 3.0 μ m

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S.No.	Feature	Minimum Requirement
7	Maximum Core Non-circularity	6 %
8	Maximum Core/cladding Concentricity Error	3 μ m
9	Cladding Diameter	125.0 \pm 2.0 μ m
10	Cladding Non-circularity	2 %
11	Coating Diameter	245 \pm 10 μ m
12	Maximum Coating Concentricity Error	12.5 μ m
13	Temperature Dependence (-60 to +85C)	0.2 dB/km
14	Temperature & Humidity Cycling (-10 to +85C, 4 to 90% RH)	0.2 dB/km
15	Minimum Proof Test	100 kpsi
16	Bending Induced Attenuation (100 turns, 75mm diameter)	0.5 dB

10. The cables shall be supplied in non-returnable strong wooden (or alternatively steel) drums provided with lagging of adequate strength, constructed to protect the cable against any damage and displacement during transit, storage and subsequent handling and stringing operations in the field.

11. Test on Fiber optic cable:

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-II
SECTION-II, PART-D
DETAILED TECHNICAL SPECIFICATION-CIVIL**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

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**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)**

**VOLUME-II,
SECTION-II, PART-D
DETAILED TECHNICAL SPECIFICATION-CVIL**

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1 CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

1.1 Introduction

This specification covers the design, preparation of general arrangement, construction as well as fabrication drawings, supply of all labour as well as materials and construction of all civil, structural as well as architectural work on EPC basis for Renovation and Modernisation of Electrical Balance of Plant structures for the existing [Name of project...] of [210/215/220/250] MW capacity. Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope shall be as per Volume-II, Section-I, CIVIL SCOPE OF WORK.

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2 [BUILDINGS & STRUCTURES

Design and construction of new buildings, structures, foundations etc. as well as repairing / retrofitting of existing buildings, structures, foundations shall take into account requirement for operation and maintenance of all equipments and its users. The buildings will have good architectural features. The surrounding areas shall be properly micro levelled and graded. The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials fittings and finishes.

- *Due consideration shall be given for adequate natural lighting and ventilation for both plant and non-plant buildings.*
- *Retrofitting / repair works / new constructions shall not cause damage to the existing structures. The temporary supports shall not be allowed on the existing structures for any of these works unless the loads are minor and may not cause any damage to any existing structure. However in such a case Bidder shall take approval from the Owner/Consultant prior to initiating the work.*
- *Internal finishes shall be provided with latest available materials approved by Owner/Consultant with due consideration of the functional aspect of the area.*
- *External finishes shall be provided with latest materials approved by Owner/Consultant for improving the aesthetics.*
- *The orientation of the important buildings shall be in line with the existing site condition and function as such.*
- *Each building shall have its own identity. However, a total homogeneity shall be maintained in the design of all buildings.*
- *Adequate frontage shall be provided to all important buildings to create a better visual impact.*
- *All other civil and structural buildings shall be developed in conjunction with the above aspects.*

All Civil, Structural and Architectural works of the following systems shall be covered under this package.

- a) Substation & Switchyard structures*
- b) Transformer pits*
- c) Switch Yard Control Room*
- d) Power Transformers Foundations (GSU, UAT, Etc.)*
- e) GCB foundation and supporting structures*
- f) GIS Building (if applicable)*

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- g) Fire walls
- h) Illumination system structures
- i) Any building inadvertently left out in the above list, however required for proper functioning of the power plant as per system requirement stipulated under Electrical & IC section of this specification shall also be included.]

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3 DESIGN REQUIREMENTS

3.1 Location

Geographical location of the plant site is approximately between [11°34'00" N] to [11°35'00" N], Latitude and [79°26'00" E] to [79°27'00" E], Longitude.

3.2 Ground Condition

Subsurface condition: The natural ground surface level approximately varies from [60 m to 74.5 m] from MSL.

[The soil profile in the plant area can be broadly classified into 3 layers namely laterite, cemented sand and cemented silt in general as per detail soil investigation report. Top soil upto a depth ranging from 0.4 m to 0.75 m is entirely non-uniform. The underlying layer is laterite whose depth varies from 4.0 m to 5.5 m followed by deep layers of cemented silt and cemented sand].

The ground water table (GWT) at finished ground level shall be considered for foundation design purposes.

The detailed soil investigation report conducted for plant shall be made available to Bidder for required replacement / refurbishment / retrofitting of Foundations, if any.

Bidder is advised to carefully study the content of detailed Soil investigation report for the existing type of foundations and design of new ones.

The type, size, depth of the foundation shall be based on the detail soil investigation report provided by OWNER.

3.3 Climatic Condition

a) Temperature

Maximum : [.....] °C

Minimum : [.....] °C

For design purpose, maximum temperature to be considered: [50.0] °C

minimum temperature to be considered: [.....] °C.

b) Rain fall

Minimum : [..... mm in May]

Maximum : [..... mm in October]

Peak hourly rain fall: [....mm] (corresponding to 50 years return period)

[Note: Maximum per day rainfall as per weather report has been considered conservatively as peak hourly rain fall which will be used for drainage system design etc.]

Annual average: [..... mm to mm & average mm]

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3.4 Seismic Zone

The site is located in [Zone II] as per IS: 1893-2002. Zone factor shall be [0.10]. Importance factor shall be considered as [1.75].

3.5 Wind Zone

The site is located in wind speed zone [...] m/s] as per IS: 875 (Part 3)-1987.

3.6 Loads and Load Combinations

All new structures shall be designed and old structures requiring modification shall be checked for the most critical combinations of dead loads, imposed loads, equipment loads, wind loads, seismic loads, temperature loads, forces developed due to differential settlement and any other loading conditions which can occur during the design life of the facility.

(a) Dead Loads

Dead loads consist of the weights of the complete structure with finishes, fixtures, partitions, wall panels and all existing / modified / replaced equipments of semi-permanent nature including storage structures (Tanks, bins etc.) partitions, roofing, piping, cable trays, bus ducts etc. The content of storage structures etc. shall be measured at full capacity for this purpose.

The piping loads (for empty, operating and test conditions), cable tray loads and the contents of the storage structures shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing load for uplift.

The following unit weight of material shall be considered for computation of loads. Loads given in IS: 875 (part-I) shall be made use of for material not listed below.

Table 2.1
Weights of Material

Material	Unit weight (kN/m ³)
Plain cement concrete	24.0
Reinforced cement concrete	25.0
Structural steel	78.5
Brick work	19.0
Cement plaster	21.0
Floor Finish	24.0

(b) Superimposed Live Load (SILL)

Listed below is the minimum SILL for the areas involved. Floors and supporting members subjected to heavy equipment live loads shall be designed on the basis of the equipment loads specified by vendor or specifically defined SILL whichever is greater.

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The specific minimum floor SILL is listed below:

Table 2.2
Superimposed Live Load (SILL).

S.No	Description	SILL Value
a)	Roof	
	Flat accessible roof	1.5 kN/m ²
	Flat accessible roof with HVAC equipments, etc.	5 kN/m ²
	Flat inaccessible roof	0.75 kN/m ²
	Sloped Roof	As per code IS: 875 (Part-2)
b)	All building floors & Stairs	5 kN/m ²
c)	M.C.C. Floor	10 kN/m ²
d)	Equipment Load	As applicable
e)	Underground basement,	Surcharge of 10 kN/m ²
f)	Vehicular traffic	Surcharge of 20 kN/m ²
g)	Covers for Channels	Surcharge of 10 kN/m ²
h)	Other areas:	
	• RCC floors (Offices, laboratories, conference rooms and general floors)	5 kN/m ²
	• Balconies	5 kN/m ²
	• Chequered plate / gratings	5 kN/m ²
	• Walkways	3 kN/m ²
	• Toilets	2 kN/m ²

- In addition to LL, Hung loads for electrical, ventilation & air conditioning minimum of 0.5 kN/m² shall be considered.
- Load of 1 kN/m² shall be considered as hung load for piping unless otherwise mentioned. However, the actual loads will be as furnished by the supplier. The stringent most will be followed.
- For other areas LL shall be considered as per IS: 875 (Part-2).

(c) Seismic Load

The proposed plant is located in Seismic [Zone-I] as per IS: 1893, Seismic force on the structures will be considered accordingly.

(d) Wind Load

The proposed plant is located in Wind Speed Zone of [...] m/s] as per IS: 875 (Part 3). The wind force on the structures will be considered as follows:

Table 2.3
Wind Speeds

Description	Wind Speed
Basic Wind Speed V _b (at 10m above mean ground level)	[50 m/sec]

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Description	Wind Speed
Risk coefficient K1 (for 100 years)	[1.07]
Category of terrain	[Category 1]
Factor K2	As per IS: 875
Topography factor K3	As per IS: 875

For the design of structures, wind force on Equipment, supported on frame including all fixtures, piping, staircase, ladder, etc, shall be considered.

Design of structures shall be checked for the condition of wind load with gust factor.

(e) Earth Pressure Loads

For earth pressure the worst condition with dry / submerged and active, passive or at rest shall be considered. The pressure coefficient shall be adopted as recommended in Soil Report or for the backfill material used.

(f) Temperature Loads

The total temperature variation shall be considered as $2/3^{\text{rd}}$ of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the average between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50 % of the total considered temperature variation with temperature load applied with positive and negative sense.

For design purpose average maximum annual variation shall be taken as $[+50^{\circ}\text{C}]$ to $+5^{\circ}\text{C}$.

Coefficient of thermal expansion of steel shall be taken as per IS: 800 where the value is given as $12 \times 10^{-6}/^{\circ}\text{C}$. Coefficient for thermal expansion for concrete shall be taken as per IS: 456.

(g) Thermal Loads (during operating condition)

When thermal loads (such as produced by temperature changes in piping, equipment and structures) results in friction between equipment and supports (exchangers) or piping and supports, the friction force will be taken as the operating load on the support multiplied by the applicable friction coefficient given below:

Table 2.4
Thermal Loads

Description	Value
Surfaces	Friction coefficient
Rolling supports	0.05
Steel to steel	0.30 (longitudinal) and 0.10 (lateral)

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Description	Value
Concrete to steel	0.30

(h) Equipment Loads

Static and dynamic loads of major existing / modified / replaced equipments shall be based on the manufacturer's data of the specified equipments and shall be considered in design in addition to the live load.

Equipments to be tested for hydraulic test, tanks and piping design loading shall include hydraulic test loading. Weight of equipments, ducts, tanks, pipes, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads applicable.

(i) Cranes, Hoists, Monorail and Elevator loads

All lifting beams and monorails shall have their design loads increased for impact factor. Loads for overhead cranes, hoists, monorails and elevators shall be taken as per IS: 875.

100 % of the lifted load including elevator live load plus the cab weight shall be considered for the elevator support beam design. Pedestals in elevator pits shall be designed assuming impact factor as per IS codes.

(j) Vibration and Noise

The design shall ensure that vibrations from any moving machinery transmitted from its immediate foundations to adjacent buildings or areas of the same building shall be suppressed in accordance with the recommendations of relevant codes of practice.

(k) Other Loads

- Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance loads, creep and shrinkage shall also be considered in design of all structures.
- Roof girders / trusses in the service / maintenance bay shall be designed for crane erection loads.
- Dust loads

All buildings / structures shall be designed for a dust load of 1 kN/m² for flat roof and 0.5 kN/m² for sloped roof.

- Construction /Erection/Maintenance Loads

The integrity of the structures shall be maintained without use of temporary framing struts or ties and cable bracing as far as possible. However, construction or access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure

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the stability and integrity of the structures during any periods involving use of temporary bracing systems.

- Future Loads

Loads from future expansion shall be considered when so directed by the Owner/Consultant. Future loads may include any of the loads listed above.

- Surge Loads

Surge loads may occur in some vessels or equipment. In such cases, the magnitude and direction of the load shall be given by the equipment supplier.

(l) Basic Load Cases

Following basic loads shall be considered for analysis and design:

Dead load	: DL
Superimposed dead load	: SIDL
Self weight of permanent equipment	: EL
Steam piping (Static & Dynamic) & other piping loads	: PL
Cable loads	: CL
Live load on floor / walkway	: LL
Superimposed live load	: SILL
Live load on roof	: LLR
Seismic load	: SL
Wind load	: WL
Load due to soil pressure	: SP
Load due to surcharge	: SCL
Load due to hydrostatic pressure	: HP
Load due to temperature	: TL
Hoist, monorail loads	: MR1
Crane Loads	: CLR
Special loads	: SPL

(m) Load Combinations

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load combinations shall be taken as per IS: 456, IS: 800 & IS: 875 (all parts) and other relevant IS codes.

Wind and seismic forces shall not be considered to act simultaneously.

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Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loading.

(n) Load Combinations for underground structures

- For the design of sub structure only liquid pressure from inside and no earth pressure and ground water Pressure and surcharge pressure from outside (applicable only to the Structures which are liable to be filled with water or any other liquid) shall be checked.
- For the design of sub structure combination of earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside shall be applied.

(o) Switchyard Structures

The loading for the design of switchyard structures shall be as per IS: 802 Part 1/Sec 1:1995. Following loads shall be considered.

- Dead load due to equipment and structure
- Wind load on towers, gantries, conductors, ground wires and insulator strings calculated as per Clause 8 and 9 of IS: 802.
- Temperature effects consisting of effect of temperature variation and sag tension as per clause 10 of IS: 802
- Climatic loads as per Clause 11.2 of IS: 802
- Anti cascading loads as per clause 11.3.1 of IS: 802
- Torsional and longitudinal loads caused by breakage of conductor as per Clause 11.3.2 and 16 of IS: 802.
- Construction and maintenance loads
- Seismic loads as per IS: 1893
- Short circuit forces including "snap effect" in the case of bundled conductors

Switchyard structure shall be designed for the worst combination of above loads. The factor of safety for design of members shall be considered as 2 for normal & broken wire conditions and 1.5 for combined short circuit and broken wire conditions. Short circuit forces and wind forces shall not be considered simultaneously.

Foundation shall be designed for a factor of safety 2.2 for normal and broken wire condition and 1.65 for combined short circuit and broken wire conditions. Design of foundation shall be carried out as per IS: 4091.

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4 EARTHWORK AND ROCKWORK

4.1 General

This section applies to all earth and rockwork required for the replacement / refurbishment / retrofitting of existing foundations or construction of new buildings foundations (if any), any types of structure and burying service lines in the ground.

The Bidder shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the detailed soil investigation and of the available information and instruction given in writing by the Owner/Consultant.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Owner/Consultant. All necessary precautions shall be taken to cause the minimum possible alteration or disturbance to the other existing foundations, material lying under and adjacent to the excavation final lines.

4.2 Fill Materials

The fill materials used and source are to be examined and approved. Excavation materials can be used if they fulfil the requirements.

a) Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials, which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas etc.

b) Ordinary fill shall have the following properties:

- Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.
- The intention is to use ordinary fill for non-built areas.

c) Special fill:

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- Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks.

4.3 Excavation

The works shall be excavated either by hand or by use of excavating plant and tools acceptable to the Owner/Consultant.

Last 300 mm shall be excavated by hand tools only to ensure that natural conditions of soil at foundation level should not be disturbed. In case if over excavation has been done, the depth of soil over excavated shall be filled with M10 Grade concrete and no earth filling shall be allowed to fill over excavated earth.

Also excavation by hand may be required close to existing installations, existing foundations and/or underground services, but subject to special instruction of the Owner/Consultant.

The Bidder shall carry out all kind of earth and rockwork for the following particular works as defined hereafter (where applicable):-

- Clearing and grubbing
- Excavation of topsoil
- Open cut excavation
- Backfilling
- Safety precaution during earthwork
- Mining or underground excavation (if required)
- Grading
- Replacement of material
- Trench excavation for service lines
- Embankments
- Archaeological findings

4.4 Safety Precautions

The Bidder shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc shall be to the Bidder's debit. The additional moving of soil resulting from such damages will not be paid for.

4.5 Over Excavation

Bidder shall ensure that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

4.6 Stockpiles and Disposal

Excavated material from the works selected by the Owner/Consultant for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on site as directed by the Owner/Consultant.

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The Bidder shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Owner and shall not be permanently deposited elsewhere. The Bidder shall trim and form the edges of spoil to profiles and levels as directed by the Owner/Consultant. Distance of stockpiling of excavated material from the pit edge shall be minimum 1.5 meters or half of the depth of the pit whichever is higher.

The placing of materials within the waste disposal areas shall be made in layers not exceeding 0.50 m in thickness in order to obtain an appreciable degree of compaction by means of transportation equipment and/or if required by appropriate compaction equipment.

All traffic to or from the waste disposal areas shall run over the surface of such areas in order to achieve compaction.

4.7 Preparation of Foundation

All earth surfaces against which concrete is to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Owner/Consultant and then protected by means of a lean concrete layer, 7.5 cm or PCC thickness as shown in the design drawings, whichever is greater. No concrete is to be poured until formation is inspected and approved by the Owner/Consultant. No structural concrete shall be poured against earth surface. Shuttering shall be used at sides and PCC shall be provided below foundations.

4.8 Backfilling

Foundations and structures shall be backfilled with approved material compacted in layers not exceeding 150 mm by suitable equipment upto the required designed levels. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Owner/Consultant.

Density requirements as per standard Proctor Test shall be in accordance with relevant parts of IS: 2720 and all tests shall be made by/on under the supervision of Owner/Consultant at Bidder's own expenses, at optimum moisture content:

- a) Backfilling of foundations and under grade slabs - 98%
- b) Under roadways and parking areas - 98%
- c) Embankment - 95%

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Owner/Consultant after compaction tests have been made.

Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the sub-grade.

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Backfilling of foundation work with approved materials shall be carried out only after foundations have been inspected by the Owner/Consultant.

4.9 Soil Replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange. The suitability of soil for its use for filling shall be as per provisions of Indian Standards.

Prior to the commencement of work, three samples shall be taken from the anticipated borrow area and tested in respect of IS: 2720 or Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

These three samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of not more than 15 cm in compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for watering of soils.

The fill material shall be compacted by vibratory roller (min. weight 20T.). However for small compaction works such as small patches etc., comparatively low weight compactors or other compaction methods may be used after taking approval from Owner / Consultant. The minimum required degree of compaction should be as defined under "Tests and Properties". One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Owner/Consultant. The Bidder shall either provide all required laboratory facilities and staff to perform the tests or he shall co-operate with an experienced soil testing laboratory, subject to the approval of the Owner/Consultant.

Filling work may be continued in case all tests performed show satisfactory results.

4.10 Protection of Existing Utilities and Services

During modification/rehabilitation of existing structures or construction of new structures, the Bidder shall provide all protection for existing utilities and services as may be required by his modification and construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Owner/Consultant.

In addition to the requirements as specified, herein the Bidder shall comply with the following requirements:

- a) Use all necessary precautionary and protective measures required to maintain existing structures, utilities, services and appurtenances that must be kept in operation. In particular, the Bidder shall take adequate measures to prevent undermining of existing structures and utilities/services presently in service.

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- b) Protect existing or new utilities and services where required by the Bidder's operations and/or as directed by the Owner/Consultant. The Bidder shall be responsible for bracing and supporting existing structures, utilities and services to prevent settlement, displacement or damage.

4.11 Dust Control

The Bidder shall use all means necessary to control dust on roads, dismantling/demolition and modification areas, construction areas and borrow pits.

Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

4.12 Dewatering during Construction

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the detail soil investigation and/or information given in writing by the Owner/Consultant.

Ground water control for keeping the construction pits dry shall be included in the Bidder's scope of work.

The method and technique shall be based on the IS: 3764.

The scope of supply includes removal of all equipment, plants, pipes, machinery, etc for modification /rehabilitation of existing foundations and re-installation of all equipment, plants, pipes, machinery, etc and its removal after completion including operation & maintenance of the equipment during the construction period.

The Bidder must ensure that any dewatering works will not cause any interference to his own work and to those of other Bidders working elsewhere on site. Any damage occurring during the above mentioned period should then be made good by the Bidder at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least *[0.50]* m below the foundation level.

4.13 Equipments

All equipments, instruments, machineries, tools, pipelines, etc required for execution of the water control shall be kept in good working condition throughout the operation period.

4.14 Execution

The Bidder shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to the

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Owner/Consultant for information and checking every working day. For that purpose, the lowering of the water table shall be controlled by piezometers. The numbers and position of them shall be submitted to the Owner/Consultant's approval. The Bidder shall provide and maintain these piezometers at his own expenses during the dewatering works or as long as the Owner/Consultant requires it.

Pump operations shall not be stopped nor pipes, channels and equipment for dewatering and water control removed or altered in any way, except with the express permission of the Owner/Consultant. The Owner/Consultant will stipulate the time of removal. Until then, the pumps and water drainage facilities shall be kept in proper working order without extra payment being granted.

Difficulties during dewatering:

The Bidder shall consider all difficulties and additional work due to the presence of unexpected ground water during subsequent construction work. Where it is possible to keep off or divert such water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from Owner/Consultant has been obtained.

Ready for service condition:

The Bidder shall maintain ready for service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by the Owner/Consultant in this matter shall be carried out immediately.

Leakage:

Blockouts and pipe connections through structures and their closure, proper grouting of joints, etc or repairs in the event of leakage shall be the responsibility of the Bidder.

Piezometers:

The ground water lowering effect is to be checked by piezometers in unfavourable positions (e.g. in the middle of the building pit) before starting the excavation.

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5 REINFORCED CONCRETE STRUCTURES AND FOUNDATIONS

5.1 General

All structures, building foundations, machines / equipment foundation, water retaining structures, trenches, pits, etc. shall be checked / designed as per latest relevant IS codes in general. Construction in general shall follow provisions of IS: 456 and IS: 3370 for normal and water retaining structures respectively.

5.2 Design Methodology

(a) General

All designs of RCC structures shall be carried out by limit state method as per IS: 456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456.

IS: 11384 shall be followed for design of steel concrete composite beam.

For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

(b) Foundation and Underground Structures

Type of foundation system, i.e. isolated, strip, raft shall be decided based on the loading arrangement, load intensity and soil strata. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

Foundation system adopted shall ensure that settlement / relative settlement is as per provision of IS: 1904 and other Indian Standards. However, the settlement shall be restricted to a lower value, if necessary as per the system requirement.

All foundation including machine / equipment foundations shall be of RCC construction. All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian standards IS: 2974 and IS: 456. Raft foundations shall be designed as per IS: 2950.

All foundations shall be treated as per the guidelines prescribed in IS 456: 2000 against sulphate/other aggressive chemicals if found present in soil or as per the requirements of detail Geotechnical Investigation Report.

For design of underground structures, subsoil water level shall be assumed at Finished Ground level. All underground pits, tunnels, basements, cable and pipe trenches, etc. shall be designed as leak proof RCC structure, where depth of ground water table so warrants. In case of leakage in the above structures injection grouting method shall be applied to repair the structure according to the requirement of IS: 6494. Effects of uplift and reduction in bearing capacity due to underground water table shall also be considered.

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For Subsoil conditions, Average ground water table, Foundation system, Earth Pressure Coefficient, refer to detail geo-technical investigation report of the site.

The soil conditions met during the foundation works especially in the foundation level are to be checked by the Bidder's soil Engineer, recorded and compared with previous known or investigated results. If essential differences occur, which could be detrimental to the structures, the Bidder has to inform the Owner/Consultant and to propose further measures. Foundation works in such areas are to be continued only after approval of such measures by the Owner/Consultant

If there is any doubt about the soil quality or if discrepancies appear with regard to the previous decisions or investigations stated by the Owner/Consultant, then additional measures are to be taken after consulting the Owner/Consultant (e.g. additional excavation and lean concrete fill)

Allowable settlements, elastic plus consolidation, shall be limited as follows: -

- i) Total settlement : 38 mm
- ii) Differential settlement : 6 mm

Foundations for equipment shall be designed to meet the total and differential settlement established by the equipment manufacturer if they are more stringent than the allowable settlements listed above. Foundations for buildings shall be designed to meet the total and differential settlement as required for the building function if they are more stringent than the allowable settlements listed above.

(c) Movement and Expansion Joints

Joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc do not adversely affect the structures. This primarily applies to differently loaded areas and structures having different foundations or foundations of different depths. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations.

The joint width is to be at least 2 cm is to be planned considering all relevant factors (settlements, tilting, movements, aspects etc.).

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to IS: 8009 – "Code of Practice for calculation of settlement of foundation".

(d) Foundations at Different Depths

Foundations at different levels should be based beyond a load-spread angle of 30° (against the horizontal). Otherwise, the load influence (e.g. earth pressure) of the higher-level structures on the lower ones must be taken into consideration.

(e) Replacement

If unsuitable soils are encountered below the grade slabs or basement floor, they are to be replaced by suitable layer wise compacted material down to the good bearing soil.

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Materials and compaction method as well as quality control are described in clause 'Earth and Rockworks' of this section. Selected fill is to be employed below all grade paving and basement floors.

(f) Modification of the existing foundation (as required) for the new equipment supplied

The new equipment shall be supported on an RCC deck which in turn shall be supported over steel helical springs and viscous dampers. The steel helical springs and viscous dampers shall be supported over structural steel beams which in turn shall rest over columns. The columns shall be supported over foundation. The modification of existing foundation may involve partial to full dismantling and reconstruction of new foundation as per design & constraints of space.

Precautions shall be taken not to disturb the basic building structure & other foundation and it shall be ensured that no excavation work is carried out beyond the founding level of existing nearby building/equipment. Any damage to adjoining structure/ foundation shall be rectified by the Bidder without any extra cost to Owner.

The contractor shall be responsible for maintaining all safety norms including the stability of existing structures. Any propping, shoring and under pinning required to this effect shall be put in place before the dismantling work is undertaken.

Wherever any existing concrete member is required to be partially dismantled, a coat of epoxy paint shall be applied to the exposed reinforcement and the cut surface of concrete shall be built up by providing 40 mm thick concrete with wire mesh.

(g) Machine Foundations

General

Design of equipment foundation for block type machine foundation (if any) shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in mind the existing structural arrangement and space limitation.

The design of machine / equipment foundation shall be as per IS: 456 and IS: 2974. The provisions of DIN 4024 shall also be followed for machine foundations. All machine / equipment foundations and structures subject to vibrations shall be suitably proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

For the foundations supporting minor equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor

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equipment is to be supported on building structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining part of building and other foundations. Joints at floor/ slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitable to ensure integral action.

The extent of foundation shall be based on the general arrangement of the equipment and the design requirement. However minimum width of any foundation shall not be less than one meter. Water table has to be considered at finished ground level for design of all foundations.

Suitable arrangement shall be made for prevention of transmission of vibration from the proposed foundation to the nearby structure/ foundation/ paving slab.

All design calculations and drawings shall be submitted to Owner for approval.

In case any modification to any existing nearby structural steel bracing/support system/ concrete work is required, the contractor shall check the adequacy of the design of the existing structures for the new loads. Suitable modification to the existing structure as required shall be carried out by the contractor.

Loose pockets if any found below the foundation shall be removed and filled up with PCC of grade M10.

Loads

All static and dynamic forces / loads which equipment supplier considers applicable shall be considered for analysis and design of machine foundations.

Foundation Sizing

The outline plan dimensions of foundations as given by the machine supplier will be adopted. The height of foundation will be selected after taking into consideration soil strata and operating level of the machine. The eccentricity of common CG of machine and foundation with respect to the centroid of base area should not exceed 5 % of the corresponding base dimensions of foundation. Partial contact between the foundation and soil strata shall be considered wherever applicable. The footing will be checked for minimum contact area of 80 % and maximum bearing pressure will be calculated for the actual contact area only.

Analysis and Design

The minimum grade of reinforced cement concrete shall be M25, unless specified otherwise.

The analysis and design of machine foundations will be carried out to ensure the following:

- Compliance with the manufacturer's requirements and relevant standards
- No resonance phenomenon of a disturbing nature to machine operation should exist at the normal running speed

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- Calculations to be performed for dynamic as well as static cases for reinforced concrete block type pedestal
- Soil bearing capacities
- Deep foundation capacities
- Lateral earth pressures
- Allowable settlements
- Structure, equipment and environmental loadings
- Equipment performance criteria
- Access and maintenance requirements
- Temporary construction loadings

The foundation will be designed for the most critical combinations of forces and moments, resulting from all possible combinations of the various loading from the equipment system. The foundation sections will be sized and reinforced adequately for bending moments and shear stresses and uplift.

The foundation shall be checked for overturning, sliding and uplift as per relevant IS Codes. The foundation will be checked for overturning with minimum and maximum vertical loads.

For analysis of machine foundation following data will be furnished by the equipment manufacturer:

- Loading diagram showing static and dynamic loads and points of application of loads
- Operating speed of machine
- Weight of rotating parts, maximum eccentricity of rotating mass from the geometric axis of rotation
- Location of C.G. of machines in all three axis
- Mass moment of inertia
- Allowable amplitude / velocity of vibration at machine bearing points
- Temperatures at various areas during operation

While designing following aspects shall also be taken care of:

- All dynamic foundations shall be isolated from building foundations. The isolation gap shall be of minimum 25 mm.
- Natural frequencies of structures and components shall be away from running speed of equipment by at least 20 % generally but for important ones it shall be away by at least 30 %.
- For design of foundation of large fans etc., provision shall be kept in the foundation for addition of mass / area for retaining of the foundations if required at a later date

However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral loads shall be 1.5
- Factor of safety against sliding shall be 1.5

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- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5. Uplift check shall be carried out during construction stage also.

For miscellaneous machines, most suitable type of foundation shall be provided. Foundation for pumps, and minor rotating equipment etc., are usually in the form of solid block foundations, resting on the ground or on a floor of the building. At such machine supports, floor may be thickened and extra reinforcement may be provided. Also the machines, which are almost vibration free, light to moderately heavy, may be supported in the above manner. Rubber or neoprene pads under some of these machines to reduce transmission of vibrations to the supporting floor will be provided if required.

All block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456. Suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system shall be designed suitably. All such foundation shall be separated from adjoining foundations.

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25°C when placed. For maintaining the temperature of 25°C in the top decks of machine foundations, crushed ice shall be used in mixing water.

Non-Shrink Grout for Equipment Foundations

Special non-shrinking grout of approved make shall be provided in strict accordance with the manufacturer's instructions / specifications. Ready mix non-shrink grout of GP2 brand or equivalent, of approved make shall be used for base grouting of major rotating equipments.

(h) Increase in Stresses

Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

Bearing capacity of the soil shall be allowed to be increased by 25 % under seismic/ wind load condition.

(i) Elevated Foundations

Design of all equipment foundations shall be done for the actual equipment loading data. The foundation arrangement shall be decided keeping in view the existing structural arrangement and space limitation. Adequacy of the design of the existing structures, for the new loads shall be, checked by the contractor. Suitable modification as required shall be carried out by the Contractor and complete design for the same shall be furnished to owner for approval. Where

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ever new columns/foundation is required the same shall be designed and constructed by the contractor as per relevant Indian Standard Code.

For the foundations of the all equipments details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic forces as per IS:1893. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Design of RCC foundations/as well as structures, checking of design of existing structure shall be carried out by working stress method. A fatigue factor of 2.0 shall be considered for dynamic forces.

The foundation general arrangement shall be such that the spring units are placed over the structural steel beams. The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The vibration amplitudes at the bearing locations shall not exceed the limits as per VDI 2060 or limits specified by the machine supplier whichever is more stringent. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

The grade of concrete for the top deck shall be M35.

(j) Steel Helical Springs and Viscous Dampers

The supporting structural beam and columns shall be designed for the loads transferred through springs and all other loads such as piping loads, seismic loads as per IS:1893. The stiffness of the beams supporting the springs shall be at least 10 times the stiffness of the springs supported over it along both vertical and horizontal direction.

The scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implied for the successful completion of the work for which these specifications are intended.

Scope of work of the bidder shall include manufacturing, testing, supply, transport to site, pre-stressing, erection, supervision of erection, release of pre-stress, alignment, commissioning etc of Steel helical springs and viscous dampers:

- Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
- Frames for pre-stressing of spring elements.
- Suitable hydraulic jack system including electric pumps, high- pressure tubes etc. required for the installation, alignment etc, of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.
- Any other items which may be required for the complete installation and satisfactory commissioning of the spring system.

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Supervision of complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

The steel helical springs and viscous dampers supplied should be of proven make. The bidder or his sub-contractor should have designed spring supported machine foundations, manufactured, supplied and installed steel helical springs and viscous dampers (conforming to DIN 2096 & DIN2089) and viscous dampers (providing damping resistance in all three planes) for not less than 2 (two) machine foundations of heavy rotating machine systems.

The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of units.

All design calculations and drawings shall be submitted to Owner for approval.

5.3 Stability of Structures

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like underground storage tanks, pits, trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For the purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area of the base slab shall be taken in to consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS: 456 and other latest relevant IS codes. However following minimum factor of safety shall be followed:

- Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum
- Factor of safety against sliding shall be 1.5 minimum
- Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In cases where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

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5.4 Minimum Thickness of Concrete Structural Elements

The following minimum thickness shall be followed:

Table 2.5
Minimum Thickness of Concrete

S.No	Description	Thickness, mm
a)	Suspended floor / slab / walkways /canopy slabs, etc.	125
b)	Ground floor slab (non-suspended)	150
c)	Water Retaining slabs / walls	200
d)	Cable/pipe trenches/underground pits/Launder walls and base slab	125
e)	All footings (including raft foundations)	300
f)	Parapets	125
g)	Sunshades	75 at edge
h)	Precast louvers / fins	50
i)	Precast trench cover slabs / floor slabs / louvers	75
j)	Paving	100
k)	Basement walls and base slab	200
l)	Underground tank:	
	Below ground water table	200
	Above ground water table	150

From fire resistance point of view minimum cover to reinforced concrete members shall be as per Table 16A of IS: 456.

5.5 Minimum Heights for Pedestal of Steel Columns

Pedestals to Steel Columns for building structures:

Top of RCC foundations (pedestals) shall normally be kept at a minimum [250 mm] above finished floor level (FFL) unless specified otherwise. Foundation levels for columns shall be decided to accommodate underground services, pits, trenches, etc.

Stair and ladder pedestal shall be kept [200 mm] above the finished floor level.

Pedestals to Steel Columns for Equipment structures:

a) Equipment in open area : as required [(300 mm min)]

b) Equipment in covered area : as required [(150 mm min)]

c) Structures and equipment

Supplied by vendor : as per vendor's data subject to minimum as specified above.

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5.6 Minimum heights for encasement of steel columns

In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following:

- a) Open area : [300 mm] above paved level
- b) Covered area : [150 mm] above FFL

5.7 Concrete Works

i) General Description, Proportions and Mixing

Mix Design

At the commencement of the contract the Bidder shall make preliminary tests to determine the proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling and placing and when concrete hardens, it shall have the required strength, durability and surface finish. The Bidder shall get approval of Owner/Consultant to such proportions before he starts concreting. However, such approval shall not relieve the Bidder of his responsibility to produce concrete having compressive strengths as laid down in the foregoing Table.

No departure from the approved proportions will be permitted during the works unless and until the Owner/Consultant gives written authorisation for any change in proportion. The Owner/Consultant shall have authority at any time to check whether the mixing of concrete is being carried out according to the approved proportions.

For the all major and important R.C. works and for all special works, the design of mixes shall be made by the Bidder at his own cost, for each grade of concrete as well as for various workability. The design of mixes shall be made according to I.S. 10262 or any other approved standard methods.

The concrete made by designing the mix is termed hereinafter as "Design Mix Concrete".

The cement content for various grades of concrete shall be based on design mix. However, irrespective of requirement of cement found out from design mix, cement content of concrete shall not be reduced below the quantities specified as under.

Grade of concrete	Minimum cement content per Cu.m finished concrete
M-15	290 kg
M-20	320 kg
M-25	380 kg

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Grade of concrete	Minimum cement content per Cu.m finished concrete
M-30	not less than 400 kg
M-35	not less than 400 kg

Water Cement Ratio

Where a particular water cement ratio is stipulated in the design or drawing along with the characteristic grade of concrete the design of mix shall be carried out by adjusting the other variable factors to obtain the characteristic strength of concrete with stipulated water cement ratio.

In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, such as water retaining structures, basements, underground premises, tunnels, pump houses, pre-stressed structure, thin precast members etc. the water cement ratio shall be kept low and preferably not exceeding 0.45.

The water cement ratio, as achieved in the Mix Design, or as specified in the drawings shall be adhered to strictly and shall not be varied without the permission of the Owner/Consultant.

Workability

The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling & placing so that after compaction it becomes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

The workability of fresh concrete at the place of batching/mixing shall be measured by compacting factor test and at the place of disposition by means of slump test. During the finalisation of Trial Mixes, the relationship between compacting factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS:1199.

Normally, in the condition of low water cement ratio as well as for medium/high workability, the workability shall be achieved by increasing the cement content, in consistent with added water.

In cases where the cement content is to be limited to reduce the heat of hydration, and the water/cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of plasticiser or air entraining agent. In such cases the method of mixing and dosage of the plasticiser/air entraining agent shall be according to the manufacturer's specification and with the approval of the Owner/Consultant.

The usual limits of consistency for various types of structures are given below:

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Limits of consistency

Degree of Workability	Slump in mm with Standard - Cone		Use for which concrete is suitable as per IS : 1199
	Minimum	Maximum	
Very low	0.0	25.0	Large mass concrete structure with heavy compaction equipment, roads and the like.
Low	25.0	50.0	Uncongested wide and shallow R.C.C structures
Medium	25.0	75.0	Deep but wide R.C.C structures with congestion of reinforcement and inserts
High	75.0	125.0	Very narrow and deep R.C.C structures with congestion due to reinforcement and Inserts

Durability

The durability of concrete, depending on the exposure condition, is to be taken into account while designing the mix. For given aggregates, the cement content should be sufficient to make sufficiently low water cement ratio and Appendix A of IS: 456 shall be taken as guideline for durability considerations.

Minimum fire rating of 2 hours shall be considered where fire hazard is expected and accordingly minimum cover shall be taken as per Table 16 A of IS: 456. For structures below ground level which are exposed to sulphate attack, requirement of cement shall be as per Table 5 of IS: 456. Intermixing of different grades of concrete in the same structure shall not be allowed in a particular element.

Mix design concrete shall be used for all areas other than plain concrete work used for lean concrete, screeds and backfill.

The following minimum grades of concrete as per IS: 456 shall generally be used for the type of structures noted against each grade.

Table 2.6
Grades of Concrete

Concrete mix/Grade	Type of structure
1:5:10	Fill concrete
1:4:8	Blinding layer below foundations, trenches and underground structures, foundation below brick wall, etc. Minimum thickness of layer shall be 75 mm
M15	Plinth protection work around buildings

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Concrete mix/Grade	Type of structure
M25	Base plate encasement, encasement of structural steel work, all RCC paving work, ground floor slabs, cable and pipe trenches, precast concrete work etc.
M30	All RCC structures and equipment foundations, super structure, grade beams, columns, roof slabs and all underground RCC structures, cable and pipe rack foundation, pedestals etc. water retaining structures below and above ground etc.

Inter mixing of different grade of concrete in the same structure shall not be allowed normally.

ii) Trial Mixes

- Before concreting commences, the Bidder shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation. Only materials which the Bidder intends to use for concreting (including all admixtures) shall be used in the trial mixes.
- Test cubes from trial mixes shall be made and tested in accordance with IS: 516.
- As per IS: 456 and IS: 516, three separate batches of concrete should be made, workability of each batch determined and three test cubes shall be made from each batch for each age (e.g. for 7 and 28 days) at which tests are required. The strength shall conform to target mean strength as per IS: 456 – Requirements for design mixes.
- The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength and if the average strength of the nine cubes is not less than recommended by IS: 456 and IS: 516, trial mixes.

iii) Quality and Testing

Not more than 5% of the test results may fall below the 28 days specified strength. Making and curing of test specimens shall be in accordance with relevant IS: 456, IS: 516 and IS: 1199.

All mixes can only be placed following approval by the Owner/Consultant. The mean strength shall exceed the characteristic strength by a margin of 1.65 times the standards deviation expected from the batching plant. However, no standard deviation less than 3.5 N/mm² shall be used as a basis for designing a mix.

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iv) Trial Mixes and Field Tests

Sufficient laboratory trial mixes shall be prepared to show that concrete complies fully with the specified performance criteria. The following tests are to be included:

- Air content < 1%
- Slump: Piles 170 + 25 mm, regular work 80 + 20 mm as per IS: 1199
- Fresh and hardened concrete densities
- Field trial mixes shall be carried out under full-scale site conditions as per IS: 4925 (for structural concrete only).
- Where directed by the Owner/Consultant, concrete incorporating reinforcement details shall be cored to assess stratification of mixes. Cores of 150 x 200 mm (diameter and length) shall be used.
- Each trial mix shall have 9 x (150 x 150 x 150 mm) cubes taken to measure 24 hours/7 days and 28 day compressive strengths. These trials shall be run for three consecutive days (for structural concrete only).
- At least 3 x sets of field trials shall be tested according to the provisions laid down in laboratory testing.
- The average 28 day characteristic strength for trial mixes shall be as per IS: 456.. Failure to comply shall result in the mix having to be re-designed.
- All test results shall have to be complied before approval can be given.

v) Consistency of Concrete

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests measured in accordance with IS: 1199 and shall not exceed the values given in clause 7.1 of IS: 456-2000.

vi) Mixing of Concrete

- The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 1 (one) cubic meter and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way and shall comply with the requirements of IS: 456, IS: 1791 and IS: 12119.
- The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in colour and for not less than 2 (two) minutes after all the materials and water are in the drum.
- Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

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Bidder shall make suitable arrangements for carrying out all the necessary quality tests and ensure that testing work shall be carried out in compliance with the standards.

5.8 Strength of Concrete

i) Testing of fresh concrete by means of test cubes

- a) All test cubes shall be made and tested for compressive strength in accordance with IS: 456, IS: 516 and IS: 1199.
 - b) The minimum required strength for different classes of concrete shall be as shown in clause "General description and proportions and mixing" here above.
- c) The grade of concrete required will depend partly on the particular use and the characteristic strength needed to provide the structure with adequate ultimate strength and partly on the exposure conditions and the cover provided to any reinforcement.
- d) A minimum of four test samples (of six test cubes each) shall be taken on each concreting day (from the same mix) and for at least each 40 m³ of concrete mixed. At least one sample shall be taken for each shift.
- e) For columns, beams and cantilevers seven (7) cubes for every 15 m³ of concrete poured shall be taken. The concrete for test samples shall be taken directly from the concrete mixer and shall be handled (vibrated etc) under similar conditions to those prevailing during the construction. The moulds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.
- f) The strength level of each type and each strength concrete will be evaluated separately and the concrete strength will be considered satisfactory if:
 - Compressive strength: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:-
 - The mean strength determined from any group of four consecutive test results complies with the appropriate limits in column 2 of table 11 of IS: 456.
 - Any individual test result complies with the appropriate limits in column 3 of table 11 of IS: 456.
 - Flexural strength: When both the following conditions are met, the concrete complies with the specified flexural strength:-
 - The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm².
 - The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm².
- g) If the results are less than those specified, the Owner must suspend all concreting work and order further tests. Any concrete found not to comply

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with the specification shall be broken out and replaced to the satisfaction of the owner.

- h) The Bidder shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

ii) Testing of concrete in structures

- a) The types of tests described hereinafter are applicable to the finished parts of the structures. They may be used in routine inspection and for quality control.

b) Type of tests:

- Cutting cores: The procedure used shall comply with the requirements of IS: 516 or an approved equivalent standard.
- Gamma radiography: The testing shall be carried out in accordance with the requirement of IS: 13311, part 1 or equivalent.
- Ultrasonic test: Such tests may be used to obtain approximate indications of the strength of the concrete in the structures (IS: 13311, part 1).
- Electromagnetic cover measuring devices: Such tests may be used to verify the position of the reinforcement and shall be in accordance with the requirements of design (IS: 13311, part 1).
- Rebound hammer test: Such tests may be used to obtain approximate indications of the strength of the concrete (Ref. IS: 13311, part 2).
- Load tests of structures or parts of structures: If the results of the above mentioned check tests show that the quality of the materials is inadequate or if other defects are revealed, the owner may require a loading test to be made.

- c) For the purpose of testing floors, roofs and similar structures and their supports, the test load shall be equivalent to the sum of the characteristic dead load and one-and-a quarter times (1.25 times) the characteristic imposed load for a period of 24 hours which the works or part thereof to be tested have been designed.

- d) Wherever certain procedures for testing of parts in structures are required by standards or codes of practice, these are to be followed. All tests must be conducted in the presence of the Owner/Consultant.

- e) If within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under superimposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.

- f) If the result of the test is not satisfactory, the Owner/Consultant shall instruct that the part of the works concerned be taken down or cut and reconstructed to comply with this specification. The Bidder shall at his own cost take down or cut out and reconstruct the defective work.

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- g) The Owner/Consultant may require other tests to be made. Number of samples, tests and types will be as per Owner requirements.
- h) All the costs for the above mentioned tests shall be borne by the Bidder.

5.9 Materials

a) Storage of materials

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Storage of materials shall conform to IS-4082 "Recommendation on stacking and storage of construction materials and components at site". Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Bidder.

b) Cement

OPC/PPC Cement of reputed make conforming to relevant codes, shall be used for all Concreting works and the certificate of manufacturer shall be furnished with each batch. Cement used shall be ordinary Portland cement unless the chemical nature of the soil warrants special cement for structures below ground level.

Sampling and Testing of Cement

- All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties as required by relevant IS: 8112 for grade 43 and IS-12330 for sulphate resistant cement.
- The manufacturer's test certificate will normally be accepted as proof of compliance with the specification, but the Owner may order further tests of a character specified in the appropriate Indian standards. The confirmatory tests are to be conducted by a recognized quality control organization. The Bidder shall bear all expenses required for the preparation, dispatch, and tests of the samples. In case the results of such tests show any sample to be inferior to specifications, the whole consignment from which the sample was taken shall not be used and shall be immediately removed from the site.

Delivery and Storage of Cement

- The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture, date of original loading, destinations en-route, date of unloading, intended date of delivery to site.
- The Bidder shall obtain and provide to the owner the manufacturer's average test certificate for each consignment of cement to the works.
- The certificates shall be provided before the consignments are required for use and shall show the chemical composition and physical properties determined in accordance with the relevant standard.

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- Samples shall be taken from each consignment of cement and tested as directed by the owner in an approved independent laboratory.
- Consignments shall be used in the order in which they were delivered.
- Bagged cement shall be stored in a weatherproof building having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements shall be fully completed and approved by the owner before any cement is delivered to site.
- Each consignment of cement shall be separately stored for ease of access, identification, inspection and sampling. Sufficient stocks shall be maintained on site to ensure the proper progress of the works and the stock holdings shall be to the approval of the owner.
- No cement from any consignment shall be used in permanent works without the approval of the owner.
- Cement which contains air-set or hardened lumps, re-powdered air-set material, foreign matter or which has been contaminated or is otherwise unsatisfactory in the opinion of the Owner/Consultant will be rejected and shall be removed from site without delay.
- The Bidder shall be responsible for satisfying himself that the performance characteristics of cement are not such as to necessitate excessive cement content or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete notwithstanding apparent compliance with this specification.

c) Reinforcing steel

General

Reinforcing steel used in reinforced concrete shall comply with the following standards:-

Deformed bars shall be of grade Fe500 and conform to IS: 1786.

Mild steel shall conform to IS: 432.

Mesh reinforcement shall conform to IS: 1566.

Binding wire

Binding wire for general use shall be annealed wire 16/18/20 BWG conforming to IS 280. The number of strands shall be as per IS specification.

Reinforcement supports

- Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing; supporting, and fastening the reinforcement.
- Spacers shall be cast from concrete of the same quality as that in which they will be embedded.

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- Concrete block spacers shall be cast in metal moulds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.
- Binding wire shall be incorporated into the blocks to enable them to be securely attached to vertical or horizontal bars and the Bidder shall demonstrate both that the blocks are of the requisite strength and that the means of attachment to the reinforcement are adequate.

Certificates

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analyzed and the date of such tests and analyses and that such tests and analyses comply in all respects with the standards. The following tests shall be carried out on reinforcement:-

- Cast analysis
- Carbon equivalent value
- Tensile strength, yield stress, elongation
- Bend test
- Bond classification
- Chemical analysis

Stock of reinforcing steel

In order to ensure due progress of the works, the Bidder shall at all times maintain on the site a stock of reinforcing steel sufficient for the following month's work. No reinforcing steel shall be used upon the works until it has been accepted as satisfactory by the Owner/Consultant.

Rejection

The owner at his discretion may order random testing of the reinforcement steel and in the event of any failed test reject the entire lot notwithstanding the manufacturer's or coating applicator's certificates.

The Bidder shall remove all rejected reinforcing steel from the site without delay at his own expense.

Storage

All bars for reinforcement and steel fabric reinforcement shall be stored on the site under cover on timber or concrete supports suitably spaced and of sufficient height to keep the steel not less than 150 mm clear of the ground.

Bar-bending Schedules

The Bidder shall prepare bar bending schedules based on the detailed reinforcement drawings. These shall be presented to the Owner/Consultant for review. The Bidder is fully responsible for their completeness and correctness in every way nor shall any claim for extra cost or time be allowed on the grounds of errors or discrepancies which may arise between drawings and schedules.

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d) Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. pH value of water shall not be less than 6.

Only potable water shall be used. Tests and quality of water shall be in accordance with IS: 456 or equivalent.

e) Aggregates

General

The aggregates for concrete shall be crushed natural rock subject to Owner's approval.

The aggregate to be used in the work shall be supplied from an established pit or quarry.

The concrete supplier shall obtain from the aggregate producer, or otherwise provide current test, examination, and inspection reports performed and certified by an approved laboratory for submittal to the Owner/Consultant.

As a minimum, this information shall include the following items:-

- **Item 1**

A comprehensive description, with current photographs of the pit or quarry, including but not limited to, identification by name and location, type of deposit, age, potential reserves, primary products by size including average gradation based on previous six (6) months production and the range for each sieve size; mining methods, process equipment, quality control organization and laboratory; the primary and alternate means of product transportation; listing of primary and secondary users of the product.

- **Item 2**

Petrographic examination in accordance with IS: 2386 (Part-8) and ASTM C-295 performed by a qualified concrete aggregate petrographer. This report shall be based on material produced and examined within the previous six (6) months and must be representative of the current production.

- **Item 3**

Coarse aggregate shall be sampled from current production in accordance with IS: 2386 (Part 1 to 8). Three [20 mm, 10 mm & 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:

IS 2386(Part 1): Methods of test for aggregates for cement: Part 1
Particle size and shape (Amendments 3)

IS 2386(Part 2): Methods of test for aggregates for concrete: Part 2
Estimation of deleterious materials and organic
impurities (Amendment 1)

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IS 2386(Part 3):	Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking
IS 2386(Part 4):	Methods of test for aggregates for concrete: Part 4 Mechanical properties (Amendments 3)
IS 2386(Part 5):	Methods of test for aggregates for concrete: Part 5 Soundness
IS 2386(Part 6):	Methods of test for aggregates for concrete: Part 6 Measuring mortar making properties of fine aggregates (Amendments 2)
IS 2386(Part 7):	Methods of test for aggregates for concrete: Part 7 Alkali aggregate reactivity
IS 2386(Part 8):	Methods of test for aggregates for concrete: Part 8 Petrographic examination
ASTM C-295	Standard guide for petrographic examination of aggregates for concrete

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the Owner/Consultant shall meet the requirements of IS: 383 and IS: 456.

Testing is to be carried out at the following intervals:

Table 2.7
Grades of Concrete

Type	Coarse Agg.	Fine Agg.
Grading	Daily	Daily
Specific Gravity	7 days	7 days
Magn Sulphate soundness	30 days	-
Clay, Silt and dust content	Daily	Daily
Shape (elongation and flakiness)	3.5 days	-
Los Angeles Abrasion	Initial stage only	Initial stage only
Moisture content	2 days	Daily
Drying shrinkage	Initial only	Initial only
Organic impurities	30 days	30 days
10% fines value for concrete	7 days	-

Combined grading shall also be done on a daily basis.

Storage and handling of aggregates

- Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent wind blown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.

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- Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect against wind blown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.
- Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.
- Rescreening Coarse Aggregate: Rescreening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If rescreening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.
- Natural or manufactured sand shall be allowed to drain until it has reached somewhat uniform moisture content before it is used.

Fine Aggregate

Fine aggregate source shall be manufactured crushed stone or river sand, excluding fines, which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone nor 4% for natural sand.

The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

Crushed Stone Sand

- i) Concrete subject to abrasion 1% by weight
- ii) All other concrete 3% by weight

There shall be no clay or fine silt present.

The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on an IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS: 383.

The grading of the aggregates should be such as to produce a concrete of the specified proportions, which will work readily into position without segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should

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be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of silt adhering to the aggregate is found to be unacceptably high.

Coarse Aggregate

Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The unit weight of the coarse aggregate shall not be less than 2.5 t/m³. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm² when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

Samples of aggregates shall be submitted to the Owner/Consultant, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the Owner/Consultant have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

f) Concrete additives

Use of Concrete Additives

Concrete additives approved by the Owner/Consultant shall be used to improve consistency, workability, quality and strength of the concrete.

Chemical admixtures manufacturer shall provide certified test reports from qualified independent laboratories showing actual test results indicating material that complies in all respects with the applicable specification.

Admixtures used in concrete shall conform to the appropriate specification and requirements as indicated below:-

- Air entraining admixtures shall conform to IS: 9103.
- Water reducing and retarding admixtures shall conform to IS: 9103. Accelerating admixtures shall not be used.
- High range water reducers shall be naphthalene-sulfonated polymer based material. No admixtures containing chlorides shall be used.
- Chemical admixture suppliers shall provide certified test reports with each shipment indicating compliance with the appropriate specification. The test reports shall include the chloride content of the admixture, specific gravity and solids content.
- Fibers: Polypropylene fibers shall be collated, fibrillated polypropylene fiber of approved manufacture.

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- Admixtures used in production of concrete shall be the same as used in establishing the required concrete mix and shall be used in accordance with the manufacturer's directions.
- Liquid admixtures shall be stored in such a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations

Accelerating and Retarding Additives

Such additives shall only be used in case of necessity and after obtaining the written approval of the Owner/Consultant.

Plasticizers and Air entraining Additives

Plasticizers and air entrainers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Owner/Consultant and in accordance with the manufacturer's instructions.

5.10 Dismantling/Demolishing and Modification in PCC&RCC

- The dismantling implies, carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of a structure. This includes chipping work, cutting of reinforcement, making holes/opening etc. in concrete members, according to the required shape, size and profile at all elevations.
- The term demolition implies, taking up or down or breaking up of a structure/member, in part or full, as specified or shown in the drawings or as directed by Engineer.
- In a structural member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as directed by the Engineer.
- All material obtained from the demolition/dismantling work shall be property of the Owner, unless otherwise specified.
- All serviceable materials obtained, shall be separated out and stacked properly upto a lead of [500 meter] or shall be returned to OWNER's stores and all unserviceable materials, rubbish etc., shall be disposed off as directed by the Engineer, upto a lead of [2kms].
- The dismantling / demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process or work.
- Necessary propping, shoring and under pinning shall be provided for safety of adjoining work or property which is to be left intact, before dismantling/demolishing work.
- All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall

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be taken to keep the dust nuisance down. Safety requirements stipulated in IS: 4130 shall also be followed.

- As and where necessary, the dismantled/demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Engineer. Wherever required, temporary enclosures shall be erected to minimize the dust or moisture infiltration.
- Wherever fresh concrete is laid over old concrete, to ensure proper bond between old concrete and fresh concrete, the surface of old concrete shall be thoroughly cleared by removing all loose particles and coat of epoxy paint shall be applied.

5.11 Minimum Cover to Foundation Bolts

Minimum distance from the centre line of foundation / anchor bolt to edge of pedestal shall be the maximum of the following:

Clear distance from the edge of base plate / base frames to the outer edge of the pedestal shall be minimum 50 mm

Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm

Clear distance from the edge of sleeve or anchor plate to the edge of pedestal shall be 75 mm

5.12 Miscellaneous Requirements

Fillets at the junction of roof and vertical walls shall be provided with cast in-situ cement concrete 1:2:4 (nominal mix) followed by 12 mm thick 1:4 cement mortar.

A screed layer not less than 100 mm thick of cast in-situ concrete of nominal mix 1:3:6 shall be provided below all water retaining structures. A sliding layer of craft paper or bitumen paper shall be provided over the screed layer to destroy the bond between screed and base slab.

Plywood formwork shall be used for all water retaining / conveying structures and for all over ground concrete works. For other areas steel/ plywood formwork shall be used.

Unless specified 20 mm and down graded aggregates shall be used for all structural concrete works. However 40 mm and down graded aggregates may also be used under special conditions for foundation.

Tolerance for formed and concrete dimension shall be as per IS: 456.

5.13 Major Equipment Foundation

Special requirements for concreting of major equipment foundations shall be as given below:

Coarse Aggregates

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Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali aggregate reaction. Materials, which contain high percentage of reactive silica, shall not be used. In exceptional cases of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations, which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundations).

Temperature Control of Concrete

The temperature of fresh concrete shall not exceed 25° C when placed. For maintaining the temperature of 25° C in the top deck of machine foundations, crushed ice shall be used in mixing water.

Admixture

Plasticizer cum retarder/accelerating type admixture shall generally be added to the concrete for promoting workability in addition to retarding / accelerating setting time for mass concreting work. The Bidder shall submit the mixing proportion/report after conducting the design mix as per the relevant codes and standards. The slump of concrete shall generally be in the range given below:

Block foundation	: 100mm to 150mm
Column	: 100mm to 150mm

Formwork

Plywood formwork shall be used for the top deck of all machine foundations. Any other type of formwork required to be used may be permitted subject to prior approval of the OWNER/CONSULTANT after submission of the required data.

Scheme for Concreting

Batching plants shall be mobilized for all RCC works. Concrete pump shall be mobilized for foundations. Arrangements for stand-by Plant and Equipments shall also be made.

Placing of Concrete

Base mat as well as top deck of machine Foundations shall be cast in a single pour. However the BIDDER shall submit method statements for various structures and shall get the prior approval from the OWNER/CONSULTANT before placing the concrete.

Ultrasonic Testing

Ultrasonic pulse velocity test shall be carried out for the top deck of all machine foundations to ascertain the homogeneity and integrity of concrete. In addition, additional cubes (at the rate of one cube per 150 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values. Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the BIDDER shall rectify the defects suitably using cement / epoxy grout etc.

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5.14 Transport of Concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods, which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

The Concrete shall be transported by transit mixers of adequate capacity. Before using concrete pumps, placer pipelines, chutes or spouts it is necessary to have the written approval of the Owner/Consultant.

The Bidder shall obtain permission well in advance of any concrete pour.

5.15 Concreting Operations

Inspection prior to Concreting

All concreting methods shall be subject to the approval of the Owner/Consultant.

Concrete placing shall not be started until the Owner/Consultant has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

Placing of Concrete

Concrete shall be placed in the forms as close as possible to its final position in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height in a single pour in walls, columns and similar members.

The Bidder shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous and each operation shall be completed prior to a stoppage.

The temperature of concrete shall not exceed 40°C measured at discharge into the works.

The maximum allowable temperature of any point within any cast element is 60°C. The maximum allowable differential temperature between any two points in the same element is 15°C. Additional temperature control measures during construction (such as the use of insulated formwork) will be required. Bidder to prepare a process control chart and method statement verifying measures to achieve these requirements.

Temperature monitoring of concrete work is required where:

The minimum dimension of any casting is 0.8 metres or more, or otherwise instructed by the Owner/Consultant.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints than shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by

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more than 6 hours time shall be subject to the same treatment as the construction joints.

Concrete shall not be dropped into place from a height exceeding 1.5 metres. Trunking and chutes to Owner/Consultant's approval shall be used for any concrete to be deposited from a height exceeding 1.5 m.

Concrete which has partially hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

5.16 Compaction and mechanical vibration of concrete

As concrete is being placed it shall be compacted by mechanical vibrators complying with IS: 2505, IS: 2506, IS: 2514 & IS: 4656, to obtain a dense material free from honeycombing, free from water and air holes.

The Bidder shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged and no segregation/bleeding caused, but complete compaction of the concrete is achieved.

5.17 Finish of concrete

The concrete face shall have the finishes indicated on the drawings or in the present specification. The finished surface of the concrete shall be sound, solid and free from honeycombing, protuberances, air holes or exposed aggregate. No plastering, cement wash, mortar or paint shall be applied to cover defective concrete surfaces.

5.18 Construction, expansion and contraction joints

Construction joints

The number of construction joints should be kept as low as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subject to agreement between the Owner/Consultant and the Bidder before any work commences. Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Concrete should not be allowed to run to a featheredge and vertical joints should be formed against a stop board.

The top surface of a layer of concrete should be level and reasonably flat unless design considerations make this undesirable. Joint lines should be so arranged that they coincide with features of the finished work.

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If a kicker (i.e. a starter stub) is used it should be at least 70 mm high and carefully constructed. The kicker must be incorporated with the previous concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

The maximum horizontal length of wall to be poured in one operation in any one direction is 7.5 metres. A period of 7 days to be allowed between adjacent pours except where water stops are provided when this can be reduced with Owner/Consultant's approval. Alternatively a gap of 600 mm width shall be left between adjacent pours and filled after 7 days from the date of formation subject to Owner/Consultant's approval.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible a vibrator should be used.

Where the Owner/Consultant considers that special preparation is necessary, i.e. for an in-situ structural connection, preparation should be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush, which is sufficient to remove the outer mortar skin and expose the larger aggregate. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking of hardened surfaces should be avoided.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.

Joints shall be straight and vertical, except where otherwise specified, and concrete surfaces on both sides of the joint shall be flush. Where necessary, water stoppers of a type approved by the Owner/Consultant shall be embedded in the concrete. The water stopper should be made of high quality material, which must obtain its resilience through the service life of the structure for the double function of movement and sealing. The surface of water stoppers should be carefully rounded to ensure tightness of the joint even under heavy water pressure. To ensure a good tightness with or without movement of the joints the water stopper should be provided with anchor parts. The cross-section of the water stoppers should be determined in accordance with the presumed maximum water pressure and joint movements. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

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All joints between structural steel and concrete parts shall be sealed by a suitable permanent flexible compound.

5.19 Concreting at night

When approval is given to carry out concreting operations (under control of the Owner/Consultant) at night or in places where daylight is excluded, the Bidder has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

5.20 Protective measures for concrete

In general, the cover of rebars shall be as per IS: 456 taking into account the site conditions. However, the minimum concrete cover shall not be less than:

Concrete parts above ground (external surface)	: 40 mm
Concrete exposed to underground & groundwater	: 50 mm
Isolated footings	: 50 mm
Raft	: 75 mm
Slabs	: 25 mm
Beams	: 25 mm
Columns	: 40 mm

Immediately after the compaction of the concrete has been finished, the Bidder shall ensure adequate protection from the weather. Excessive drying can lead to crack formation as a result of plastic contraction. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constant moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Owner/Consultant. Where formwork cannot be removed within 24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Owner/Consultant's approval to the use of a particular curing compound and to the method of application will only be given after the Bidder has completed satisfactory site trials and a sample panel has stood for at least 28 days.

Where large sections of concrete are poured, special precautions to the approval of the Owner/Consultant shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete.

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind, however light, shall be allowed on concrete which has not properly set and the Bidder shall prevent any load to be imposed on the concrete structures until it has been declared by the Owner/Consultant to be ready to carry loads.

5.21 Concrete with Special Properties

General requirements

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The pre-condition for obtaining concrete with special properties is that it should be made with the appropriate composition, that it is placed in such a way that segregation does not occur and further that it is fully compacted and given appropriate curing.

Waterproof concrete

This concrete must meet the provisions of IS: 3370. Waterproof concrete must be sufficiently dense (impermeable).

Waterproofing and protection of underground concrete structures

Water aggressive to concrete should be kept away from the fresh concrete.

Concrete, which is exposed for a prolonged period to “very severe” chemical attack, must be protected against direct access of the aggressive substances.

The protection, which is to be laid as protection to all concrete surfaces in contact with the ground, shall consist of an approved waterproofing membrane. The membrane shall adhere to all concrete surfaces, including undersides of structures and other surfaces where concrete is cast in contact with the membrane.

Such membranes shall be PVC sheets of minimum 0.35 mm thickness with knobs of Maxlock.

The waterproof membranes shall be installed in strict accordance with manufacturer’s instructions.

The membranes shall extend 15 cm above ground level.

When setting forms and reinforcing steel caution shall be exercised to avoid damage to the impervious membrane. The surface of the impervious membrane extending outside the forms shall be protected during subsequent operations.

Any puncture or damaged areas shall be cleaned and patched according to manufacturer’s instructions.

Concrete with high wearing resistance

Concrete which is exposed to severe mechanical action, e.g., due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, should possess high wearing resistance and correspond at least to grade M30.

The aggregate upto 4 mm size should consist predominantly of quartz or materials of at least equal hardness; the coarser particles should consist of stone or artificial materials possessing high abrasion resistance. In the case of particularly severe mechanical action, it will be necessary to use special hard materials. The particles of all types of aggregate should have a moderately rough surface and be of compact shape. The combined aggregate should be as coarsely graded as possible.

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Furthermore, the concrete should be as stiff as possible, in order that there will be no concentration of cement slurry or water in the top layer. The concrete should be kept moist for at least 7 days after placing.

Finishing of formed surfaces

Fins and other surface projections shall be removed from all formed surfaces except exterior surfaces that shall be covered with earth backfill. Exterior surfaces that shall be exposed above grade and all interior surfaces, except those not usually exposed to view shall be cleaned and rubbed. Rubbing shall produce a smooth, uniform surface free of marks, voids, surface glaze, and discolorations.

Rubbing shall be done by hand with a carborundum stone using only the mortar produced by the rubbing action and the application of water.

Projecting ends of all form ties shall be removed. The resulting recesses shall be cleaned, wetted, and filled with patching mortar. Patches on rubbed surfaces shall match the texture of the adjacent concrete.

Finishing of unformed surfaces

No surface treatment shall be required for buried or permanently submerged concrete. As a minimum, unformed surfaces shall be finished by screeding and floating. Surfaces requiring a trowelled finish shall be finished by screeding, floating, and trowelling.

Float finished and screeded surfaces shall be finished to provide a flat profile within a 6 mm deviation as measured from a 3 m straightedge. Trowel finished surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 3 mm when measured from a 3 m straightedge.

Screeding

Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

Floating

The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and colour.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

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Trowelling

The exposed portions of the tops of equipment bases, tops of interior curbs, and the surfaces of interior slabs not receiving a separate finish shall receive a steel trowel finish. Trowelling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Trowelling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

Surfaces to be covered with neoprene-hypalon coatings shall be lightly trowelled but not burnished.

Brooming

Brooming shall follow the float finish for exterior surfaces where a nonslip surface is required. Brooming shall be done with an acceptable steel or fiber broom not less than 450 mm wide. Brooming ridges shall be transverse to the normal traffic direction and shall be between 1.5 mm and 3 mm deep. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

Aggregate Exposure

Surface mortar shall be removed and the aggregate exposed from surfaces that shall be covered with mortar, concrete, or grout at a later time.

Edging

Unless specified otherwise, exposed edges of floated or troweled surfaces shall be edged with a tool having a 6 mm corner radius.

Finishing mortar

Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 102 kilograms of concrete sand to one sack of Portland cement, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 50 mm.

Separate finishes

Certain slabs surfaces shall be finished with a separate concrete finish or floor covering.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances. Low areas shall be filled. High spots shall be ground slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 3 mm from a 3 m straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the drawings or a float finished surface set 3 mm low and levelled with trowel finished fill material.

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Surfaces that receive a mortar set quarry tile, ceramic tile, or vitrified finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 6 mm as measured from a 3 m straightedge.

5.22 Formwork

Design and construction

For stability and type of formwork and support framing used, IS: 14687 is to be observed.

The formwork and the supporting structure are to be so dimensioned as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances specified in section) "Dimensional Tolerances".

The Bidder shall submit in sufficient time in advance for the approval of the Owner/Consultant the calculations, designs and details of the methods adopted and materials proposed for the formwork.

Particular attention must be paid to the formwork supports and braces to avoid any slip when the concrete is poured.

Materials for formwork

Forms shall be constructed from steel or from sound timber well seasoned and free from shakes. Plywood lining for forms shall be of timber, which is resin-bonded and water repellent.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete. Where a slope exceeds 1 V: 2 ½ H, formwork shall be provided for the top of the concrete faces and anchored to prevent flotation.

The details of fair-faced concrete facades have to be to the satisfaction of the Owner/Consultant. The concrete surface for facades has to be absolutely stainless and all efforts have to be taken to achieve this. All the proposed formwork shall be properly designed before its usage.

Grading of formwork and of finished concrete surfaces

Quality of formwork, materials to be used and treatments of surface are graded according to the finish of the concrete surface as given in IS: 14687.

The type and treatment of the formwork lining (plywood, metal, plastics, etc) should be appropriate to the grade of concrete finish required.

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Preparation and inspection of formwork

Before concrete is placed, all formwork shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces, which are not oiled, shall be wetted thoroughly to prevent warping.

Erection and placing of formwork

All formwork shall be erected and placed in accordance with the construction drawings approved by the Owner/Consultant. Shuttering shall be true to line and braced and strutted to prevent deformation under weight and pressure of the wet concrete, live loads, wind and other forces. The deflections shall not exceed 3 mm.

The formwork for beams and slabs shall be erected so that the form on the sides of the beams and of the soffits of slabs can be removed without disturbing the beam soffit.

If the formwork for columns is erected to the full height of the columns, one side shall be provided with openings for concreting in order to guarantee a proper compaction of the poured concrete.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Wherever necessary, panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

Before placing of concrete, bolts, ties and fixings shall be positioned and all devices used for forming openings, holes, pockets, chases, recesses, etc shall be fixed to the formwork carefully.

Panels shall be put together to ensure a perfect fit at the joint and fixed in both directions.

Where concrete surfaces will be exposed to view (permanently exposed surfaces) the formwork shall be such as to produce a completely true, smooth surface, free from perceptible irregularities or to show clearly the desired texture. Such formwork shall be marked on the drawings as "Fair-faced Formwork".

Where concrete surfaces are covered (non-exposed surfaces), the formwork shall be referred to and marked as "Sawn Formwork".

Internal spacers and ties, if any, shall be so arranged that after removing of the forms no holes shall extend through the concrete, in the case of watertight concrete or to be closed by plastic plugs and epoxy mortar in all other cases.

All formwork will be inspected and approved by the Owner/Consultant before concrete placing commences but this shall not relieve the Bidder of any of his responsibilities under the contract.

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Striking of formwork

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined and removal shall proceed only on the instructions and under the supervision of a competent person.

In accordance with IS: 456 clause 11.3.1, the striking period for cast in-situ concrete under certain conditions may be taken as follows: -

Table 2.8
Formwork

Type of Formwork	Minimum period before striking formwork
Vertical formwork to columns, walls, beams	16 to 24 hours
Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs:	
1) Spanning upto 4.5 m	7 days
2) Spanning over 4.5 m	14 days
Props to beams and arches:	
1) Spanning upto 6 m	14 days
2) Spanning over 6 m	21 days

Special care is necessary in the case of components, which have to carry nearly the full-calculated load as soon as the formwork is struck.

Columns, piers and walls are to be struck before the beams and slabs supported by them. Scaffolds, formwork supports and self-supporting floor formwork are to be carefully lowered by releasing the devices.

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

To keep deflections through creep and shrinkage to a small amount, auxiliary supports should be left in place or immediately repositioned after striking.

5.23 Water stoppers

Water stoppers shall be of PVC or equivalent and shall be eye-letted with a minimum 25 cm width. Type and manufacturer shall be submitted to the Owner/Consultant's approval.

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All intersection pieces shall be prefabricated by the manufacturer and only welding of butt-joints in running lengths will be allowed to be carried out on the site.

The site welding of butt-joints shall be executed by using the manufacturer's purpose-made electrically heated jig and work shall be done by competent and trained personnel only. The manufacturer's instructions shall be carefully observed.

The wings of the water stoppers shall be formed with corrugations or bulbs to achieve a good bond. Moreover, the water stoppers shall conform to the following requirements:-

- The tensile strength not less than 10 N/sq.mm when tested.
- The ultimate elongation shall not be less than 22% when tested.
- The tear resistance shall not be less than 2 N/sq.mm when tested.
- The material shall not crack when tested.
- Under accelerated elongation, the tensile strength shall not be less than 8 N/sq.mm and the ultimate elongation shall not be less than 200%.

The water stoppers shall be installed so that they are securely held in position during the placing of concrete, which shall be fully and properly compacted around the water stoppers to prevent voids or porous areas. Adequate clearance between the reinforcement and all the water stoppers shall be kept to permit proper compaction of concrete.

No holes or nailing shall be made through any water stopper for fixing purposes. Jointing by lapping two pieces of water stoppers shall not be permitted.

The free edges of water stoppers shall at all times be protected from direct sunlight.

5.24 Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed and if required the concrete may be protected for few more days as per the design mix / approved methodology.

Trowelled surfaces except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane-curing compound or with water. Only water curing shall be used if the surface receives a separate finish.

Water curing

Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete. Water curing shall begin within 12 hours in dry weather and within 24 hours in damp weather. The rate of water application shall be regulated to provide complete surface coverage with a minimum of

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runoff. The application of water may be interrupted for surface rubbing. The concrete surface shall not be permitted to dry.

After the rubbing has been completed, rubbed surfaces shall be covered with burlap and kept saturated for the remainder of the curing period.

Membrane curing

Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at coverage of not more than 7.4 sqm/litre. Membrane curing shall not be used on surfaces that shall be covered at a later date with mortar, concrete, damp proofing, tile, or any coating. Membrane curing shall not be used on cast-in-place concrete bases for field-erected tanks. Membrane curing will be permitted only after prior approval of the OWNER/CONSULTANT.

Floor sealer

All concrete floors shall be given two coats of clear floor sealer in addition to that applied as membrane curing compound. The first coat shall be applied at the end of the curing period before any traffic is permitted on the floor. The second coat shall be applied after the floor has been cleaned in preparation for the final inspection. Floor sealer shall be applied in strict accordance with the manufacturer's recommendations.

5.25 Waterproofing/Damp proofing

A waterproofing seal shall be provided for all below grade structures where applicable by external tanking with PVC sheets of 1.0 mm thickness with knobs for membrane type waterproofing. In addition, joints in deep underground structures shall be provided with structural waterproofing.

Damp-proof course 40 mm thick, consisting of cement concrete 1:2:4, with admixture of approved water-proofing compound shall be laid at plinth level for walls of all buildings for protection of super-structure against moisture and dampness.

5.26 Repair of damaged and defective concrete

Concrete after its final setting shall be inspected by the Owner/Consultant and any cracks, honeycomb areas, segregations, etc shall be marked. No repairs shall be carried out until directed by the Owner/Consultant.

Surface defects in formed concrete shall be repaired to the satisfaction of the Construction Manager within 24 hours. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 25 mm shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Cut surfaces shall be coated with epoxy bonding compound before the concrete is placed.

Defective concrete shall be replaced within 48 hours after the forms have been removed.

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6 PRESSURE GROUTING

The work shall consist of drilling grout holes, exploratory holes and check holes, pressure testing, pressure washing, and injecting suspension grout under pressure, and shall include furnishing of all materials, labor, and equipment as described and specified.

6.1 Materials

a) Cement

Portland cement shall be contains less than 0.6 percent alkali.

b) Aggregate

Aggregate shall be non reactive and shall be washed before use. When sources of aggregate are changed, test reports shall be provided for the material from the new source prior to commencing grout work. Fine aggregate shall be sand or crushed stone.

c) Admixtures

Admixtures shall be compatible with the grout and shall comply with the manufacturer's recommendations. Admixtures shall be added to the grout mix separately.

Water Reducing Retarder: Water reducing retarder shall comply with relevant Indian standard or as approved by Owner.

Lubricant: Lubricant additive for cement pressure grouting shall be Intrusion Prepakt Intrusion Aid, Sika Intraplast N, or as approved by Owner.

d) Water

Waste for washing aggregate, for mixing and for curing shall be potable, shall not contain more than 1000 mg/l of chlorides as Cl, nor more than 1300 mg/l of sulfates as SO₄, and shall not contain impurities which may change the setting time by more than 25 percent or a reduction of more than 5 percent of the compressive strength of the grout at 14 days when compared to the results for grout made with distilled water.

e) Grout

Drypack Grout

Drypack grout shall be a mixture of approximately one part cement, 1.5 parts sand, water reducing retarder and sufficient water to make a stiff workable mix, branded Dry Pack or approved equal.

Cement Grout

Cement grout shall be a mixture of one part cement, two parts sand proportioned by volume admixtures for pressure grouting and sufficient water to form a workable mix.

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Nonshrink Grout:

- Non-shrink expansive flowable grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticiser admixture shall be added in the grout. For grouting of base of machine foundation high strength ready mixed non-shrink flowable grout shall be used.
- Type and grade of grouting for structural columns and equipment bases shall be as indicated. Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M 30.
- Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipment. For secondary posts, stair and ladder base, etc. grouting shall not be less than 25 mm thick.
- Special grout, where specified on the drawings, shall be provided in strict accordance with the manufacturer's instructions/specifications. Pre-mixed Grout Conbextra GP-2 of 'FOSROC' make or equivalent of crushing strength 650 kg/cm² for major equipment foundations and Conbextra GP-1 or equivalent having crushing strength of 450 kg/cm² for other foundations where concrete grade M30 or higher is provided
- Forms and shims used to obtain adequate clearance shall not be removed and the anchor bolts shall not be tightened for at least three days after placing the grout. After the removal of forms and shims, area occupied by shims shall be filled and the area between the base and edge of the foundation shall be finished smooth to allow drainage away from the base. Attachment of interconnecting piping of machinery and complete load transfer of machinery shall not be done before the bolts are tightened. During this period, grouting work shall be properly cured using rags/gunny bags.

In view of extremely small proportion (about 0.01% by weight of cement) of the aluminium powder required, it is necessary to take all precautions to ensure thorough mixing. It is advisable to mix the blend of aluminium powder thoroughly with sand and cement before water is added because aluminium powder has a tendency to float on water.

- Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement: 1 admixture: 1 sand), or as per manufacturer's instructions.

Pre-mixed non-shrinking grout shall be used as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

Epoxy Grout for Crack Repair and Dowel Anchorage

Except for applications involving pressure grouting or crack injection, epoxy shall be a high modulus, moisture insensitive, two components, 100 percent solids, thermosetting modified polyamid epoxy compound. The material shall equal which is capable of not sagging in horizontal or overhead anchoring applications.

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Epoxy for applications involving pressure grouting or crack injection, shall be a high modulus, moisture insensitive, two components, injection grade, 100 percent solids blend of epoxy resin compounds. The material shall equal which is capable of achieving complete penetration of hairline and larger cracks.

Polymer Concrete for Resurfacing and Patching

Polymer concrete shall consist of a liquid binder and dry aggregate mixed together to make a flowable mortar. The liquid binder shall be a chemical and oil resistant, stress relieved, low modulus, moisture insensitive, two component epoxy resin compound. The binder material shall equal with a consistency similar to light weight oil for proper mixing with the aggregate. The aggregate shall be oven dry, kept in sealed packages until the time of mixing and be of size and consistency compatible with recommendations of the manufacturer of the liquid binder for the intended application.

Adhesive Resin for Dowel Anchorage:

Pneumatically operated caulk gun and automatically mixed at nozzle. Subject to compliance with one of the following: HIT RE500-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-2322), HIT-HY 150 MAX-SD Adhesive Anchoring System, Hilti, Inc. (ICC ESR-3013), SET-XP Adhesive Anchoring Systems, Simpson Strong-Tie Co. (ICC ESR-2508).

6.2 Pressure Grouting Equipment

Pressure grouting equipment shall include a mixer and holdover agitator tanks designed to place grout at pressures up to 0.345N/mm² (50 psi). Gauges indicating grouting pressure shall be provided and the mixer shall be equipped with a meter capable of indicating to within 0.003 m³ the volume of grout placed.

6.3 Execution

Bonding compounds for use with grout is to be provided and installed per the manufacturer's recommendations.

a) Drypack Grout

Drypack grout is to be used for built-up surfaces, setting miscellaneous metal items and minor repairs.

Surfaces required to be built-up with drypack grout are to be roughened by brushing, cleaned and coated with the bonding compound before application of grout. The grout is to be applied to the required thickness.

b) Cement Grout

Cement grout is to be used for filling nonbearing portions of equipment pads and pressure grouting.

Except for the specialized requirements for pressure grouting, grout is to be mixed and placed in the same manner as cast-in-place concrete. Grout is to be mixed for at least one minute and diluted grout is to agitated until placed.

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c) **Non-shrink Grout**

Nonshrink, nonmetallic aggregate grout is to be used under equipment, bearing plates and column base plates. Nonshrink, metallic aggregate grout is to be used under rotating equipment where high strength and fatigue are of concern, to grout anchor bolts and to grout reinforcing steel. Grout is to be placed and cured in accordance with the manufacturer's recommendations.

Holes required for grouting shall be blown clean with compressed air and are to be free of dust or standing water. Horizontal holes for grouting are to be drilled at a slight downward angle and with the inserted dowel or bolt bent to match.

d) **Epoxy Grout**

Epoxy grout shall be used for repairing cracks by pressure grouting or gravity, repairing structural concrete and may be used for setting dowels or bolts in holes. Concrete is to be primed in accordance with the grout manufacturer's recommendations.

The use of epoxy grout must comply with the following restrictions:

- Limited to areas where exposure, on an intermittent or continuous basis, to acid, chlorine gas or to machine or diesel oils, is extremely unlikely.
- Limited to applications where exposure to fire or to concrete temperatures above the product heat deflection temperature or 120 deg F (40 deg C)(whichever is less) is extremely unlikely. Overhead applications are not allowed.
- Holes for the anchors shall be drilled (not cored), shall be blown clean with compressed air and shall be free of dust or standing water.
- The anchor type, size and embedment depth shall be as shown on the drawings and the anchor must be installed in accordance with the manufacturer's recommendations.
- The anchor must not be loaded until after the full curing period has elapsed.

e) **Pressure Grouting**

Prior to grouting, cracks and holes to be grouted shall be washed clean. Washing is not required for grouting soil voids. Once started, grouting shall be continuous until completed. In case of a mechanical failure or other stoppage of the work, the grout equipment shall be washed out sufficiently to ensure that fresh only grout is pumped when the work is restarted.

After grouting is completed, the Contractor shall remove the grouting plant and all related parts, equipment, and supplies from the site, including unused materials and waste.

6.4 Field Quality Control

- The Testing Laboratory will Develop and utilize an effective method of field marking anchor and dowel test locations and results.

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- Testing of grout mixes for conformance to manufacturer's specified strength: The independent testing laboratory shall take four test samples of each day's grout mix and test grout mix samples at 7 and 28 days. Test reports shall be submitted to the Owner for review.
- Test 25 % of reinforcing steel dowels installed with adhesive resin on a given day in tension using pullout procedure. Test to 80% of specified yield strength of the dowel with special inspection. Dowels specifically noted on the drawings as "No test required" do not require tension testing.
- If the failure rate of dowels exceeds 10 percent, testing will be increased to 100 percent of that day's installation of similar anchors or dowels. Testing will be reduced to 25 % of that day's installation when the failure rate is reduced to 10 percent or less. Failed dowels will be replaced at no additional cost to the Owner. The Contractor will produce daily reports of all testing activities; copies of daily reports will be submitted to the Owner in a timely manner.

6.5 Submittal

- Manufacturer's data shall be provided for bonding compounds, dry pack, non-shrink, pressure grout, retardants, epoxy grout, polymer concrete.
- Test reports, accompanied by a manufacturer's statement that previously tested material is of similar type, quality, and manufacture as that which is proposed for use on this projects, shall be submitted for Cement, Aggregates, Retardants, Bonding compounds and Epoxy resin
- The Contractor's testing laboratory shall provide evidence of correction of deficiencies noted in the inspection report before materials specified in this section are delivered to the job site.

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7 RETROFITTING WORKS

7.1 General

- a) The Work shall, in general, conform to other works/items specified in this Specification.
 - If the specifications for any item are not available in this Specification cited above, relevant BIS Specifications should be followed.
 - In case BIS Specifications are also not available, the decision of Engineer-in-Charge given in writing based on acceptable sound engineering practice and local usage shall be final and binding on the contractor.
- b) The work will be carried out in accordance with the architectural and structural drawings to be approved by Owner. The structural and architectural drawings shall have to be properly correlated before executing the work.
- c) For items where so desired, samples shall be prepared before starting the particular items of work for prior approval of the Owner and nothing extra shall be payable on this account.
- d) Materials brought at site of work shall not be used in the work before getting satisfactory Mandatory test results.
 - Equivalents for the various materials and the materials of approved make shall be got approved from the Owner in writing before using them on the work.
- e) The contractor shall submit the required documents regarding the genuineness of materials used such as manufacturer's certification that the firm has manufactured the supplied materials.
- f) The contractor shall get approved from the Owner the storage space for epoxy/polymer/patented/other manufacture of materials to ensure that the storage temperature is maintained between 5° C and 38° C unless recommended otherwise by the manufacturer.
- g) Contractor shall comply with manufacturer recommendations so as to comply with environmental conditions under which the repair materials may be applied.
- h) The contractor shall employ Principal Technical Representative & skilled site workers who shall have adequate qualifications and experience for the proper execution of such works and already performed works of this kind with success.
- i) Contractor shall advise all workers working with epoxies to avoid contact with eyes and skin, inhalation of vapours, and ingestion. Necessary protective and safety equipments in the form of hand gloves, welders' goggles, shall be provided by the contractor and used on site.

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- j) Care shall be taken to ensure that vibrations are well within acceptable limits for structural safety and users of the building.
- k) For the execution of protection and repair works, properly maintained plant and equipment permitting adequate treatment of the concrete substrate, proper execution of the work and determination of the required properties of the construction materials and construction measures must be present on the construction site.
- l) To ensure efficient and effective functioning, all plant and equipment must be checked on-site and at field material testing laboratory prior to first use and at appropriate intervals thereafter.

7.2 Chipping of Unsound/Weak Concrete Material

a) Purpose

To remove weak, loose or carbonated concrete over an area from its surface with pneumatically operated or power driven tools by chiselling, chipping etc.

b) Materials and Tools & Plants (T&P)

Power or pneumatically driven chisel, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator (0.2% phenolphthalein solution) with pH range at least up to 10.5 and clinical injection syringe.

c) Safety

Safety shall be ensured in accordance with contract conditions and specifications.

d) Procedure

Step-1: Prop and support to relieve the structural member of stress and strains.

Step-2: Scaffolding, if necessary for the exterior members, shall be done for working upon the area.

Step-3: Working Platforms for interior members, if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if necessary.

Step-5: Mark off the area to be repaired using straight lines between corners. The marked area shall have 90° corners with the sides parallel or normal to the direction of the reinforcement. The marked boundaries for the repair area should be a minimum of 50 mm outside the perimeter of the spall. For a single spall, the repair area should have a minimum width of 100mm in any direction. If a number of spalls are closely located to each other, these spalls should be included in a single area marked for repair.

Step-6: Cut shall be made along the marked boundary, normal-to-the surface. It should be made with a diamond cutter blade. However, when diamond cutting is not practical, the normal cut can be made with a power driven chisel. Minimum depth of cut shall be 10 mm. In situations where the diamond saw could cut into the reinforcing steel due to inadequate concrete cover, the boundary edge

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should be formed manually by means of chisel and impact hammers. A cover meter could be used to estimate the depth of cover.

Step-7: Chipping to remove all the unsound and weak concrete material shall be done carefully from the damaged portions of structural members by adopting mechanical or manual means up to the required depth to produce sound concrete surface to a near uniform depth for the repair area.

e) **Tolerance**

The chipping tolerances shall be $\pm 5\text{mm}$.

f) **Chiselling**

Hand Tools are typically applicable for concrete removal for smaller, moderate and areas of limited access. Removal should begin at the interior of the repair area and progress toward the boundaries, using suitable hammer. Power Driven Chisels/Hammers are normally applicable for chiselling smaller thicknesses up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger thicknesses in excess of 50 mm Mechanical Milling (single drum, rotary cutter head with Tungsten-carbide bits) is applicable for large areas where the concrete cover is to be removed. Care must be taken to avoid contact with the reinforcing steel as both the reinforcement and the cutter drum could be damaged. Rounded And Feathered Edges should be hand cut to form normal-to-the-surface boundaries. All the edges and cavities shall be square shouldered.

Step-8: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on concrete in contact and in the immediate vicinity of reinforcement soon after its chipping. As otherwise, chipped concrete surface in contact with air is likely to get carbonated soon after its coming in contact with atmospheric carbon dioxide.

Step-9: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, in case the concrete in contact and in immediate vicinity of the reinforcement is carbonated.

Step-10: Inspection and soundness testing, after concrete removal & cleaning, for weaknesses and delamination of exposed surfaces shall be visually carried out. If required, additional removal will be done.

Step-11: Cleaning of debris and dust shall be carried out from within the chiselled/ chipped area and its disposal as per direction of the Engineer-in-Charge.

7.3 Removing concrete all around reinforcement including from its behind

a) **Purpose**

To create an average clear air gap equal to nominal size of coarse aggregate plus 5 mm all around embedded reinforcement, in contact with carbonated concrete for rust removal & passivating its surface with fresh alkaline passivating coat and concrete/ mortar.

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b) **Materials and T&P**

Power or pneumatically driven chiselling, abrading, chipping tools complete with accessories, hand-tools like chisels, hammer, pH indicator i.e. 0.2% solution of phenolphthalein indicator for pH range preferably up to 11.5 or at least up to 10.5, clinical injection syringe.

c) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

d) **Procedure**

Step-1: Prop and support, if not done already, to relieve the structural member of stress and strains.

Step-2: Scaffolding & working platforms for the exterior members, if not already done and if necessary, shall be erected for working upon the area.

Step-3: Working Platforms for interior members, if not already done and if necessary, shall be erected suitably or provided as mobile.

Step-4: Provide Protective Screen, if not already done and if necessary.

Step-5: Test for carbonation shall be carried out at embedded or exposed reinforcement locations, by spraying phenolphthalein indicator on freshly chipped concrete in contact and in the immediate vicinity of reinforcement.

Step-6: A full-depth chiselling and removal of concrete all round reinforcement shall be carried out, if the concrete in contact and in immediate vicinity of the reinforcement is carbonated. The concrete around reinforcement shall be removed so as to have a near uniform air gap of about 5 mm plus the nominal size of coarse aggregate to be used in repair concrete/mortar. However, the air gap shall not be less than 15 mm in any case. Power/pneumatic driven tools/chisels shall be used for such portions of carbonated concrete around reinforcement, which could not be removed manually, to achieve a near uniform required air gap all around including behind the reinforcement. Power Driven Chisels/Hammers are normally applicable for chiselling smaller depths up to about 50 mm. Pneumatic Hammers are normally applicable for chiselling larger depth in excess of 50 mm.

Step-7: Cleaning of debris and dust shall be carried out from within the chiselled /chipped area and its disposal as per direction of the Engineer-in-Charge.

7.4 Rust Cleaning from reinforcement

a) **Materials and T&P**

Chiselling, abrading, chipping, hammering, wire brushes, paint brush, abrading cloth, etc hand tools complete with accessories, tested and approved chemical rust remover.

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b) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

c) **Procedure**

Step-1: Cleaning by manual method-

Remove the rust manually from all round the surface along the length of reinforcement, using hand tools like chisels, hammers, wire brushes, abrading cloth/paper, etc. This shall be continued manually along the length of the rusted reinforcement till such time that the steel surface is cleared of all rust that could be removed manually.

Step-2: Cleaning by chemicals –

Remove the Rust by using tested chemicals, if directed by Engineer-in-Charge, due to unsatisfactory results of manual rust removal. Chemical rust remover shall be brush applied over the reinforcement surface thoroughly all around the circumference and along the full length of rusted reinforcement. After 24 hours (or as prescribed by manufacturer) of its application, the surface shall be cleaned with wire brush and all loose particles removed. It shall be washed with water thoroughly and allowed to dry.

7.5 Cleaning Reinforcement and exposed concrete surface of loose and foreign material by means of sand blasting

a) **Purpose**

Clean the prepared concrete surface of all-loose, lightly sticking materials including the foreign materials, loose concrete, aggregates etc to provide a good bond with the applied repair material and clean the reinforcement surface of any minor rust remaining after manual and chemical cleaning to achieve shining bright metal.

b) **Materials and T&P**

Coarse sand conforming to Zone I or II as per IS: 383, Air compressor of a minimum 35 Kilowatt capacity, spray gun for sand, all related accessories for sand blasting, hand tools like wire brushes, chisels, etc

c) **Testing of Materials and T&P**

The sand shall be tested to conform to the specification.

The air compressor shall be tested to perform to the required standards as laid down in specifications of shotcreting.

d) **Safety**

Safety shall be ensured in accordance with contract conditions and specifications.

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e) Procedure

Step-1: Specified tested coarse sand shall be collected at site in required quantity for sand blasting.

Step-2: Make available mechanical power driven air compressor in working condition at site with all required accessories for carrying out sand blasting as well as air blasting operations.

Step-3: Coarse sand shall be sprayed under pressure over the exposed surface so as remove all loose and foreign material and to cause an intense abrading of the reinforcement and removal of rust from entire surface of reinforcement to achieve shining bright surface. The sand blasted surface shall be subsequently cleaned with oil free air blast.

7.6 Providing drilling and inserting nipples along crack lines

a) Purpose

To fix injection nipples and seal the remaining portion of honey combed or cracked concrete /masonry for grout injection.

b) Materials and T&P

12 mm diameter approved PVC/aluminium /Galvanised Iron nipples, Chisel, hammer, power driven tool for chase cutting & drilling, hand operated blow out pump, sealing putty of polyester/epoxy/polymer modified mortar etc. and all related accessories and materials.

c) Testing

The sealing putty and the nipples shall be tested to conform to the manufacturers specifications. The power driven tools shall be test driven and their drill/cutting bits shall be tested for effectiveness before taking up the repair operation.

d) Procedure

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Personnel, Supervision, Product delivery, Storage and Handling etc.

Step-2: Identify the Cracks and mark the area for injection grouting.

Step-3: Prop & support the structural member, if required, to relieve it of stress and strains.

Step-4: Open up cracked surface by making 'V' notch or groove of size 12 mm x 12mm.

Step-5: Remove plaster, if required, to identify and mark the honey combed area.

Step-6: Drill holes at least 25 mm diameter and 40mm deep along crack lines at spacing of 300 mm or thickness of the structural member, whichever is less. In honey combed area @ 9 nos per sqm. as directed by Engineer-in-Charge and up to 30 mm to 40 mm depth.

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Step-7: Remove coarse debris and dust in opened up cracks and drilled holes by blowing oil free compressed air, if available with air compressor, otherwise with hand operated blow out pump. Concrete surfaces required to be grouted shall be free from all loose and unsound materials by means of mechanical abrasion using stiff wire brushes, after removing all loose areas with chisel and hammer. Area shall be made free from any deleterious materials, such as oil dust dirt etc. by means of oil free jet of compressed air. All prepared concrete surfaces shall be thoroughly inspected and got approved by the contractor.

Step-8: Insert 12mm dia specified injection nipples in holes drilled along crack lines and fix them by sealing only its sides with epoxy or polymer modified mortar.

Step-9: Seal the crack or the honey combed surface between the nipples by polymer modified mortar as may be approved by Engineer-in charge. The polymer used shall be of approved grade and applied as per specifications mentioned separately elsewhere. The polymer-modified mortar shall be moist cured for 1-3 days and allowed to gain strength before actual grouting commences.

7.7 Sealing of cracks by injection of advance grout

a) Purpose

To inject the specified grout into honeycombed or cracked concrete/ masonry

b) Materials and T&P:

Cement, sand. Water and admixture for cementitious grout shall be as per clause 5 of this specification.

Polymer: It shall be as specified and shall conform to ASTM-C-1059.

Hand/power operated grouting pressure pump/gun with pressure gauge. The grouting equipment shall be capable of supplying, mixing, stirring and pumping grout to the satisfaction of the Owner. The equipment shall have the capacity to inject grout at a pressure upto 7 kg per square centimeter measured at the grout connections. It shall be capable of mixing and pumping of cement sand grout 1:2 with water cement ratio ranging from 0.5 to 1.

Air compressor with all related accessories for carrying compressed air to the required location. Hand operated blow out pump may be allowed by Owner for small crack depths/areas.

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing, Spray equipment/brush for application of polymer modified/ bonding cement slurry

c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured material (e.g. specified resin, hardener, polymer, cement, etc as may be required) shall be received at site in factory

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sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the storage period shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: If directed by Owner, collect random samples of materials for test and send to approved laboratories so as to ensure that they satisfy the physical and mechanical properties. The grout pump and the pressure gauge shall be tested before taking up the repair operation.

Step-4: Identify the Cracks and mark the area for injection grouting.

Step-5: Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

- Prop & support the structural member to relieve it of stress and strains.
- Provide grouting nipples.

Step-6: Blow the compressed air followed by washing with water through nipples located at the highest level and downwards to ensure removal of even fine dust particles from the cracked surface, which could obstruct the free flow of grout material and impede its bonding with cracked surface (and drying with air blast wherever epoxy injection grout is to be used).

Step-7: Saturate the cracked surface in the vicinity of crack/honeycombed concrete/ masonry with water (but without excess water), only if the cementitious grout is to be injected. Otherwise, this step may be skipped.

Step-8: Prepare the injection grout as specified under clause 5 of this specification.

Step-9: Inject the approved & specified grout into the cracks by means of suitable gun or pump at a pressure of 1- 2 kg./cm² for epoxy grout and 4-7 kg./cm² for cementitious grout. In case of vertical cracks injection shall be started at the lowest nipple and continued until the injected grout begins to flow out at the next higher nipple. Whereas in other cases of horizontal locations, the injection shall be started from one nipple and continued until the injected grout begins to flow out at the other nipple.

The first nipple shall then be closed off and injection continued at the second until the grout flows out at the third. The process shall be repeated until the whole of the crack has been sealed. As soon as the system is cured, the nipples shall be cut.

In case of Honeycombed Area, each grout hole shall be grouted individually. Grouting pressures to be used in the work will vary with the conditions encountered and different areas and the pressure used shall be between 1 to 4 kg/cm². The sequence of injection shall be as per the direction of Engineer-in-Charge.

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7.8 Providing and inserting shear key bars

a) Purpose

Shear key bars are used for providing a structural connection of the applied repair material with the substrate/parent surface for transfer of forces occurring at the interface.

b) Materials and T&P:

Epoxy cartridges and specified lengths and diameter of steel reinforcement.

Standard Power driven drilling/hammering equipment, Hand operated blow out pump, brushes, epoxy dispenser, epoxy cartridge holder, disposable PVC mixing nozzle for epoxy, and any other incidental accessories and T&P items.

c) Procedure

Step 1: Mark the locations of shear keys and get the same approved for structural connection from the Owner.

Step 2: Drill holes to specified depth and diameter in concrete at marked locations for the specified dia of shear key bars.

Step 3: The drilled hole in dry state shall be cleaned with round brushes and by blowing air through a tube inserted in the hole and connected to hand operated blow out pump.

Step 4: Inject epoxy from the foil pack with the help of epoxy dispenser, epoxy cartridge holder and disposable PVC mixing nozzle inserted inside the drilled hole to fill it from bottom of the hole and upwards.

Step 5: Insert the reinforcing bar and allow the epoxy adhesive to cure.

7.9 Reinforcement for RCC works etc.

a) Purpose

To provide reinforcement in repair concrete for structural purposes, controlling effects of thermal variation or holding shotcrete/gunite material in position. The reinforcement material may comprise specified grade and quality with or without zinc coating.

b) Material & T&P:

Specified reinforcing material, necessary hand or power driven tools for cutting, bending, binding, transportation, handling and placement etc. Reinforcement bars if used shall conform to I.S. 432 (Part-I) or I.S. 1786. Welded wire fabric where used shall conform to I.S. 1566.

c) Procedure

The general requirements, placing in position, measurement etc. shall be generally followed as in clause 4 of this specifications excepting those specifications provided in the following clauses.

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

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Step-2: Testing of Material: The requisite number of test specimens of specified reinforcing material shall be collected from each batch of manufacture or supply received (whichever is less) for these to be tested for conformance to the specified requirements before use on the work.

Step-3: Execution:

The required reinforcement as per approved detailed drawings in the form of round bars or welded wire fabric in such a way so as to cause the least interference with placement of repair material.

d) Overlaps:

Lapped reinforcing bars shall not be tied together. They shall be separated by at least 50 mm wherever possible. Wire mesh shall be lapped by 1-1/2 squares in all direction. Minimum requirement of lap length of bars shall be as specified in I.S. 456.

e) Clearance around reinforcement:

Sufficient clearance shall be provided around the existing exposed and additional reinforcement to permit complete encasement with sound repair material.

f) Cover:

Minimum cover to reinforcement shall be as specified under clause 4 or as per I.S. 456. As far as possible the bars shall be arranged so as to permit shooting from opposite side.

g) Fixing:

Reinforcement shall be fixed to existing shear key bars and depth gauges driven into the concrete with wires and secured rigidly so that the vibration resulting from the deposition of repair material shall not impair or displace them.

h) Where Gunite /shotcrete to be done in more than one layer

In such cases, the additional reinforcement should be so fixed that it is encased in succeeding layer. No additional reinforcement is required to be fixed in first layer of gunite.

Mesh reinforcement shall be fixed in the manner so that it is firmly held at least 12 mm away from the parent concrete surface as well as from the final finished surface. It shall be ensured that it is stiffened enough and cannot belly out during the guniting / jacketing / concrete overlays with consequent lack of cover. It shall be done by tying with parent concrete surface through shear key bars or depth gauges. GI-wire mesh fabric will add sacrificial "Zinc" coating & shall reduce corrosion process in the reinforcement. The wire mesh spacing shall be as specified in the drawings.

7.10 Alkaline Passivating bond coat over Reinforcement

a) Purpose

To protect steel reinforcement with a passivating alkaline layer provided all around its circumference along the length with strong adhesive to bond with applied repair concrete or mortar.

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b) Materials and T&P:

Specified alkaline passivating & bonding materials e.g. CPCC material, epoxy, epoxy phenolic IPN-RB or specified polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, mechanical mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882.

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

Patented materials e.g. CPCC or epoxy-phenolic IPN-RB as per licensee's specifications

c) Execution:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3: Prepare the surface for treatment.

Step-4: Thoroughly inspect all the concrete surfaces prior to applications of passivating/ bond coat and get approved from the Engineer-in-Charge.

Step-5: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-6: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions),

Mechanical blender for mixing

Brush for application of specified and approved passivating/bond coat.

Step-7: Material Mixing: Components of the passivating/ bond coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-8: Material Application: The alkaline passivating & bonding material shall be applied to prepared reinforcement substrate after tying in new reinforcement wherever specified in the form of bars or welded wire fabric. It shall be applied to reinforcement surfaces by stiff nylon bristle brush. The coating material shall be worked well all round the periphery and along its exposed length using a stiff brush ensuring that no pinholes are remaining. The second coat, if required, the

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same shall be applied as per manufacturer's recommendation after the first coat is touch dry.

7.11 Bonding coat for hardened concrete with repair concrete/shotcrete/cement mortar

a) Purpose

To provide adequately strong adhesion of parent concrete with applied repair concrete or mortar.

b) Materials and T&P

Specified bonding materials e.g. epoxy or polymer and cement, mixing water, necessary T&P for mixing and applying bond coat e.g. brush, spray gun, mixer, mechanical stirrer, etc.

Epoxy Adhesives shall conform to ASTM C-882

Polymer Latex shall conform to ASTM C-1059.

Cement shall be ordinary Portland cement conforming to IS: 269.

c) Execution

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of manufactured repair materials shall be received at site in factory sealed containers with labels legible and intact, if the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer- in-Charge Full quantity shall be worked out as theoretically required for consumption in the whole work

Step-3: Prepare the surface for treatment.

Step-4: Saturate the surface with water but shall be free of excess surface water, debris and dust, where cementitious bond coat is to be applied. Otherwise, surface to remain dry and clean of debris and dust.

Step-5: Thoroughly inspect all the concrete surfaces prior to applications of adhesive and get approved from the Engineer-in-Charge.

Step-6: Test the materials by taking random samples and testing in approved laboratories so as to check whether they satisfy the physical and mechanical properties.

Step-7: Make available at site all necessary mechanical equipment as under:

Calibrated Spring Balance (for accurately weighing different components of materials in required proportions), Mechanical blender for mixing Spray equipment, brush for application of epoxy, polymer modified, bonding cement slurry.

Step-8 Bond Coat Mixing: Components of the bonding coat mix shall be weigh batched and mixed in specified proportions in a clear container free from harmful residue or foreign particles. The components shall be thoroughly blended with a

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mechanical mixer to a uniform and homogeneous mixture. Small batches (upto 1 litre) may however be allowed by manual mixing using spatulas, palette, knives etc.

Step-9 Bond coat application for jacket concrete/ shotcrete/ Mortar placement: The specified adhesive shall be applied to concrete surface at atmospheric temperatures below 40°C for epoxy adhesive and below 30°C for polymer modified cement or cement-sand slurry adhesive. Bonding coat shall be applied by spray equipment or stiff nylon bristle brush as approved by Engineer-in-Charge. The bonding material shall be worked well into the surface of the parent body ensuring that no pinholes are visible.

Polymer modified bonding cement slurry shall be applied to a thickness not in excess of 2 mm.

If necessary, a second coat shall be applied at right angles to the first to ensure complete coverage and absence of pin holes.

All concrete surface shall be well protected beyond limits of surface receiving adhesive against spillage.

Step-10 Repair Material Application: Fresh plastic concrete/ shotcrete/ mortar shall be applied while adhesive is still tacky and well within the pot-life/ setting period. If adhesive cures to the extent of losing its tack or has set before plastic concrete/shotcrete/mortar is placed, the same shall be removed or slightly abraded and second coat of adhesive applied. Freshly placed plastic concrete shall be thoroughly consolidated to ensure full bonding of new concrete with the substrate.

d) Bond of repair with parent concrete:

Evaluate bonding of fresh concrete/ shotcrete/ mortar to existing concrete after the fresh material has cured for not less than 7 days by sounding and tapping fresh concrete with a blunt metal instrument to the satisfaction of Engineer-in-charge. Suspect inadequate bonding, if a hollow sound is detected in any area. In case of conflicted location contractor shall extract one core from the repaired surface area at the end of 28 days.

Conduct one core test at random for checking the bond, for every 100 square metre or part thereof. The contractor shall core each area after 28 days of application of concreting/ shotcreting/ repair mortar application for determination of bonding adequacy.

Core drilling shall be done through applied repair material and into the existing concrete. Core diameter shall be not less than three times the nominal size of the coarse aggregate used in repair material or as required by the Engineer-in-Charge. Length of cylindrical cores shall preferably be twice the core diameter or twice the thickness of applied repair material or as instructed by Engineer-in-Charge but in any case not less than the dia of the core.

Cores shall be visually inspected by Engineer-in-Charge for evidence of poor workmanship.

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Cores shall be tested in tension to evaluate the quality of bond between new concrete/shotcrete/mortar and the parent concrete. If the failure is in the parent concrete the bond of new repair material shall be deemed to be satisfactory.

Failure at the bond line or in the repair material shall be concluded as lack of proper bond or inadequate strength of repair mortar

Dismantle such areas of work failed in bond or repair material and re-prepare the surface after chipping off new concrete/mortar work and abrading the epoxy/polymer/cement slurry interface. Nothing for testing concrete for bond between old and new concrete shall be paid separately.

7.12 Curing of RCC Surfaces etc

a) Purpose

To ensure satisfactory hydration of cement by retaining or replenishing the mixing water lost due to natural drying and evaporation process for a specified period through exposed cementitious surfaces of the freshly placed cement mortar/ concrete.

b) General

Importance of wet curing to all items of work involving use of cement can not be over emphasised. Any surface experiencing discontinuity of dampness of surface with any patch having dried out during the specified period of curing, it shall be prominently marked with lime or other suitable prominent colour.

c) Materials and T&P:

Curing compound, brush or hand operated spraying gun and all other related accessories for application on Concrete/Plastered Surface.

d) Procedure:

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified manufactured material shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out theoretically for consumption in the whole work.

Step-3

- Moist Curing:**

Cover all exposed surface of concrete, when the concrete begins to harden i.e. two to three hours after compaction with moist gunny bags or any other material approved by the Owner.

Keep the exposed surfaces continuously damp after its final setting (i.e. after a maximum of 8 hours of concreting) by ponding with a sheet of water or by covering with a layer of sacks, canvass, hessian or similar water absorbent materials constantly kept wet by water sprinkling for at least 7 days, where

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ordinary portland cement is used and 10 days, where portland pozzolana cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as per manufacturer's recommendations or as directed by the Owner.

- Using Curing compound:

Testing of Materials:

It must be ensured that curing compound should neither affect the strength nor the surface of concrete. It shall not leave any undesirable stains on surface to affect the bond of plaster or other finishes to be applied later. It should be soluble in water, so that it can be removed by splashing or washing with water without scrubbing the surface.

Test for Efficacy:

The testing of curing compounds shall be done from each lot of curing compound received at site by casting two sets of 15 cm cubes with each set having 6 cubes. One set shall be moist cured by covering with damp gunny bags and subsequently by immersing under water and the other set by applying curing compound on top after 2 to 3 hours of casting and subsequently on de-moulding apply on the remaining faces all around. The cubes shall be kept in an environment similar to which the actual structure is exposed for a period of 7 days after its casting. Three concrete cubes each from both sets shall be tested after 7 days for their crushing strength as per standard test procedure. The average crushing strength of cubes cured with curing compound shall be not less than 95% of the crushing strength of cubes cured under damp or immersion curing.

Test for Staining:

The set of three sample cubes applied with curing compound, remaining after 7-day cube crushing strength test, shall be washed with water with soft brush scrubbing with nylon bristles and allowed to dry for a period of seven days in an atmosphere with relative humidity not exceeding 40% at ambient temperature. The other set of three cubes cured for seven days under damp or immersion conditions shall also be kept for another seven days under identical humidity and temperature conditions. The surface of the two sets of such cubes shall be compared by closely observing for any visible stain and texture that may detrimentally affect its bond with subsequently applied plain plaster or aesthetic appearance. Such observations shall be recorded in three categories as no effect, slight effect and moderate effect. The curing compound shall be considered as acceptable in the 'no effect' category and unacceptable in the 'moderate' category. The decision of Engineer-in-Charge, which shall be final and binding, based on the likely use of finished surface of concrete/plaster shall determine the acceptability of the 'slight effect' category.

Concrete curing compounds, after testing satisfactorily for efficacy, may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying

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or brushing within two to three hours of casting and well within an hour of removal of formwork.

7.13 Engineered Steel Tubular double Scaffolding System

a) Purpose

To provide a scaffolding system with adjustable working platforms on the exterior of the building for the workmen to work upon any part of the area to be accessed safely and with ease for surface preparation, application of repairs and construction activity.

b) Materials

The standard proprietary tubular double scaffolding system of repute with all accessories, working platforms etc.

c) Design

It shall be designed for all the incidental dead, live and wind loads as per IS: 875 in steel tubular sections as per general design considerations governed by IS:800. The design of the scaffolding system shall cater to the safety features for the workmen.

d) Fabrication and Erection

Fabrication and erection shall be done as per the design brief and installation instructions of the proprietary firm. It shall be maintained in functional condition for the work duration.

7.14 Temporary barricading using angle iron verticals and sheet panels

a) Purpose

To provide a barricading on ground to physically define the boundaries of the site of construction/repair activity for restricted entry of only those involved with the construction work.

b) Materials

Available Corrugated G.I. Sheet minimum 24 G thick; Framing structural material at least MS Angle iron of size [40x40x5mm] or equivalent.

c) Fabrication & Erection

Size of framing panel shall be decided depending upon site conditions and these could be approximately 2.0 metres long with height as 1.8 metre.

It shall be made up at least of two verticals, each with additional length of about 600 mm for fixing in to ground firmly and two horizontals equal to the length of panel.

It shall be made up by cutting the structural sections to size, shear punching holes in verticals and horizontals for nuts and bolts or making other suitable provision for receiving CGI sheet or other specified panelling material and connection of panel with adjoining panels.

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Fabrication of frame of an individual panel shall be by welding at corners, welding MS plate at base of verticals or any other acceptable practice approved by Engineer-in-charge.

G. I sheet or other specified panelling material shall be suitably fixed. It shall preferably be done by means of nuts and bolts at its ends spaced at about 300 mm c/c transversely and at about 600 c/c longitudinally along corrugations. The corrugations of CGI sheet shall run along the shorter span of the panel.

In case of newly fabricated panels, these shall be painted with red oxide zinc chromate primer on steel work and approved primer on other material and at least one coat of paint of approved shade. In case of used panels, one coat of paint of approved shade shall be applied over the existing paint. The portion of verticals to be embedded in ground shall be suitably protected against rusting by painting it with bitumen or other suitable paint.

The fabricated panels shall be suitably fixed vertically and firmly in to the ground to the satisfaction of Engineer-in charge by maintaining a uniform height of about 1.8 metres above GL and connecting each panel with the adjoining panels with nut and bolts or other suitable means.

Suitable provision of frame/posts in the openings provided in barricading shall be made for receiving door shutter at locations as approved by Engineer-in-Charge.

7.15 Temporary protective fabric screens

a) Purpose

To protect passersby from falling debris and also to protect the workmen and structure being repaired against direct exposure to sun.

b) Materials:

For screening purpose jute cloth, woven PVC cloth, geo-textile or wire-mesh as specified and approved by Engineer-in-Charge shall be used, which shall conform to their relevant BIS Code. Screen materials shall be fixed by suitable means comprising of M.S.Flats/ J-bolts /nails/clamps, etc with washer or any other suitable means on frames of existing scaffolding etc.

c) Procedure

Scaffolding, if required, comprising of verticals, horizontals and diagonal bracings of steel tubes shall be fixed over ground which is payable separately.

One end of the screening material, brought to site in looms/rolls, shall be properly fixed over top horizontal member with suitable means and suspended so as to cover the required area.

The vertical fall of screen shall be suitably fixed/firmed up at intermediate levels so as to keep it in position during the work duration.

Next strip of the screening material shall be fixed with its sides stitched or suitably jointed or lapped with the previous ones as approved by Engineer-in-charge.

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Spacing of frame member of scaffolding shall be so selected that the sagging of screen shall not hinder the repair process.

The contractor shall maintain the protective screens in acceptable conditions for the entire work duration as required by the Owner.

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8 CONCRETE RETROFITTING METHODS

In selecting the retrofitting method, the current status of the existing concrete structure as determined through inspection, the performance of the structure, the performance required of the structure after retrofitting, the conditions for retrofitting construction work, the ease of maintenance, economy and other factors shall be considered.

At the stage of selecting the retrofitting method, the current status of the existing structure and its performance shall be obtained, and the performance required for the structure after retrofitting and the conditions for retrofitting work shall be determined. Factors that should be considered in selecting the method include the effectiveness of the various retrofitting methods with respect to the required performance improvements, the viability of execution of the retrofitting work, the impact of the retrofitting work on the surrounding environment, the ease of maintenance after retrofitting, economy and other factors.

Various retrofitting methods listed below shall be used for retrofitting objective:

8.1 Retrofitting of concrete members

a) **Continuous fiber reinforced plate bonding construction method:**

Bonding continuous fiber reinforced plates to the surface of the existing structure to restore or improve load-carrying capacity

b) **Continuous fiber reinforced plate jacketing construction method:**

Jacketing with continuous fiber reinforced plates around the periphery of the existing structure to restore or improve load-carrying capacity and deformation characteristics

c) **Prestressed concrete jacketing construction method:**

Placing pre-stressing wires and pre-stressing stranded steel wires in place of lateral ties around the periphery of existing member sections and using mortar and concrete to bond them in order to reinforce the structure. To increase the restraining effect of the inner concrete, the pre-stressing steel is generally stressed during placement.

d) **Pre-stressing introduction (internal cable) construction method:**

Using internal cables for the existing concrete members to provide pre-stressing and restore or improve the load-carrying capacity of the members.

e) **Repaving method:**

Replacing some or all of the existing concrete members with new members through the use of precast members or concreting on site to restore or improve load-carrying capacity.

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8.2 Retrofitting as a structural body

a) Beam (girder) addition method:

Adding beams between the main girders of the existing reinforced concrete deck to reduce the deck span and restore or improve the load-carrying capacity of the reinforced concrete deck.

b) Seismic wall addition method:

Placing new reinforced concrete walls between existing reinforced concrete rigid-frame bridge piers and bonding them to form a continuous unit in order to restore or improve the load-carrying capacity as a structural body.

c) Support point addition method:

Supporting the intermediate sections of the beams and other existing concrete members with new members to reduce the span of the members in order to restore or improve the load-carrying capacity as a structure.

d) Seismic isolation method:

Using seismic isolation bearings and the like to reduce the seismic energy applied to the structure in order to improve its various performance values during an earthquake.

8.3 Foundation retrofitting

a) Underground wall (beam) addition method:

Connecting the foundations with cast-in-site diaphragm walls and underground connecting beams to distribute stress and ensure the stability of the entire system.

b) Pile/footing addition construction method:

When pile foundations are damaged or there is residual displacement, adding piles or footings to increase the load-carrying capacity of the foundation.

c) Foundation improvement method:

Improving the ground around the foundation with cement improvement materials to improve the ground bearing capacity and horizontal foundation resistance. Also prevents excessive pore water pressure and liquefaction.

d) Steel sheet-pile coffering construction method:

Placing sheet-piles around the periphery of the footings and bonding them to the footings to improve bearing capacity and horizontal resistance.

e) Foundation compacting method:

When insufficient foundation bearing capacity is a concern due to scouring or the like, using concrete or the like to compact the ground around the foundation in order to restore bearing capacity.

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8.4 Repair of cracks and missing sections

a) **Cracks fill method:**

Forcing low viscosity resin and ultra-fine cement into the cracks in existing concrete members to seal the cracks.

b) **Fill method:**

Filling cracks, rock pockets, cavities, peeling and other small-scale missing sections in existing concrete members with resin and mortar to repair sections.

c) **Section repair method:**

Removing deteriorated or damaged portions of existing concrete members and then restoring these members to their original sectional status using materials with excellent bonding to existing concrete.

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9 SHORING AND UNDERPINNING

9.1 Material and Equipment

- a) The contractor shall furnish all materials, tools, equipment, facilities and services as required for providing the necessary shoring and underpinning work and facilities. Jack and jacking equipment shall be more than adequate for the imposed loads and shall be provided with calibrated gauges.
- b) Shoring and bracing materials
Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles, and accessories as required.
- c) Lagging and sheeting material
Provide heavy timber boards, planking or sheeting as required. Lagging board shall be secured in place by steel H-piles, with boards inserted between the H-flanges.
- d) Underpinning Pier
An excavation pit, provided generally by manual excavation, which is carried to a pre-selected bearing surface and then filled with concrete to provide supplementary foundation support for the underpinning structure.
- e) Concrete
Refer clause 4 of this specification for concrete requirements.
- f) Grout
Refer to Clause 5 of this specification for Non-Shrink Grout requirements.
- g) Structural Steel
Refer to Clause 9 of this specification for Structural steel requirements

9.2 Execution

- a) Detection of Movement
 - For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding improvements to be monitored. Settlement markers shall be capable of being read to an accuracy of 1.52mm.
 - Take and record readings not less than once per week during performance of the work until the permanent structures is complete to the ground level.
 - Stop work; notify the Engineer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.
 - Upon completion of the work, take weekly readings of the measurement points for a period of 4 weeks or longer if movement persists, and report the results to the Engineer.

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- The detection of movement shall be performed by a qualified licensed land surveyor or civil engineer.

9.3 Shoring and Underpinning

- Existing footings, foundations, pile caps, grade beams, retaining walls, or pavement which may be affected by excavation operations shall be shored or underpinned adequately or otherwise protected against settlement and shall be protected against lateral movement.
- Provide soldier piling, lagging and sheeting, tie-backs, slurry diaphragm wall, and cementitious grouting, as required, to hold back earth at excavations and as required to prevent cave-ins and earth sloughs.
- Footings, foundations, pile caps, grade beams, retaining walls, or pavements which have been undermined by earthwork and pile-driving operations shall be filled and supported with concrete extended to undisturbed bearing earth or bedrock.
- Concrete may be placed as a stiff mix of minimum slump (dry pack), or concrete may be pneumatically placed (shotcrete), or concrete may be placed by conventional methods with concrete formed to hold it in proper position.

9.4 Concrete Piers, Walls and Pile caps

- Install concrete underpinning piers, walls, and pile caps as indicated, with the bottom at the indicated or bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed.
- Where earth forms are indicated, install waterproof building paper or board between the earth and concrete to prevent water loss from the fresh concrete.
- Do not remove support of existing structure until concrete piers, walls, or pile caps have attained design strength.

9.5 Piles and Caissons

- Install pipe pile shells or drilled shafts at locations indicated, and extend from underside of existing footings to indicated elevations, plus additional penetration if required to develop the design working load of the pile or caisson.
- Distribute jacking reactions over the existing structure in a manner that will not overstress or deflect the existing structure.
- Weld splices where indicated. Provide watertight welds capable of developing the full strength of the pile or caisson. Align splices to ensure the straightness of the pile from top to tip. Use outside sleeves and backup rings as necessary.

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- Where the pile tip is below the ground-water table, maintain the elevation of the water inside the shell at approximately the elevation of the ground-water table during installation of the shell.
- After installation of the shell, apply the full design-working load to the empty pile shell and maintain until there is no measurable settlement over a one hour period.
- Maintain the excavation within the pile shell approximately 12 inches above the tip during driving, and dewater pile shells prior to filling with concrete in a manner which will prevent loss of earth or soil at the tip. An earth plug may be left in the pile tip or a concrete plug may be placed and cured prior to dewatering pile shells.
- After load testing to the design load, dewatering, and inspection of the shell by the Engineer, fill accepted pile shells with concrete in the presence of the Engineer. Keep an accurate record of the volume of concrete deposited in each pile. Deficiencies revealed by comparing the volume of the inside of the pile with the volume of placed concrete will be cause for rejection of the pile or correction of the deficiency.
- Securely wedge in place with steel wedges those piles that have satisfied the load-testing requirements. Weld and encase in concrete all wedges, plates, wedging struts and piles, as indicated or required.
- Following completion of load transfer of underpinned structures, fill the underpinning pits with concrete as indicated. Provide reinforcement, shear keys, dowels, and water stops as indicated or required. Place concrete to within 3 inches of the underside of the existing foundation. After three days, dry pack the space between the foundation and concrete.

9.6 Load testing of piles and acceptance criteria

- After the concrete within the pile or shaft has set for at least 24 hours, test each pile or pier by jacking to a load equal to 150 percent of the design-working load of the pile. Maintain the load until there is no measurable settlement of the pile over a one-hour period.
- Load-test piles in sequences and groupings that will minimize or eliminate eccentric loadings on the existing foundation and piles.
- Piles will be rejected and shall be retested if, in the opinion of the Engineer, there is a danger of unequal loading.
- Should the existing structure fail to furnish sufficient reaction to installed underpinning piles to the test loads specified, provide additional reaction to prevent damage to, and movement of, the structure during installation of piles, and to obtain specified underpinning test loads. The additional reaction shall not detrimentally affect the structure.
- Maximum out-of-plumb tolerance for installed piles: two percent.
- Maximum offset of top of pile from the design center: 3 inches.

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9.7 Fill and backfill

Provide engineered fill and backfill in accordance with Clause 3 of this specification, after acceptance of the underpinning by the Owner.

9.8 Temporary Supports

Install temporary supports where necessary to support structures to be underpinned and those that will be affected by underpinning and restoration work.

9.9 Restoration

Restore existing structures to conditions equivalent to those existing prior to the start of shoring and underpinning work, including repair of any settlement-related damage.

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10 STRUCTURAL STEEL WORK

Design of structural steel work shall include generally but not be limited to the steel constructions listed below:

- Steel building structure and open structures including beams, columns, bracings, supporting structures for floors, roof slabs, cladding etc.
- Hoist & monorail supporting beams etc.
- Platforms and walkways
- Ladders, staircases, handrails, etc.

10.1 Design

(a) General

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However where large cut outs are to be provided in the floor slabs horizontal floor bracing shall be provided. Grating / Chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support and horizontal bracing shall be provided as required in such cases.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimize vibration, avoid resonance and maintain alignment and level.

(b) Design of structure

The Design of steel structures shall be done by Working stress or Limit state method, in accordance with the provisions of IS: 800 and other relevant IS codes as applicable to specific structures. Basic consideration for structural framing shall be stability, rigidity, building usage, ease of fabrication / erection and overall economy. Additional bracings / moment connections shall be used to assure stability of structures. Structure shall be designed such that the surfaces of all parts shall be accessible for inspection, cleaning, painting and maintenance. Most of steel superstructure shall be designed as simple space frame structures. Simple space frame design utilizes single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Large span built-up girders shall be single web plate girders of welded construction with bearing and intermediate stiffeners. For lifting / monorails beams ISMB sections shall be preferred and the bottom flange of all beams shall be checked separately for distortion and reinforced suitably if required.

Columns shall be designed to support the load combination which results in maximum interaction ratio. Exterior columns shall be designed to resist moments due to wind & seismic. Columns shall also be designed to resist moments

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caused by discontinuous vertical bracing or non-concentric bracing work points. Column base can be fixed or pinned. Lateral forces shall be resisted by rigid jointed moment connections in rigid frame design. For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension, etc.) use 90 % of the column dead load and no live load. Uplift forces from vertical bracing and Wind uplift on the roof shall be included where applicable.

Permissible stresses for different members shall not be allowed to exceed by 33.33 % under wind and seismic conditions. However, members who shall be designed primarily to resist wind load such as bracing members, no increase in permissible stresses will be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. All anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself. No anchor pockets in foundation shall be allowed. Design of base plates shall be based on design pressure on foundation which shall not exceed the following:

Pedestal in concrete grade M30 7.50 N/mm²

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A coefficient of friction of 0.30 shall be used in conjunction with the minimum column load. If the horizontal shear force exceeds the frictional resistance force or if the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Anchor bolts are not assumed to resist any horizontal shear force. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Static analysis of overhead conveyor galleries upto a span of 24 m is allowed. However dynamic analysis shall be carried out for overhead conveyor galleries exceeding 24 m span.

For equipments, the bolt shall be either embedded or placed inside the pedestal and grouted with non-shrink grout.

The following criteria shall be followed for posting loads on the design drawings. For vertical beam reactions, the load shall be posted whenever the value exceeds the maximum allowable uniform distributed load. For axial loads in floor beams, the actual horizontal load which the beam end connection must resist shall be posted for each end of the beam. Note that this value may be different for opposite end of the same beam. For truss members, only one member force shall be noted for each member.

(c) Permissible deflections

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed

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when wind or seismic loads are acting concurrent with normal loading conditions.

• **Vertical deflection**

a) For beams supporting dynamic equipment	Span / 500
b) For beams supporting floors / masonry	Span / 325
c) For beams supporting pipes (pipe racks)	Span / 400
d) For roofing and cladding components	Span / 250
e) For gratings and chequered plates	Span / 200 subject to a maximum of 6 mm

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

For manually operated cranes and monorails : Span / 500

For electric overhead cranes

i) Up to 50 t capacity : Span / 750

ii) Over 50 t capacity : Span / 1000

• **Horizontal deflections**

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	Height / 325
b)	Multistoried building (without crane load)	Height / 500
c)	Pipe rack columns	Height / 200
d)	Open Structures	Height / 200
e)	Crane gantry girder due to surge	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail due to action of crane surge load only	Height / 2500 limited to level maximum of 10 mm
g)	Open gantry columns at crane rail level due to action of crane surge load only	Height / 4000 limited to maximum of 10 mm

Provisions of IS: 800 and relevant latest IS Codes shall be followed for limiting deflections of structural elements not listed above.

(d) Minimum thickness and size of steel elements

• **Minimum Thickness**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or

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suitably protected otherwise as per good practice and sound engineering judgement in each instance.

Trusses, purlins, girts and bracing	6 mm
Columns and beams	8 mm
Gussets	8 mm
Stiffeners	8 mm
Base plate	10 mm
Chequered plates	6 mm o/p
Grating flats	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc shall be 6 mm.

- **Minimum Sizes**

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

(e) Slenderness and depth ratios

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

Truss	1 / 10
Rolled beams and girders for Ordinary floors and rafters	1 / 24
Supporting floor beams for vibrating Machines / equipments	1 / 15
Roof purlins and girts	1 / 45
Gable columns	1 / 30

(f) Design of Connections

Welding will be done in accordance with the recommendations of IS: 816 and IS: 9595.

Shear connections will be designed for 75 % of section strength for rolled sections and 80 % of section strength for built up section or rolled section with cover plates. Designed shear force shall be more than actual shear. Moment connections between beam and column will be designed for 100 % of moment capacity of the beam section.

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All butt welds will be full penetration butt welds.

Size of fillet weld for flange to web connection for built up section will be as follows:

- i) Able to take full shear capacity or actual shear whichever is more for box section
- ii) Able to take 80 % of full shear capacity or actual shear (if indicated in drawings) or shall be 0.5 times of the web thickness whichever is more. For I-section Weld will be double fillet
- iii) All welds will be continuous. The minimum size of the fillet weld will be 6 mm as per relevant IS code

Connection of vertical bracings with connecting members will be designed for full tensile capacity of the bracings. The connection between top flange & web of built-up girder will be full penetration butt weld & for bottom flange, connection may be fillet weld.

Connection of base plate & gusset members with the columns will be done considering that total load gets transferred through weld.

Splicing

All splicing work will be full strength. Field splicing will be done with web / flange cover plates. For, exceptional cases the field splicing will be designed for 50 % of load carried by the cover plates and remaining 50 % load through full penetration butt weld. Shop splicing for all sections other than rolled will be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections will be carried out using web and flange cover plate. For design efficiency of site weld shall be considered as 80 %.

Insert plates

Insert plates shall be designed / checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall also be checked. Lugs using steel bars shall preferably be fillet welded to the plate to transfer full strength of the lug.

10.2 Fabrication

(a) General

Fabrication drawings shall be prepared according to the provision of IS: 800, IS: 813, IS: 816, IS: 9595, IS: 1367 and IS: 9178.

The work to be provided by the Bidder, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following:

- i) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on design drawings submitted by the Bidder and approved by the Owner/Consultant.

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- ii) To submit revised design with calculations and detailed fabrication (drawings in case any substitution of the designed sections are to be made.
- iii) To submit design calculations for joints and connections developed by the Bidder along with detailed fabrication drawings.
- iv) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding \ electrodes for field connections. The field connection materials supplied by the Bidder shall be to the extent of actual requirement plus 10 % (ten percent).
- v) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- vi) Suitably mark, bundle and pack for transport all fabricated materials.
- vii) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

(b) Conformity with Design

Except where the standard connection details are furnished, the Bidder shall design all connections, supply and fabricate all steelwork and furnish all connection materials, Shear connectors / shear lugs on the beams in accordance with the approved drawings and / or as instructed by the Owner/Consultant Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and / or as approved by the Owner/Consultant. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

(c) Quality control

The Bidder shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work shall be performed in accordance with this specification. In addition to the Bidder's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Owner/Consultant. As far as possible, all inspection by the Owner/Consultant shall be made at the Bidder's fabrication shop whether located at Site or elsewhere. The Bidder shall co-operate with the Owner/Consultant in permitting access for inspection to all places where work shall be done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Bidder.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

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- a) Steel Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
- b) Bolts, Nuts Manufacturer's certificate, dimension & Washers checks, material testing.
- c) Electrodes Manufacturer's certificate, thickness and quality of flux coating.
- d) Welders .Qualifying Tests
- e) Welding sets Performance Tests
- f) Welds Inspection, X-ray, Ultrasonic tests
- g) Paints Manufacturer's certificate, physical Inspection reports
- h) Galvanizing Tests in accordance with IS: 2633 and IS: 4759.

(d) Materials

If desired by the Owner/Consultant, Test Certificates of materials supplied by the Bidder in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Owner/Consultant, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

Materials for main and secondary members shall be selected in line with good engineering practice and shall be arranged within any structure with due regard for maintenance of the structure and Plant and Equipment supported or sheltered by the Structure and also with regard to corrosion.

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pitting, rusts, etc. that may impair their strength, durability and appearance.

All rolled steel shall conform to the requirements of the Indian Standards.

- i) Structural Steel will conform to IS: 2062 Grade-A for rolled steel members or plates up to 20 mm thickness.
- ii) For plates above 20 mm thickness and welded construction, steel conforming to IS: 2062 Grade-B will be used.

(e) Workmanship

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of IS: 800 and other relevant Indian Standards or equivalent.

Straightening Material

Rollled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed as per IS:1852. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

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Cutting

Cutting shall be affected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Owner/Consultant.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

Planning of Edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Owner/Consultant.

Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end, but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

Bolted construction

All bolts and nuts shall conform to the requirements of IS: 1367.

Field connections shall preferably be bolted connections unless specified otherwise. Weld connections at site shall be avoided.

High strength friction grip bolts shall be of property class 8.8 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter unless designated otherwise. High strength bolts shall be installed as bearing type joint except where loads are reversible. Bearing Type connection (H.T. bolts Grade 8.8) shall be used for all removable type connections. Bolts will be tightened to develop the required pre-tension during their installation.

All erection bolts shall be of minimum 16 mm diameter of property class 4.6 conforming to IS: 1367 unless specified otherwise.

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Holes for bolts shall not be more than 1.5 mm for bolt of diameter equal or lesser than 25 mm and shall not be more than 2 mm for bolt of diameter greater than 25 mm.

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS: 919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

Assembly

Drifting to enlarge un-matching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted nor damaged and shall be so prepared that the specified cambers, if any, are maintained.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Owner/Consultant.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or locknut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

Welded Construction

Welding shall be in accordance with relevant Indian Standards. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817. All shop connections shall be welded type.

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Preparation of Material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears, Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than 20C.

The work shall be positioned for flat welding whenever practicable.

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Owner/Consultant, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Owner/Consultant.

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding shall be started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed

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upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

No welding shall normally be done on parent material at a temperature below (-) 50C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 50C and 00C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 200C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

Submerged arc welding process shall be used for welding longitudinal fillet welds (connecting flanges with web) and longitudinal / transverse butt joints for fabrication of columns, framing beams and all other built up members unless manual arc welding is specifically required. All electrodes, flux, bare wire etc will be procured from approved manufacturers. All butt welds in beams, girders & columns will be of full penetration. All butt welds will be radio-graphically or ultrasonically tested as per relevant IS codes and standard practice. The base wire electrodes for submerged arc welding will conform to IS: 7280. The combination of wire and flux will satisfy requirements of IS: 3613.

Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the Owner/Consultant.

Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-buttressed over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so

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that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2 mm.

Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

Miscellaneous

- Lacing bars

The ends of lacing bars shall be neat and free from burrs.

- Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

- Bearing Plates

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

- Architectural Clearances

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

- Shop Connections

- i) All shop connections shall be welded as specified on the Drawings.
- ii) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Owner/Consultant for convenience of erection and the Bidder will have to make the desired changes at no extra cost to the Owner.

- Shop Erection

The steelwork shall be temporarily shop-erected complete or as directed by the Owner/Consultant so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

(f) Shop Painting

All fabricated steel material, except those galvanized or to be embedded in concrete, shall receive paint coatings as specified below. All paints shall be of approved brand and shade as per the Owner's requirement.

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Steel surface, which is to paint, shall thoroughly be cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by wire brush & if required by sand blasting prior to actual surface preparation. The surface shall be cleaned to grade ST-2.5 as per SIS05-5900 or as per IS: 1477 (Part -I).

All steel structures shall receive two primer coats and two finish coats of painting. After fabrication the first coat of primer shall be immediately given over the prepared steel surface. The second coat of primer shall be applied over the dried first primer coat. Two finish coats shall be applied over the primer coats before dispatch of structure at site.

Primer paint shall be red oxide zinc chromate conforming to IS: 2074. Dry film thickness of each coat shall be 50 microns. Adequate care should be taken such that the surface does not possess a slick finish to which paint may not adhere properly. Top coat shall consist of two coats of HB Synthetic enamel of approved shade and colour with glossy finish and DFT as 75 microns (total). Thus the total DFT of painting including that of primer coats shall not be less than 175 microns.

Following care shall be taken while painting:

- i) Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.
- ii) Surfaces inaccessible after assembly shall receive two coats of primer prior to assembling.
- iii) Surfaces inaccessible after erection, including top surfaces of floor beams supporting gratings or chequered plate, shall receive one additional coat of finish paint over and above number of coats specified above before erection.
- iv) Portion of steel member embedded / to be encased in concrete shall not be painted.
- v) Areas / Surfaces subjected to chemical attacks shall be painted with acid resistant paint.
- vi) Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

(g) Inspection, testing and acceptance criteria

Unless specified otherwise, inspection to all work shall be made by the Owner/Consultant at the place of manufacture prior to delivery. The Owner / Consultant shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification. The Bidder shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and

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instruments as may be required by the Owner/Consultant to carry out inspection and / or tests in accordance with the Contract.

The Bidder shall guarantee compliance with the provisions of this Specification.

The Bidder shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Bidder shall get the specimens tested in a laboratory approved by the Owner/Consultant and submit to the Owner/Consultant the test results in triplicate within 3 (three) days after completion of the test.

Steel

All steel supplied by the Bidder shall conform to the relevant Indian Standards, except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Owner/Consultant, random samples of materials will be taken from each unidentified lot of 50 ton or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be borne by the Bidder.

All material shall be free from all imperfections like mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

All raw steel plate of thickness more than 20 mm supplied by the Bidder shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Owner/Consultant:

- i) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.
- ii) If the results of the tests in (i) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (i) or as directed by the Owner/Consultant.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Owner/Consultant requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Bidder. If the plates in the fabricated item are found to be laminated, the component will be rejected.

Welding

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Owner may ask for at least one test-destructive or non-destructive including X-ray,

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ultrasonic test or similar, the cost of which shall be borne by the Bidder. In the event of further tests as may be desired by the Owner. The cost of such test shall be borne by the Bidder if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Owner / Consultant shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

Bolts, nuts and washers

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Owner/Consultant and shall conform to the relevant Indian Standards. If desired by the Owner/Consultant, representative samples of these materials may have

- i) Name of the Bidder
- ii) Number and date of the Contract
- iii) Name of the office placing the contract
- iv) Nomenclature of stores
- v) A schedule of parts or pieces, giving the parts or piece number with
- vi) Tolerance

The tolerance on the dimension of the individual rolled steel components shall be as specified in IS: 1852. The tolerances on straightness, length etc. of various fabricated components (such as beams, girders, columns, etc) of the steel structures (other than steel railway and road bridges structure) subjected to dynamic loading (like wind, seismic etc.) and thin walled constructions (like box girders) shall be as specified in IS: 7215.

10.3 Erection

(a) General

The work to be provided for by the Bidder, unless otherwise specified in the Bid, shall include but not be limited to the following:

- i) The Bidder shall provide all transport equipment, lifting equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- ii) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Bidder shall pay all demurrage and / or wharfage charges etc. on account of default on his part.
- iii) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and / or as directed by the

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Owner/Consultant. If necessary, suitable temporary approach roads to be built for transportation of fabricated steel structures.

- iv) Checking centre lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Owner/Consultant. The Bidder shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.
- v) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Owner/Consultant.
- vi) Touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Bidder free of cost to the Owner.
- vii) All minor modifications of the fabricated steel structures as directed by the Owner/Consultant including but not limited to the following:
 - Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
 - Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.
 - Reaming of holes for use of higher size bolt if required.
 - Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Owner/Consultant.
 - Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
 - Fabrication of parts omitted during fabrication by error, or subsequently found necessary.
 - Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
 - Carry out tests in accordance with this Specification if directed.

(b) Conformity with design

The Bidder will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and / or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and / or the instructions of the Owner/Consultant. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and / or the instructions of the Owner/Consultant.

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(c) Storage of materials

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site.

(d) Yard

The Bidder will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access, trailers and other heavy equipments. The yard shall be fenced all round with security / arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

The Bidder should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. All of which shall be carried out by the Bidder at his own cost as directed by the Owner.

(e) Covered Store

All field connection materials, paints, etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Bidder.

(f) Workmanship

Erection Plant and equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Owner/Consultant.

Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Owner/Consultant. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

Temporary bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

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If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure Installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Bidder in respect of temporary bracings and guys shall cease when the structural steel is once located plumbed levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Owner/Consultant.

The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Bidder to take out the materials from 'the project site. The Owner may remove and return the materials in good condition to the Bidder without any charge if they have been left in place under other agreed arrangement.

Temporary floors for buildings

It shall be the responsibility of the Bidder to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and / or by-laws of state, Municipal or other local authorities.

Setting out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Owner/Consultant. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Bidder shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations.

He shall remain responsible for correct positioning. For heavy columns, etc. the Bidder shall set proper screed bars if desired by the Owner/Consultant, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those

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adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

Drifting

Correction of minor misfits of bolts will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

(g) Testing and Acceptance Criteria

General

Loading tests shall be carried out on erected structures, if required by the Owner/Consultant, to check adequacy of fabrication and / or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract of either fabrication or erection of steelwork whoever is responsible for it and no payment towards the cost of the dismantled portion and any connected work shall be made to the Bidder, unless it is proved that the deficiency is due to reasons beyond the Bidder's scope. If any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Bidder responsible, to the satisfaction of the Owner/Consultant. The cost of the tests specified hereinafter shall be borne by the Owner. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed. The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated below. The method of testing and application of loading shall be as approved by the Owner/Consultant.

Stiffness Test

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 % of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 % of the maximum increase in strain or deflection recorded during the second test.

Strength Test

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load

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and twice the specified superimposed load, and this load shall be maintained for 24 hours. In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

Structure of same design

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure when a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Owner/Consultant. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20 % of the maximum strain or deflection recorded at similar load in the test on the prototype.

Repair after inspection tests

An actual structure which has passed the "Strength Test" as specified above herein before and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' above.

10.4 Requirement for specific structures

Switchyard structures

All switchyard structures comprising of towers, gantries, lightning masts, lighting towers, equipment structures etc. shall be galvanised steel with bolted site connection.

Three dimensional analysis shall be carried out for structures like towers and gantries whereas two dimensional approach may be followed for equipment support structures.

All structural steel shall be of tested quality and shall conform to IS: 2062. Steel tubes where used for equipment support structures shall conform to IS: 1161.

All bolts and nuts shall be galvanised. In addition to heavy washers conforming to IS: 6610, spring washers conforming to IS: 3063 shall be provided at all bolted connections. Bolts shall conform to IS: 12427.

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Fabrication and erection shall in generally be as per IS: 802 and IS: 800; wherever there is a contradiction between two codes the provision in IS: 802 shall govern.

Galvanising of switchyard structures

Galvanising of the towers shall be as per IS: 4759 and IS: 2633 and as given in the following sections.

Before galvanising, the steel shall be thoroughly cleaned of any paint, grease, rust, scale, acid or alkali or such other foreign matters as are likely to interfere with the galvanising process.

The acceptable values of the coating of zinc on the steel materials shall be in accordance with Table below:

KIND OF MATERIAL	COATING	
	Average value	Minimum value
Structural steel members except bolts, nuts and washers	Over 900 gm/sq. m	800 gm/sq. m
For bolts, nuts and washers	Over 750 gm/sq. m	700 gm/sq. m

The galvanised surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth, and shall be free from defects like discoloured patches, bare spots, globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The galvanised steel member shall withstand minimum four number of one minute successive dips in copper sulphate solution as per IS: 2633 unless specified otherwise.

All galvanised members shall be treated with sodium dichromate solution or an approved equivalent after galvanising so as to prevent white storage stains.

Wherever galvanised bolts, nuts, washers, accessories, etc. are specified these shall be hot-dip galvanised. Spring washers shall be electro-galvanised. Readily available GI nuts, bolts and washers conforming to galvanising requirements may also be used.

BIDDER shall ensure that galvanising is not damaged in transit. In the event of occurrence of any damage, BIDDER shall at his own cost adopt scrapping and re-galvanising the member to satisfy the specific requirements.

Large diameter steel pipes

Design, installation and testing of the pipe shall in general follow the following provision:

“Steel pipe - A guide for design and installation” – AWWA Manual M11 – published by American Water Works Association. Steel used shall conform to IS:

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2062. Minimum earth cover over the pipe shall be 1500 mm. Internal cement mortar lining of 15 mm shall be provided. External surface shall be provided with coal tar enamel wrapping. Bedding shall be of sand. Thrust blocks shall be provided at all bends. Internal design pressure shall be the shut off head as furnished by the pump vendor, 1.5 times the pump working head or maximum surge pressure computed from surge analysis. However for surge pressure the allowable stresses can be increased by 25%. External pressure due to earth pressure, surcharge pressure of 20 KN/sq.m and at road crossings pressure due to vehicles shall be considered. In addition a vacuum pressure of 9 m water column shall be considered while checking against buckling. All site joints shall be inspected by radiography.

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11 ARCHITECTURAL WORKS

The architectural design concept of buildings shall be evolved considering the functional, technical and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes. To achieve above objective Bidder shall employ a qualified architect / architectural firm to carry out all designs and hold all other architectural responsibilities for the project.

The Bidder shall obtain and be conversant with all laws, by-laws and regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The Bidder shall provide the drawings and documents for such statutory approvals.

11.1 General

The architectural services shall cover finishing work of new buildings and modernised existing buildings/structures, included under the specification starting from masonry work, partition walls, cladding walls, roof protection, finishing of walls, floors and ceilings, false ceiling as required potable water system, sanitation etc.

During execution of the contract, the Bidder shall take approval from the Owner, for all building materials and finish items (e.g. floor tiles, doors, and windows, paints etc.) to be used for the contract by submitting samples and/or product literature as appropriate.

Finishing works including material used for renovation/modernisation work shall be matched with the finishing of existing structures to make similarity in the architectural view of new and existing structures.

11.2 Finishes

All exposed surfaces shall be clean and smooth and members shall be sized to give a pleasing appearance. The Finishes for all Structures and Buildings shall meet the functional requirements and shall be as per the approved Finishing Schedule. However, the finishing schedule shall be pre-approved by the Owner/Consultant.

11.3 Design Requirement

(a) Architectural Concepts

- All buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to all buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

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- Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipments, exposed structural elements, piping, trestles, bus ducts and other service elements.
- Overall emphasis shall be on developing an eco-friendly architecture, merging with the nature with its own sustainable energy management systems.
- The scheme shall be conceptually finalized in totality including that of equipments so that the proper co-ordination with other agencies can be taken up at appropriate time.

(b) Architectural Design

- Natural light shall be used to the maximum extent. For adequate light and ventilation, National Building Code recommendation shall be followed.
- Entrance canopies, chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.
- All the buildings shall be architecturally designed to meet the National Building Code.
- Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect Statutory requirement and any clearances from local authority may be required to be met with, wherever essential. The Architect Consultant shall be of national - International repute having experience in similar kind of works. The consultant shall evolve the design philosophy and shall present it in the form of presentation drawings, prospective views, 3-D Models & detail drawings.
- A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving plant technology and architectural & civil engineering for a smooth control hierarchy and man machine interface.

The Bidder shall develop the architectural layout of all the buildings listed in this document as per the final approved equipment disposition and other layout considerations indicated elsewhere in this specification. These drawings shall need the approval of the Owner/Consultant before construction. The Bidder shall also have to submit perspective views if so desired by the Owner/Consultant at no expenditure to the Owner. Approval from statutory authorities, e.g. Factories Inspector, Explosives Inspector, Loss Prevention Association of India / Tariff Advisory Committee etc. shall be the responsibility of the Bidder without any obligation of the Owner.

The entire complex shall have an architectural character and style of its own and shall be visually and functionally integrated with the existing landscape. The

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Bidder must visit the site and have a feel of the overall environment, so that a harmonious as well as integrated architectural concept of the proposed phase of development is achieved. Special care must be taken to enhance the visual and technological quality of development by adopting updated technology, materials, finish etc.

11.4 Guideline for Architectural Works

11.4.1 Roof Insulation and Ventilation

Wherever required the roof of buildings shall be insulated with foam concrete. For ventilation requirements relevant section of the specification shall be referred.

11.4.2 Roof Waterproofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size 230x230x18 mm laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

11.4.3 Brick/stone masonry and parapet wall

All masonry works shall be designed in accordance with IS: 1597, IS: 1905, IS: 2212, IS: 4326 and other relevant IS codes as applicable. Structural design of load bearing and non-load bearing walls constructed with solid or perforated burnt clay bricks or concrete blocks shall be in accordance with criteria specified by National Building Code of India.

All walls shall be non-load bearing infill panel walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change rooms, first aid rooms and toilets, which may be half brick thick.

Minimum 50 kg/sq.cm compressive strength brick shall be used for non-load bearing super structure brickwork. Cement sand mortar 1:6 for one brick thick wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided to reinforce the wall where required.

All brickwork shall be plastered as per specification.

Even where metal cladding is specified, for initial *[3 m]* height from the ground level, minimum one brick thick masonry wall shall be provided.

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All up stands and parapet walls on roof shall be of RCC construction, minimum height of parapet walls shall be [1050 mm] and a minimum thickness of [125 mm].

11.4.4 Cement based polymer modified mortar

a) Purpose

To carry out structural repairs to prepared patches of spalled concrete with an alkaline impervious repair material comprised of polymer admixed cement-sand mortar.

b) Materials and T&P

Polymers in emulsion or powder forms as may be specified conforming to ASTM C1059, Ordinary Portland Cement of 43 grade conforming to relevant BIS code, Sand conforming to Zone-II or Zone-III grade of IS: 383, Mixing water conforming to IS: 456-2000, mortar mixer with mechanical water dozer, spatulas, trowels, etc.

c) Procedure

Step-1: Follow the guidelines for Safety, Quality Assurance, Environmental Protection, Product delivery, Personnel, Supervision, Storage and Handling, etc.

Step-2: Full quantity of specified polymers shall be received at site in factory sealed containers with labels legible and intact provided that the shelf life so permits. Otherwise substantial quantity as could be consumed within the shelf life shall be received as per quantity approved by Engineer-in-Charge. Full quantity shall be worked out as theoretically required for consumption in the whole work.

Step-3 Testing of Material: The requisite number of test specimens of mortar shall be cast from each batch of manufactured or supplied materials received (whichever is less). These are to be tested for conformance to the specified requirements before use on the work. Polymer modified cement mortar with cement: sand proportion by weight as (1:3) shall have the following properties

Minimum compressive strength -20N/sq.mm after 28 days at 27oC

Step-4: Identify and mark the area for Polymer modified mortar repair.

Step-5 Surface Preparation: The appropriate propping/supporting, surface preparation and crack sealing as per site requirements shall be completed, which may sequentially cover one or more of the following items of work:

Prop & support the structural member to relieve it of stress and strains.

Removal of existing surface plaster/treatment shall be done.

Chipping unsound/weak concrete material shall be done.

Removing concrete all around embedded rusted reinforcement shall be done.

Removing and cleaning reinforcement of rust from its surface to give it a shining bright metal shall be done.

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Sealing the cracked or honeycombed concrete with injection grouting shall be done.

Providing and inserting mild steel shear key bars shall be done with minimum 3 nos per square meter of surface area of substrate, which may also be used as depth measuring gauge.

Additional fresh reinforcement, if required, shall be tied with required overlaps or welded.

The rust, if any, persisting over the existing exposed reinforcement or the new reinforcement shall be removed mechanically or chemically.

Cleaning of lightly sticking materials and foreign matter from the exposed concrete surface and steel reinforcement by suitable means shall be done.

Step-6: Clean the dust and saturate the prepared surface of concrete and reinforcement with a clean oil free air blast and water fit for construction.

Step-7: Inspection of concrete surface prior to adhesive application shall be thoroughly inspected and got approved by the Engineer-in-Charge. Surfaces shall be ensured to be free from any deleterious materials such as oil, dust, dirt etc. using oil free air blast.

Step-8: Alignment & thickness Control- Ground wires shall be fixed at reference points to measure and control the thickness of overlay. Shear keys fixed earlier could also function as depth gauges. Adequate ground wires shall be installed to establish thickness and surface planes of the overlay build up. Ground wires shall be tight and true to line and placed in such a manner that they may be further tightened.

Step-9: Apply Passivating & bonding coat over the cleaned existing and new reinforcement.

Step-10: Apply bond coat on the cleaned concrete substrate.

Step-11: Mix and Prepare Polymer Modified Mortar to have a uniform consistency and texture by adding cement sand and polymer as weigh batched ingredients of the design mix, a specified proportion of water through water dozer.

Use of prepacked ready to use components supplied by manufacturers in containers may be allowed subject to approval of Owner. In case where prepacked ready to use materials are to be used, the contractor shall submit the manufacturer's certificate verifying conformance to material specification as specified, manufacturer's mixing and application procedure for approval by Engineer-in-charge.

Plastering with cement based polymer modified mortar shall be done immediately after applying the bonding slurry to the prepared surfaces, preferably in coats of approximately 10mm thickness as greater thickness may lead to delamination/collapse. However, coats shall be applied in fairly rapid successions within 15 to 30 minutes. After applications of mortar the surface shall be finished using a wooden float.

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Step-12: Moist cure the polymer modified mortar surface for 1-3 days followed by air curing at ambient temperature or as per manufacturer's specification, if specified otherwise. Use of flowing water or ponding of water shall not be done for curing. Steam curing shall not be permitted.

Step-13: Test the Surface of 7-day cured concrete overlay for soundness by tapping or sounding with hard blunt surface.

d) Inspection & Quality control

The mortar application work shall be continuously inspected by a qualified supervisor who shall check materials, application of mortar, curing stoppage of work during low temperatures (minimum working temperature being 8°C in most of the polymer modified mortar or as per manufacturer direction) and high winds etc. Each completed work of mortar shall be systematically sounded with a hammer to check for drummy areas after hardening.

In suspect areas or whenever directed by Engineer-in-Charge, the contractor shall drill the cores from the finished work and in to the host concrete after 28 days of mortar application. The cores shall be examined for evidence of poor workmanship by the Owner, and if he is satisfied that either the bonding work or the subsequent layer of mortar are not of the required workmanship, the contractor at the instruction of Engineer-in-Charge shall dismantle such areas of work as required by the Owner and re-do the same after re-preparing the surface by chipping off mortar work and abrading the bonding slurry interface.

11.4.5 Partition Wall

All intermediate walls shall be full brick thick wall in 1:6 cement sand mortar. Half brick thick wall in 1:4 cement: sand mortar with [2 nos. 6 mm] diameter rod in every fourth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area.

11.4.6 Metal cladding

a) Permanent colour coated sandwiched insulated metal cladding system

Trough zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6 mm minimum thickness (or high tensile steel sheet of 0.5 mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 180 gm / sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of Dry Film Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

Galvanised M.S. sheets of minimum 0.6 mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with

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suitable pre-coating of minimum 7 microns. The rate of galvanising shall not be less than 180 gm / sq. m.

The permanent colour coated sheet shall meet the general requirements of IS: 14246 and shall conform to class 3 for the durability.

Inner sheet shall fixed directly to side runners and Z spacers made of at least 2 mm thick galvanised steel sheet of grade 375 as per IS: 277. Inner sheet shall be fixed at the rate not more than 0.75 m centre to centre to hold the insulation and external sheeting.

The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS: 8183, having a density of 32 kg / cu. m for glass wool & 48 kg / cu. m for rock wool.

b) Permanent colour coated (non-insulated) metal cladding system

Trough zinc-aluminium alloy coated not less than 180 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet of 0.5 mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS: 14246 and shall conform to class 3 for the durability.

c) Flashings, Cap, Trim Closures etc.

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

11.4.7 Plastering

On the exterior wall & rough side of interior brick wall [18 mm] thick minimum with cement-sand mortar in two layers shall be applied. Where external finish will require rich plastering for special finish plaster shall be of 1:4/1:3.

Interior wall: [12 mm] thick with 1:4 cement-sand mortars

Ceiling: [6 mm] thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

11.4.8 Removal of plaster manually from masonry or concrete surface using chisel and hammer and disposal of debris etc

a) Purpose

For removal of all type of loose /delaminated /damaged/weak cement plaster from surface of masonry or concrete.

b) Procedure

Step-1: Safety shall be ensured in accordance with contract conditions and specifications.

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Step-2: Provide double scaffolding, protective screens etc.

Step-3: Existing plaster to be identified for removal by tapping all areas and its boundary shall be marked with a colour marking (in an optimal rectangular shape), which shall be approved by Engineer-in-Charge.

Step-4: Make a cut normal to the surface all along the boundaries with power driven cutters. The depth of cut shall not exceed the thickness of plaster.

Step-5: Remove the plaster manually with the help of chisel and hammers to completely expose the parent masonry or concrete surface, so as not to have any traces of such plaster left behind.

11.4.9 False ceiling and under deck insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the under side of the roof / floor slab of the air-conditioned areas based on the functional requirement. Aluminium false ceiling system shall comprise of [84 mm] wide [12.5 mm] deep closed type plain panels of approved colour, roll formed out of [0.5 mm] thick corrosion resistant aluminium alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, AC ducts etc. Suitable M.S channel (minimum ISMC100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc.

Bidder shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire detectors, fire protection sprinklers etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the Owner approves the layout. Under deck insulation shall comprise of [50 mm] thick resin bonded mineral wool insulation mat conforming to IS:8183. This mat shall be backed with [0.05 mm] thick aluminium foil and [24 Gx25 mm] wire mesh netting. These shall be fixed to ceiling or wall as the case may be with [100x50x6 mm] slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at [600 mm c/c and 14 G] steel wire drawn through slots and fixed to wire netting.

11.4.10 Doors

- Generally hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas.
- Solid core factory made wooden flush doors in hard wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.
- Special areas like control rooms and other special area shall be provided with minimum 15 micron pre-coated Le. colour anodised aluminium glazed partitions with air lock facilities having two sets of doors.

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- Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard and also to all fire exists as per TAC requirement.
- Doors shall be provided at appropriate location to prevent dust ingress from outside.
- FRP Doors with FRP Frames shall be provided for all the toilet doors.
- Weather stripping shall be provided to all outside doors as well as air-conditioned areas and all other doors where dust-free environment is required.

11.4.11 Rolling shutters

Rolling steel shutters conforming to IS: 6248 will be used for large openings where frequent use is not envisaged. Unless noted otherwise, main entry doors of width and height to suit the requirements. Rolling shutters with area up to 8 m² shall be pull and push type hand operated, while above 8 m² shall be pull and push type with ball bearings (Electrically operated) as per IS specification.

11.4.12 Windows & Ventilators

In all buildings, full glazed windows and ventilators in minimum [15 micron] colour anodized aluminium window frame shall be provided with [4 to 6 mm] thick (depending on the size of panel) clear float glass and [6 mm] thick clear wired/laminated glass where required from safety point of view. Structural glazing may be considered as an important facade element.

The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Glass thickness and member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Bidder before execution.

11.4.13 Plywood Covering Panels to Cover Windows etc. During repairs

a) Purpose

To protect the finished items against their spoiling/damage to finishes during the process of carrying out repairs in a building. The items could include finished windows, doors, glass curtain wall or other such items.

b) Materials:

Wooden Battens of size 50mm X 50mm (approximately) or as approved by Engineer-in-charge, free from warping, cracks etc. made from locally available timber.

Plywood of suitable thickness, preferably 6 mm thick, as approved by Engineer-in-Charge.

Nails, screws etc. as per requirement.

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c) Fabrication:

Size of covering panels shall be more than the size of windows etc. to be shielded/ protected, enough to be fixed to the walls without damaging the windows etc.

Wooden battens shall be cut approximately to the size of panels of windows etc. to be protected. The joints of the wooden framework shall be lap joint or as approved by Engineer-in-Charge.

Where the panel size is more than 2 square metres or as specified by the Engineer-in-Charge, the stiffening shall be done with batten backing to impart stiffness enough to provide rigidity against undue deflection due to impact of falling debris, self load, etc.

Plywood shall be fixed with nails/screws over the batten frames. The spacing of nails/screws shall be about 300mm c/c or as may be required at site.

d) Fixing:

The plywood covering panel shall be suitably fixed without damaging the windows etc. being protected by such panels with nails/screws fixed in walls strong enough to resist the forces likely to be imparted during repair work. It shall be done in such a manner that it can be removed with ease without damaging the covered windows etc. after completion of repairs.

e) Removal:

After completion of work, the covering panels shall be removed carefully, so as not to cause any damage to windows etc. covered. The damages, if any, shall be made good.

11.4.14 Facilities in Buildings

Adequate toilet and drinking water facilities shall be provided for personnel working in each building. Each building shall have toilet facilities both for Gents and Ladies. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.

However minimum 1 Water Closet, 1 washbasin, 1 urinal shall be provided in each toilet.

Each floor shall have drinking water facility connected through water purification system like Aquaguard or similar approved make.

11.4.15 Glazing & Glazed Partition

- Glazing in Control room between AC. and non-AC. areas shall be insulating glass consisting of [two 6 mm] thick toughened float glass sheet hermetically sealed and separated by [12 mm] gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.
- [4 mm] thick ground glass shall be provided for toilets.

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- Glazing between two AC. areas shall be with 6 mm thick clear float glass.
- All glazing shall be in aluminium frame.
- [6mm] thick Wired / laminated glass shall be used for windows / ventilators at higher level for safety.
- [24mm] thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with [12mm] air gap & hermetically sealed shall be mounted on [15 micron] coloured anodised aluminium frame suitable for structural glazing system.

11.4.16 Sealant

Silicon sealant or polyurethane sealant shall be used in all expansion joints exposed to weather. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water-lightness.

11.4.17 Damp Proof Course

[40 mm thick 1:1.5:3] concrete with waterproofing admixture. Water proofing compound shall be of Zydex, SIKA, or similar approved.

11.4.18 Plinth Protection

Minimum [1000 mm] wide and minimum [100 mm] thick M 15-grade concrete plinth protection along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be provided. The plinth protection shall be laid over prepared sub-grade and base formed with locally available broken laterite stone to thickness of [150 mm].

11.4.19 Painting

- Exterior Masonry Surface : Buildings shall be finished with [Acrylic Emulsion pain] as per IS specification with approved colour and scheme.
- Exterior Steel Work : Anti-corrosive synthetic enamel paint over [anti corrosive primer].
- All Woodwork: [Synthetic paint over a coat of primer].
- All Internal Steel Work : [Synthetic enamel over a coat of primer].
- Interior Office Spaces Rooms, All AC Areas : Acrylic emulsion paint over [2 mm] control thick plaster of paris punning.
- Balance areas: As indicated in finish schedule in this document.
- Fire Door: Post Office red shade shall be provided.

11.4.20 Flooring

Unless and otherwise specified, the nominal total thickness of floor finish shall be [50 mm] including under bed and topping. The flooring shall be laid on

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already matured concrete base. The under bed for floors shall consist of minimum grade of M 15 with stone chips [12.5 mm] downgraded as coarse aggregates. The under bed shall be provided appropriate slope towards catch pit for floor drainage.

- **False Flooring System**

Removable type false flooring system shall be provided wherever required (computer rooms etc.). RCC floor slab will be sunk to a depth [800 mm], which shall be height of the false floor system. The flooring shall consist of fire resistant phenol formaldehyde bonded particle board panels [600x600x35 mm] size, mounted on steel pedestals of adjustable height and supporting steel grid system to provide under floor space. [2 mm] thick flexible anti-static PVC topping on top and PVC strip edging on sides of each panel shall be provided.

- **PVC Floor Finish**

Two mm thick PVC as per IS: 3462 and laid as per IS: 5318 over concrete under bed of [48 mm] shall be provided in electronic cubicle rooms, conference room, etc. PVC tiles shall ensure anti static surface.

- **Vitrified ceramic Tiles**

Heavy duty vitrified ceramic tiles of appropriate thickness and of minimum size [600 mm x 600 mm] of approved shade & colour shall be provided for control room as per relevant code and manufacturer's specification over concrete bedding to result in an overall thickness of [50 mm].

- **IPS Flooring**

IPS (cement concrete flooring) with metallic floor hardener topping [12 mm] thick with a total thickness of [50 mm] shall be provided in maintenance and unloading area, ground floors, floor of pump house, permanent stores and other plant building areas where heavy duty flooring is required.

IPS flooring with non-metallic floor hardener shall be provided in all MCC and switchgear rooms, which are not air-conditioned.

IPS flooring shall also be provided in areas, which are not provided with any special finish. Areas which are likely to be subjected to oil spillage shall be provided with two coats of oil resistant painting over IPS floor finish. If required, Bidder has to use floor hardeners at appropriate locations.

- **Heavy Duty Ceramic Tiles**

Heavy duty vitrified ceramic tiles with suitable finish shall be used in toilets, pantry, dining hall of canteen, locker rooms etc. The tiles shall be minimum of [300 x 300 x 7 mm] of approved shade, brand and colour.

- **Acid / Alkali Resisting Tiles**

- Battery rooms and other areas coming into contact with acid / alkali vapours or fumes shall be given acid / alkali resistant tiles 25 mm thick, jointed with acid / alkali resistant cement slurry. Bedding shall comprise

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of potassium silicate mortar conforming to IS: 4832 (Part-I) and resin based mortar like epoxy for jointing. Total thickness of flooring shall be 50 mm. Ceramic unglazed vitreous tiles conforming to IS: 4457 with minimum thickness of 20 mm may also be used as acid / alkali resistant tile.

- **Integral Floor Finish**

For cable vaults floor finish integral to the concrete base shall be provided as per IS: 2571.

- **Cast-in-situ Terrazzo**

Risers and treads of staircases shall be provided with cast in-situ terrazzo. This shall be laid as per IS: 2114, using white cement or cement with colouring pigment. Chequered finish shall be provided for treads. Total thickness of the finish shall be 25 mm.

11.4.21 Miscellaneous

PVC nosing shall be provided for edge protection of R.C.C. stair treads.

Angles [50x50x6 mm] (minimum) with lugs shall be provided for edge protection of cutouts / openings in floor slabs, edge of drains covering gratings, edge of R.C.C cable / pipe trenches of any other place where breakage of edges / corners is expected.

Floors of switchgear rooms shall have embedded steel channel suitable for easy movement of breaker panel.

11.4.22 Skirting/DADO

- [150] mm skirting matching with floor finish shall be provided in all areas unless specified otherwise elsewhere.
- Toilets and locker rooms shall be provided with dado of [2100] mm high with glazed tiles of minimum [5] mm thickness generally as per IS: 777.
- For Control room and control equipment room minimum 5 mm thick decorative coloured ceramic tiles shall be provided upto false ceiling level.
- For battery room and other areas coming in contact with acid / alkali spillage / fume, dado of acid / alkali resistant tiling as per IS: 4457 shall be provided to a height of [2100] mm set in potassium silicate mortar and joints pointed with resin bonded mortar
- Staircase wall shall be given dado of cast in-situ terrazzo to a height of [2100] mm or as per approved drawings.
- Before wall surfaces are covered with tiles, flags or mosaic to be set in normal mortar bedding, a sprayed coating of cement mortar shall be applied to the base unless otherwise specified. Where no adequately even surface is available for work involving thin beddings, special provisions shall be made to compensate for this, e.g., rendering coat, screed. The concrete surface to

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which tiles, flags, terrazzo, screed, etc are to be placed, shall be cleaned by wet sandblasting and washed with water under pressure, so as to produce the specified surface condition.

- The exterior brickwork walls shall consist of load bearing and non-load bearing type construction. Exterior surfaces shall be treated with approved chemical waterproofing over cement plaster. Bricks of minimum 75 kg/cm² crushing strength shall be provided. Brickwork shall be carried out in cement sand mortar conforming to IS: 1077. Cement sand mortar shall conform to IS: 2250.

11.4.23 Roof access

All roofs shall be provided with access thorough a staircase / cage ladder. Minimum [1000 mm] wide access path shall be provided with suitable tiles to approach equipment on roof.

11.4.24 Roof Drains

Roof drains design criteria

Minimum diameter of the pipe shall be [150 mm]. The roof drains shall be sized for the roof area runoff for a maximum rainfall per hour at site.

Detailed specification is mentioned elsewhere in this specification.

Roof Drainage and Water Proofing

All roofs of buildings shall be provided with 3 layers, first being elastomeric membrane water proofing treatment, secondly screed concrete shall be laid and finally the wearing course. Elastomeric membrane shall be laid as per manufacturer's specifications which shall adhere to specifications as given in IS 2645. Run off gradient shall be given a minimum of 1 in 100. Gradient shall comprise screed concrete 1:2:4 using 12.5 mm or below coarse aggregate. Over the screed concrete waterproofing treatment shall be provided as below:

A wearing course shall consist of pressed clay tiles of size [230x230x18 mm] laid in water proofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

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12 GENERAL REQUIREMENTS

12.1 Roof

All the buildings having R.C.C slabs over structural steel framing are provided with troughed metal sheet decking which acts as permanent shuttering. These sheets shall meet the general requirements of IS: 14246 and shall conform to class 3 for durability. The sheeting shall be permanently colour coated galvanised M.S. troughed metal sheet decking of approved profile with minimum base metal thickness of 0.8 mm and minimum trough depth of 38 mm. Silicon modified polyester painting shall be used for permanent coating over galvanised surface with minimum rate of galvanising of 180 gm of zinc per sq. m. Dry film thickness of colour coating shall be at least 20 micron.

Roof of all buildings having R.C.C. framework shall have cast in-situ R.C.C. slab with conventional shuttering.

Structural steel roofing wherever required shall be of permanently colour coated galvanised M.S troughed metal sheet of approved profile. Minimum base metal thickness shall be 0.8 mm. The rate of zinc consumption for galvanising shall be 275 gm/sq. m. The external face shall have permanent colour coating of PVF 2 paint of minimum DFT of 20 microns and inner surface shall be coated with silicon modified polyester paint with DFT of 20 microns

12.2 Platforms and walkways

Platforms shall be provided to all major equipment, not directly accessible from the floors, for maintenance. Platforms and connecting walkways shall have a minimum width of 750 mm. Platforms in front of the entry shall be at least 900 mm wide. Platforms located close to each other shall be connected with walkways.

All steel platforms above grade level shall be constructed with kick plates at edge of the platform to prevent tools or materials from falling off. It shall consist of 8 mm thick steel plate projecting 100 mm above the platform surface. Kick plate shall be painted with the same type of coating as the material to which it is attached. Approach to EOT crane shall be ensured by Cage ladder or staircase.

12.3 Stairs and ladders

Steel Stairs

All steel staircases shall normally have minimum clear width (back to back of stringer) of 1000 mm and maximum inclination with horizontal of 35.75°. However, in case of space restriction, minimum clear width up to 750 mm and slope up to 45° may be provided. The vertical height between successive landings shall not exceed 5 m. Channels (minimum MC 200) shall be provided as stair stringers. Treads shall be minimum 250 mm wide of chequered plate/grating, with suitable nosing, and spaced equally so as to restrict the rise to maximum 180 mm (200 mm in exceptional cases).

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Steel Ladders

Ladders shall be provided to platforms, walkways, instruments and equipments, which do not require frequent access. Ladders shall preferably be vertical and its angle with vertical shall not exceed 50. Ladders shall be of minimum 450 mm clear width with 20 mm diameter MS rungs spaced at 300 mm (maximum).

Ladders shall be provided with a safety cage of minimum 750 mm diameter clear when the top of ladder is more than 4.5 m above the landing level. However safety cages shall start at 2.5 m above the lower landing level.

RCC Stairs

All stairs shall have maximum riser of 180 mm and a minimum tread of 250 mm. However, for public buildings riser shall be limited to 150 mm and tread width of 300 mm. Minimum width of stairs shall be 1200 mm generally. All stairs normally shall not have more than 15 risers in one flight. Aluminium angle nosing with minimum 50X25X3 angle or PVC nosing shall be provided for edge protection of RCC stairs.

12.4 Handrails

Handrails shall be provided at appropriate places to ensure safety e.g. around all floors/roof openings, projections / balconies, walkways, platforms, steel stairs etc.

All handrails shall be of 32 mm nominal bore MS pipes (medium class) as per IS: 1161 galvanised using 900 gm/sq. m of zinc. Handrails for platforms, walkways and projections shall be a two-rail system with the top rail 1000 mm above the walkway surface and the intermediate rail 450 mm below the top rail. Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the protected horizontal opening. In such a case spacing shall not exceed 1850 mm centre to centre of posts. Handrails shall be shop fabricated for specific locations and field welded or bolted to the erected structural steel. For platforms at elevation more than 30 m, three rail system with top rail at 1500 mm shall be adopted.

For RCC stairs, handrails with 20 mm square MS bar balustrade with suitable MS flat & aluminium / Teakwood handrail shall be provided, unless specifically mentioned otherwise. All hand rails except stairways shall be provided with toe guard plate of 100x8mm thick.

12.5 Edge protection

Wherever possible around floor openings an RCC kerb of 100 mm wide 150 mm high shall be provided. All concrete edges, where breakage of concrete corner is expected, shall be provided with angles at least L 50x50x6 with lugs for edge protection e.g. all round the cut-outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers and supporting edges of precast covers etc.

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12.6 Vertical Headroom

All accessible areas shall be provided with minimum clear headroom as follows, unless otherwise specified:

Table 2.9

Headroom

Description	Headroom, mm
Finished floors to ceiling (buildings)	3000
Doors, Walkways, Platforms, Stairs etc.	2100
False ceiling of office areas	3000
False ceiling walkway	1000
Safety cage for ladders	2500
Access for forklift trucks	2800
Main roads/Railway crossings & crane access	7000
Other plant roads and truck access	5000
Cable & Pipe rack (except road/rail crossings)	3000

12.7 Waterproofing of underground structures

All underground structures like basements, pump houses, water retaining structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sq.m (minimum) for water/ damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that waterproofing grouting can be injected later in case of leakage.

12.8 Anti-termite treatment/Anti-weed treatment

Pre-constructional anti termite treatment shall be given to all buildings as per IS: 6313 and other relevant Indian Standards.

Reservoirs shall be given an anti-weed treatment of approved quality and quantity as per the manufacturer's specification. Anti weed treatment shall be carried out before carrying out the lining work.

12.9 Plinth Level

The finished floor levels shall be 800 mm higher than the external finished ground level. Finished ground floor level (plinth level) of all buildings shall be minimum 500 mm above the formation level/grade level.

All cable vaults shall be located above ground level i.e. cable vaults shall not be provided as basements in the buildings.

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12.10 Statutory Requirements

All the applicable statutory rules pertaining to Indian Factories act, Factory rules of state government, Fire safety rules of Tariff Advisory Committee, Water act of Pollution Control Boards, Explosives act etc. and stipulations of other relevant statutory authorities shall be taken into consideration at the time of design.

Provisions of safety, health and welfare according to Factories act shall be complied with design stage. These shall include provision of continuous walkway (minimum 500 mm wide) along crane-girder at crane girder level on both sides of the building, comfortable approach to EOT crane cabin, railings, fire escape, locker room for workmen, pantry, toilets, rest room etc.

Adequate number of fire escapes shall be provided in a building. Fireproof doors, number of staircases, fire separation walls, lath plastering on structural steel member (in fire prone areas) shall be made according to the recommendation of TAC. For fire safety requirements of buildings IS: 1641 and IS: 1642 shall be followed in addition to TAC requirements. All masonry firewalls shall be minimum 345 mm thick and RCC firewall shall be minimum 200 mm thick.

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13 GENERAL CIVIL WORKS AND CONSTRUCTION TOLERANCES

13.1 Basic requirements for all civil works

Design requirements

The design of all structures under this contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other joints. The design shall be to the approval of the Owner/Consultant.

- Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and/or the limits prescribed by the machinery manufacturers (whichever is less).
- The superstructures and foundations subjected to vibrations (the primary source of these vibrations being the unbalanced forces generated by rotating or reciprocating equipment) shall be designed such that vibrations will be neither intolerable nor troublesome to personnel and will not cause damage to the machine or structure.
- The natural frequency of the whole of the superstructures and foundations or parts thereof and all structures adjacent thereto shall not coincide with the operating frequency of the vibrating plant.
- The differences between frequencies and the dynamic analysis of the superstructures and foundations shall be in accordance with the relevant design standard.
- The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all plant and equipment.
- Throughout the works all floor slabs above rooms containing electrical equipment shall be watertight. No drainpipes or water pipes are permitted to pass through these rooms.
- All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Owner/Consultant and shall comply strictly with the tests prescribed hereinafter or, where tests are not laid down in this specification, with the requirements of the latest issue of the relevant Indian, American, British, German Standards or other Standards approved by the Owner/Consultant.
- Samples of all materials proposed to be used in the works may be called for at any time by the Owner/Consultant.
- The work shall be carried out by competent personnel skilled in their various trades.

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- Before commencing the works, the Bidder shall ascertain the locations and nature of all existing underground services and shall take every possible precaution against any damage occurring to them or interference therewith, during the execution of the works.
- Suitable access to the roofs of the buildings by means of steel stairs shall be provided for maintenance and repair of any installation.
- All rooms with fire hazard shall be provided with suitable emergency exists.
- Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles, which will be used (cars, forklifts, trucks/trailers etc) to reach up to the point of unloading of the equipment.
- Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms, at all levels using suitable stair wells and suitable electric hoists. The dimensions of rooms, stairwells, doors, etc shall be designed to suit the a.m. transport concept.
- Before starting of design works, the Bidder shall submit to the Owner/Consultant for approval the project design manual containing the design data and the detailed design criteria for all civil works. Design works shall commence only after approval of the project design manual by the Owner/Consultant.

13.2 Basic requirements during construction

Basic Cleaning

Basic cleaning includes all floors, walls, ceilings, built-in fittings and equipment, including the furnishings. The basic cleaning operation must result in a degree of cleanness, which permits the fully equipped buildings and rooms and associated outdoor installations and secured surfaces to be taken over without complaint.

Advertising boards and stickers, temporary protective coatings and claddings, remains and splashes of paint, must be removed with water or suitable solvents.

Dust and other dirt must be completely removed from all wall and floor surfaces, as well as from all furniture.

Windows and mirrors must be cleaned so that they are completely clear and without streaks.

Perlator gauges, showerheads, odour traps and floor drains of the sanitary installations must be cleaned and the fittings and bright pipe work must be spotlessly polished.

Petrol and oil separators must be emptied, cleaned and refilled if necessary during basic cleaning.

Lamps, including dishes, lighting units and tubes, switches and sockets as well as bases and skirting boards, doors with frames and glazing, windows, window seats and other furniture and fittings must be included in the basic cleaning operation.

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Initial Equipment

The specification is drawn up on the assumption that the scope of the initial equipment and consumption materials is to be provided complete in every respect; everything required for the use and care of the installations must be supplied, even if this is not expressly specified in the documentation.

Bidder shall ensure that during excavation ground water level shall be lowered by at least 0.50 m below the founding level adopting appropriate method of dewatering. Lean concrete below foundation shall be laid soon after excavation with minimum loss of time.

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14 STANDARDS, CODES AND REFERENCES

14.1 General

The Design of the Steel Structural Works shall be prepared and presented in accordance with IS codes. In absence of guidelines of specific items in the IS codes, International codes viz., American, BS, DIN or Australian code shall be used. All the Indian Standards referred to shall be the latest revision (including all amendments issued thereto) on the date of opening of the price bid. The Standards adopted shall be clearly stated in the calculations.

The Design shall comply with the current Local Authority Building Regulations (National Building Code) where appropriate. Subject to the agreement of the Owner, other International / Foreign National Standards, and, International / Foreign National Standard Codes of Practice, may be used.

To the extent that the Design shall include materials, methods or workmanship to be incorporated into the works, they shall be selected and incorporated into the design in accordance with the recommendations and requirements of the following (as appropriate in order of precedence but not mutually exclusive):

Statutory requirements

The Contract provisions

Bureau of Indian Standard Codes of Practice

International / Foreign National Standards

Agreement Certification for Materials

Manufacturer's recommendations for materials

Competent Trade Association recommendation

Engineering judgment

In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.

Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.

Where British / American / DIN or other codes and standards are referred to in this document, equivalent Indian Standards may be substituted if available.

Materials supplied from India shall follow the Indian Standard Specifications.

Field and laboratory testing procedures for materials follow Indian Standard Specifications.

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14.2 Codes for Loads

- IS: 875 : Code of Practice for design loads (other than earthquake) for Buildings and structures (All parts)
- IS: 1911 : Schedule of unit weights of building materials
- IS: 1893 (Part 1) : Criteria for earthquake resistant design of structure – General provisions and buildings
- IS: 1893 (Part 4) : Criteria for earthquake resistant design of structure – Industrial structures including stack-like structures

14.3 Codes for RCC

- IS: 456 : Plain and reinforced concrete - Code of Practice
- IS: 2974 : Code of Practice for design and construction of machine foundations
- IS: 2911 : Code of Practice for design and construction of pile foundation
- IS: 4326 : Code of Practice for earthquake resistant design and construction of buildings
- IS: 4995 : Criteria for design of reinforced concrete bins for storage of granular (all parts) and powdery materials
- IS: 4998 : Criteria for design of reinforced concrete chimneys: (All parts)
- IS: 5525 : Recommendation for detailing of reinforced concrete works
- IS: 1786 : Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS: 11384 : Code of Practice for composite construction in structural steel and concrete
- IS: 11504 : Criteria for structural design of Reinforced concrete Natural Draft Cooling Tower
- IS: 11682 : Criteria for design of RCC staging for overhead water tanks
- IS: 13920 : Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces

14.4 Codes for Structural Steel

- IS: 800 : Code of Practice for general construction in steel
- IS: 801 : Code of practice for use of cold-formed light gauge steel structural members in general building construction
- IS: 806 : Code of Practice for use of steel tubes in general building construction
- IS: 808 : Dimensions for hot rolled steel beam, column channel and angle section
- IS: 812 : Glossary of terms relating to welding & cutting of metals
- IS: 813 : Scheme of symbols for welding

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- IS: 814 : Covered electrodes for manual metal arc welding of carbon and carbon manganese steel - Specification
- IS: 815 : Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel
- IS: 816 : Code of Practice for use of metal arc welding for general construction in mild steel
- IS: 817 : Training of welders - Code of practice (Part 1 & 2)
- IS: 818 : Code of practice for safety and health requirements in electric and gas welding and cutting operation.
- IS: 819 : Code of practice for resistance spot welding for light assemblies in mild welding
- IS: 822 : Code of practice for inspection of welds.
- IS: 1182 : Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
- IS: 1200 : Method of measurement of building and civil engineering works
- IS: 1161 : Steel tubes for structural purpose
- IS: 1363 : Indian standard- Hexagonal head bolts, screws and nuts of product grade C
- IS: 1367 : Technical supply condition for threaded fasteners
- IS: 1477 : Code of practice for painting of ferrous metal in building
- IS: 1852 : Specification for rolling and cutting tolerance for hot-rolled steel products
- IS: 2062 : Structural steel (fusion welding quality)
- IS: 2074 : Ready mixed paint, air drying, red oxide zinc-chrome, priming
- IS: 2645 : Specification for integral cement waterproofing compound
- IS: 2932 : Specification for enamel, synthetic exterior type –I
- IS: 3613 : Acceptance tests for Wire flux combination of submerged arc welding
- IS: 3757 : Specification for high strength structural bolts
- IS: 4000 : Code of practice for High Strength bolts in steel structures
- IS: 7205 : Safety code for erection of structural steel work
- IS: 7215 : Specification for Tolerances for fabrication of steel structures
- IS: 7280 : Specification for Bare wire electrodes for submerged arc welding of structural steel
- IS: 8640 : Recommendations for dimensional parameters for industrial building
- IS: 9178 : Criteria for design of steel bins for storage of bulk material

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(All parts)

- IS: 9595 : For Metal arc welding of carbon and carbon manganese steel - Recommendation
- IS: 11592 : Conveyor galleries
- IS: 12843 : Tolerances for erection of steel structures

14.5 Miscellaneous Codes

- IS: 919 : ISO system of limits and fits
- IS: 1038 : Specification for steel doors, windows and ventilators
- IS: 1172 : Code of basic requirements for water supply, drainage and sanitation
- IS: 1346 : Code of Practice for water proofing of roofs with bitumen felts
- IS: 1742 : Code of Practice for building drainage
- IS: 1905 : Code of Practice for structural use of unreinforced masonry
- IS: 2210 : Criteria for design of reinforced concrete shell structures and folded plates
- IS: 2633 : Method for testing uniformity of coating on Zinc Coated Articles
- IS: 3067 : Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
- IS: 4759 : Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products
- IS: 10440 : Code of Practice for construction of reinforced brick and reinforced brick concrete floors and roofs
- IS: 13592 : Un-plasticized polyvinyl chloride (UPVC) Injection molded fittings for soil & waste discharge system for inside and outside buildings including ventilation and rail water system specification
- IS: 15658 : Precast concrete blocks for paving
- SP: 6 : Handbook for structural engineers - All parts
- SP: 7 : National Building Code of India
- SP: 16 : Design Aids for reinforced concrete to IS: 456-1978
- SP: 20 : Handbook on masonry design and construction
- SP: 22 : Explanatory handbooks on codes for earthquake engineering (IS: 1893-1975 and IS: 4326-1976)
- SP: 24 : Explanatory handbooks on Indian Standard code of Practice for plain and reinforced concrete
- SP: 25 : Handbook on causes and prevention of cracks in buildings
- SP: 32 : Handbook on functional requirements of industrial buildings

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- SP: 34 : Handbook of concrete reinforcement and detailing (SCIP)
- TAC : Traffic Advisory Committee
- : Indian Explosive Act
- : Indian Factory Act and State Factory Act
- : Indian Electricity Act

Any statutory codes / standards / regulations other than listed above, as may be applicable, shall be followed.

Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in this document, the latest editions of the codes and standards given below shall also apply:

- a) Japanese Industrial Standards (JIS).
- b) American National Standards Institute (ANSI).
- c) American Society of Testing and Materials (ASTM).
- d) American Society of Mechanical Engineers (ASME).
- e) International Organization for Standardization (ISO).
- f) American Welding Society (AWS).
- g) National Electrical Manufacturers Association (NEMA).
- h) National Fire Protection Association (NFPA).
- i) International Electro-Technical Commission (IEC).
- j) German national codes (DIN)
- k) Expansion Joint Manufacturers Association (EJMA)

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-III
TECHNICAL SCHEDULES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Not used
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications- C&I
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Not used
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – C&I
	---	Part-D	Not Used

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VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

* * * * *

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VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I:PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II:DETAILED TECHNICAL SPECIFICATION

- A. Not used
- B. Detailed Technical Specification- Electrical
- C. Not used
- D. Detailed Technical Specification- Civil

* * * * *

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**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

- A. Not used
- B. Technical Schedules- Electrical
- C. Not used
- D. Not used

* * * * *

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MODEL TENDER DOCUMENT FOR SELECTION OF R&M CONTRACTORS

ELECTRICAL BALANCE OF PLANT (eBOP) (PACKAGE NUMBER: R&M-SP-06)

VOLUME-III TECHNICAL SCHEDULES-ELECTRICAL PART- B

RENOVATION & MODERNISATION OF FOSSIL FUEL BASED POWER PLANTS IN INDIA

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Tender Document for R&M of Unit No. [..] Capacity [..] of [Name of the Power Plant]

[Logo of Utility]

*{Only the Applicable portion of the Data Sheet based on the scope of work as
firmed up in Section-I, Volume-II should be retained and the remaining portion
should be deleted. The scope of work in Section-I, Volume-II is based on Residual
Life Assessment (RLA) / Condition Assessment (CA) and Energy Audit (EA)}*

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1 400KV & 220KV SWITCHYARD

S.NO	DESCRIPTION	UNIT	220 kV	400 kV
1	Nominal / Rated voltage			
2	Maximum System Voltage			
3	Rated Frequency			
4	No. Of Phases			
5	Rated power frequency withstand voltage (1 min)			
6	Rated lighting impulse withstand voltage (1.2/50 μ s)			
7	Rated switching impulse withstand voltage (250/2500 μ s)			
8	Rated Normal Current bus bar			
9	Rated Normal Current feeder			
10	Rated short breaking Current			
11	Rated peak withstand current			
12	Rated Short-time withstand current			
13	Leakage rate per year and gas compartment			
14	Auxiliary DC supply (2 wire ungrounded)			
15	Auxiliary AC supply (3 ph. 4 wire, 50 Hz)			
16	Seismic Acceleration			
17	Ambient temperature range			
18	Creepage Distance			

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1.1 Circuit Breakers

S.No.	DESCRIPTION	220 kV	400 kV
1.	Service		
2.	Type		
3.	Auto Reclosing		
4.	Rated Frequency (Hz)		
5.	Nominal system voltage		
6.	Maximum system voltage		
7.	System Neutral Earthing:		
8.	Mechanical Endurance class		
9.	Insulating level (kVp)		
	i. 1.2/50 μ sec Lightning Impulse Withstand Voltage		
	a) Between Line terminals and ground (kVp)		
	b) Between terminals with circuit breaker open		
	ii. 1 min power frequency withstand Voltage (kV rms)(Dry and Wet)		
	a) Between Line terminals and ground (kVp)		
	b) Between terminals with circuit breaker open (kVp)		
	iii. 250/2500 μ sec switching impulse withstand voltage (dry and wet)		
	a) Between Line terminals and ground (kVp)		

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S.No.	DESCRIPTION	220 kV	400 kV
	b) Between terminals with circuit breaker open		
10.	Rated current (Amp)		
11.	Short time current Rating		
12.	Maximum Noise level		
13.	Min Creepage Distance (mm) b/w ph. To ground and between C.B terminals (heavily polluted atmosphere)		
14.	Rated breaking time (m.sec)		
15.	Total Closing time		
16.	Rated line charging breaking current (Amps)		
17.	Rated cable charging breaking current (Amps)		
18.	Rated operating sequence (O-Operating-C-Closing)		
19.	Operating Mechanism		
20.	Mode of operation		
21.	No of trip coils		
22.	Trip coil and closing coil voltage. (DC Voltage)		
23.	First pole to clear factor		
24.	Supply voltage for operating device		
25.	Corona extinction voltage kV (rms)(Min.)		
26.	Maximum radio interference voltage (micro volt) between 0.5 MHz and 2 MHz in all position of equipment		
27.	Thermal Rating of Auxiliary Contacts	10 A at 220 V DC	

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1.2 Isolators

S.No	DESCRIPTION	220 kV	400 kV
1.	Maximum System voltage (rms) Um		
2.	Rated continuous current (A) at design ambient temp.		
3.	Rated short time withstand current of isolator and earth switch		
4.	Rated dynamic short circuit withstand current withstand current of isolator and earth switch		
5.	Operating mechanism		
6.	System earthing		
7.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp		
a)	Between line terminals and ground (kVp)		
b)	Between terminals with disconnecter contacts open: <ul style="list-style-type: none"> Lightning impulse voltage applied to one terminal (kVp) Power frequency voltage of opposite polarity applied to other terminal (kVp). 		
8.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)		
a)	Between line terminals and ground (kVp)		
b)	Between terminals with circuit breaker contacts open: <ul style="list-style-type: none"> Switching Impulse voltage applied to one terminal (kVp) Power frequency voltage of opposite polarity applied to other terminal (kVp). 		
9.	One Minute power frequency withstand voltage <ul style="list-style-type: none"> Between line terminals and ground Between terminals with disconnectors contacts open 		

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10.	Mechanical endurance class		
11.	No. of spare auxiliary contacts on each isolator		
12.	No. of spare auxiliary contacts on each earthing switch		
13.	Max. radio interference voltage for frequency between 0.5MHz and 2MHz (μ V)		
14.	Auxiliary contacts continuous rating (A)		
15.	Auxiliary contacts breaking capacity (for circuit time constant \geq 20ms)		

1.3 400 kV & 220kV High Voltage Outdoor Bushing-Porcelain Type

S.NO	DESCRIPTION	UNIT	220 kV	400 kV
1.	Max system voltage			
2.	Rated short-circuit withstand current			
3.	Rated peak withstand current			
4.	Material of enclosures			
5.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure			
6.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)			
7.	One minute power frequency withstand voltage at minimum operating gas pressure			

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S.NO	DESCRIPTION	UNIT	220 kV	400 kV
8.	Creepage distance at rated voltage			

1.4 Lightning Arrestor

S. NO	DESCRIPTION	220 kV	400 kV
1.	Max. system voltage		
2.	Type of arrester		
3.	Rated voltage of arrester		
4.	Maximum continuous operating voltage (MCOV)		
5.	Nominal discharge		
6.	Line discharge class		
7.	Service		
8.	Watt loss at MCOV		
9.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure		
10.	One min power frequency with stand voltage of the housing (wet & dry).		
11.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)		
12.	Long duration discharge class		
13.	High current impulse with stand (4/10 micro sec wave)		
14.	Creepage distance of the insulating housing		
15.	The thickness of		

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	galvanizing of metal parts		
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1.5 Current Transformers

S. No.	DESCRIPTION	220kV	400 kV
1.	Maximum system voltage Um		
2.	Rated Primary Current (Amp)		
3.	Rated short time thermal current		
4.	Rated dynamic current		
5.	System neutral earthing		
6.	No. of cores		
7.	Maximum temperature rise over an ambient temperature of 50°C		
8.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure		
9.	One min power frequency with stand voltage of the housing		
10.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)		
11.	One minute power frequency withstand voltage between secondary terminal & earth		
12.	Radio interference voltage at 1.1 Um/ $\sqrt{3}$ and frequency range 0.5 to 2 MHz		
13.	Partial discharge level		
14.	Corona extinction voltage (min) (kV rms)		

1.6 Voltage Transformers

S.No.	DESCRIPTION	220 kV	400 kV
1.	Maximum system voltage Um		
2.	Rated burden		
3.	Maximum temperature rise over an		

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S.No.	DESCRIPTION	220 kV	400 kV
	ambient temperature of 50°C		
4.	System neutral earthing		
5.	System fault level		
6.	Rated primary voltage		
7.	Rated secondary voltage		
8.	Connection group		
9.	Number of secondary windings		
10.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec Wave front) in kVp pressure		
11.	One min power frequency with stand voltage of the housing (wet & dry).		
12.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)		
13.	One minute power frequency withstand voltage for secondary		
14.	Radio interference voltage at 1.1 Um/ $\sqrt{3}$ and frequency range 0.5 to 2 MHz		
15.	Partial discharge level		
16.	Corona extinction voltage (min) (kV rms)		

1.7 220kV Capacitive Voltage Transformer

S.No.	DESCRIPTION	220 kV	400 kV
1.	Maximum system voltage Um		
2.	Rated burden		
3.	Maximum temperature rise over an ambient temperature of 50°C		
4.	System neutral earthing		
5.	System fault level		
6.	Rated primary voltage		
7.	Rated secondary voltage		
8.	Lightning (Full Wave) impulse withstand voltage (1.25/50 μ sec		

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S.No.	DESCRIPTION	220 kV	400 kV
	Wave front) in kVp pressure		
9.	One min power frequency with stand voltage of the housing (wet & dry).		
10.	Switching Impulse withstand voltage (250/2500 μ sec Wavefront) in (kVp)		
11.	Connection group		
12.	Number of secondary windings		
13.	Equivalent series resistance over the entire carrier frequency range (ohms)		
14.	Rated total Capacitance (pF)		
15.	Acceptable limit of variation of total capacitance over the entire carrier frequency range		
16.	Creepage distance		
17.	Partial discharge level		
18.	Corona extinction voltage KV (RMS)		

1.8 Power Line Carrier Communication

S NO	DESCRIPTION	DATA
1	Mode of Transmission	
2	H.F. range	
3	Nominal carrier frequency band	
4	Effectively transmitted speech frequency band or signal frequency band when only speech or signal is transmitted	
5	Effectively transmitted speech plus signal frequency band in case of multipurpose use	
6	Nominal Impedance	
	a) Carrier Frequency Side	
	b) VF Side	
7	Nominal carrier Frequency Power	
8	Supply voltage	
9	Frequency difference between voice	

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S NO	DESCRIPTION	DATA
	frequency band transmitter and receiver in a pair of PLC terminals	
10	Stability of carrier frequency from its nominal value	
13	Telephone signaling channel:	
S NO	DESCRIPTION	DATA
Wave Trap		
1.	Rated Voltage (Nominal/Max)	
2.	Rated Frequency	
3.	Rated continuous current at 50 °C	
4.	Rated short time current for 1sec	
5.	Nominal discharge current of protective device	
6.	Rated inductance	
7.	Resistive component of impedance within carrier frequency blocking range	
8.	Minimum Corona extinction voltage level	
9.	Type of tuning	

1.9 Reactor

S NO	DESCRIPTION	220kV	400kV
1.	Maximum system voltage		
2.	Rated MVAR		
3.	Service		
4.	Type Of reactor		
5.	Phases		
6.	Quantity		
7.	Neutral Earthing		
8.	System fault level		
9.	Connection		
10.	Insulation level (for winding		
	a)	Lightning impulse 1.2/50	

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S NO	DESCRIPTION		220kV	400kV
		micro-seconds withstand voltage		
	b)	Switching surge withstand voltage		
	c)	One minute power frequency withstand voltage		
11.	Maximum admissible temp. Rise over an ambient temp of 50°C and at highest Voltage			
	a)	of winding measured by resistance method		
	b)	top of oil measured by thermometer		
12.	Cooling system			
13.	Ratio of zero sequence reactance to positive reactance (X0/X1)			
14.	Range of voltage upto which impedance shall be constant			
	Guaranteed max, losses at rated voltage and frequency at rated output at 75 deg. C (KW)			
15.	Noise Level			
16.	Magnetizing characteristic			
17.	Harmonics Level			

1.10 ACSR (Moose) Conductor

S NO	DESCRIPTION	DATA	
1.	ACSR Conductor		
2.	Code Name		
3.	Overall diameter		
4.	Stranding no. of wire Al/Steel:		

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5.	Nominal Diameter of Strand (Al./Steel)(mm)	
6.	Number of Strands	
	a) Steel centre	
	b) 1st steel layer	
	c) 1st Aluminium layer	
	d) 2nd Aluminium layer	
	e) 3rd Aluminium layer	
7.	Sectional area of aluminium	
8.	Total sectional area	
9.	Appox. Weight	
10.	Calculated DC resistance at 20°. C (calculated from maximum value of resistivity and minimum cross-sectional area)	
11.	Ultimate Strength (min)	
12.	Co. efficient of liner expansion	
13.	Nominal current rating at 30° C	

1.11 IPS Aluminum Tubular Bus Bars

S NO	DESCRIPTION	DATA
1.	Tubular Aluminum Conductor	
	a) Type	
	b) Size	
2.	Material grade	
3.	Continuous current carrying capacity (rms) at 50oC ambient temperature	
4.	Outer diameter	
5.	Inner diameter	

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S NO	DESCRIPTION	DATA
6.	Tolerance on diameter	
7.	Tolerance on thickness	
8.	Ovality tolerance	
9.	Maximum temperature rise over ambient of 50° C	

1.12 Shield Wire

S NO	DESCRIPTION	DATA
	Size & Material	

1.13 Connectors / Pg Clamp Assembly

S NO	DESCRIPTION	DATA
1.	Material	
2.	Continuous current carrying capacity (rms) at 50° C ambient temperature	
3.	Short time current carrying Capacity	

1.14 Post Insulator

S NO	DESCRIPTION	DATA
1.	Type	
2.	Service	
3.	Voltage	
4.	System neutral earthing	
5.	Insulation Level	

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S NO	DESCRIPTION	DATA	
a.	One minute Dry Power frequency Withstand Voltage (kV rms)		
b.	One minute Wet power frequency Withstand Voltage (kV rms)		
c.	Lightning Impulse withstand (kVp)		
6.	Creepage distance		
7.	Type of insulator		
8.	Metal parts		
9.	Applicable standards		

1.15 String Insulators

S NO	DESCRIPTION	220 kV	400 kV
1.	Type		
2.	Applicable standard		
3.	Type of insulator		
4.	No. of unit insulators in string		
5.	1 min power frequency withstand Voltage of insulator string (kV rms)(Dry and Wet)		
6.	1.2/50 μ sec Lightning Impulse Withstand Voltage		
7.	250/2500 μ sec switching impulse withstand voltage (dry and wet)		
8.	Electromechanical strength		
9.	Corona extinction voltage kV (rms)(Min.)		
10.	Unit Insulator rating, type		
11.	Minimum creepage distance of each disc (so as to meet the total required creepage distance)		

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2 220 KV/400 KV SWITCHYARD CONTROL AND PROTECTION SYSTEM

S. No.	Technical Particulars	Unit	Parameters
1.0	General		
1.1	Type (simplex / duplex / panel cum desk)		
1.2	Make		
1.3	Maximum dimensions width x depth x height		
1.4	Weight of each panel		
1.5	Degree of protection		
1.6	Colour shade		
1.7	Cold rolled sheet steel thickness		
a	Load bearing members		
b	Non-loading members		
1.8	Cable entry top / bottom		
1.9	Control cable glands to be supplied		
1.10	Purchaser's external cable sizes		
1.11	Any special interconnecting cable between panels to be provided by vendor.		
1.12	Special requirements:		
a	Matching with existing / new panels of others		
b	Coordination with other suppliers		
c	Hardware and accessories for protocol converter and connection to DCS		
1.13	Earth bus material & size inside the panel		
1.14	Equipment list for each panel		
1.15	Auxiliary voltages		
a	A.C.		
b	DC		

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S. No.	Technical Particulars	Unit	Parameters
2.0	Particulars of Protective relays		
2.1	Relay type required		
2.2	Mounting		
2.3	Communication protocol		
2.4	Wiring arrangement		
2.5	Testing facility		
2.6	Minimum rating of contacts for auxiliary and output relays :		
a	Voltage		
b	Continuous current		
c	Make & carry for 1 sec.		
d	3 Breaking capacity (i) Resistive (ii) Inductive		
2.7	Relay type and protection [For Generator] (List out all protection and relay type used)		
2.8	Relay type and protection [For Generator Transformer] (List out all protection and relay type used)		
2.9	Relay type and protection [For Unit Transformer] (List out all protection and relay type used)		
2.10	Tripping Relays		

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S. No.	Technical Particulars	Unit	Parameters
a	Make / designation		
b	Static / Electromagnetic		
c	Rated voltage		
2.11	Trip circuit Super Vision Relays		
a	Make / designation		
b	Static / Electromagnetic		
c	(Rated voltage		
2.12	Indicating Lamps		
a	Type		
b	Ratings		
c	Voltage		
d	Wattage		
3.0	Meters		
3.1	Make		
3.2	Type of measurement		
3.3	Measuring range in primary watts.		
3.4	CT ratio		
3.5	VT ratio		

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S. No.	Technical Particulars	Unit	Parameters
3.6	Accuracy class		
3.7	Burden		
a	Current coil		
b	(b)Voltage coil		
3.8	Transducers		
a	Output		
b	Accuracy		
c	Burden		
4.0	Timers		
4.1	Make		
4.2	Type designation		
4.3	Range of time delay		
a	On energization		
b	On de-energization		

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3 POWER TRANSFORMER

For GT, ICT

S.N	DESCRIPTION	GENERATOR TRANSFORMER	INTERCONNECTING TRANSFORMER (if applicable)
1	3 Phase power supply system in which transformer is to be used		
a)	HV side max. Voltage		
b)	LV side Max.Voltage		
c)	System earthing		
	- Primary Side (HV)		
	- Secondary Side (LV)		
2	Max. 3 phase fault levels		
	- Primary Side (HV)		
	- Secondary side (LV)		
3	Direction of power flow		
4	Transformer application		
	Applicable standards		
5	Transformer type		
A	Indoor/ outdoor		
B	Dry type / oil immersed		
C	Core type/ shell type		
6	Auto wound / two winding/ three winding		
7	Number of phases		
8	Rated frequency		
9	Rated no load voltage		
	- HV Winding		
	- LV Winding		
10	Cooling		
	a) Method of cooling		
	b) Cooling liquid		
11	Rated MVA at no load voltage & principle tap		
	ONAN		
	ONAF		

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S.N	DESCRIPTION	GENERATOR TRANSFORMER	INTERCONNECTING TRANSFORMER (if applicable)
	OFAF		
	Tertiary winding (OFAF rating)		
12	Overloading as per IS: 6600		
13	Design ambient temperature		
14	Max. temp. rise at rated MVA & principal tap		
	a Top oil by thermometer method over design ambient temp. of 50 °C		
	b Any winding (HV&LV) by resistance method over design ambient temp. of 50 °C		
	c Hot spot temp. based on the design ambient of 50 °C		
15	Percentage impedance voltage at rated current, frequency, principle tap and 75°C		
16	Tappings		
	a		
	b		
	c		
	d		
	e		
17	External terminal Short circuit withstand capability of transformer on any tapping for 3 phase and line to ground faults across LV winding		
18	Insulation		
	HV winding		
	LV winding		

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S.N	DESCRIPTION	GENERATOR TRANSFORMER			INTERCONNECTING TRANSFORMER (if applicable)		
	HV Neutral						
	Tertiary winding						
	HV Bushing						
	LV Bushing						
19	Winding insulation category						
	a HV-uniform/Graded Insulated						
	b LV-uniform/ Graded Insulated						
	c Tertiary Winding						
20	Winding data						
	a No. Of windings						
	b Winding material						
	c Winding connection (HV / LV winding)						
	d Vector groups HV-LV						
21	Core laminations						
	- Type						
	- Material						
	- Thickness mm (Max. Permissible)						
22	Noise level in DB scale when measured 4 ft. from the transformer edge at a height of 5 ft. above the floor at rated voltage and load						
23	Bushing current transformers						
	a) Location						
	b) Application						

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S.N	DESCRIPTION	GENERATOR TRANSFORMER		INTERCONNECTING TRANSFORMER (if applicable)			
	No. of cores on the CT (Quantity)						
	Type						
	Ratio Core 1						
	Core 2						
	Class and Accuracy Core 1						
	Core 2						
	Knee point voltage						
	CT sec. Resistance at 75°C (for Core 1)						
	Burden for Core 2						
	Short time rating for 2 Sec						
	Magnetizing current at $V_k/2$						
	Accessibility						
24	CT for winding Temperature compensation						
	-Type						
	-Ratio						
	-Class						
	-Burden						
25	Bushings						
	a Type						
	g Short time rating						
26.	Terminal Arrangement:						
	a High Voltage						
	b Low Voltage						
	c HV Neutral						
	d LV Neutral						
27	Radiators						
28	Transformer mounted on:						
	Rollers/flanged wheels						

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S.N	DESCRIPTION	GENERATOR TRANSFORMER	INTERCONNECTING TRANSFORMER (if applicable)
	Flanged wheels (removable)		
	Rail gauge (in both axis)		

Criteria for ST, UT

S N.	DESCRIPTION	STATION TRANSFORMER	UNIT TRANSFORMER
1	3 Phase power supply system in which transformer is to be used		
	a) HV side max.Voltage		
	b) LV side max. Voltage		
	b) System earthing		
	- Primary side (HV)		
	- Secondary side (LV)		
2	Max. 3 phase fault levels		
	- Primary side (HV)		
	- Secondary side (LV)		
3	Direction of power flow		
4	a) Transformer application		
	b) Applicable standards		
5	Transformer type		
	a) Indoor/ outdoor		
	b) Dry type/Oil immersed		
	c) Core type/shell type		
6	Auto wound / two winding/ three winding		
7	Number of phases		
8	Rated frequency		
9	Rated no voltage		
	- HV winding		
	- LV1 winding		
	- LV2 winding		

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S N.	DESCRIPTION	STATION TRANSFORMER	UNIT TRANSFORMER
10	Cooling		
	a) Method of cooling		
	b) Cooling liquid		
11	Rated MVA at no load voltage & principle tap (ONAN rating)		
	ONAN		
	ONAF		
	Tertiary winding (ONAF rating)		
12	Overloading as per IS 6600		
13	Design ambient temperature		
14	Max. temp. rise at rated MVA & principal tap		
	a) Top oil by thermometer method over design ambient temp. of 50°C		
	b) Any winding (HV&LV) by resistance method over design ambient temp. of 50°C		
	c) Hot spot temp. based on the design ambient of 50°C		
15	Percentage Impedance Voltage at rated current, frequency, principal tap and 75°C Between		
	HV-LV1		
	HV-LV2		
	LV1-LV2		
16	Tappings		
	a) Off-circuit/ ON load		
	b) Manual /automatic		
	c) No. of steps		
	d) Percentage variation /step		

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S N.	DESCRIPTION	STATION TRANSFORMER	UNIT TRANSFORMER
	e) Winding in which tappings are required		
17	External terminal Short circuit withstand capability of transformer on any tapping for 3 phase and line to ground faults across LV winding		
	a) HV-uniform /Graded Insulated		
	b) LV-uniform/ Graded Insulated		
18	Insulation		
	HV winding		
	LV winding		
19	Winding insulation category		
	a HV-uniform/Graded Insulated		
	b LV-uniform/ Graded Insulated		
20	Winding Data		
	a) No. of windings		
	b) Winding material		
	c) Winding connection - (HV / LV winding)		
	d) Vector groups - HV- LV		
21	Core Laminations		
	- Type		
	- Material		
	- Thickness mm (max. permissible)		
22	Noise level in DB scale when measured 4 ft. from the transformer edge at a height of 5 ft. above the floor at rated voltage and load		

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For NGR

SI	Description	Station transformer NGR	Unit Transformer NGR
1	Service		
2	Nature of Pollution		
3	Design Ambient °C		
4	Reference std.		
5	Application		
6	Rated value of resistance at design Ambient temperature		
7	Rated voltage kV		
8	Insulation class kV (RMS)		
9	Rated current Amps		
10	Rated frequency Hz		
11	Rated time at rated current in Sec.		
12	Material		
13	Max. temp. rise over design ambient (°C)		
14	1 min. PF withstand value kV (RMS)		
15	Type of insulator supports		
16	Termination Incoming		
	Outgoing (ground)		
17	Enclosure class of protection		
18	Max. limiting dimensions in mm length X Breadth X Height (excluding support structure if any)		
19	Mounting arrangement		
20	Painting of resistance enclosure		

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4 MOTOR

SL. NO.	DESCRIPTION	UNIT	DATA
1.	Manufacturer		
2.	Type and frame size		
3.	Nos. required		
4.	Application		
5.	Specification & Codes		
6.	Capacity for specified climatic conditions [50°C]		
7.	Location for installation		
8.	Type of enclosure & ventilation		
9.	Degree of protection		
10.	Type of duty		
11.	No. of phases, frequency & voltage		
12.	Permissible variations in		
a)	Voltage		
b)	Frequency		
c)	Combined		
13.	At rated voltage & frequency		
a)	Full load current		
b)	Full load speed		
c)	No load current		
14.	Minimum permissible voltage during starting :		
15.	Maximum permissible time at minimum permissible voltage during running at full load.		
16.	Maximum permissible time at 75% of rated voltage during running at full load.		
17.	Whether motor stalls at 70% of rated voltage Efficiency & power factor.		
18.	Stator winding		
	Type & nos. of terminals Brought out		
	Resistance between terminals at 20°C		
	Resistance per phase at 20°C		
	Inductance per phase		

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SL. NO.	DESCRIPTION	UNIT	DATA
	Capacitance per phase		
	Starting current as % of full load current		
19.	Torque at full load in Kgm.		
a)	Break away torque in % of full load torque		
b)	Pull up torque in % of full load torque		
c)	Pull out torque in % of full load torque		
20.	Starting time in sec.		
a)	Without mechanism coupled		
b)	Mechanism coupled through hydraulic coupling when it may be presumed that load is transferred to motor shaft only after attaining almost full speed.		
	i. with rated voltage		
	ii. with 80% of rated voltage		
	iii. with 110% of rated voltage		
21.	Starting time in sec. With mechanism coupled through flexible coupling		
a)	with rated voltage		
b)	with 80% of rated voltage		
c)	with 110% of rated voltage		
22.	Safe stall time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
23.	Safe stall time (Cold motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
24.	Limiting motor temperature to determine safe stall time		
25.	Permissible maximum accelerating time (hot motor)		
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
26.	Permissible maximum accelerating time (cold motor)		

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SL. NO.	DESCRIPTION	UNIT	DATA
	i. At rated voltage		
	ii. At 80% of rated voltage		
	iii. At 110% of rated voltage		
27.	Class of Insulation And Material		
28.	Whether insulation is suitable for 415 V, 6.6kV system		
29.	Temperature rise under normal conditions over 50°C ambient temperature		
30.	By resistance method --- °C over cooling water temp. for CACW motors.		
31.	Degree centigrade over cooling air temp. for CACA motor.		
32.	By Thermometer method ---- Degree centigrade over cooling water temp. for CACW motor.		
33.	Degree centigrade over cooling air temp. for CACA motor.		
34.	Method of starting :		
35.	Permissible starting duty cycles :		
36.	Stator thermal time constant :		
37.	Method of cooling (If applicable)		
	Details of water cooling system		
a)	No. of cooler		
b)	Water requirement per cooler		
c)	Losses removed by cooler		
d)	Max. permissible temperature of cooling water at inlet		
e)	Max. permissible temperature of cooling water at outlet		
f)	Maximum permissible pressure at water outlet		
g)	Water pressure drop through the cooler		
h)	Temp. of cold air coming out & entering the machine For permissible cooling water temperature of [31°C]		
i)	Temp. rise of air passing through machine at full load.		
j)	Air pressure drop through The cooler		
k)	Temp. rise of water through cooler		
l)	Protection against leakage of water :		
m)	Arrangement to ensure the water flow		

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SL. NO.	DESCRIPTION	UNIT	DATA
38.	Bearings		
a)	Number :		
b)	Type :		
c)	Lubrication system :		
d)	Quantity of lubricant reqd. For both the bearings. Life in hours at rated speed :		
e)	Recommended lubricant :		
f)	Bearing end play :		
g)	Inlet oil pressure :		
h)	Temp. rise of oil :		
i)	Max. permissible temp. of bearing :		
j)	Max. Permissible temp. of Oil		
k)	Permissible running time without forced oil at full load & full speed :		
39.	Whether bearings are provided with 4 wire, platinum RTD having 100-ohm resistance at 0°C for remote temp. Indication.		
a)	Whether bearings are provided with local temperature indicator having two adjustable contacts rated for 5A at 240V AC or 0.5A at 220V DC. : Yes/No		
b)	If forced lube oil system provided : Yes / No		
c)	Qty of lubricant required for initial filling.		
d)	Recommended period after which lubricant should be replaced		
e)	Bearing cooling water requirement		
f)	Max. Permissible bearing cooling water inlet temp. (permissible)		
g)	Max. Permissible bearing cooling water outlet temp.		
h)	Terminal designation corresponds to direction of rotation (Facing driving end).		
i)	Terminal boxes with accessories separate terminal boxes provided.		
40.	Winding temp. detectors		
41.	Bearing temp. detectors		
42.	Moisture detectors		

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SL. NO.	DESCRIPTION	UNIT	DATA
43.	Neutral terminals		
44.	Main terminal box details		
a)	Type & Nos.		
b)	Fault level permissible for 0.25 sec.		
c)	Location		
d)	Cable gland size & no.		
e)	Direction of cable entry.		
45.	Space Heater		
a)	Number		
b)	Location		
c)	Capacity of each		
d)	Total power requirement		
e)	Voltage.		
46.	Details of 4 wire platinum RTD having 100 ohm resistance at 0°C for winding temp. detector.		
a)	Nos. provided		
b)	Location		
47.	Whether CTs for differential protection are provided : Yes / No		
a)	If Yes, no. of CTs supplied along with motors C.T. details		
	i. C.T. ratio		
	ii. Knee point voltage		
b)	S.C. withstand capacity		
c)	Type of mounting		
48.	Shaft orientation		
49.	Shaft extension		
50.	Grounding pads size nos. & location		
51.	Method of coupling to driven mechanism		
52.	Motor GD ² :		
53.	Lifting device		
54.	Weight		
a)	Weight of stator (wound)		

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SL. NO.	DESCRIPTION	UNIT	DATA
b)	Weight of rotor (wound)		
c)	Weight of base plate		
d)	Weight of cooler		
e)	Net weight of motor		
f)	Shipping dimensions & weight		
55.	Thermometer provided		
a)	In cold air path		
b)	In hot air path		
c)	For measurement of oil temp.		
56.	Characteristic curves furnished		
a)	Speed vs. current at rated voltage	Yes / No	
b)	Speed vs. torque at 110%, 100%, 90% and 80% of rated voltage:	Yes / No	
c)	Thermal withstand curve for hot & cold conditions.	Yes / No	
d)	Efficiency vs. load:	Yes / No	
e)	P.F. Vs. load:	Yes / No	
f)	Current vs. time:	Yes / No	
g)	Negative phase sequence curve:	Yes / No	
57.	Drawings furnished		
a)	General arrangement of motor	Yes / No	
b)	Main terminal box showing the method of terminating the incoming cables Yes/No	Yes / No	
c)	Instruction manuals	Yes / No	
	MOTOR (DC)		
1.	GENERAL		
a)	Manufacturer :		
b)	Equipment driven by Motor :		
c)	Motor type :		
d)	Country of origin :		
2.	DESIGN & PERFORMANCE		
a)	Frame Size :		
b)	Type of duty :		

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SL. NO.	DESCRIPTION	UNIT	DATA
c)	Type of enclosure & type of cooling :		
d)	Applicable standard to which motor generally confirms:		
e)	Type of mounting :		
f)	Direction of rotation :		
g)	KW rating at amb. Temp. 50 °C :		
h)	Rated power supply voltage		
	i. Armature circuit (V) :	V	
	ii. Field circuit (V) :	V	
i)	Permissible voltage variation :		
j)	Minimum permissible starting voltage :		
k)	Rated speed at rated voltage (RPM) :	RPM	
l)	At rated voltage		
	i. Full load current (A) :	A	
	ii. NO load current (A) :	A	
m)	Starting current (A) :		
	i. 100% voltage :		
	ii. 85% voltage :		
n)	Starting time (with pump coupled) :		
	i. 100% voltage (Sec) :		
	ii. 85 % voltage :		
	iii. 80 % voltage :		
o)	Efficiency at rated voltage at :		
	i. 100% load :		
	ii. 75% load:		
	iii. 50% load:		
p)	Safe stall time (sec) at 110% :		
	i. Hot condition :		
	ii. Cold condition :		
q)	Torque (Kg-m) :		
	i. Starting at min. permissible voltage:		
	ii. Rated:		
r)	Fly wheel moment (GD2) motor (Kg-m)		

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SL. NO.	DESCRIPTION	UNIT	DATA
3.	CONSTRUCTIONAL FEATURES		
a)	Winding insulation :		
	i. Class & type :		
	ii. Tropicalised (Yes/No) :		
	iii. Temp. rise over specified ambient of 50 °C. :		
	iv. Method of temp. measurement :		
b)	Degree of protection of terminal box for :		
	i. Main terminal box :		
	ii. Space heaters (AUX. TB) :		
c)	For main terminal box :		
	i. No. and type of cable gland :		
	ii. Recommended cable size (Armature/field) :		
d)	Fault level (KA, sec) :		
e)	Bearings :		
	i. Type (at DE/NDE):		
	ii. Make :		
	iii. Recommended lubricant :		
	iv. Life :		
f)	Weight of motor (Kg.) :		
g)	Field current at rated speed (A)		
h)	Field resistance (Ohm) at rated speed at 30 °C		
i)	Field trimmer rating (Ohm) for getting basic speed at 30 °C.		
j)	Resistance (Ohm) between terminals at 30°C.		
	i. Armature :		
	ii. Series winding :		
	iii. Inter pole winding :		
	iv. Shunt winding resistance:		
k)	1 st and 2 nd critical speed :		
l)	Overload that can be carried by motor without changing overall performance and period for which it is applicable		
m)	Grounding device :		

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SL. NO.	DESCRIPTION	UNIT	DATA
n)	Space heater :		
	i. No. & location :		
	ii. Volt & KW rating :		
4.	RESISTORS		
a)	Starting (external) resistance :		
	i. Type of resistor :		
	ii. Ohmic, current & power rating of resistor elements		
	iii. Max. permissible temp. of resistor elements :		
	iv. Connection diag. Of resistor elements		
	v. No. of startup stages/steps :		
	vi. Resistance values of stages :		
	-at 30 deg. C (Ohm) :		
	-at running condition (Ohm) :		
	vii. Expected temp of resistor at running condition		
	viii. Expected temp of box at running condition		
	ix. Mounting/stacking of resistor elements and G.A. of resistor box		
b)	Schematic connection diag. Of motor with starting resistor and field trimmer resistor.		
5.	CHARACTERISTIC CURVES		
a)	Starting current/times :		
b)	Thermal withstand curve for hot and cold condition		
c)	Torque/speed		
d)	Load/Efficiency		
e)	Speed/Time		

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5 MOTOR ACTUATORS

S. NO.	DESCRIPTION	UNIT	DATA
1.	Type		
2.	Application		
3.	Motor type		
	Supply voltage	V	
4.	Phase, frequency	Hz	
5.	Motor rated voltage	V	
6.	Control Voltage	V	
7.	Voltage and its variation	V	
8.	Frequency and its variation	Hz	
9.	Combined V & f variation	%	
10.	Degree of Protection		
11.	Winding Insulation		
12.	Temperature Rise (over ambient temperature)	°C	
13.	Painting		
14.	Motor Starting		
a)	Method		
b)	Starting Current		

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6 220V DC System

SL. NO.	DESCRIPTION	UNIT	DATA
A.	DC SYSTEM		
	BATTERY		
	General		
	• Make		
	• Catalogue No.		
	• Type		
	• Reference Standard		
	Rating		
	• Rated Voltage	Volt	
	• 10-hour rating at 27 Deg.C to end cell voltage	AH	
	• 2-hour discharge rate to end cell voltage	Amp	
	• 1 –hour discharge rate to end cell voltage	Amp	
	• 1 -minute discharge rate to end cell voltage	Amp	
	Performance		
	• Battery duty cycle curve furnished	Yes/No	
	• Cell voltage characteristics during duty cycle furnished	Yes/No	
	• Minimum cell voltage during duty cycle	Volt	
	• AH efficiency at 10-hour discharge rate	%	
	• Expected life of Battery	Yr	
	Battery Characteristics		
	• Recommended charging rate for		
	i) Float charging	Amp	
	ii) Equalising Charge	Amp	
	iii) Boost charging in 10 hrs.		
	• Start	Amp	
	• Finish	Amp	
	• Recommend specific gravity at 27 Deg.C		
	i) For first filling		
	ii) At full charge		

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SL. NO.	DESCRIPTION	UNIT	DATA
	iii) At end of 10-hour discharge		
	• Short-circuit current for a dead-short across battery terminals, when		
	i) Float charge at 2.15 V/Cell	kA	
	ii) Boost charge at 2.75 V/Cell	kA	
	• Battery internal resistance	Ohm	
1	Cells		
	• Number of cells per battery	Nos.	
	• Nominal Cell voltage	V	
	• Cell voltage at the end of duty cycle	V	
	• Cell voltage at the end of full discharge at 10-hour rate	V	
	• Type of the cell		
	• Cell designation as per relevant Standard		
	• Material of the container		
	• Overall dimension of each cell (LxDxH)	mm	
	• Weight of complete cell		
	i) Without electrolyte	kg	
	ii) With electrolyte	Kg	
	• Internal resistance of cell	Ohm	
2	Intercell Connector		
	• Intercell connector furnished	Yes/No	
	• Type of intercell connector	bolted/bur ned	
	• Material of intercell connector		
3	Plates		
	• Number of positive plates per cell	Nos.	
	• Type of positive plate		
	• Type of negative plate		
4	Separator		
	• Type		
	• Material		
	• Thickness	mm	

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SL. NO.	DESCRIPTION	UNIT	DATA
5	Electrolyte		
	• Amount of electrolyte for first filling		
	i) Per cell	litre	
	ii) Per set	litre	
	• First filling with 10% extra furnished	Yes/No	
	• Electrolyte conforms to		
6	Racks		
	• Number of racks per battery	Nos.	
	• Number of cells per rack	Nos.	
	• Type of racks	Rows/Tiers	
	• Material of rack		
	• Racks provided with		
	i) Numbering tags for cells	Yes/No	
	ii) Clamps for cables	Yes/No	
	• Insulator furnished for		
	i) Cell	Yes/No	
	ii) Stand	Yes/No	
	• Inter-row, Miter-tier connectors and end take-off furnished	Yes/No	
	• Connector hardwares furnished	Yes/No	
7	Dimension & Weight		
	• Overall dimension (LxDxH)	mm	
	• Approx. Weight	Kg	
	• Battery layout drawing furnished	Yes/No	
8	Ventilation requirement furnished	Yes/No	
9	List of accessories furnished	Yes/No	
10	Technical leaflets furnished	Yes/No	
	BATTERY CHARGER		
i)	GENERAL		
	a. Make		

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SL. NO.	DESCRIPTION	UNIT	DATA
	b. Catalogue No.		
	c. Type		
	d. Reference Standard		
ii)	A.C. Input		
	a. Voltage \pm % variation	Volt, %	
	b. Phase	No.	
	c. Frequency \pm % variation	Hz., %	
	d. Input current	Amp	
iii)	D.C. Output		
	a. Voltage	Volt/Cell	
	b. Current	Amp.	
	Type of Cooling		
iv)	Max. Temp rise within cubicle above site ambient		
	a. Rectifier transformer	°C	
	b. SCR	°C	
v)	Performance		
	a. Regulation for 0-100% rated load with \pm 10% Input voltage and \pm 5% input frequency variation	%	
	b. Ripple content in O.C. output		
	i) With battery	%	
	ii) Without battery	%	
	c. Guaranteed efficiency at rated load	%	
	d. Power factor at rated load	%	
vi)	Miscellaneous		
	a. Charger provided with following features		
	i) Automatic voltage regulation	Yes/No	
	ii) Current limiting circuitry	Yes/No	
	iii) Smoothing filter circuit	Yes/No	
	iv) Soft-start feature	Yes/No	
	v) Automatic load sharing during parallel operation	Yes/No	
	b. SCR elements provided with		

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SL. NO.	DESCRIPTION	UNIT	DATA
	i) Surge protection	Yes/No	
	ii) Fast acting HRC fuse	Yes/No	
vii)	A. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
viii)	A. C. Fuse / MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current rating		
	i) Continuous	Amp	
	ii) Interrupting	kA	
ix)	A.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rated Current	Amp	
	e. Utilization category		
	f. Thermal overload with In-built single-phase preventer provided	Yes/No	
x)	Rectifier Transformer		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating		
	i) KVA	KVA	
	ii) Voltage	V	

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SL. NO.	DESCRIPTION	UNIT	DATA
	iii) % reactance	%	
	e. Class of insulation		
	f. Method of cooling		
xi)	Controlled Rectifier (SCR)		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. RMS Current rating	Amp	
	e. Surge Current		
	i) One-cycle	Amp	
	ii) Repetitive Cycle	Amp	
	f. Peak inverse voltage		
	i) Continuous	Volt	
	ii) Surge	Volt	
xii)	D.C. Fuse/MCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating		
	i) Continuous	Amp	
	ii) Interrupting	KA	
xiii)	D.C. Contactor		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Current Rating	Amp	
	e. Utilization category		
xiv)	Blocking Diodes		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		

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SL. NO.	DESCRIPTION	UNIT	DATA
	d. Current Rating		
	i) One – minute	Amp	
	ii) One-hour	Amp	
	e. Peak inverse voltage	Volt	
xv)	Indication Lamps		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Wattage	Watt	
	e. Series resistor	Ohm	
xvi)	Meters		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Size	mm	
	e. Accuracy		
xvii)	Alarm Facia		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. No. of window per facia	Nos.	
xviii)	D. C. Switch / MCCB		
	a. Make		
	b. Type/Cat. No.		
	c. Reference Standard		
	d. Rating	Amp	
	e. No. of poles	Nos.	
xix)	Charger Panel		
	a. Make		
	b. Type		
	c. Reference Standard		

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SL. NO.	DESCRIPTION	UNIT	DATA
	d. Enclosure		
	i) Degree of protection		
	ii) Sheet steel thickness	mm	
	e. Panel provided with		
	i) Internal lamp with door-switch	Yes/No	
	ii) Space heater with thermostat	Yes/No	
	iii) 5A, 3-pin receptacle with plug	Yes/No	
	f. Internal Wiring		
	i) Insulation		
	ii) Voltage grade	V	
	iii) Minimum conductor size	mm ²	
	g. Power Terminals		
	i) Make		
	ii) Size/Cat. No.		
	h. Control Terminals		
	i) Make		
	ii) Size/Cat. No.		
	iii) 20% spare terminal furnished	Yes/No	
	i. Ground Terminal furnished	Yes/No	
	j. Overall dimension (LxDxH)	mm	
	k. Weight	Kg	
	l. General Arrangement drawings furnished	Yes/No	

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7 LT TRANSFORMER (OIL TYPE/DRY TYPE)

6.6/0.433 kV LV AUXILIARY TRANSFORMER			
		Dry Type	Oil Type
1.	Make		
2.	Application		
3.	Location		
4.	Type		
5.	Reference standard		
6.	Rated power (indicative)		
7.	Rated winding voltage ratio (line to line)		
8.	Number of phases		
9.	Winding		
10.	Rated frequency		
11.	Type of cooling		
12.	Insulation Class		
13.	Temperature rise Over ambient temperature of 50°C		
a	For Winding by resistance method		
b	For Oil by Thermometer method		
14.	Insulation level (LI/AC)		
a	HV- (LI/AC)		
b	LV- (LI/AC)	- Vp/3KVrms	-KVp/3KVrms
15.	Vector group		

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16.	Short-circuit impedance on principal tap				
17.	Parallel operation of transformer				
18.	Type of taps provided				
19.	Taps provided on				
20.	Range of taps				
21.	Method of Tap charge control-				
a	Manual local				
b	Electrical local				
c	Electrical remote				
d	Automatic				
22.	System earthing				
a	H.V.				
b	L.V.				
23.	Terminal arrangement				
a	H.V.				
b	L.V.				
24.	Neutral for earthing				
25.	Transformer bushing	HV	LV	LV - N	
26.	Voltage class KV(r.m.s.)				
27.	Creepage distance mm				
28.	Min. Ph-Ph/ Ph-E clearance mm				
29.	System fault Level				
a	HV Side				
b	LV Side				

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30.	Max. Noise level		
31.	Auxiliary supply		
32.	LV neutral side current transformer for standby earth fault protection		
33.	Guaranteed no load loss (kW)		
34.	Guaranteed load loss (kW)		
35.	Efficiency		
a	At full load		
b	At 75% load		
c	At 50% load		
36.	Accessories		
	Each transformer furnished With fittings and accessories as per specification.		
37.	Approximate overall dimensions		
a	Length		
b	Breadth		
c	Height		
38.	Crane lift for un taking core and coil assembly Approximate Weights		
a	Core and coil		
b	Enclosure and fittings		
c	Oil		
d	Total weight		
39.	Shipping Details:		
a	Weight of the heaviest package		
b	Dimension of the largest package : (LxBxH)		
40.	Tests		
	Routine test as per IS and other		

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	tests as per specification		
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8 LT PCC/MCC/DISTRIBUTION BOARD

S. No.	DESCRIPTION	UNIT	DATA
1.0	General		
1.1	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
2.0	Switchgear Details		
2.1	Rated voltage, phases & frequency		
2.2	System neutral earthing		
2.3	Voltage & frequency variation	%	
2.4	Rated frequency	Hz	
2.4	One minute power frequency Voltage a) For power Circuits b) For Control Circuits		
2.5	Continuous current rating of busbars under site reference ambient temp.		
2.6	Reference ambient temperature		
2.7	Maximum temperature of bus bars and droppers/connectors under site conditions specified		
2.8	Short circuit current withstand for busbars and droppers		
a	Short time	kA (rms)	
b	Dynamic Rating	kA (peak)	
2.9	Whether busbars have been insulated	Yes	
2.10	Type of insulation		
2.11	Material of bus bar supports		
2.12	Switchgear designation		
2.13	Bus bar material	Cu/Al	
2.14	Fully draw out (FD)/ Fixed (F)		
2.15	Entry –Top (T)/Bottom (B)		
2.16	Degree of protection		
2.17	Colour finish shade	Interior exterior	

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S. No.	DESCRIPTION	UNIT	DATA
2.18	Earthing bus	Material	
2.19	Minimum clearances in air of live parts	mm	
3.0	Starters		
3.1	Type	DOL Rev / Star-Delta	
3.2	Contactor rated duty		
3.3	Single phasing preventer required.	Yes / no	
3.4	Thermal overload relay reset	Manual / Auto	
4.0	Circuit breakers		
4.1	Maker's name		
4.2	Voltage, frequency & no.of phases , poles		
4.3	Rated operating duty		
4.4	Circuit breakers type		
4.5	Short circuit withstand current for 1 sec. Duration	kA	
4.6	Rated making current	kAp	
4.7	Rated current at site reference ambient temp	A °C	
4.8	Type of operating mechanism		
4.9	Minimum no. of auxiliary Contacts for purchaser's use		
4.10	Control voltage		
a	For Spring charging motor	V AC/DC	
b	For closing/tripping	V AC/DC	
4.11	Limits of voltage for satisfactory operation of the following devices as a % of normal voltage		
a	Operating mechanism	%	
b	Closing at normal voltage	%	
c	Trip coil	%	
4.12	Power required for closing at normal voltage	W	
4.13	Power required for tripping at normal voltage	W	

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S. No.	DESCRIPTION	UNIT	DATA
4.14	Spring charging motor details:		
a	Rating	kW	
b	Rated voltage	V, AC/DC	
c	Spring charging	Sec.	
	Electrical and mechanical anti-pumping features been provided	Yes/No	
5.0	MCCBs/MPCBs		
5.1	Voltage, frequency & no. of phases		
5.2	Rated operating duty		
5.3	Rated breaking capacity	kA (rms)	
5.4	Rated making current	kA (Peak)	
5.5	On/Off operation		
5.6	Manual	Yes/No	
5.7	Over-load inverse time, short circuit and earth fault	Yes/No	
5.8	Auxiliary contacts required	Yes/No	
6.0	Contactors		
6.1	Make		
6.2	Rated duty	AC3/AC4	
6.3	No of poles		
6.4	Utilization category		
6.5	Rated voltage of auxiliary contacts	V	
6.6	Rated voltage of coil	V	
6.7	Rated breaking capacity	Factor of rated current	
6.8	Rated making capacity	Factor of rated current	
6.9	Limits of operation		
a	Supply voltage variation		

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S. No.	DESCRIPTION	UNIT	DATA
b	Supply frequency variation for closing		
c	Drop out voltage		
6.10	No of auxiliary contacts:		
a	Normally open		
b	Normally closed		
7.0	Instrumentation transformers		
7.1	Voltage Ratio		
7.2	CT Ratio		
7.3	Measuring CTs		
7.4	Protection CTs		
7.5	Measuring VTs		
7.6	Protection VTs		
8.0	Control transformers		
8.1	Make		
8.2	Type		
8.3	Applicable standards		
8.4	Ratio		
8.5	Class of insulation		
8.6	Rated output	VA	
9.0	Fuse (if applicable)		
a	Type		
b	Voltage rating		
10.0	Instantaneous over current relay		
10.1	Application (phase fault or earth fault)		
10.2	Make		
10.3	Type designation		
10.4	Setting range		
11.0	Inverse time and thermal overcurrent relay		
11.1	Application		
11.2	Make		
11.3	Type		
11.4	Current setting range		

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S. No.	DESCRIPTION	UNIT	DATA
11.5	Time setting range at 10 times the current setting	Sec	
12.0	Under voltage relay		
12.1	Make		
12.2	Type		
12.3	Voltage rating	V	
12.4	Setting range	V	
13.0	Auxiliary relays and timers		
13.1	Make		
13.2	Type		
13.3	Coil voltage	V	
14.0	Control/selector switch		
14.1	Make		
14.2	Type designation		
15.0	Meters		
15.1	Applicable Standards		
15.3	Accuracy Class		
15.4	Make		
15.5	Type		
16.0	<u>Voltmeter</u>		
16.1	Make		
16.2	Type		
16.3	Applicable standards		
16.4	Accuracy class		
17.0	<u>Ammeter</u>		
17.1	Make		
17.2	Type		
17.3	Applicable standards		
17.4	Accuracy class		

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S. No.	DESCRIPTION	UNIT	DATA
18.0	<u>Indicating lamps</u>		
18.1	Make		
18.2	Type		
18.3	Voltage	V	
18.4	Wattage of lamp	W	
19.0	<u>Push buttons</u>		
19.1	Make		
19.2	Type designation		
19.3	Contact rating	A	
20.0	<u>Space heater</u>		
20.1	Make		
20.2	Type		
20.3	Rated voltage	V	
21.0	<u>Wiring and terminal blocks</u>		
21.1	Voltage grade		
21.2	Insulation		
21.3	Minimum size of conductor for:		
a	Power wiring	Sq.mm	
b	Control wiring	Sq.mm	
21.4	Type of terminal blocks:		
	I) For Withdrawable Type		
	II) For Fixed Type		
21.5	Minimum current rating of terminal blocks	A	

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9 415V NON SEGREGATED PHASE BUS DUCT

S. No.	DESCRIPTION	UNIT	DATA
1.	Make/ Name of Manufacturer		
2.	Type of Busduct	Segregated /non segregated	
3.	Type of cooling	Natural/Forced	
4.	Reference Standard		
5.	Rated Voltage	V	
6.	No of phase and Frequency	Hz	
7.	Insulation level a) Min Power frequency Voltage b) Impulse withstand voltage	kVrms kVp	
8.	Rated Continuous current	Amp	
9.	Short time withstand capability a) Symmetrical for 1 sec b) Momentary	kA kAp	
10.	Maximum temperature rise over 50 degree design ambient temperature a) Bus bar b) Enclosure	Degree	
11.	Degree of protection of enclosure		
12.	Bus bar a) Material & Grade b) Conductivity c) Size		
13.	Enclosure a) Material & Grade b) Thickness c) Ph- ph spacing d) Over all dimension		
14.	Dc resistance in micro ohm/metre/phase a) At 20 degree		

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S. No.	DESCRIPTION	UNIT	DATA
	b) At 85 degree		
15.	Reactance in ohm/meter/phase		
16.	Capacitance to ground		
17.	Losses in watt/meter/phase		
18.	Insulators		
	a) Make		
	b) Material		
	c) No per support		
	d) Voltage Glass		
	e) Compression strength		
	f) Cantilever strength		
19.	Size and material of ground bus		
20.	Support steel structure		
21.	Whether the following has been provided		
	a) Thermostat controlled space heater		
	b) Silica gel breather		
	c) Drain plug		
	d) Neoprene rubber gaskets at joints		
	e) Disconnecting links		
22.	Painting shade		
	a) Interior		
	b) Exterior		

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10 HV CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.1.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
a)	In air	A	
b)	In ground	A	
c)	In duct	A	
d)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
a)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
b)	Grad and Shape of conductor		
c)	Nominal cross section area	mm ²	
d)	Number of wires		
e)	Diameter of wire	mm	
f)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
i.	Between cores	mm	
ii.	Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
a)	Material		
b)	Type/applicable std.		
c)	Thickness		
1.20	Inner sheath		
a)	Material, confirming standard / type		
b)	Extruded	Yes/No	
c)	Calculated diameter over laid up cores		
d)	Thickness (min)	mm	
e)	Diameter of cable over inner sheath	mm	
f)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
g)	Filler Material details		
1.21	Armouring		
a)	Material		
b)	Type of armouring		

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S. No.	DESCRIPTION	UNIT	DATA
c)	No. and size of strip/wire		
d)	Whether galvanized	Yes/No	
e)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
a)	Material confirming standard/ type		
b)	Extruded	Yes/No	
c)	Minimum Thickness of sheath	mm	
d)	Tolerance on thickness of sheath	mm	
e)	Min. tensile strength	N/sq mm	
f)	Min. elongation percentage at rupture		
g)	Colour of Outer sheath		
h)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification and standards	Yes/No	
1.23	Overall diameter of cable and and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous current		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/k m	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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11 LT POWER & CONTROL CABLES

S. No.	DESCRIPTION	UNIT	DATA
1.2.	Name of Manufacturer		
1.2	Place & Country of manufacture		
1.3	Specifications and Standards		
1.4	Design ambient temperature	°C	
1.5	System Particulars (Fill separate columns for the following particulars for each type and size of cables)		
1.6	ISI registration and validity date		
1.7	Cable type		
1.8	Whether cable shall carry ISI mark		
1.9	Voltage grade		
1.10	No. of cores and size	in sq.mm	
1.11	Suitable for earthed/unearthed system		
1.12	Permissible voltage and frequency variation for satisfactory operation		
a	Voltage		
b	Frequency		
c	Voltage and Frequency combined Continuous current carrying capacity		
1.13	For standard conditions as per IS		
a	In air	A	
b	In ground	A	
c	In duct	A	
d	In trench	A	
1.14	For site conditions :		
e)	In air	A	
f)	In ground	A	
g)	In duct	A	
h)	In trench	A	
1.15	De-rating factors for various conditions of laying are not worse than the ones specified in applicable IS Yes/No		
1.16	Conductor		
g)	Material reference standard for conductor		

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S. No.	DESCRIPTION	UNIT	DATA
h)	Grad and Shape of conductor		
i)	Nominal cross section area	mm ²	
j)	Number of wires		
k)	Diameter of wire	mm	
l)	Diameter/size of conductor	mm	
1.17	Screening/Shielding / heat barrier tape (as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.18	Insulation		
a)	Material composition and confirming standard and type		
b)	Thickness of insulation		
iii.	Between cores	mm	
iv.	Between cores and inner sheath	mm	
c)	Tolerance on thickness of insulation	%	
d)	Diameter of core over insulation	mm	
e)	Specific insulation resistance at 90 degrees centigrade	ohm-cm	
1.19	Screening/Shielding / barrier tape(as applicable)		
d)	Material		
e)	Type/applicable std.		
f)	Thickness		
1.20	Inner sheath		
h)	Material, confirming standard / type		
i)	Extruded	Yes/No	
j)	Calculated diameter over laid up cores		
k)	Thickness (min)	mm	
l)	Diameter of cable over inner sheath	mm	
m)	Whether inner sheath shall be of FRLS material and meet special Tests as per specification for FRLS cables	Yes/No	
n)	Filler Material details		
1.21	Armouring		
f)	Material		
g)	Type of armouring		

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S. No.	DESCRIPTION	UNIT	DATA
h)	No. and size of strip/wire		
i)	Whether galvanized	Yes/No	
j)	Diameter of cable over armouring	mm	
1.22	Outer sheath		
i)	Material confirming standard/ type		
j)	Extruded	Yes/No	
k)	Minimum Thickness of sheath	mm	
l)	Tolerance on thickness of sheath	mm	
m)	Min. tensile strength	N/sq mm	
n)	Min. elongation percentage at rupture		
o)	Colour of Outer sheath		
p)	Whether outer sheath shall be of FRLS material and shall meet the special tests as per specification	Yes/No	
1.23	Overall diameter of cable and tolerance for Outer Diameter		
1.24	Scheme for identification of cores		
1.25	Short circuit withstand capacity		
a)	Short circuit current	KA	
b)	Duration of short circuit	sec	
1.26	Allowable/attainable maximum conductor temperature when carrying rated continuous currents		
1.27	Allowable/attainable maximum conductor temperature at the termination of short circuit current		
1.28	Cable constants		
a)	Max. DC resistance of conductor at twenty (20) °C	ohm/km	
b)	AC resistance per core at twenty (20) °C	ohm/km	
c)	Reactance per core at 50 HZ	ohm/km	
d)	Capacitance per core at 50Hz	microfarad/km	
e)	Insulation		
	Insulation resistance constant at 27°C and at max. rated temperature	ohm-km	
	Volume resistivity ohm cm at 27°C and at max. rated temperature		

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S. No.	DESCRIPTION	UNIT	DATA
	Min. tensile strength	N/sq.mm	
	Min. elongation percentage at rupture		
	Loss tangent		
	Dielectric constant		
1.29	Maximum cable charging current at normal operating voltage	A/km	
1.30	Factory tests (Enumerate in detail for each type of cable)		
	a) Type tests		
	b) Acceptance tests		
	c) Routine tests		
	d) Special tests to prove FRLS/FS properties.		
1.31	Is the offered cable guaranteed to safely withstand continuous conductor temperature of 90°C for XLPE	Yes/No	
1.32	Cable weight	kg/km	
1.33	Recommended minimum bending radius	mm	
1.34	Safe pulling force	Kg	
1.35	Maximum allowable spacing for angle iron supports	mm	
1.36	Length of cable per drum	m	
1.37	Cable drum		
a)	Material		
b)	Dimensions of drum		
c)	IS reference		
d)	Standard drum length for each size of cable (single length)		
e)	Cable weight	Kg	
f)	Shipping weight	Kg	
g)	Drum weight	Kg	

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12 ILLUMINATION System

S. No.	DESCRIPTION	UNIT	DATA
1.0	GENERAL		
1.1	Normal Supply Voltage, Phase and Frequency	AC	
1.2	Variation in Supply		
	a) Voltage	%	
	b) Frequency	%	
	c) Combined voltage & frequency	%	
1.3	Design Ambient Air Temperature	°C	
1.4	System Short-Circuit Level		
	a) At 415V AC	kA(rms)	
	b) At 220V DC (For DC LP)	kA(DC)	
1.4	Luminaries Earthing Terminal Suitable for		
a	Conductor material		
b	Conductor size	SWG	
2.0	Lighting Distribution Board and Lighting panel		
2.1	Manufacturer Name		
2.2	Rated Voltage, phase and Frequency	AC	
2.3	One Minute Withstand Voltage	V	
2.4	Mounting Type		
	a) LDBs		
	b) Single Phase LP		
2.5	Type and no of circuits & feeder rating		
2.6	Colour shade		
2.7	Lighting Transformer		
	a) Type		
	b) Voltage Ratio	V	
	c) Taps	%	
	d) Vector Group		
	e) Impedance	%	
	f) Rating	KVA	
3.0	Fixture details:		
3.1	Name of Manufacturer and Country		
3.2	Luminaries		
	a) Fluorescent		
	b) HPMV		
	c) HPSV		
	d) Metal Halide		
	e) Compact Fluorescent Lamp		
	f) Flame proof		
3.3	Applicable Standards for		

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	a) Luminaires		
	b) Accessories		
3.4	Manufacturer's type and Catalogue No.		
	a) Luminaires		
	b) Accessories		
4.0	Schedule of fitting and Accessories		
5.0	Technical details of luminaries		
5.1	Lamps		
a	Maximum permissible supply voltage variation	± %	
b	Luminous output		
	i) After 100 burning hours	Lumens	
	ii) After 1000 burning hours	Lumens	
c	Average burning hour life	Hours	
5.2	Ballasts & Starters		
a	Maximum permissible supply voltage variation	± %	
b	Power loss at nominal working voltage		
c	Maximum hot spot temperature of ballast		
d	Conductor material of ballast		
e	Insulation class of ballast winding		
f	Average life of		
	i) Ballast	Hrs.	
	ii) Starters	Hrs.	
5.3	Capacitors		
a	Power factor		
5.4	Luminaires		
a	Weight of luminaries	Kgs	
b	Earthing terminal		
	i) Material		
	ii) Suitable upto conductor size	SWG	
c	Internal wiring size	Sq.mm	
d	Terminal block suitable for conductor size	Sq.mm	
e	Sheet steel thickness of		
	i) Housing	SWG	
	ii) Reflector	SWG	
f	Wire guard thickness	mm	
g	Descriptive catalogues enclosed	Yes/No	
6.0	Miniature circuit breaker		

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6.1	Make		
6.2	Type		
6.3	Literature enclosed	Yes/No	
7.0	Earth leakage circuit breaker		
7.1	Make		
7.2	Type		
7.3	Leakage Current I _N	mA	
7.4	Literature enclosed	Yes/No	
8.0	Instrument transformers		
8.1	Make		
8.2	Type		
8.3	Output	VA	
8.4	Accuracy Class		
8.5	Literature enclosed	Yes/No	
9.0	Meters		
9.1	Make		
9.2	Type		
9.3	Accuracy Class		
9.4	Literature enclosed	Yes/No	
10.0	Relays (if any provided)		
10.1	Make		
10.2	Type		
10.3	Voltage Rating	V	
10.4	Setting Range	%	
10.5	No. of Contacts		
	a) Normally open		
	b) Normally closed		
10.6	Literature enclosed	Yes/No	
11.0	Flame proof enclosure		
11.1	Make		
11.2	Suitable for use in hazardous area		
	a) Area classification		
	b) Gases/Vapor group		
11.3	Dimensional Drawings and Literature of each required equipment flameproof enclosure including fixing details enclosed	Yes/No	
11.4	Approval certificates of relevant statutory authorities enclosed	Yes/No	
12.0	Lighting Control Switches		
12.1	Make		
12.2	Decorative		

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12.3	Industrial		
12.4	Flame proof		
12.5	Literature Enclosed	Yes/No	
13.0	Receptacle units		
13.1	Make		
13.2	Decorative		
13.3	Industrial		
13.4	Flame proof		
13.5	Literature Enclosed	Yes/No	
14.0	Lighting wires		
14.1	Make		
14.2	Applicable Standard		
14.3	Voltage Grade	V	
14.4	Conductor Material	Cu/Al	
14.5	Size	Sq.mm	
14.6	No. of Strands		
14.7	Colour Coding		
15.0	CONDUITS		
15.1	Make		
15.2	Rigid Steel		
15.3	Rigid Non-metallic		
15.4	Sizes offered and wall thicknesses		
15.5	Supply of necessary couplings, bends, tees, necessary for conduit routing included	Yes/No	
15.6	Literature Enclosed	Yes/No	
16.0	Junction boxes		
16.1	Make		
16.2	Material and Gauge		
16.3	Galvanised		
16.4	Dimensioned Drawings Enclosed	Yes/No	
16.5	Weather Proof Construction Required	Yes/No	
16.6	Flame Proof / Non-flame proof		
17.0	<u>Lighting poles/towers</u>		
17.1	Make		
17.2	Type of Poles/Towers		
17.3	Dimensioned Drawing/Particulars of Flood Light Tower enclosed	Yes/No	
17.4	Junction Box with Pole	Yes/No	
18.0	Ceiling fans		
18.1	Make		
18.2	Blade Sweep	mm	
18.3	Suspension Rod Length	mm	

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LII-GETS12021-G-00129-006	00	Tender Document for Selection of R&M Contractors – Electrical Balance of Plant Volume-III,Part B	[75]	25.09.2014

13 CABLE CARRIER SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.	Make/Manufacturer		
2.	Size of Tray	mm	
3.	Material		
4.	Application		
5.	Type of Tray		
6.	Thickness of Tray	mm	
7.	Thickness of Galvanization	mm	
8.	Tray Cover Size	mm	
9.	Cable Tray Accessories		
9.1	Tee	mm	
9.2	Cross	mm	
9.3	Bends	Deg	
9.4	Reducer	mm	
9.5	Steel Supports		
9.6	a) ISMC b) ISA	mm	

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Tender Document for R&M of Unit No. [...] Capacity [...] of [Name of the Power Plant]	[Logo of Utility]
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14 EARTHING & LIGHTNING PROTECTION SYSTEM

SL NO.	DESCRIPTION	UNIT	DATA
1.0	EARTHING SYSTEM		
1.1	Manufacturer Name		
1.2	Main ground grid conductor material & size		
1.3	Ground electrode material & size		
1.4	Riser material & size		
1.5	Grounding installation work carried out as per specification	Y/N	
2.0	LIGHTNING PROTECTION SYSTEM		
2.1	Manufacturer Name		
2.2	Vertical air termination conductor material & size		
2.3	Horizontal air termination conductor material & size		
2.4	Down Conductor material & size		
2.5	Electrode material & size		
2.6	Riser conductor material & size		
2.7	Lightning Protection work carried out as per specification.	Y/N	

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**RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

**MODEL TENDER DOCUMENT FOR SELECTION OF
R&M CONTRACTORS**

**ELECTRICAL BALANCE OF PLANT (eBOP)
(PACKAGE NUMBER: R&M-SP-06)
VOLUME-III
TECHNICAL SCHEDULES**

**PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT**

MASTER INDEX (ALL VOLUMES)

Volume	Section	Part	Description
Volume-I	---	---	Commercial
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Not used
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – C&I
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Not used
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – C&I
	---	Part-D	Not Used

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-006	02	Tender Document for Selection of R&M Contractors – Electrical Balance of Plant Volume-III, Part C	[i]	29.09.2015

VOLUME-I: COMMERCIAL

1. Invitation For Bid
2. Instruction to Bidder
3. General Project Information
4. General Condition of Contract (GCC)
5. Special Condition of Contract (SCC)
6. Forms and Schedules

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LII-GETS12021-G-00129-006	02	Tender Document for Selection of R&M Contractors – Electrical Balance of Plant Volume-III, Part C	[ii]	29.09.2015

VOLUME-II: TECHNICAL SPECIFICATIONS

SECTION-I:PROJECT TECHNICAL SPECIFICATION

1. Intent of Specification
2. Site & Project Specific Information
3. Existing Plant Details
4. Scope of Supply & Services
5. Terminal Points & Exclusions
6. General Technical Requirements
7. Layout Consideration
8. Performance Guarantees
9. Spare Parts
10. Annexure

SECTION-II:DETAILED TECHNICAL SPECIFICATION

- A. Not used
- B. Detailed Technical Specification- Electrical
- C. Detailed Technical Specification- C&I
- D. Detailed Technical Specification- Civil

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LII-GETS12021-G-00129-006	02	Tender Document for Selection of R&M Contractors – Electrical Balance of Plant Volume-III, Part C	[iii]	29.09.2015

**VOLUME-III: TECHNICAL SCHEDULES
(TO BE FILLED BY BIDDER)**

- A. Not used
- B. Technical Schedules- Electrical
- C. Technical Schedules- C&I
- D. Not used

Document Number	Rev No.	Description	Page No.	Date of Issue
LII-GETS12021-G-00129-006	02	Tender Document for Selection of R&M Contractors – Electrical Balance of Plant Volume-III, Part C	[iv]	29.09.2015

TABLE OF CONTENT

1	COMMUNICATION SYSTEM.....	1
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1 COMMUNICATION SYSTEM

Table 1.1
Data Sheet for Communication System

S. No.	Description	To be filled by bidder
1	TELEPHONE EXCHANGE	
1	Make and model no of EPABX	
2	Capacity of the offered exchange	
3	Is the exchange microprocessor based stored programme controlled	YES/ NO
4	What is the multiplexing technique and the modulation technique used in the offered exchange?	
5	Does the system have duplicated control unit and redundancy in other critical PCBs for hot stand by mode? Does the system have decentralised peripheral processor card?	YES/ NO
6	Indicate if the system has provision to prevent loss/ corruption of memory content caused due to improper operating procedures & power supply failure.	YES/ NO
7	What is the maximum traffic handling capacity of the exchange?	
8	Is the exchange non blocking in nature? What is the maximum numbers of simultaneous calls possible in the offered exchange?	
9	Whether the system configuration is enclosed with the offer.	YES/ NO
10	Does the exchange support the flexible numbering scheme.	YES/ NO
11	What is the maximum line loop resistance for: the exchange the junction	
12	Is the system suitable for using DP/DTMF/DECT and DMKT telephones?	YES/ NO
13	What are the different types of tones available in the exchange? - Furnish the details of their frequencies & duration.	
14	Capability for simultaneously accepting, processing & delivering information in forms such as voice, data & text in a wholly integrated manner.	
15	Can simultaneous transmission of voice/data through 0.5 mm dia twin pair cable is possible. If yes then indicate: Transmission speed in- Synchronous mode Asynchronous mode	
16	Capability of inter working with different types of switching systems (Exchanges) existing in the country.	
17	Does the system has in-built online diagnostic features to monitor it's own performance, to detect, analyse & locate faults	YES/ NO

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S. No.	Description	To be filled by bidder
	when they occur.	
18	What is the provision for routine tests, measurements & checks of the exchange equipment, junction lines & subscriber lines?	
19	What are the protection devices in the system against electrical short circuits & induced heavy currents?	
20	Is the system modular in constructions to allow system up gradation in short?	YES/ NO
21	Whether all compound units are mounted on plug-in type PCB's to facilitate easy replacement.	YES/ NO
22	Whether the exchange design has flexibility for interchanging various cards without making any modification in software as well as the hardware?	YES/ NO
23	What is the type & make of the main Distribution Frame provided. Indicate the offered capacity & the expansion provisions. What types of protection devices are offered with the MDF. Number of lines mounted with protection circuits on both sides of the MDF.	
24	Compatibility of the exchange with ISDN Network.	YES/ NO
25	Maximum permissible distance between operator console and EPAX.	
26	Whether following subscriber features are available in the offered exchange:- Calling between subscribers Calling the operator Conference facility transfer Music on hold Internal consultation Executive/secretary facility Call forwarding Automatic call back Priority interrupt Call pick up Paging access Emergency transfer Hot line facility	YES/ NO
27	Whether following operator feature are available in the offered exchange:- Answering incoming calls Trunk offering	YES/ NO

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S. No.	Description	To be filled by bidder
	Setting up external calls Call queuing Operator call intercept Call waiting display Operator call transfer Night service Consultation of calls on Hold Music on hold Position busy Auto hunting facility Abbreviated dialing	
28	Does the exchange has provision access to public exchange network?	YES/ NO
29	Does the exchange has provision for direct inward dialing from public exchange network?	YES/ NO
30	Specify the distance of coverage of DECT Phones	
II	RECTIFIER FLOAT CUM BOOST CHARGER	
1	Make, model and type	
2	Input : a) Voltage b) current c) frequency	
3	Output: a) voltage b)efficiency c)overload protection d)Current	
4	Safety protection details.	
5	Indications details	
6	Float & charging current details	
7	Dimensional details and Weight	
8	Alarm indication details	
III	BATTERY	
1	Make, model and type	
2	Ah rating details	
3	Dimensional details and Weights.	
IV	LSTB SYSTEM	
1	Name of supplier	
2	Names of sub-suppliers their products range and their products	

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S. No.	Description	To be filled by bidder
	range	
3	Make, model and type	
4	Technology used	
5	Standards followed	
6	System-features	
7	Whether system is suitable for areas with high ambient noise level. Specify the noise level up to which the system can work satisfactorily.	YES/ NO
8	Whether the system is amplifier type distributed amplifier type.	YES/ NO
9	Whether the system is intended for perfectly clear and intelligible speech communication under adverse environmental conditions specified in the TS.	YES/ NO
10	Whether the system is designed to operate as open line two" channels of" communication ie., in paging and private" channels.	YES/ NO
11	Whether the system is provided with call attention tone facility preceding all paging or announcement calls.	YES/ NO
12	Whether each communication station is provided with indication such as power ON, channel busy, volume control etc.	YES/ NO
13	Whether the system has provision for automatic muting of the associated loudspeaker while making announcement to avoid acoustic feed back.	YES/ NO
14	Whether the system is of modular construction for easy expansion of subscriber stations as and when required without affecting the installed equipment.	YES/ NO
15	Whether the System is suitable for operation from a centralised power source of 240V +/- 6%, 50Hz +/- 5% , Single phase , AC power supply.	YES/ NO
16	Whether the power supply equipments are provided with protections against short circuit ,over voltage, under voltage & transients.	YES/ NO
17	Whether schematic of system giving cabling scheme has been furnished.	YES/ NO
18	Whether the PTT switch is provided in the handset.	YES/ NO
	Equipment details:	
19	Subscriber station	
i	Desk type Make Model no.	

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S. No.	Description	To be filled by bidder
ii	Wall mounted type Make Model no.	
iii	Pilfer proof handset station Make Model no. Whether the system shall be switched on through press to page switch.	
20	Loudspeaker	
i	Horn type loudspeaker Model No. Quantity Driver unit details Peak power output Impedance Sensitivity (SPL at 1W,1m) Frequency response	
ii	Box type loudspeaker Model No. Quantity Impedance Sensitivity (SPL at 1W,1m)	

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LII-GETS12021-G-00129-006	02	Tender Document for Selection of R&M Contractors – Electrical Balance of Plant Volume-III, Part C	[5]	29.09.2015

S. No.	Description	To be filled by bidder
	Frequency response	
21	<p>For both Power Amplifier and Line Amplifier</p> <p>Model No.</p> <p>Quantity</p> <p>Input sensitivity</p> <p>Rated output</p> <p>Frequency response</p> <p>Distortion at rated output</p> <p>Hum and noise level</p> <p>Amplifier type</p> <p>Protection for short circuit</p>	
V	GENERAL ANNOUNCEMENT SYSTEM	
1	Whether the system is of central amplifier type. Is the central amplifier solid state type?	YES/ NO
2	Specify the working amplifier and the standby amplifier capacity.	
3	Does the system have a provision for a second announcement point from the shop in charge's room.	YES/ NO
4	Does the system have the provision group wise operation?	YES/ NO
5	Can the amplifier capacity be increased by addition of power amplifier module.	YES/ NO
6	Technical particulars	
i	<p>Amplifier:</p> <p>Input sensitivity</p> <p>Bandwidth</p> <p>Signal to noise ratio</p> <p>Hum and noise level</p>	-

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S. No.	Description	To be filled by bidder
	Distortion Floating outputs Protection Safety requirement	
ii	Microphone: Type Frequency response - Impedance Loudspeaker: Type Bandwidth Input voltage Voice coil impedance - Sensitivity at 1KHz SPL	
VI	UHF/VHF COMMUNICATION SYSTEM	
1	Hand held sets	
	Model No.	
	Quantity	
	Frequency range	Hz
	RF Power output	Watts
	No. of Channels , Whether programmable	
	Channel spacing	
	Type of Antenna	
	Whether the battery charger offered shall charge Ni-MH, Li-ION, Ni-CD batteries	YES/ NO
2	Fixed base sets & Mobile sets	
	Model No.	
	Quantity	
	Frequency range	Hz

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S. No.	Description	To be filled by bidder
	RF Power output	Watts
	No. of Channels , Whether programmable	
	Channel spacing	
	Power supply	
	Whether the power supply unit with rechargeable weather proof lead acid maintenance free battery offered for mobile sets.	
	Battery charger for charging Ni-Cd/Ni-MH/Li-ION batteries for Walkie Talkie sets	YES/ NO
	Whether Radio Telephone interface equipment is offered	YES/ NO
3	5 Channel controller	
	Type of controller	
	Does if any working channel fails the other channel will take over the function without any interruption	YES/ NO
	Type of Antenna	
	RF output of the repeater station	
4	Does all the wireless sets are field programmable	YES/ NO

Signature :

Name :

Designation :

Date :

Seal of Company

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**DEVELOPMENT OF TENDERING PROCEDURE
AND
MODEL CONTRACT DOCUMENTS
FOR
RENOVATION & MODERNISATION
OF
FOSSIL FUEL BASED POWER PLANTS IN INDIA**

REPORT ON PHASE-II ACTIVITY

PREPARED BY
LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
THE CONSULTANT

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1 EXECUTIVE SUMMARY

Central Electricity Authority (CEA) the Project Executing Agency / Employer selected Lahmeyer International India Pvt. Ltd. (LII), the Consultant through ICB route to Develop Standard Procedures and Model Contract Documents for the Renovation and Modernization (R&M) of Fossil Fuel based Power Plants in India. Accordingly a contract was signed between CEA and LII on 16th March 2012. The Assignment awarded to LII constitutes Phase-II Activity and is in continuation to the Phase-I Activity which was performed by M/s Evonik Energy Services (India) Pvt. Ltd. The Assignment under Phase-II Activity is being financed by KfW Entwicklungsbank.

India has a large number of 200/210 MW units which are potential candidates for R&M as they have crossed 20 to 25 years of useful life. Moreover in due course of time, many 500 MW units will also become due for R&M.

The importance of R&M was recognized by the Government of India in 1984 when Phase-I R&M Programme for 34 thermal power stations in the country was initiated by CEA as a Centrally sponsored scheme. After achieving encouraging results from CEA's initiative, Government of India has been making regular programmes for rehabilitating the older units through R&M & LE works during the successive plan periods. However, the progress in R&M projects was quite good till the 9th Plan but considerable shortfalls in the progress were witnessed during the subsequent plan periods.

On the other hand, the new thermal capacity addition has been facing unprecedented challenges in the recent past on account of acute shortages in domestic coal, issues related to environmental clearances and problems of land acquisition. The rising cost of new projects has enabled R&M projects to emerge out as the least cost option for capacity addition, since, cost of R&M Projects is less than 50% cost of a new Project of similar capacity.

However, despite its huge potential the progress of R&M Market in India is stagnant. An analysis of various reasons of its poor growth would indicate that the same is attributed to lack of interest on the part of stake holders due to various factors. R&M Market in India has a great potential to develop provided the factors impeding its growth are properly addressed.

Important concerns on the part of utilities include, their lack of internal expertise to evaluate the health condition of their plants and to formulate strategies for renovation, lack of clarity about the documentation and procedures for going forward, uncertainty about the approval from the Regulator, inability to take a long shut- down in a period of shortages and

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uncertainty about the achievement of objectives after the completion of R&M Projects.

Important concerns of bidders include, long time gap between the completion of R&M studies and execution of R&M works leading to technical surprises, problems in handling increased scope of work and lack of clarity on the methodology of verifying the functional guarantees.

Important concerns of the funding agencies include the delay in obtaining the approval of the Regulator and the impact of technical surprises on the Project Cost and the completion time of the Project. Regulators are concerned about the justification of the expenditure on R&M Project and the justification of the investment as a least cost option.

To facilitate the implementation of R&M Projects, Standard procedures and model tender documents have been prepared under this assignment. These documents include, Model Feasibility Report, Model Detailed Project Report, Model Residual Life Assessment (RLA)/ Condition Assessment (CA) Report, Model Energy Audit (EA) Report, Model Tendering Procedure and Model Contract Documents for the selection of Consultants and R&M Contractors. The standard procedures developed under this assignment, envisage the appointment of an R&M Consultant whose scope will include facilitating the approval from the Regulator. The standard procedures have also made the R&M Consultant responsible for preparing the bidding documents for R&M Contractors and also to assist the utilities in bid evaluation for the appointment of R&M Contractors. The above two provisions will not only expedite the R&M activities but will also reduce the time gap between the completion of R&M studies and execution of R&M works thereby minimizing the technical surprises during execution.

The appointment of an Implementation Support Consultant (ISC) has been envisaged who will do the site supervision of works to be done by the R&M contractors and will assist the utilities in completion of R&M works as per the scope of work defined in the contract packages.

It is, thus, believed that Standardization of Tendering Procedures and Model Contract Documents will help in addressing to a large extent, a majority of concerns of the various stake holders which will enable them to implement the R&M Processes of their units systematically and effectively. However, it is not practicable to standardize the complete documentation. Some parts of the documentation have been deliberately left open for a case-to-case finalization by the utilities as scope of R&M works will vary from project to project depending upon various conditions of a specific project.

LII reviewed the findings of Phase-I Activity and the suggestions of the Task Force. These findings and suggestions have been suitably addressed while preparing the standard documents. Various R&M documents provided by CEA and the Guidelines published by KfW and the World Bank

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were also studied by LII before starting the preparation of Standard Documents.

LII also held interactions with the R&M Consultant M/s Energo and R&M Contractors M/s. Alstom as well as M/s. Doosan to obtain the feedback of their experience in implementation of R&M programmes of different power stations.

As per the contract of this assignment, the development of Standard Documents by LII were to be closely linked with the tender documents which were to be developed by MAHAGENCO for the R&M programme for KfW funded Project of Nashik TPS Unit-3. According to the original plan, LII was required to visit the MAHAGENCO HQ as well as Nashik TPS in July 2012 to have discussions with MAHAGENCO and Nashik TPS authorities and to collect the documents developed for Nashik TPS Unit-3 for utilizing the same while standardizing the various documents and procedures. However the above visit and meeting with MAHAGENCO could not take place as planned since bidding documents could not be issued by MAHAGENCO in public domain. Since the issue of NIT for selection of R&M Contract for Nashik TPS Unit-3 was deferred, it was decided that documents issued by MAHAGENCO for the World Bank funded Project of Koradi Unit-6 will be collected and studied.

Standard procedures and documents prepared under this assignment for diagnosing the health status of plant and equipments as also for tendering procedures and documents will go a long way in laying the road map for the utilities to implement the R&M Projects in a smooth, systematic and structured manner. The guidelines provided at the end of the Standard Residual Life Assessment (RLA)/Condition Assessment (CA) Report and Standard Energy Audit (EA) Report will provide detailed knowledge and information to the utilities about the procedures of conducting various tests and the methods to determine the test results. This will encourage the plant engineers to develop their expertise which will help in accelerating the R&M activities.

LII thankfully acknowledges the receipt of valuable suggestions during the course of assignment, provided by Central Electricity Authority, KfW, World Bank, IGEF, VGB, MAHAGENCO, WBPDC, NTPC, DVC, APGENCO, PFC and others. Their valuable comments/suggestions have been of a great help in addressing R&M related concerns & issues and developing the Tendering Procedure and Model Tender Documents.

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2 INTRODUCTION

2.1 Background

Central Electricity Authority (CEA) the Project Executing Agency / Employer selected Lahmeyer International India Pvt. Ltd. (LII), the Consultant to Develop Standard Procedures and Model Contracts for the Renovation and Modernization (R&M) of Fossil Fuel based Power Plants in India. Accordingly a contract was signed between CEA and LII on 16th March 2012, as per which LII rendered the consulting services for the same. The Assignment awarded to LII constituted Phase-II of the Activity and was in continuation to the Phase-I of the Activity which was performed by M/s Evonik Energy Services (India) Pvt. Ltd. The Assignment under Phase-II of the Activity is financed by KfW Entwicklungsbank.

2.2 Definitions

Project Executing Agency/Employer	:	Central Electricity Authority (CEA), Ministry of Power, Govt. of India.
Financing Agency	:	KfW Entwicklungsbank.
Consultant	:	Lahmeyer International (India) Pvt. Ltd. (LII)
Task Force	:	Members from Ministry of Power, Govt. of India, CEA, NTPC and representatives of State Generation Utilities of Andhra Pradesh, West Bengal & Maharashtra.

2.3 Scope of Work as per Contract

As per the Article 6.1 to 6.6 of the Contract, the scope of the services of LII, the Consultant includes the following:

- The Consultant shall review the findings under the Phase-I report and incorporate suitably the findings/suggestions of Phase-I report in the standard documents to be prepared under Phase-II activity.
- The Consultant shall define the scope of rehabilitation based on technical, ecological and economic considerations. The consultant shall also prepare a matrix of options which the owner can consider based on the applicable conditions for each individual case and the objectives to be achieved.
- The Consultant will provide the guideline for the content of the tender documents especially related to goals to be achieved, guarantee figures etc.
- The Consultant shall draw up indicative time-line for each stage during the R&M intervention i.e. data review, RLA/CA studies, energy audit,

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- steam path audit, feasibility studies, DPR preparation, tendering process, R&M works implementation/execution, PG test etc.
- e) The Consultant shall elaborate the feasibility of having a single consultant to carry out the activity up to the stage of finalizing the R&M contract and to facilitate approval from regulatory commission.
 - f) The Consultant shall develop the standard documents on tendering procedures and contract for the R&M projects. The following procedures and documents are suggested to be considered for standardization during the Phase-II activities. Documents listed below under items (I) to (VI) were to be prepared by LII for which CEA shared the available documents with them for the ongoing R&M programmes. Apart from this, LII was also required to concentrate on technical specifications under item (VII).
- I. Standard Bidding Procedure for engagement of consultants and R&M Works Contractor where:
 - a) Single Stage Bidding Procedure is most suitable.
 - b) Two Stage Bidding Procedure is most suitable.
 - c) Prequalification is suitable.
 - d) Without prequalification is suitable.
 - e) For which International Competitive Bidding (ICB) is suited.
 - f) For which Local Competitive Bidding (LCB) is suited.
 - g) For which combination of ICB and LCB is suited.
 - II. Request for Qualification (RfQ): The document for pre qualification procedures for Consultancy Services for R&M and LE Studies should include standard formats for the following:
 - III. Letter of invitation (LOI)
 - a) Instructions to applicants (ITA)
 - b) Qualification and Evaluation Criteria
 - c) Application data sheet (ADS)
 - d) Letter certifying ADS
 - i. Power of attorney of lead bidders
 - ii. QR questionnaires
 - e) Application Forms
 - i. Client overview
 - ii. Project profile
 - IV. Request for Proposal (RfP) from qualified consultants for consultancy services for R&M/LE studies including, in particular, the following:
 - a) Letter of invitation (LOI)
 - b) Instructions to Consultants (ITC)
 - c) Qualification and Evaluation criteria
 - d) Data Sheet
 - e) Technical Proposal – standard forms

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- f) Financial Proposal – standard forms
 - g) Terms of Reference including plant data and information
 - h) Standard forms of contract and annexure including:
 - i. Form of contract
 - ii. General conditions of contract
 - iii. Special conditions of contract
 - iv. Appendices
- V. Standard formats shall be developed for the following reports to be submitted by R&M Consultant:
- a) RLA & LE /CA Report
 - i. Feedback from plant operators system wise / plant operating history /operating data.
 - ii. Failure record and trend analysis of last 10 years.
 - iii. Major replacement in last 10 years.
 - iv. Condition Assessment of each system and major equipment. This shall also include cold walk down & hot walk down survey.
 - v. Standard Test Procedures.
 - vi. Performance Evaluation Test of Boiler, Turbine & other major equipments.
 - vii. Steam Path Audit of turbine.
 - viii. List of obsolete systems & equipment.
 - ix. Analysis of civil structures for equipments.
 - b) Energy Audit (EA)
 - i. Power consumption of all major equipment.
 - ii. Performance check of all major equipment such as Boiler, Turbine, Pumps, Fans, Condensers, HP & LP Heaters, Compressor, APH etc.
 - iii. Efficiency calculation of all major equipment as per standard code.
 - iv. Calculation of heat and mass balance.
 - v. Calculation of emission.
 - c) Feasibility Studies
 - i. Chapterization of the Technical volume.
 - ii. Chapterization of the Financial volume.
 - d) Detailed Project Report (DPR) / Project Design Report (PDR)
 - i. Chapterization of the Technical volume.
 - ii. Chapterization of the Financial volume.

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VI. Request for Qualification (RfQ): Pre qualification procedure for R&M Works Contractor where pre-qualification is considered suitable including, in particular, format for the following:

- a) Letter of Invitation (LOI)
- b) Instructions to Applicants (ITA)
- c) Application Data Sheet (ADS)
- d) Qualification Criteria
- e) Application Forms

VII. Request for Proposal (RfP) for R&M Works Contractor including, in particular, the following:

- a) For single stage bidding
 - i. Invitation for Bid (IFB)
 - ii. Instructions to Bidders (ITB)
 - iii. Bid Data Sheet
 - iv. Evaluation and qualification criteria (following prequalification)
 - v. Evaluation and qualification criteria (without prequalification)
 - vi. Owner's requirements
 - vii. Conditions of Contract and contract forms
 - General conditions (GC)
 - Special conditions (SC)
 - Contract forms.
 - Performance Security
 - Functional guarantees & liquidated damages
- b) For two stage bidding
 - i. Invitation for Bid (IFB)
 - ii. Instructions to Bidders(ITB)
 - iii. Bid Data Sheet
 - iv. Evaluation and qualification criteria (following prequalification)
 - v. Evaluation and qualification criteria (without prequalification)
 - vi. Bidding forms
 - vii. Eligible countries
- c) Owner's requirements.
- d) Conditions of contract and contract forms.
 - i. General conditions (GC)
 - ii. Special conditions (SC)
 - iii. Contract forms.
 - iv. Functional guarantees & liquidated damages.

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VIII. Technical Specifications may be standardized to the extent given below:

- a) Chapterization of specification for different types of boiler such as tangential fired, down shot fall & front wall fired boiler etc.
- b) Standard specifications for turbine retrofit options to enhance efficiency/ output particularly for 210 MW LMZ turbines. Different options namely only LP turbine retrofit or HP/LP turbine retrofit or retrofit of HP/IP/LP module including generator.
- c) Grouping into appropriate contract packages with due consideration to:
 - i. Complex nature and technically compatible aspects.
 - ii. To ensure that the package can attract competitive response.
- d) General Technical Conditions.

As per the Article 6.7 of the Contract, the Consultant shall provide the following reports and documents:

- i. Inception Report
- ii. Draft Documents
- iii. Final Documents
- iv. Monthly progress reports
- v. Report on Phase-II activity.
- vi. Other reports as deemed necessary.

2.4 Importance of Standardizing the Documents

From the Quarterly Review Reports of CEA LII noted that the importance of R&M was recognized by the Government of India in 1984 when Phase-I R&M Programme for 34 thermal power stations in the country was initiated by the CEA as a Centrally sponsored scheme. After achieving encouraging results from CEA's initiative, Government of India has been making regular programmes for rehabilitating the older units through R&M & LE works during the successive plan periods. The results of these achievements are presented in the table below in terms of the additional generation in Million Units (MU) and equivalent Megawatt (MW).

Table: 2.1
Plan and Achievements in R&M

Sl. No.	Five Year Plan	No. of Units	Capacity (MW)	Additional Generation Achieved MU/Annum	Equivalent MW
1	7 th	163	13,570	10,000	2,000

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Sl. No.	Five Year Plan	No. of Units	Capacity (MW)	Additional Generation Achieved MU/Annum	Equivalent MW
2	8 th (R&M) (LEP)	198 (194) (4)	20,869	5,085	763
3	9 th (R&M) (LEP)	152 (127) (25)	18,991	14,500	2,200
4	10 th (R&M) (LEP)	25 (14) (11)	3,445	2,000	300
5	11 th (R&M) (LEP)	129 (76) (53)	16,146	5,400	820

From the information given in the above table, LII noted that the progress in R&M projects was quite good till the 9th Plan but considerable shortfalls in the progress were witnessed during the subsequent plan periods. LII noted that the progress of rehabilitating the older plants through R&M initiatives can be substantially improved provided the concerns of various stake holders are addressed suitably.

2.5 Concerns of the Stake Holders

Phase-I Activity Report has identified the following commonly articulated concerns of the different stakeholders:

2.5.1 Concerns of Utilities

- Limited agencies to carry out R&M studies competently.
- Lack of competent agencies to carry out R&M works.
- Extended shut down periods required for R&M not acceptable in a period of shortages.
- Lack of internal expertise to evaluate actual condition of equipment and costs for repair/renovation.
- Cost escalation on account of surprises found during project execution and the difficulty to build them into the contract
- Regulatory Aspects – including uncertainty of capital cost approval and reasonableness of tariff for recovery of capital cost.
- Financing arrangements.
- Problems of ensuring expected and sustained plant performance after completion of R&M.

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2.5.2 Concerns of Bidders

- Time gap between study of RLA and actual initiation of R&M bidding process.
- Uncertainty about the exact scope of work which makes it difficult to estimate the actual work to be undertaken.
- Unforeseen items/surprises during execution and impact on cost – how to build them into the estimate and how to reduce risk on this account.
- Functional Guarantees which form part of the contract are often difficult to achieve owing to lack of clarity on how verification will be carried out.
- Problem of ensuring a reasonable LD clause
- Delays in payments of invoices
- Fixed Price insisted upon by State Utilities
- Fluctuations in prices of materials especially steel

2.5.3 Concerns of Funding Agencies

- Accuracy of the estimated costs
- Ensuring a strategy that takes care of unforeseen items/surprises and their impact on project cost and time for execution.
- Delays in regulatory clearances.
- Lack of appropriate infrastructure for project execution.
- Ensuring that the study preceding the preparation of Detailed Project Report reflects actual conditions in the plant.
- Credit worthiness of the utilities.
- Material market fluctuations.

2.5.4 Concern of the Regulators

- Justification that the expenditure on R&M Project is the least cost option.

2.6 Harmonizing the Concerns of the Stakeholders

To facilitate the implementation of R&M program for a large fleet of 200/210 MW units in a planned, systematic, structured and time bound manner, formats for the plant investigative studies like Residual Life Assessment (RLA) & Condition Assessment (CA) Reports, Energy Audit (EA) Reports, Feasibility Reports, Detailed Project Reports, Tendering Procedures, Contract documents and Contract Specifications have been standardized. Standardization will harmonize the requirements of all the stakeholders in the following ways and will lead to their increased participation.

2.6.1 Concerns of Utilities

- Concern: Lack of internal expertise to evaluate actual condition of equipment.

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The guidelines provided at the end of the Standard Residual Life Assessment (RLA)/Condition Assessment (CA) Report and Standard Energy Audit (EA) Report will provide detailed knowledge and information to the utilities about the procedures of conducting various tests and the methods to evaluate the test results. The extracts of the guidelines are placed at **Annexures-1 to 3**. This will encourage the plant engineers to develop their expertise which will help in accelerating the R&M activities.

- Concern: Cost escalation on account of surprises found during project execution.

The Standard documents provide for the appointment of a Single R&M Consultant whose role also includes bid evaluation for the selection of R&M Contractor. The above provision will reduce the time gap between the completion of studies and the start of R&M works, which is one of the main reasons contributing to huge risk of technical surprises and the corresponding increase in cost.

- Concern: Regulatory Aspects – including uncertainty of capital cost approval and reasonableness of tariff for recovery of capital cost.

The Standard documents provide for the appointment of a Single R&M Consultant whose role includes facilitating the approval from the appropriate regulatory commission on the items of capital cost and reasonableness of tariff for recovery of capital cost.

- Concern: Problems of ensuring expected and sustained plant performance after completion of R&M.

The Standard documents clearly define the achievement of goals and objectives to be demonstrated by the R&M Contractors and the consequential Liquidated Damages to be paid them in case of delay in completion or deficiency in performance.

2.6.2 Concerns of Bidders

- Concern: Time gap between study of RLA and actual initiation of R&M bidding process.

Since the bid evaluation for the selection of R&M Contractor is included in the scope of R&M Consultant, time gap between study of RLA and actual initiation of R&M bidding process will reduce.

- Concern: Uncertainty about the exact scope of work which makes it difficult to estimate the actual work to be undertaken.

The standard documents have provided the formats for correctly defining the scope of work with certain amount of certainty.

- Concern: Unforeseen items/surprises during execution and impact on cost.

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The detailed methodology provided in the Standard RLA / CA & EA Documents coupled with the reduction in the time gap between the completion of studies and the start of R&M works will reduce unforeseen items/surprises during execution and impact on cost.

- Concern: Functional Guarantees which form part of the contract are often difficult to achieve owing to lack of clarity on how verification will be carried out.

Methods of conducting various Performance Guarantee Tests have been clearly defined. This will eliminate any lack of clarity faced by the bidders till date.

2.6.3 Concerns of Funding Agencies

- Concern: Ensuring a strategy that takes care of unforeseen items/surprises and their impact on project cost and time for execution.

One of the strategies provided in the bid documents is that the bid evaluation for the selection of R&M Contractor is included in the scope of R&M Consultant. This will reduce the time gap between RLA/CA & EA studies and actual time of executing the R&M works. The reduction in the time gap between the studies and R&M works will reduce the surprises and the corresponding increase in cost.

- Concern: Delays in Regulatory Clearances

Facilitating the Regulatory Clearances has been included in the scope of R&M Consultant which will enable the utilities to obtain the requisite clearances expeditiously.

LII opines that Standardization of Tendering Procedures and Model Contract Documents will help in addressing to a large extent, a majority of concerns of the various stake holders which will enable them to implement their R&M Projects in a smooth, systematic and structured manner. However, it is not practicable to standardize the complete documentation. Some parts of the documentation have been deliberately left open for a case-to-case finalization by the utilities as scope of R&M works will vary from project to project depending upon various conditions of a specific project.

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3 PHASE- I ACTIVITY REPORT

3.1 Information about Phase-I Activity

Phase-I of this activity was carried out by M/s Evonik Energy Services (India) Pvt. Ltd through a grant provided by GTZ. Phase-I activity provided an assessment of tendering procedures currently being followed by public utilities in India and a review of documents used for standard R&M projects and the documents which have already been developed for energy efficient R&M projects financed by particularly World Bank. The scope of work covered under Phase-I activity was as follows:

3.2 Findings and Suggestions of Phase-I Activity

After reviewing the tendering procedures and documents followed by public utilities for renovation & modernization projects, Phase-I activity Report gave the following Findings and Suggestions:

- i) Essentials of the R&M Works to be undertaken become known only after and on the basis of the completion and findings of the studies such as Energy Audit (EA), Residual Life Assessment (RLA), Condition Assessment (CA) studies and these studies are to be done necessarily by specialized and experienced consultancy firms. This would ensure that the status is examined fully and the recommendations focus on the latest available technologies.
- ii) There is enough scope for standardization of Terms of Reference (TOR) including 'Scope of Work of Consultants' to be engaged by the Utilities intending to undertake R&M Works.
- iii) Essentials of R&M Works are bound to vary depending on site conditions. The scope of works in a given bidding document, accordingly, needs to be adjusted to suit the requirements of each unit on the basis of the findings of the studies. However, given the large fleet of 200/210 MW units which require R&M, there is scope to have standard technical specifications particularly for the 'Turbine retrofit' and 'C&I' since this can be managed in about 3 or 4 options. The work pertaining to boiler varies considerably in scope and while there exists a case for some level of standardization; this can be left by and large to individual utilities to develop. A similar situation exists for balance of plant. However, there is enough scope for standardization of formats for Technical Specifications to be followed by the Utilities / Consultants for R&M Works.
- iv) There is scope for reasonable level of standardization of the formats of the reports of the studies to be undertaken such as EA, RLA, CA, PDR/DPR, financial analysis etc; based on the studies conducted and reports available.
- v) There is a strong case for standardization of the various key issues such as qualification requirement, performance guarantee requirement,

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Performance test procedures, liquidated damages, penalties & bonus conditions, shut-down requirement (time-line), which leads to delay in most of R&M tenders.

- vi) There is a strong case for development of standard commercial document for selection of R&M contractor. The World Bank has published Standard Bidding Document in this regard and the same format could be considered as a guide.

3.3 Suggestions of the Task Force

A Task Force on “Development of Tender Procedure and Model Contracts for the Renovation & Modernization (R&M) of Fossil Fuel Based Power Plants” under the chairmanship of Member (Thermal), CEA was constituted vide Ministry of Power, Government of India letter no. 5/33/2009-S.Th. dated 29/10/2009 comprising the members from MoP, CEA, National Thermal Power Corporation (NTPC) and representatives of State Generation Utilities (GENCOs) of Andhra Pradesh, West Bengal & Maharashtra.

The above report of Phase-I Activity was discussed during the first meeting of Task Force held on 20th November 2009 in CEA, New Delhi and the Task Force suggested the following among others to be incorporated in the standard documents to be prepared under Phase-II activity:

(i) The time taken for R&M works need to be cut down to the optimal possible level. It was desired that the report should recommend optimal suitable timeline for each stage during the R&M intervention (e.g. data review, RLA/CA studies, DPR preparation, bidding and implementation etc.)

(ii) During the R&M of the projects, various studies such as RLA, CA, Energy Audit etc. and preparation of DPR is being done by one consultant and the preparation of technical specification for bidding by another consultant. The studies being carried out by the first consultant, in certain cases, are not acceptable by the second consultant. Many a times, there is a big time gap between the studies and the actual implementation of the R&M scheme. The Phase-II study should examine the feasibility of having a single consultant to carry out the activities up to the stage of finalizing the R&M contract and to facilitate approval from regulatory agency.

(iii) The report should have a provision for standard qualification criteria for determining the capability of consultants for carrying out studies and implementation support consultant during the R&M works.

(iv) The representatives from the utilities suggested for standardization of technical specifications for similar capacity / type of turbines to avoid the problems being faced during the retrofitting of the various equipments.

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(v) It was opined that generally the RLA of BTG foundations and structures in various Balance of Plant (BOP) such as Coal Handling Plant (CHP), Ash Handling Plant AHP (AHP) and Water Treatment Plant (WTP) etc. is not being carried out. The structures in these areas might have become weak over the time of operation for 20-25 years due to corrosion and rusting. It was suggested by the representatives that the structural analysis in such areas should also be carried out for deciding the scope of R&M works. Also, the consultants carrying out such structural analysis may be identified.

(vi) Need was expressed for developing standardized DPR format including various tests to be carried out for establishing plant health and defining scope of works and final performance bench marking.

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4 APPROACH ADOPTED FOR EXECUTION OF ASSIGNMENT

To facilitate the implementation of R&M program for a large fleet of 200/210 MW units in a planned, systematic, structured and time bound manner, there exists a strong need to provide standardized formats for the plant investigative studies like Residual Life Assessment (RLA) / Condition Assessment (CA) Reports, Energy Audit (EA) Reports, Feasibility Reports, Detailed Project Reports, Tendering procedures, Contract documents and Contract Specifications etc to the utilities. Standardization will harmonize the requirements of all the stakeholders and will lead to their increased participation. LII adopted the following approach for execution of the assignment.

4.1 Review of the problems being currently faced by the R&M Projects

Before approaching the assignment, LII did its own due diligence and reviewed the various problems being faced by the old plants in Conducting the investigative studies to identify the exact plant problems and their solutions, Formulating various options for R&M intervention, Selecting the best option on the basis of detailed techno economic evaluation, Preparations of appropriate contract documents, Selection of Consultants , Selection of R&M Works Contractors and Achieving the desired objectives after completion of R&M works in a time bound manner.

4.2 Review of Findings of Phase-I Activity and Suggestions of Task Force

LII reviewed the findings of Phase-I Activity and the suggestions of the Task Force. These findings and suggestions have been suitably addressed while preparing standard documents as explained in detail in Chapter-5.0. (Refer Tables 5.1 and 5.2).

4.3 Due Diligence done by LII while Standardizing the Documents

While standardizing the formats for the R&M processes and tendering procedures, LII did the due diligence on the basis of the following:

- Analysis of the Data provided in the Phase-I Activity Report
- Review of its own experience in the field of R&M of the Thermal Power Projects.
- Review of R&M Documents received from CEA, MAHAGENCO and WBPDC
- Study of KfW's Guidelines for the assignment of Consultants.
- Study of Standard Bidding Document published by the World Bank.
- Discussions with the CEA and members of Task Force.
- Interactions with MAHAGENCO regarding the R&M initiatives for Nashik Unit-3 (210 MW) and Koradi Unit-6 (210 MW).
- Interactions held with M/s Alstom, M/s Energo and M/s Doosan.

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- Analysis of the Data provided in M/s Mercados Reports on 'Reduction of Barriers to Renovation and Modernisation Intervention in Thermal Power Stations in India'.
- Analysis of the Data provided in M/s Mercados Reports on 'Developing Markets for implementation of Renovation and Modernisation Schemes in Thermal Power Stations in India'
- Summary of the Data on procurement of experience provided by CEA as given in **Annexure-4**.

4.4 Visit to MAHAGENCO HQ and Nashik TPS Unit-3

Visit was made to MAHAGENCO HQ at Mumbai and Nashik TPS during April 2013, to interact with these authorities and to obtain the feedback regarding their experience of R&M activities for their power plants namely, Nashik Unit-3 (210 MW) and Koradi Unit-6 (210 MW). Record notes of discussions held with MAHAGENCO HQ and Nashik TPS are placed at **Annexure-5**.

4.5 Interactions with R&M Consultants and R&M Contractors

Interactions were held with the R&M Consultant M/s Energo and R&M Contractors namely, M/s. Alstom and M/s. Doosan to obtain the feedback of their experience in implementation of R&M programmes of different power stations.

4.6 Meetings held with CEA and Task Force

Meetings were held with CEA and Task Force from time to time. Record notes of meetings are placed at **Annexure-6**.

4.7 Concept Adopted For the Preparation of Standard Documents

The Standard formats for the Documents and Tendering Procedures prepared for R&M & LE Projects contain two kinds of texts/ data i.e., fixed and variable, written in black and in blue colours respectively. The variable text/ data written in blue colour in italics and enclosed in square bracket is to be suitably modified by the utilities based on the project's specific requirements which may vary from Project to Project. The text /data in blue colour indicate typical data and values applicable for typical coal fired power plants. In the beginning of each model document, applicable notes & guidelines have been provided for using that model document. The Project Authorities and their Consultants carrying out R&M & LE activities of a particular plant/project have been advised to review this text/data in respect of their plant/project and modify the same with the text/data applicable to their specific Project. In addition, a few guidelines at appropriate places have also been provided in blue italics enclosed within red curly brackets, for some of the documents.

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5 BASIS OF STANDARDISATION OF PROCEDURES & DOCUMENTS

Since majority of 200/210 MW units are potential candidates for consideration of Renovation as they have crossed 20 to 25 years of useful life, the standard formats have been prepared keeping those 200 MW/210 MW units in view. Since in due course of time, many 500 MW units will also become due for R&M, the Utilities are advised to suitably modify these documents for its application to 500 MW units.

The procedures to be adopted and documents to be used for implementing the R&M schemes of Projects have been standardized based on the mandate as per various items of scope of services, as discussed below:

5.1 Critical Review of Phase-I Report's findings

Item of Scope of Service:

'The Consultant shall critically review the findings under the Phase-I report and incorporate suitably the findings/recommendations of Phase-I report in the standard documents to be prepared under Phase-II activity.'

Conclusion drawn by LII on reviewing the Findings of Phase-I Activity Report

LII agreed with the opening remarks of Phase-I Activity Report that in the past, R&M measures have been hampered by lack of proper planning and uncertainty about costs resulting in excessive implementation time, long shutdown periods of plants and cost overruns and that in the absence of standard commercial rules and policies suppliers showed little interest in R&M work.

LII reviewed in detail the findings of Phase-I Activity Report and noted that tendering procedures being followed by various utilities for the appointment of R&M Consultants and R&M Contractors varied considerably in terms of Qualification Criteria, Scope of Work and Method of Bid evaluation. LII also noted the disparities among the utilities in specifying the key requirements such as Performance Guarantees, Performance Test Procedures, Liquidated Damages, Bonus Conditions and Shut down Time Lines in R&M Contract Documents. LII recognised the need and importance of developing standard commercial terms for the selection of R&M Contractors. LII reviewed the prevailing practice of appointment of R&M Consultants and R&M Contractors as discussed below.

Data Analysis Regarding R&M Consultants

The findings of Phase-I Activity for the appointment of R&M consultants is based on the survey of the documents and procedures adopted by the following seven (7) power utilities, which had taken up R&M activities in the past:

- i) Bokaro TPS (3X 210) MW

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- ii) KorbaWest TPS (4X 210) MW
- iii) Nasik TPS (1X 210) MW
- iv) Kolaghat (TPS 3X210) MW
- v) Bandel TPS (1X 210) MW
- vi) Koradi TPS (1X210) MW
- vii) Patratu TPS (2 X 110) MW

Practice of Appointing the R&M Consultants

Regarding the practice of appointing the R&M Consultants, LII noted that Expressions of Interest were invited for the World Bank Projects at Bandel TPS (1X 210) MW and Koradi TPS(1X210) MW, while the remaining five power stations adopted open tendering system but the qualification criteria were mentioned in the tender documents. In two cases, namely those of Korba West TPS (4X 210MW) and Patratu (2 X 110) MW power stations, the National Competitive Bidding (NCB) rules were followed. In five other cases including two World Bank projects International Competitive Bidding (ICB) rules were followed.

Assigning the Scope of Work to the Consultants

After reviewing the scope of work assigned to the consultants, LII found from Annexure-3 of Phase –I Activity Report that in case of all the above utilities, the scope of R&M Consultants essentially consisted of conducting the RLA/CA & EA studies and providing recommendations to the utilities for the preparation of Feasibility Reports and Detailed Project Reports. However, LII noted that in the case Korba West (4X 210) MW, Bandel (1X 210) MW, Koradi (1X210) MW and Patratu (2 X 110) MW power stations, the scope of work also included preparation of Tender Documents, assisting the utilities in the bidding process, carrying out bid evaluation and also supervising & evaluating of PG tests to be undertaken by the R&M contractors.

Data Analysis Regarding R&M Contractors

From Phase-I report, LII studied the documents and procedures followed by the following six (6) utilities for the appointment of R&M contractors.

- i) Kothagudem TPS (4 x 110 MW)
- ii) Ennore TPS (2 x 60 + 3 x 110) MW
- iii) Patratu TPS (3 x 50 MW)
- iv) Badarpur TPS (2 x 210 MW)
- v) Bhatinda TPS (2 x 110 MW)
- vi) Bandel TPS (1 x 210 MW)

Practice of Appointing the R&M Contractors

Regarding the practice of appointing the R&M Contractors, LII noted that Bids were invited on the basis of Pre-Qualification and that 'Single Stage Bidding' was followed in case of Kothagudem TPS (4 x 110 MW), Ennore

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TPS (2 x 60 + 3 x 110) MW, Patratu TPS (3 x 50 MW) and Bhatinda TPS (2 x 110 MW), whereas 'Two Stage Bidding' was followed in case of Bandel TPS (1 x 210 MW) and Badarpur TPS (2 x 210 MW) had also proposed to follow 'Two Stage Bidding'.

In three cases, namely those of Kothagudem TPS (4 x 110 MW), Ennore TPS (2x60 MW + 3x110 MW) and Bhatinda TPS (2 x 110 MW) power stations, the National Competitive Bidding (NCB) rules were followed. In two cases of Patratu TPS (3x50 MW) and Bandel TPS (1x210MW) International Competitive Bidding (ICB) rules were followed. Badarpur TPS (2 x 210 MW) had also proposed to follow International Competitive Bidding (ICB) rules.

Tendering Conditions for the R&M Contractors

LII noted that validity period of the Tenders varied between 120 to 180 days. Contract Performance Guarantee varied between 5% to 15%. However, the same was 10% in four out of six cases. The warranty period was 12 months in four cases and 18 months in two cases. While Liquidated Damages (LDs) on account of delay were specified in all the cases, LII did not find the mention of Liquidated Damages (LDs) on account of Performance in any of the six cases.

Action Taken by LII for Standardization of Procedures and Documents

LII critically reviewed each of the findings under Phase-I activity Report and took due care in suitably addressing the findings/recommendations of Phase-I report while standardizing the procedures and documents under Phase-II activity, as discussed in the tables below:

**Table: 5.1
Response to the findings of Phase-I Activity Report**

S.No	Findings & Recommendations of Phase-I Activity Report	Action Taken by LII for Standardization of Procedures and Documents
1.	Essentials of the R&M Works to be undertaken become known only after and on the basis of the completion and findings of the studies such as Energy Audit (EA), Residual Life Assessment (RLA), Condition Assessment (CA) studies and these studies are to be done necessarily by specialized and experienced consultancy firms. This would ensure that the status is examined fully and the recommendations focus on the latest available technologies.	Standard Documents include RFQ (Request for Qualification) procedure to enable the utilities to appoint only those R&M consultants who are specialized in this field and possess the requisite expertise to carry out the required studies such as Residual Life Assessment (RLA) & Condition Assessment (CA) Studies and Energy Audit (EA) Studies. Point scoring system has been prescribed for the selection of Consultants as per which only those consultants whose Technical Proposals get a Technical Score of 70 marks or more out of 100 shall qualify for consideration.
2.	There is enough scope for standardization of Terms of Reference (TOR) including 'Scope of Work of	As per the Standard Procedures and Documents prepared by LII, two types of Consultants have been envisaged, namely,

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S.No	Findings & Recommendations of Phase-I Activity Report	Action Taken by LII for Standardization of Procedures and Documents
	Consultant' to be engaged by the Utilities intending to undertake R&M Works.	<p>R&M Consultant and Implementation Support Consultant (ISC).</p> <p>The consultancy work is initiated by the R&M Consultant whose Terms of Reference (TOR) and 'Scope of Work' covers Carrying out all investigative studies like RLA/CA and EA studies, Providing solutions to various operating problems in the form of formulation of R&M options, Selection of the most attractive R&M option to be implemented, Preparation of DPR (Detailed Project Report), Assisting the utility in getting the approval of appropriate Regulatory Commission and in the Preparation of Bidding Documents as well as appointment of R&M Contractors.</p> <p>The role of Implementation Support Consultant (ISC) comes during the implementation of R&M works. The Terms of Reference (TOR) and 'Scope of Work' of ISC consists of Reviewing of design documents & drawings of the R&M contractors to ensure compliance with the spirit, intent & contents of the EPC contract, Inspection & Testing, Site Supervision and Witnessing of Performance Guarantee Tests of the Equipments.</p>
3.	Essentials of R&M Works are bound to vary depending on site conditions. The scope of works in a given bidding document, accordingly, needs to be adjusted to suit the requirements of each unit on the basis of the findings of the studies. However, given the large fleet of 200/210 MW units which require R&M, there is scope to have standard technical specifications particularly for the 'Turbine retrofit' and 'C&I' since this can be managed in about 3 or 4 options. The work pertaining to boiler varies considerably in scope and while there exists a case for some level of standardization; this can be left by and large to individual utilities to develop. A similar situation exists for balance of plant. However,	<p>LII recognizes that scope of R&M Works is bound to vary depending on the site conditions and also on the results of investigations like RLA/CA and EA studies. Accordingly the scope of R&M work for any plant has to address the needs and requirements of that plant to increase output, efficiency, reliability and extension of life.</p> <p>The Standard Documents prepared by LII have covered in great detail, all conceivable scope of work and requirements of the plants in general and the utilities have been advised to select the applicable areas of work based on the result of studies, in order to finalize the scope of work for their respective plant.</p> <p><u>Retrofitting of Turbines</u> Most of the 200MW/210 MW Turbines are of LMZ design, having LP stage fitted with</p>

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S.No	Findings & Recommendations of Phase-I Activity Report	Action Taken by LII for Standardization of Procedures and Documents
	there is enough scope for standardization of formats for Technical Specifications to be followed by the Utilities / Consultants for R&M Works.	<p>Baumann Exhaust, design of which does not match with the Indian condensing conditions. The Standard documents prepared by LII envisage the following four options for retrofitting of these Turbines. Each option provides additional output and heat-rate improvements that reduces specific fuel consumption with corresponding reductions in emissions while extending the life of turbine.</p> <p><u>1st Option-LP Retrofit:</u> This gives the greatest improvement in cylinder efficiency and in output (around 6 to 12 MW).</p> <p><u>2nd Option-HP Retrofit:</u> This can deliver up to 7 MW of additional output with improvement in cylinder efficiency.</p> <p><u>3rd Option-IP Retrofit:</u> This can deliver additional output around (1 to 3 MW) with some improvement in cylinder efficiency.</p> <p><u>4th Option-Complete Turbine Retrofit:</u> Retrofitting complete new energy efficient turbine can deliver around 10 to 20 MW additional output with significant improvement in efficiency and extension of life by 25 years. This option may also require a new Generator, Generator Transformer and new static Excitation System.</p> <p><u>Retrofitting of C&I System:</u> The control and instrumentation system existing generally in the old plants is of an old analogue based system and requires large scale replacement owing to obsolescence of the existing equipment. Furnace Supervisory Safeguard System (FSSS) is of obsolete design for which, no spares are available. Soot blowers are of manual type and no online Boiler Tube Leakage detection system has been provided. HP-LP bypass system is in the form of standalone control panel. For the units undergoing R&M with extension of life for another minimum 20 years, modern equipments having state of the art technology have therefore been envisaged in the Standard Documents prepared by LII. These include integrated microprocessor based</p>

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S.No	Findings & Recommendations of Phase-I Activity Report	Action Taken by LII for Standardization of Procedures and Documents
		<p>closed loop control, open loop control, sequential control and bulk data acquisition system for Boiler & auxiliaries, TG & auxiliaries, Station C&I including auxiliaries in hierarchical levels and integrated unit monitoring and station monitoring systems in the upper level.</p> <p><u>Retrofitting of Boilers</u> Boilers suffer maximum deterioration in condition & performance primarily due to prolonged operation with abrasive quality of ash in the coal. Condition of boilers gets further adversely affected when operated with much poorer quality of coal than they are designed for. Thermal cycling and poor water & steam chemistry regime also impacts the life of boiler pressure parts. Due to different operating practices and different operating regimes, no two boilers may be requiring the same solutions. Solutions may further vary considerably due to different firing systems of boilers and different types of pulverizers being used by different utilities. Standard Bidding documents and Specifications for the R&M works of the Boilers have been developed by covering all types of solutions generally needed for the Boilers. The utilities have been advised to suitably adjust these documents for the applicable requirements of their specific units. The above logic has also been applied to the Balance of Plant. For describing the existing details of the Boilers in the bidding documents, the Utilities have been advised to clearly explain whether their boilers are of PF or CFBC design and whether the firing system is of front / front & rear/ tangential /down shot type. While the Standard Specifications of Boilers prepared by LII cover in detail the Performance Parameters of Boilers based on the given Coal Quality, Design Criteria, Materials of Construction and Codes & Standards etc, the Standard Specifications have not been prepared to specify a particular type of firing, since this will restrict the competition to one or two bidders who may inflate the prices. It</p>

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		<p>may be noted that OEMs having collaboration with Foster Wheeler or Babcock & Wilcox are manufacturing boilers with front / front & rear design, OEMs having collaboration with Combustion Engineering are manufacturing boilers with tangential firing, while OEMs like Doosan or those having collaboration with Alstom are also manufacturing boilers with down-shot type of firing.</p> <p>Among other things, specifications prepared cover membrane wall construction, low NOx burners and ceramic/basalt lined coal piping & bends for special protection due to erosion.</p>
4.	There is scope for reasonable level of standardization of the formats of the reports of the studies to be undertaken such as EA, RLA, CA, PDR/DPR, financial analysis etc; based on the studies conducted and reports available.	<p>The following Documents incorporating Standard Procedures and Formats have been developed by LII for carrying out the investigative processes and studies to determine the health assessment and condition of the Equipment & Systems of the Power Plants to be taken up for R&M as well as for determining the feasibility of various possible options along with the financial impact of various options.</p> <ul style="list-style-type: none"> • Model Residual Life Assessment (RLA) & Condition Assessment (CA) Report. • Model Energy Audit (EA) Report. • Model Feasibility Report. • Model Detailed Project Report.
5.	There is a strong case for standardization of the various key issues such as qualification requirement, the Performance guarantee requirement, Performance test procedures, liquidated damages, penalties & bonus conditions, shut-down requirement (time-line), which leads to delay in most of R&M tenders.	<p>The Standard Bidding Documents of all the Contract Packages prepared by LII have covered in detail all the following key issues which are essential part of any bidding document.</p> <ul style="list-style-type: none"> • RFQ (Request for Qualification) for the Bidders. • Performance Guarantee Parameters for Boiler, Turbo- Generators, and Balance of Plant. • Procedures for conducting the Performance Tests Boiler, Turbo-Generators, and Balance of Plant. • Liquidated damages for delay in completion of work. • Liquidated damages for shortfall in performance.

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S.No	Findings & Recommendations of Phase-I Activity Report	Action Taken by LII for Standardization of Procedures and Documents
		<ul style="list-style-type: none"> Shut down time of the units.
6.	There is a strong case for development of standard commercial document for selection of R&M contractor. The World Bank has published Standard Bidding Document in this regard and the same format could be considered as a guide.	<p>Volume-I of the Standard Bidding documents prepared by LII for various contract packages constitutes the commercial document for the selection of R&M contractors. LII prepared these commercial documents after studying & reviewing the following documents.</p> <ul style="list-style-type: none"> R&M Documents received from CEA, MAHAGENCO and WBPDC. KfW's Guidelines for the assignment of Consultants . Standard Bidding Document published by the World Bank. Tender documents of leading Indian Public Sector Utilities National Thermal Power Corporation Ltd and Neyveli Lignite Corporation for different packages of power plants. <p>All Standard bidding procedures and documents have been prepared on the basis of prequalification and in single stage two part bidding concept as represented by the flow diagram given below Clause no.7.2.4. The tendering documents consist of RFQ (Request for Qualification) and RFP (Request for Proposal). The details of Standard bidding procedures and documents have been discussed in Chapter-7 of this report.</p>

Table: 5.2
Response to the Suggestions of the Task Force

S.No.	Suggestions of the Task Force	Action Taken by LII for Standardization of Procedures and Documents
1.	The time taken for R&M works need to be cut down to the optimal possible level. It was desired that the report should recommend optimal suitable timeline for each stage during the R&M intervention (e.g. data review, RLA/CA studies, DPR Preparation, bidding and implementation etc.)	Optimal timelines have been discussed in Chapter-6 of this report, starting from Appointment of R&M Consultant to Collection of Data, Conducting of RLA/CA & EA Studies, Finalization of the Scope of R&M Works, Preparation of DPR and obtaining approval of Regulatory Commission, Preparation of Bidding Documents, Appointment of R&M Contractor(s), Completion of R&M works and conducting the PG Tests.

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S.No.	Suggestions of the Task Force	Action Taken by LII for Standardization of Procedures and Documents
2.	During the R&M of the projects, various studies such as RLA, CA, Energy Audit etc. and preparation of DPR is being done by one consultant and the preparation of technical specification for bidding by another consultant. The studies being carried out by the first consultant, in certain cases, are not acceptable by the second consultant. Many a times, there is a big time gap between the studies and the actual implementation of the R&M scheme. The Phase-II study should examine the feasibility of having a single consultant to carry out the activities up to the stage of finalizing the R&M contract and to facilitate approval from regulatory agency.	LII reviewed this aspect and arrived at the considered opinion that a single R&M Consultant should be appointed for carrying out the investigative studies such as RLA, CA, Energy Audit etc., Preparation of DPR, facilitating approval from regulatory agency, preparation of technical specification for bidding documents and finalizing the R&M contract. Standard Documents containing Qualifying Requirements and Bidding Documents have been developed accordingly. Appointment of a single R&M Consultant will also reduce the time gap between the studies and the selection of R&M Contractor.
3.	The report should have a provision for standard qualification criteria for determining the capability of consultants for carrying out studies and the Implementation support consultant during the R&M works.	Qualification documents (RFQ) for determining the capability of R&M Consultants for carrying out studies and that for the Implementation Support Consultant (ISC) for supervising the work of R&M Contractor(s) have been prepared.
4.	The representatives from the utilities suggested for standardization of technical specifications for similar capacity / type of turbines to avoid the problems being faced during the retrofitting of the various equipments.	Retrofitting of Turbines has already been discussed at item 3 of Table 5.1.2.
5.	It was opined that generally the RLA of BTG foundations and structures in various BOPs such as CHP, AHP, WTP etc. is not being carried out. The structures in these areas might have become weak over the time of operation for 20-25 years due to corrosion and rusting. It was suggested by the representatives that the structural analysis in such areas should also be carried out for deciding the scope of R&M works. Also, the	Normally, the life of Civil and Structural Works should be of the order of sixty (60) years and above, which is much more than the life of Mechanical and Electrical Components of Thermal Power Plants. However, in certain cases like exposure to harsh and corrosive environment or natural calamities, the buildings / structures/ foundations of a plant may get damaged or become weak due to corrosion or rusting etc. Therefore before taking up the R&M activity of any plant, it is utmost important to critically examine the

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S.No.	Suggestions of the Task Force	Action Taken by LII for Standardization of Procedures and Documents
	consultants carrying out such structural analysis may be identified.	condition of all the civil and structural works. Based on the examination, any part(s) of the civil and structural works which might have become weak or defective must be identified and solutions found for their repair, retrofitting or replacement so as to increase their service life. Standard RLA/ CA Report prepared by LII therefore includes guidelines for carrying out the health studies of foundations and structures of Boilers Turbines and structures in various BOPs such as CHP, AHP and WTP etc.
6.	Need was expressed for developing standardized DPR format including various tests to be carried out for establishing plant health and defining scope of works and final performance bench marking.	Standard DPR has also been prepared which defines the scope of work and also the final performance parameters. Various tests to be carried out for establishing plant health are covered in Model RLA/CA Report and Model EA Report.

5.2 Rehabilitation on Technical, Ecological and Economic Considerations

A) Item of Scope of Service:

'To define the scope of rehabilitation based on technical, ecological and economic considerations. To prepare a matrix of options which the owner can consider based on the applicable conditions for each individual case and the objectives to be achieved.'

Before deciding the scope of R&M works, the utilities have to determine the status of health of equipments of various systems as also their residual life by carrying out various Residual Life Assessment / Condition Assessment studies and Energy Audit studies. Depending upon the review of the past performance and results of above studies, decision is taken whether to run, retrofit or replace each of the critical equipments. If equipment is found to have either defective performance or less residual life, root cause analysis is done by the R&M Consultant for diagnosing the specific technical problem(s) with the equipment(s). Based on the above diagnosis, alternative solutions are found for retrofitting the equipment(s) with corresponding cost impact in each of the following cases.

- i) To restore the performance equal to its original design without increasing its life.

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- ii) To improve the performance beyond its original design without increasing its life.
- iii) To restore the performance equal to its original design and also increasing its life by 20 years.
- iv) To improve the performance beyond its original design and also increasing its life by 20 years.

The scope of rehabilitation of the units is essentially based on following considerations:

- i) Technical considerations.
- ii) Ecological considerations and
- iii) Economic considerations.

A) Rehabilitation based on technical considerations

Equipments of the units require rehabilitation on technical considerations in the following events:

- i) When the operating parameters are found below the design parameters.
- ii) When the operating efficiency is below design efficiency i.e., power consumption is more than the design value.
- iii) When the residual life of the equipment(s) is lesser than the remaining design life or extended life of the plant.
- iv) When the equipment(s) are found to fail repeatedly resulting in poor availability/plant load factor of the plant.

B) Rehabilitation based on ecological considerations

Power plants are one of the biggest emitters of Carbon Dioxide and hence are considered a principal culprit for climate change. With growing clamour over global warming, coal fired power plants are increasingly coming under scrutiny for their carbon foot print. The environmental regulations through out the world including India are becoming stricter day by day. Equipments of the units therefore require rehabilitation on ecological considerations in the following events:

- i) When higher heat rate of the units leads to higher atmospheric emissions of SPM, CO₂, NO_x and SO_x, because of increased consumption of fuel.
- ii) When NO_x emission is higher, due to non availability of low NO_x burners.
- iii) When SO_x emission is higher, due to higher percentage of sulphur in fuel.
- iv) When the quality and quantity of liquid effluents exceeds the prescribed limits of environment regulating authorities.
- v) When the methods of collection and disposal of ash is not as per the guidelines of environment regulating authorities.

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C) Rehabilitation based on economic considerations

After the completion of studies, the utilities are likely to be confronted with a host of possibilities and options to be evaluated in order to choose the most feasible and economic option of R&M to be implemented. To make the complex problem simple, the Standard Documents of Feasibility Report and Detailed Project Report have been prepared envisaging the following R&M options to be considered by the utilities. Cost implication of each option is worked out and based on the financial analysis; the most cost effective option is selected for implementation.

Table: 5.3
Matrix of R&M Options

Option	Objectives to be achieved by carrying out R&M
I	<ul style="list-style-type: none"> i) Designing Boiler to suit average coal quality likely to be available for the next 20 Years. ii) Increasing the output of the unit from 200/210 MW by retrofitting the LP turbine without retrofitting Generator. Improving heat rate beyond the original design heat rate and restoring the Auxiliary Power Consumption to the original design values. iii) Replacing the existing obsolete technology. iv) Meeting the revised statutory emission standards. v) Extending the life of the unit by a minimum of 20 years.
II	<ul style="list-style-type: none"> i) Designing Boiler to suit average coal quality likely to be available for the next 20 Years. ii) Increasing the output of the unit from 200/210 MW by retrofitting the LP and HP turbine without retrofitting Generator. Improving heat rate beyond the original design heat rate and restoring the Auxiliary Power Consumption to the original design values. iii) Replacing the existing obsolete technology. iv) Meeting the revised statutory emission standards. v) Extending the life of the unit by a minimum of 20 years.
III	<ul style="list-style-type: none"> i) Designing Boiler to suit average coal quality likely to be available for the next 20 Years. ii) Increasing the output of the unit from 200/210 MW by retrofitting complete new energy efficient turbine without retrofitting Generator. Improving heat rate beyond the heat rate of option 'II' and restoring the Auxiliary Power Consumption to the original design values. iii) Replacing the existing obsolete technology. iv) Meeting the revised statutory emission standards. v) Extending the life of the unit by a minimum of 20 years.
IV	<ul style="list-style-type: none"> i) Designing Boiler to suit average coal quality likely to be available for the next 20 Years. ii) Increasing the Output from 200/210 MW by retrofitting complete new

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Option	Objectives to be achieved by carrying out R&M
	<p>energy efficient turbine along with new Generator, Generator Transformer and new static Excitation System. Improving heat rate better than the level of option 'III' and restoring the Auxiliary Power Consumption to the original design values.</p> <p>iii) Replacing the existing obsolete technology.</p> <p>iv) Meeting the revised statutory emission standards.</p> <p>v) Extending the life of the unit by a minimum of 20 years.</p>
V	<p>i) In situ major replacement of Boiler on the existing foundations, retrofitting complete new energy efficient turbine along with new Generator, Generator Transformer and new static Excitation System. Designing the boiler to suit the average coal quality likely to be available for the next 25 years.</p> <p>ii) Increasing the Output to 250/300 MW by installing new Boiler / Turbine of higher Capacity after replacing the old one. Achieving Heat Rate and Auxiliary Power Consumption better than Options 'III' & 'IV'.</p> <p>iii) Replacing the existing obsolete technology.</p> <p>iv) Meeting the revised statutory emission standards.</p> <p>v) Extending the life of the unit by a minimum of 25 years.</p> <p>{This option is advised only when the unit to be renovated is either the first or last unit of the power plant, since the intermediate units are likely to have space constraint.}</p>

While considering various options, the following minimum objectives were considered by LII:

- Redesigning the boiler to suit the average coal quality likely to be available for the next 20 years.
- Retrofitting of majority of 200/210 MW units provided with LMZ design having LP Turbines with inherent deficiency in efficiency and output due to Baumann type exhaust.
- Improving the performance parameters at least to the original design values.
- Extending the life of the unit by a minimum of 20 years.
- Replacing the existing obsolete technology, most particularly the control instrumentation.
- Meeting the revised prevailing statutory emission standards.
- Increasing Boiler Efficiency.
- Reducing Turbine Heat Rate.
- Reducing Auxiliary Power Consumption

Before finalizing the above options, LII also studied the R&M options considered for the reference plant of Nashik Unit-3 (210 MW) of MAHAGENCO and had detailed discussions with MAHAGENCO and CEA. It was noted that the Feasibility Report of Nashik Unit-3 (210 MW) had considered eight (8) numbers of options. Out of these five (5) options were incorporated in the Standard feasibility report after making suitable

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modifications. The following three options were not considered in view of the reasons explained below:

Table: 5.4
Options not Considered for Standardization

Option	Objectives to be achieved by carrying out R&M	Reasons for not considering the R&M Option
1.	Extending the life of the unit by 20 years without compensating the inferior coal quality presently available.	The option does not address the basic problem of deteriorating coal quality.
2.	New Unit option considered at a new location in the same plant and utilizing the existing auxiliaries.	Even if an alternative space is available within the plant to relocate the main plant, utilizing the existing auxiliaries will pose many problems of not only rearranging the layouts of piping and cables network but will also require the re-engineering of various pumps and compressors due to the change in their system resistance.
3.	Modification of Boiler and Auxiliaries to achieve Re-heater temperature of 560 +/- 5 deg C by upgrading re-heater with new turbine and accessories suitable for new HRH lines and Regenerative Heaters.	The options will make the implementation of the R&M scheme complicated in view of replacement of HRH lines and all the Regenerative Heaters.

A matrix of options for the rehabilitation of the specific projects have been suggested in the of Feasibility Report / Detailed Project Report documents. The Utilities and their R&M Consultants have been advised to work out the cost of each option after taking into account the scope of R&M measures to be implemented and select the most appropriate option for implementation after carrying out financial analysis of each option.

5.3 Guidelines related to goals to be achieved.

Item of Scope of Service:

'The consultant will provide the guidelines for the content of the tender documents especially related to goals to be achieved and guarantee figures etc'.

Content of the Tender Documents

After reviewing the pros and cons of single vs multi package concepts, standard tender documents have been prepared by LII for the following six packages.

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Table: 5.5
List of Contract Packages

Package No.	Contents of the Tender Documents
1.	Boiler & Auxiliaries (including but not limited to Pulverizes, Feeders, PA Fans, FD Fans, ID Fans), ESP, Auxiliary Steam system and MS, HRH, CRH, HPBP & LPBP piping and associated Electrical, C&I and Civil Works.
2.	Turbo-Generator & Auxiliaries (including but not limited to Heaters, Deaerator, Condenser, BFPs, CEPs), TG Cycle piping including Boiler Feed piping and associated Electrical, C&I and Civil Works. This package will also including R&M of C&I system common to both SG and TG.
3.	Coal Handling Plant and associated Electrical, C&I and Civil Works.
4.	Ash Handling System and associated Electrical, C&I and civil works.
5.	Mechanical Balance of Plant (BOP) System which includes Plant Water System (Raw water intake system, Pre-treatment Plant, D.M.Plant, CW System including Cooling Towers, ACW & CCW System), Compressed Air System, Fuel Oil System, Fire Fighting System and Miscellaneous balance mechanical systems.
6.	Electrical BoP including inter alia Switchyard, Power Transformers and Switchgears.

Tender Documents of each contract package are divided in three volumes, Volume-I, Volume-II and Volume-III as explained in the table below.

Table: 5.6
Description of Different Volumes of Tender Documents

Volume No.	Section	Part	Description
Volume-I	---	---	Commercial Document
Volume-II	Section-I	---	Project Technical Specification
	Section-II	Part-A	Detailed Technical Specifications - Mechanical
		Part-B	Detailed Technical Specifications - Electrical
		Part-C	Detailed Technical Specifications – I&C
		Part-D	Detailed Technical Specifications - Civil
Volume-III	---	Part-A	Technical Schedules - Mechanical

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Volume No.	Section	Part	Description
	---	Part-B	Technical Schedules - Electrical
	---	Part-C	Technical Schedules – I&C
	---	Part-D	Technical Schedules – Civil

Goals and Guarantee to be Achieved

Three Categories of Guarantees (Category- I, Category- II and Category-III) have been prescribed in the Tender Documents for the goals to be achieved for each of the Contract Packages as described in the Table below. In case, during performance guarantee tests, it is found that the equipment/systems have failed to meet the guarantees, the Bidder shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Owner. However, if the Bidder is not able to demonstrate the guarantees, even after the above modifications/replacements within [say ninety (90) days] or a reasonable period allowed by the Owner after the initial performance guarantee tests have been completed, the Owner will have the right to impose the stipulated clauses of Liquidated Damages under Guarantee Category I, II & III as specified in the Tender Specifications.

Table: 5.7

Types of Guarantees and Goals to be Achieved

Tof Guarantees	Owner's Rights in the event the Bidder fails to demonstrate the Goals	Goals to be achieved	
		Boiler	Turbo Generator
Category- I	Reject the equipment/system/plant and recover from the Contractor payments already made. OR Accept the equipment/system /plant after levying Liquidated Damages (LD) as specified in Volume-I (Commercial Document). The LDs shall be prorated for the fractional parts of the deficiencies.	<ul style="list-style-type: none"> Steaming capacity (TPH) Boiler Efficiency Auxiliary Power Consumption 	<ul style="list-style-type: none"> Gross Output (MW) Turbine Cycle Heat Rate Auxiliary Power Consumption
Category-II	Reject the equipment/plant/system and recover, from the Contractor, the payments already made. Conformance to the performance requirements under Category-II is mandatory.	<ul style="list-style-type: none"> Solid Particulate Emission NOx Emission SOx Emission Discharge of 	<ul style="list-style-type: none"> Discharge of Liquid Effluents

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Tof Guarantees	Owner's Rights in the event the Bidder fails to demonstrate the Goals	Goals to be achieved	
		Boiler	Turbo Generator
		Liquid Effluents	
Category-III	Reject the equipment/system/plant & recover, from the Contractor, the payments already made. OR Accept the equipment/system after assessing the deficiency in respect of the various ratings, performance parameters and capabilities and recover from the Contract price an amount equivalent to the damages as determined by the Owner. Such damages shall however be limited to the cost of replacement of the equipment/systems replacement of which shall remove the deficiency so as to achieve the guaranteed performance.	<ul style="list-style-type: none"> Noise Levels from Equipments, Start up loading, unloading and shut down capabilities etc. Performance Parameters of Boiler & Auxiliaries. 	<ul style="list-style-type: none"> Noise Levels from Equipments, Start up loading, unloading and shut down capabilities etc. Performance Parameters of Turbo Generator & Auxiliaries.

5.4 Time Lines for various Stages of R&M Intervention

As per the following stipulation of TOR, indicative timelines for various stages was to be drawn up.

‘The Consultant shall draw up indicative time-line for each stage during the R&M intervention i.e. data review, RLA/CA studies, energy audit, steam path audit, feasibility studies, DPR preparation, tendering process, R&M works implementation/execution, PG test etc.’

Processes / Stages involved in the Renovation and Modernization of Thermal Power Projects involve appointment of R&M Consultant, Collection of data, Conducting of RLA/CA Studies (including steam path audit of Turbines), Conducting of EA Studies, formulation of R&M options, Selection of R&M option to be implemented, Preparation of DPR and getting approval of appropriate Regulatory Commission, Preparation of Bidding Documents, Appointment of R&M Contractors and ISC Consultant etc.

LII has drawn up the indicative time-lines for each stage during the R&M intervention and the same are discussed in Chapter-6 of this report.

5.5 Feasibility of having a Single R&M Consultant

As per the following stipulation of TOR, feasibility of having a single consultant was to be looked into.

‘The consultant shall elaborate the feasibility of having a single consultant to carry out the activity up to the stage of finalizing the R&M contract and to facilitate approval from regulatory commission.’

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LII has reviewed this aspect and arrived at the considered opinion that a single R&M Consultant should be appointed for carrying out the investigative studies such as RLA, CA, Energy Audit etc., Preparation of DPR, facilitating approval from regulatory agency, preparation of technical specification and bidding documents and finalizing the contract for R&M Contractor. Standard Documents containing Qualifying Requirements and Bidding Documents have been developed accordingly.

During implementation of many R&M Projects, various studies such as RLA, CA, Energy Audit etc. and preparation of DPR is being done by one consultant and the preparation of technical specification for bidding by another consultant. In certain cases, the studies being carried out by the first consultant are not accepted by the second consultant. Appointment of a single R&M Consultant will solve this problem.

The above aspects as well as the role of Implementation Support Consultant have been discussed in detail in Chapter-8 of this report.

5.6 Development of Standard Documents for R&M Projects

As per the following stipulation of TOR, standard documents on tendering procedures and contracts for the R&M projects were to be developed.

‘The consultant shall develop the standard documents on tendering procedures and contracts for the R&M projects. The following procedures and documents are suggested to be considered for standardization during the Phase-II activities. Documents listed below under items (I) to (VI) will be prepared by the consultant for which CEA can share the available documents with them or can be derived from documents elaborated in ongoing R&M programmes. CEA may assist the consultant in extracting standard forms from those documents. The consultant may also provide suitable standard formats available with him after getting vetted by CEA. Beyond this the Consultant’s activities will also concentrate on technical specifications under item (VII).

The above constitutes the main scope of services of LII. As discussed in detail in Chapter-9 of this report, all the draft documents were progressively submitted by LII. After the incorporation of comments of CEA and the Task Force, the following four documents have been finalized and submitted to CEA.

- Model Residual Life Assessment (RLA) & Condition Assessment (CA) Report,
- Model Energy Audit (EA) Report,
- Model Feasibility Report (FR) and
- Model Detailed Project Report (DPR).

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5.7 Standardization of Technical and Commercial Specifications

Standard Documents have envisaged maximum of six packages as mentioned below.

- Boiler & Auxiliaries.
- Turbo-Generator & Auxiliaries.
- Coal Handling Plant.
- Ash Handling System.
- Mechanical Balance of Plant.
- Electrical Balance of Plant.

Standard Tender Documents for each package have been prepared in three volumes. Volume-I is a Commercial Document, Volume –II consists of Technical Specifications and Volume-III consists of Technical Schedules which need to be filled up and submitted by the bidders for R&M Contracts during submission of the Bids. Volume–II on Technical Specification consists of two sections. Section-I is for Project Technical Specification & Section-II is for Detailed Technical Specification. Based on RLA/CA and EA studies, Utilities and their R&M consultants need to finalize the scope of work to be carried out for the R&M Project and accordingly modify the technical and commercial specifications in the standard formats of Tender Documents. Project Technical Specification (Section-I) is standardized for each package and R&M consultant should refer to applicable portion of Section-II (Detailed Technical Specification) to prepare project specific detailed technical specification in line with the scope of work as firmed up in Section-I .

5.8 Chapterisation of Specifications for different types of Boilers.

Project Technical Specification (Section-I) covers the Boilers of PF and CFBC type provided with Front & Rear/ Corner /Down shot Firing systems. Detailed Specifications of Boilers covers the Design Criteria, Codes & Standards and Materials of Construction for all components of Boilers including Structures & Platforms, Furnace, Casing, Burners, Firing Systems, Pressure parts, Drum, Air pre-heaters, Draft Systems, Piping & Valves, Mills and ESP etc.

While the Standard Specifications of Boilers prepared by LII cover in detail the Performance Parameters of Boilers based on the given Coal Quality, the Standard Specifications have not been prepared to specify a particular type of firing, since this will restrict the competition to one or two bidders who may inflate the prices. It may be noted that OEMs having collaboration with Foster Wheeler or Babcock & Wilcox are manufacturing boilers with front / front & rear design, OEMs having collaboration with Combustion Engineering are manufacturing boilers with tangential firing, while OEMs like Doosan or those having collaboration with Alstom are also manufacturing boilers with down-shot type of firing.

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Among other things, specifications prepared cover membrane wall construction, low NO_x burners and ceramic/basalt lined coal piping & bends for special protection due to erosion.

5.9 Specifications of Turbines and Retrofit options

Most of the 200MW/210 MW Turbines are of LMZ design, having LP stage fitted with Baumann Exhaust, design of which does not match with the Indian condensing conditions. The Standard documents prepared by LII envisage the following four options for retrofitting of these Turbines. Each option provides additional MW output and heat-rate improvements which reduce specific fuel consumption, corresponding reductions in emissions and extension of life.

1st Option-LP Retrofit:

This gives the greatest improvement in cylinder efficiency and in output (around 6 to 12 MW).

2nd Option-HP Retrofit:

This can deliver up to 7 MW of additional output with improvement in cylinder efficiency.

3rd Option-IP Retrofit:

This can deliver additional output around (1 to 3 MW) with some improvement in cylinder efficiency.

4th Option-Complete Turbine Retrofit:

Retrofitting complete new energy efficient turbine can deliver around 10 to 20 MW additional output with significant improvement in efficiency and extension of life by 25 years. This option may also require a new Generator, Generator Transformer and new static Excitation System.

5.10 Matrix of R&M Options and Objectives to be achieved

A matrix of options for the rehabilitation of the specific R&M Projects have been suggested in the Feasibility Report / Detailed Project Report documents. Various R&M options have been suggested with the objective of carrying out necessary repairs, refurbishments and replacement of defective equipments & components so as to extend the life of the power plant by at least 20 years and to restore the performance parameters to equal or better than the original design parameters. Matrix of R&M Options are indicated at Table 5.3.

5.11 Grouping into appropriate Contract Packages

The actual scope of work for any specific R&M Project will depend upon the essential requirements of carrying out repairs, refurbishments and replacement of equipments based on RLA/CA and EA studies. Number of R&M contract packages of any specific Project will therefore depend on the

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actual scope of work for a specific Project. There are a number of ways in which the packaging can be done. Each method has its own advantages and disadvantages which are discussed below and have also been summarized in Chapter 7.0 of this report.

Single Package on Turnkey Basis:

In contracts finalized on the basis of single package, complete scope of work of the project is included in a single package as a turnkey contract. The advantage of this system is that it reduces the work of utilities since they will have to finalize only one contract and have to coordinate only with a single contractor. On the other hand, this system increases the responsibilities of the turnkey contractor multifold, since the turnkey contractor has to shoulder the responsibility for the scope of work of all of his sub-contractors in addition to his own scope of work. The disadvantage of this method is that there are a limited number of agencies like BHEL, NASL and L&T who have the capability to deliver as a single package turnkey contractor. The other disadvantage is that due to limited competition and in order to cover their multiple risk, the prices quoted by the bidders for the single package turnkey contracts are on higher side.

One Package for BTG and one package for BOP:

In this method of packaging, the utilities have to finalize two separate contracts one for BTG (Boiler, Turbine and Generator) and one for BOP (Balance of Plant) and have to coordinate with two contractors. The main advantages of this method is that BTG contractor can focus fully on his own scope of work and the prices quoted for the BTG packages are more competitive. The only disadvantage is that there are limited numbers of players like Punj Lloyd, TECPRO and UB Engineering who have the capability to satisfactorily deliver all the BOP packages. For the R&M of Koradi Unit-6 (210 MW), Mahagenco has adopted similar packaging system with the following number of packages:

- 1) Boiler Turbine Generator (BTG)
- 2) Balance of Plant (BOP)
- 3) Electrical Package.

One BTG Package and Multiple BOP Packages

This method of packaging is most commonly practiced. In this method the role of the utilities increases since they have to finalize more number of contracts and have to coordinate with more number of contractors. This calls for increased capability and dedication on the part of the utilities. The main advantage of this method is that it increases the competition among the bidders and the total cost of the Project gets optimized. For the R&M of Bandel Unit-5 (210MW), WBPDC has adopted this packaging system with the following number of packages:

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- 1) Boiler Turbine Generator (BTG)
- 2) Coal Handling Plant
- 3) Ash Handling Plant
- 4) Electrical Package

Separate packages for Boiler, Turbine and individual BOP Packages

The main idea of this packaging system is to divide the BTG package into Boiler and Turbine Generator, so as to increase the competition among the main plant suppliers. While this method of packaging can further optimize the cost of R&M Project, it requires increased capability on the part of the utilities first to segregate the responsibilities between the Boiler and Turbo Generator contractors and then to define their Guaranteed Parameters. Because of the inherent complications involved, the utilities do not generally opt for this method of packaging.

Packaging method recommended in Standard Documents:

The standard documents prepared by LII have suggested the following six packages:

- Boiler & Auxiliaries.
- Turbo-Generator & Auxiliaries.
- Coal Handling Plant.
- Ash Handling System.
- Mechanical Balance of Plant.
- Electrical Balance of Plant

Keeping a larger view of all upcoming R&M Projects and the complexities involved with various packages, standard contract documents have been prepared considering a maximum six number of Contract Packages namely, Boiler & Auxiliaries, Turbo-Generator & Auxiliaries, Coal Handling Plant, Ash Handling System, Mechanical Balance of Plant and Electrical Balance of Plant.

5.12 General Technical Conditions

Technical Specifications provided in Volume-II of the Contract Documents consist of two sections. Section-I of the Technical Specification covers the following items:

- Intent of Specifications,
- Existing plant details,
- Scope of supply & services,

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- Terminal points & exclusions,
 - Codes & Standards,
 - Performance Guarantees and
 - Spare parts.

General Condition of Contract (GCC) and Special Condition of Contract (SCC) have been included in Volume –I (commercial bidding document) of each contract package.

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6 INDICATIVE TIMELINES FOR R&M PROCESSES

6.1 Processes involved

Process of Renovation and Modernization of Thermal Power Projects starts with the appointment of R&M Consultant who surveys the condition of the systems & equipments, collects and reviews the past operating data, conducts the RLA/CA and EA studies, identifies the equipments to be retrofitted / replaced, formulates various R&M options, selects the R&M option to be implemented, prepares the DPR, facilitates approval from appropriate Regulatory Commission, prepares Bidding Documents and evaluates the bids for the appointment of R&M Contractors.

Implementation of the R&M activities starts at an appropriate time after the plant shut down is taken, when the R&M Contractor(s) are mobilized at site and sequential supply of equipment/materials is assured. The progress of R&M works are monitored under the supervision of Implementation Support Consultant. After the completion of erection activities, the plant is re-commissioned. After re-commissioning of the plant the PG Tests are conducted by the R&M Contractors which are witnessed by Implementation Support Consultant. The process of Renovation and Modernization gets successfully completed after the performance results indicate that the goals and objectives have been achieved.

The stages involved in the Renovation and Modernization are listed below in more details.

- Appointment of R&M Consultant
- Conducting of Cold Walk-down and Hot Walk-down Survey.
- Review of the operational history of the power plant.
- Discussion with the Plant Engineers.
- Carrying out of technical studies namely, the Residual Life Assessment (RLA) and Condition assessment (CA) of the power plant equipment.
- Carrying out Energy Audit of BTG and BOP to identify the reasons and sources of excess power consumption.
- Reviewing the results of studies mentioned at v) & vi) above.
- Identification of the equipments needing retrofitting / replacement.
- Studying the variations in the present quality of coal from the quality considered at the time of original design of the plant.
- Studying the average quality of coal likely to be available during the next twenty years.
- Studying the latest environment standards prescribed by the regulating agencies at the national and state level.
- Formulating alternative options including the cost impact for the refurbishment / replacement of specific plant equipments for enhancing their performance and extending their life.

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- Preparing a matrix of R&M options for the plant as a whole for extending the useful life by minimum 20 years by either restoring the performance parameters to the original level or for achieving better parameters than the original design.
- Carrying out detailed economic evaluation of each of the R&M options proposed in the matrix.
- Discussions with Plant Management.
- Selection of R&M option to be implemented.
- Finalizing the scope of R&M Works.
- Preparation of Detailed Project Report.
- Obtaining approval from appropriate Regulatory Commission.
- Preparation of Bidding Documents for the appointment of R&M Contractors and Implementation Support Consultant.
- Evaluation of Bids mentioned at xx) above.
- Appointment of R&M Contractors and Implementation Support Consultant.
- Shutting down the Plant for carrying out R&M works.
- Re-commissioning of the Plant after completion of R&M works.
- Conducting the Performance Test.

6.2 Indicative Timelines for completion of R&M Processes

LII studied the quantum of work involved for completing various processes of R&M Projects and the reasonable time required to complete the same. LII also studied the indicative timelines provided in the National Perspective Plan prepared by CEA for the year 2016-17, which is also mentioned in figure-7 of the Report of M/s. Mercados on 'Reduction of Barriers'. In addition, LII also referred to the timelines given in the draft report of M/s WAPCOS (refer summary placed at Annexure-3) but found that the same needs some clarifications. The indicative timelines suggested by LII are mentioned in the Table below. Basis of arriving at the timelines is discussed in subsequent paragraphs.

Table: 6.1
Indicative Timelines for completion of R&M Processes

S. No.	Activity	Indicative Time Period
1	Appointment of R&M Consultant	6 months
2	Collection of Data, Conducting of RLA/CA & EA Studies and Finalization of Recommendation for the scope of R&M Works.	9 months
3	Preparation of DPR and obtaining approval of Regulatory Commission.	6 months
4	Preparation of Bidding Documents	4 months

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S. No.	Activity	Indicative Time Period
5	Appointment of R&M Contractor(s)	9 months
6	Lead Time for R&M Contractor to start the work at site	6 – 12 months
7	Shut-down time /Completion of R&M works.	6–8 months
8	PG Test	3 months
	Total	49 to 57 months

6.3 Basis of Arriving at the Timelines

Appointment of R&M Consultant

LII is of the view that R&M Consultants should be appointed on the basis of Pre-qualification. This method of selection is more suitable owing to the specialized nature of work of R&M consultants which involves considerable knowledge and experience. LII is of the view that a period of about six (6) months may be required to complete the process of selection of R&M Consultant as discussed in the Table below.

Table: 6.2
Process of Appointing R&M Consultant

S.No.	Activity	Tentative Timeline
1	Request for Qualification	
(a)	Publication of RFQ and start of issue of RFQ document	Zero Date
(b)	Last date for issue of RFQ document	15 th Day from zero date
(c)	Last date for submission of response to RFQ	45 th Day from zero date
(d)	Short listing based on response to RFQ	65 th Day from zero date
2	Request for Proposal	
(a)	Issue of RFP	80 th Day from zero date
(b)	Pre - Bid Discussion	95 th Day from zero date
(c)	Last date for submission of Both Part –I and Part – II Bid and Opening of Part-I (Techno-commercial) Bid	110 th Day from zero date
(d)	Techno – Commercial Discussion	140 th Day from zero date
(e)	Completion of Evaluation of Techno-Commercial Bids	155 th Day from zero date
(f)	Date of Opening of Price Bids	160 th Day from zero date
(g)	Selection of Successful Bidder and Placement of Lol	180 th Day from zero date

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With reference to National Perspective Plan of CEA (Up to 2016-17), LII noted that an indicative time frame of three (3) months has been recommended. LII is of the view that a period of three (3) months is possible if selection is made on the basis of post qualification.

Collection of Data, Conducting of RLA/CA & EA Studies and Finalization of Recommendation for the scope of R&M Works

RLA/ CA Studies are conducted when the unit is shut down for overhaul, whereas Energy Audit studies are carried out while the unit is in operation. Based on the detailed interactions with MAHAGENCO who shared their experience regarding Nashik Unit-3 (210 MW) and Koradi Unit-6 (210 MW), LII noted that although a period of about 1.5 to 2.0 months only was taken to complete the RLA/ CA Studies and Energy Audit Studies, finalization of recommendation for the scope of R&M works took about one year, since it involved consultation with engineers of different departments at the site as well as at the HQ. From the data provided by CEA on procurement experience, it is noted that completion of RLA studies at Bandel Unit-5 (210 MW) of WBPDC, also took more than a year to get finalized (23.09.2005 to December 2006). However, LII is of the view that it should be possible to complete the above activity in a period of 9 (nine) months.

Preparation of DPR and obtaining approval of Regulatory Commission.

LII is of the view that a total period of about six (6) months is required for completing this activity, i.e. a period of four (4) months is required for the preparation of DPR and a period of two (2) months is required for facilitating the approval from the concerned regulatory agency.

Preparation of Bidding Documents

Preparation of Bidding Documents constitutes the preparation of RFQ and RFP. Preparation of RFP also includes the work of completing the Tender Specifications based on the scope of R&M works. LII has considered a time line of four (4) months for this activity.

Appointment of R&M Contractor(s)

LII has considered a period of about nine (9) months for this activity as against a period of 6 to 8 months considered in the National Perspective Plan prepared by CEA for the year 2016-17. LII's basis for the period of about nine (9) months is based on the considerations given in the following table.

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Table: 6.3
Process of Appointing R&M Contractor

	Activity	Tentative Timeline
1	Request for Qualification	
(a)	Publication of RFQ and start of issue of RFQ document	Zero Date
(b)	Last date for issue of RFQ document	15 th Day from zero date
(c)	Last date for submission of response to RFQ	45 th Day from zero date
(d)	Short listing based on response to RFQ	75 th Day from zero date
2	Request for Proposal	
(a)	Issue of RFP	90 th Day from zero date
(b)	Pre - Bid Discussion	120 th Day from zero date
(c)	Last date for submission of Both Part –I and Part – II Bid and Opening of Part-I (Techno-commercial) Bid	150 th Day from zero date
(d)	Techno – Commercial Discussion	180 th Day from zero date
(e)	Completion of Evaluation of Techno-Commercial Bids	210 th Day from zero date
(f)	Date of Opening of Price Bids	225 th Day from zero date
(g)	Selection of Successful Bidder and Placement of Lol	255 th Day from zero date

Lead Time for R&M Contractor to start the work at site

Before starting the work at the site, a contractor has to sequentially complete a substantial amount of engineering and manufacturing of equipments / materials including their transportation to the site. LII has considered a period of about 6 to 12 months for this activity, depending upon the scope of work.

Shut-down time / Completion of R&M works

The utility has to shut down the unit and hand over the same to the contractor for starting the R&M Works. The timing of shutting down the unit has to be judiciously planned by the utility after ascertaining the status of complete mobilization of the contractor with his men, materials and the erection machinery at site. The utility has to ensure that once the shutdown is taken, the R&M works continue without any interruption. The period of shut down will vary from Project to Project depending upon the scope of work. LII noted that based on the past experience, an average period of 9 (nine) months has been considered for the shut down in the Report by Mercados on Developing Markets (Table Annexure-4, Page 119). From the data provided by CEA on procurement experience, it is noted that for the R&M contract documents of Bandel Unit-5 (210MW), a shut down time of 6 (six) months has been provided and for Koradi Unit-6 (210MW), a shut down time of 8 (eight) months has been provided. LII is therefore of the

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opinion that if the programme is properly planned, the shut down period can be limited to a period of 6 (six) to 8 (eight) months. LII has therefore considered a period of about 6 (six) to 8 (eight) months for this activity, which matches with the timeline considered by CEA. For avoidance of doubt, it is to clarify that the period of 8 (eight) months should be applicable when major in-situ modifications of the boiler are proposed and the above period of 8 (eight) months would be insufficient, if total replacement of existing boiler is proposed with a new one, a rare option not considered by LII, but was one of the options considered by MAHAGENCO for Koradi Unit- 6 (210 MW), though not finally decided for implementation. (Refer Box-6, Page 79 of Mercados Report on Reduction of Barriers)

PG (Performance Guarantee) Test

PG Test should be conducted as earlier as possible after the unit gets stabilized after re-commissioning. LII has considered a period of three (3) months for the completion of PG test of the main plant (BTG) as also any of the BOPs covered in the scope of R&M Contractor. A period of three (3) months has been considered, since after this period some OEMs normally insist on the application of correction factors (due to deterioration) on the test results. LII noted that the timelines provided in the National Perspective Plan do not include the PG test.

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7 STANDARDISATION OF TENDERING PROCEDURES

7.1 Tendering Procedures and Documents for Contractors & Consultants

To facilitate Renovation & Modernization of Thermal Power Plants in a planned, systematic and time bound manner, the tendering procedure and tender documents for engagement of Consultants and R&M Works Contractors have been standardized to a large extent. These are discussed in detail in subsequent paragraphs of this chapter. Tendering Procedure for R&M Works Contractor is discussed first since it is more complex in nature.

7.2 Tendering Procedure for R&M Works Contractor(s)

The Bidding procedure for appointment of R&M works Contractor has been standardized. For hiring of R&M Contractor(s), a two step process comprising Request for Qualification and Request for Proposal is recommended. For the Request for Proposal for selecting R&M Contractor, a Single stage Two Envelope method has been specified.

LII referred KfW guidelines for the Procurement of Supply and Work Contracts under financial cooperation with developing countries particularly with respect to Fair and Transparent Bidding Process, reasons for exclusion and qualification procedure.

LII also reviewed World Bank Guidelines (January 2011) for Procurement of Goods, Works and Non-Consulting Services under IBRD loans and IDA Credits. LII kept in view the World Bank guidelines regarding transparency and fairness of tendering process such as guidelines pertaining to Conflict of Interest and Fraud & Corruption while preparing the Standard Bidding Documents. LII also referred World Bank guidelines for the basic principles governing International Competitive Bidding.

LII also reviewed the tender documents of leading Indian Public Sector Utilities National Thermal Power Corporation Ltd and Neyveli Lignite Corporation for different packages of power plants.

LII's analysis of different options for tendering for the engagement of R&M Works Contractor(s) is summarized below:

Pre-Qualification vs. Post Qualification

Pre-qualification is carried out to assess whether or not the interested bidders are capable of properly delivering as per the contractual scope of work. The capability of the bidders is assessed on the basis of qualification documents submitted as part of the pre-qualification exercise. Only such bidders who are found qualified in the pre-qualification stage are issued the tender documents and are allowed to submit the bid for the R&M work. In tendering process with post-qualification, the qualification documents and the actual bids are submitted simultaneously.

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Advantages of Pre-Qualification

In pre-qualification route, bidders have a fair idea whether or not they are qualified to be considered as prospective contractor for the work being tendered, before spending considerable time and expenses for preparing a detailed bid. Further, prequalification gives the Owner some idea about the qualified bidders who are likely to submit the bid. In case it turns out that inadequate numbers of prospective bidders are qualified to bid; the owner may explore ways to increase participation of qualified bidders.

Advantages of Post-Qualification

Post-qualification route obviates the need for a separate pre-qualification exercise before submission of proposal. Further, as the qualification documents are submitted along with proposal, latest qualification data/status as on the date of submission of proposal can be used for qualification.

Recommended Qualification Procedure for R&M Works Contractor

LII is of the view that Pre – qualification route is more suitable for large or complex work that involves considerable time and effort for preparation of detailed bid / proposal. The Energy Efficient R&M work is technologically complex and challenging in terms of execution. It is important to ascertain the availability and willingness of capable and qualified bidders through a pre – qualification process before inviting tenders. Further, evaluating tenders from a large number of bidders, both qualified and unqualified, will make the tendering process time consuming. Therefore, only parties qualified in a pre – qualification process should be issued Tender Documents and should be allowed to participate in the Tendering process. For all the packages, bids should be invited after conducting a pre – qualification process to shortlist qualified bidders

The objective of the pre – qualification is to allow only the capable and qualified bidders having requisite technical expertise, relevant experience, project execution capability and financial resources to participate in the tendering process. The pre – qualification document should specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The prequalification route is not intended to limit the competition to a predetermined number of potential bidders. While following this route, all the interested parties meeting the specified criteria will be issued tender documents and allowed to submit bid.

Qualification Requirement

Due care should be taken to frame appropriate Qualification Requirement (QR) to ensure adequate participation of competent bidders. While framing the QR, detailed information should be collected from prospective bidders regarding their experience and capability.

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The Qualification Requirement should include Technical Qualification Requirement, Financial Qualification Requirement and should cover Reasons for Exclusion if any. The Technical Qualification Requirement should call for technological & execution capabilities and experience in the execution of comparable projects. Financial Qualification Requirement should call for evidence of financial soundness; past experience in executing projects of similar magnitude and ability to mobilize financial resources for executing the project. The reasons of exclusion are aimed at excluding parties that may have unfair advantage over other parties or may have past record of wrongdoing. Any bidder who is or was involved as a consultant in the preparation or implementation of the project or whose associate or affiliate is or was involved as a consultant in the preparation or implementation of the project is to be excluded. Any bidder who is legally barred from the procurement process in India on the grounds of previous violations of regulations on fraud and corruption is to be excluded.

Too weak a qualification requirement may lead to the entry of incompetent bidders with lower price quotes. Awarding the R&M Contract to an incapable bidder may severely jeopardize the R&M programme. Similarly, too stringent a qualification requirement may restrict the number of eligible bidders to only a few, thereby restricting competition which may lead to higher price quotes.

The specified Technical and Financial Qualification Requirement should balance the twin objectives of restricting participation in the tendering process to capable and experience bidders with ability to successfully undertake the Renovation & Modernization work and ensuring participation by adequate number of interested parties to encourage competitive bids.

Bidders should be entitled to meet the Qualification Requirements jointly with their associates or consortium partners. In such cases, bidders and their associates and/or consortium partners should be asked to furnish a joint undertaking in the prescribed format to discharge their obligations. A bidder can be a Joint Venture Company as well. In all cases of qualification through Consortium/Associate/JV, all the parties will be jointly and severally liable to the Owner to discharge all contractual obligations.

Qualification Document

The intending Bidders should be asked to furnish documentary evidence and performance certificates in support of their qualification credentials along with their response to Request for Qualification. The documentary evidence should include inter alia list of orders executed along with copies of orders, Performance Certificates indicating date of completion as well as documents of company profile incorporating information about technical man power, financial strength, resources, organization, experience to undertake such jobs and certificates of audited accounts for last three years along with copies of latest income tax return etc.

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7.2.1 Single Stage Single Envelope Bidding

In this method of bidding, the bidder is asked to submit the techno-commercial bid along with price bid, which are opened simultaneously. The quoted prices of the bidders are thus known before the evaluation of techno-commercial proposals of the bidders to assess their techno-commercial responsiveness and before any discussion with the bidders regarding deviation in bids with respect to the tender conditions. The advantage with this method is that in case of large number of bids, detailed evaluation of bids can be restricted to the lowest bid and the bids with price quote close to the lowest bid. However, it has two disadvantages. Firstly, in case the bid with lowest price quote turns out to be techno-commercially non-responsive, it becomes a tough call to reject the lowest price bid and accept a bid with higher price quote. Secondly, this method has no provision of inviting supplementary price quotes, in case; the purchaser wants to introduce some changes in the specifications on the basis of post-bid discussions.

7.2.2 Single Stage Two Envelope Bidding

In this method, the bids are submitted in two parts. Both the parts are submitted together. The Part – I bid comprises the techno-commercial bid without prices. The main components of the techno-commercial bid are Bid Guarantee, Scope of Work & Terminal Points, Technical descriptions/details, Technical data sheets, List of Tools & Tackles, Deviations to technical and commercial specifications/conditions, Overall completion period & L-1 Network Schedule, Resource deployment schedule, Detail of Sub-Contractors/Sub-Suppliers/Sub-Vendors, Spares list, Quality Assurance Programme, Details of the present commitments & details of contracts in hand, Indices and Coefficients for Price Variation etc. Part -II Bid will comprise quoted price and Performance Guarantee Parameters. Initially, only the Part-I bid is opened and Part-II bid is kept in safe custody.

After evaluation of the techno-commercial (Part-I) bids, each bidder who has submitted a broadly responsive Part-I bid, is invited for techno-commercial discussion, during which, all the required amendments, additions, deletions and other adjustments are noted and recorded in a Memorandum. Part-II bid (Price Bid) of only those bidders is opened, whose Part-I bid is found to be responsive to tender specifications and conditions.

The Part – II bid comprises quote for Prices and the Performance Guarantee parameters in the form of filled up Schedules of Prices and Performance Guarantees.

However, after the evaluation of Part – I bids (techno – commercial bids) and before opening of Part-II bids (Price Bids), in case a particular bidder is

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asked to make changes in his techno commercial offer that may have price implications, then that bidder is allowed to submit supplementary price against such changes before the opening of Part-II bids (Price Bids).

This tendering method has the advantage that the evaluation of techno-commercial bid and techno-commercial discussion is carried out without any influence of price quotes. The price-bid of techno-commercially non-responsive bid is not opened at all. Further, in case any bidder is asked to change his proposal during techno-commercial discussions for conformance to tender conditions, the bidder is given an opportunity to submit supplementary price corresponding to that change. However, in this tendering method, techno-commercial bids of all the participating bidders need to be evaluated in detail. This may consume a lot of time and effort when quite a large number of bids are received.

7.2.3 Two Stage Bidding

In this tendering method, in the first stage, the bidders are asked to submit only the techno-commercial bid without any price quote and guaranteed performance parameters. The techno-commercial bids are evaluated to assess the techno-commercial responsiveness of the bid. Techno-commercial discussion is carried out to freeze the techno-commercial conditions of the contract. In the second stage, only the bidders, whose techno-commercial bids are found to be responsive, are asked to submit price bids comprising quoted price and quoted performance guarantee parameters. The biggest advantage of this tendering method is that the bidders know the final techno-commercial contours of the tender before submitting any price bid. Therefore, they get the opportunity to base their price quotes on the final agreed techno-commercial conditions of the contract. However, the flip side is, that the bidders know who are the bidders, whose techno-commercial bids have been evaluated to be responsive, before making the price quotes. This may lead to uncompetitive price quotes in case where the number of responsive bidders is low (i.e. one/two). Further, in case only one bid is found to be responsive, the bidder is likely to quote largely inflated price to take advantage of the situation. Further, contracts/procurement norms of Government undertakings may not allow inviting price quotes from only one bidder.

7.2.4 Recommended Tendering Procedure

Each R&M project is unique and associated with many complexities regarding assessment of the quantum and nature of retrofit and replacement to be carried out. It is therefore important to firm up the technical contours of the contract before opening price quotations so that all the bidders and the owner have agreement and clarity about the nature and scope of the work on which the price bids are to be based. Considering the complexities of R&M Projects, it is recommended to invite the bids in

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two parts in single stage. The rationale behind inviting Part-II bid along with Part-I bid is that bidders will make their quotes before the number of responsive techno commercial bids is known. This will encourage competitive price quotes. However in case a bidder is asked to make changes in its techno commercial offer that may have price implications, that bidder may be allowed to submit supplementary price against such changes before opening of Part-II bids (Price Bids).

All Standard bidding procedures and documents have therefore been prepared on the basis of prequalification and in Single Stage two part bidding concept as represented by the flow diagram given below. Accordingly the tendering documents consist of RFQ (Request for Qualification) and RFP (Request for Proposal).

Figure-1: Tendering Procedure

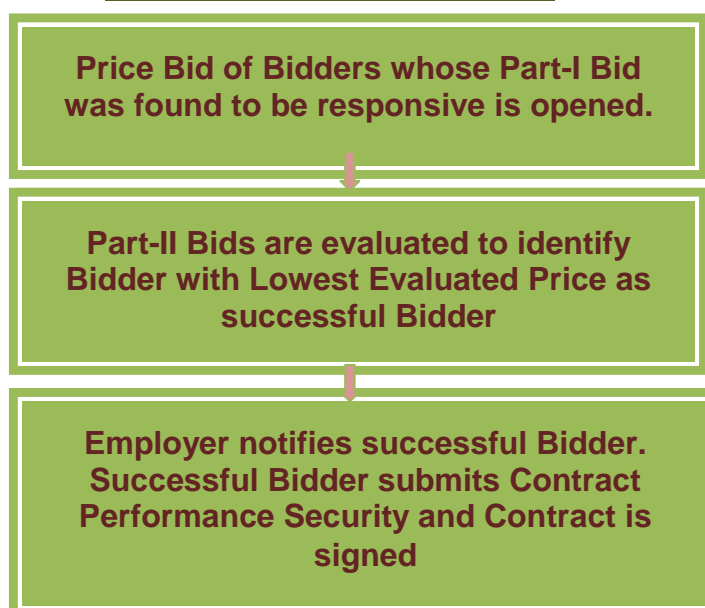


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EVALUATION OF PART-I BID



EVALUATION OF PART-II BID



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7.3 Packaging Concept

When a utility is planning to carry out renovation and modernization of the entire plant covering a number of major equipment and systems, it has the option of doing it as a single package by a single contractor or split it into a number of packages each covering a major part of the plant /system and awarding these packages to separate contractors.

Implementing the Renovation and Modernization of the entire plant as a single package by a single contractor makes the tendering and execution process simple for the owner as it obviates the need to split the work into different packages, to ensure interface between different packages during design and execution and to properly align the completion schedule of different packages. Further, single package allows owner to fix single point responsibility and avoids contractual disputes arising out of acts of omission of one contractor affecting other contractors. However, Renovation and Modernization of different systems of the plant need different expertise and experience. Hence multiple packaging contract is advised and is followed in various Public Sector Utilities as it involves competition and allows participation of varied players with their respective field expertise.

The advantages and disadvantages of single package R&M and multi – package R&M are listed in table 8.2

Table: 7.1
Single Package R&M Vs Multiple Package R&M

Single Package	Multiple Package
<u>Advantages</u> <ul style="list-style-type: none"> ⇒ An all inclusive scope of work can minimize the need for changes in scope of work during execution and minimize disputes pertaining to scope of work. ⇒ Single point responsibility of one R&M Contractor. ⇒ For delay in any part, liquidated damages will be paid by the Contractor based on total contract value. ⇒ In case of deficiency in performance, liquidated damages will be paid by Contractor based on total contract value. ⇒ Less time and effort required in selection of contractor. <u>Disadvantages</u> <ul style="list-style-type: none"> ⇒ Higher contract price. ⇒ Selection of suppliers/vendors for different sub packages at the discretion of the main 	<u>Advantages</u> <ul style="list-style-type: none"> ⇒ Lower contract price and better control on progress based payment. ⇒ Better suppliers/vendors for each package specialized in their respective area. ⇒ Owner can better monitor and control the work at more granular level. <u>Disadvantages</u> <ul style="list-style-type: none"> ⇒ No single point contractor responsibility. Owner responsible for overall R&M work. ⇒ Scope of work, terminal points and interface requirements for different Contractors need to be defined properly to ensure there is no mismatch and no system/equipment is missed. ⇒ Liquidated damage for delay is paid by individual contractor linked to his

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<p>contractor.</p> <p>⇒ Less transparency in project execution information flow.</p> <p>⇒ Number of competent Contractors available to execute such big R&M Contract is limited which leads to limited competition.</p>	<p>contract value though delay in single package may delay the whole project.</p> <p>⇒ More time and effort required for selection of contractors.</p>
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7.4 Recommended List of Packages

There will be very few contractors, if any, who have in – house expertise and experience to carry out the R&M works of all areas of a coal fired power plant. A single EPC bid for R&M work will thus restrict number of qualified bidders, which will also increase the cost of R&M. In order to balance the conflicting needs of minimizing project/contract management complexities and having adequate number of eligible and willing bidders having relevant expertise and experience to carry out the R&M work under a package, it is recommended to split the R&M work into the following packages:

1. Boiler & Auxiliaries (including but not limited to Pulverizes, Feeders, PA Fans, FD Fans, ID Fans), ESP, Auxiliary Steam system and MS, HRH, CRH, HPBP & LPBP piping and associated Electrical, C&I and Civil Works.
2. Turbo-Generator & Auxiliaries (including but not limited to Heaters, Deaerator, Condenser, BFPs, CEPs), TG Cycle piping including Boiler Feed piping and associated Electrical, C&I and Civil Works. This package will also including R&M of C&I system common to both SG and TG.
3. Coal Handling Plant and associated Electrical, C&I and Civil Works.
4. Ash Handling System and associated Electrical, C&I and civil works.
5. Mechanical Balance of Plant (BOP) System which includes Plant Water System (Raw water intake system, Pre-treatment Plant, D.M.Plant, CW System including Cooling Towers, ACW & CCW System), Compressed Air System, Fuel Oil System, Fire Fighting System and Miscellaneous balance mechanical systems.
6. Electrical BoP including inter alia Switchyard, Power Transformers and Switchgears

Separate RFQ and RFP has been prepared for the individual packages mentioned above. The details of RFQ and RFP are illustrated below.

7.5 Contracting Concepts for R&M Contractor

7.5.1 International vs Domestic Competitive Bidding

International Competitive Bidding (ICB) process will be followed for high value contracts and contracts that are complex in terms of engineering and

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execution skills to achieve the best possible supply and services at competitive prices. R&M of BTG, BTG auxiliaries, Power Transformers and Switchyard are likely to be technologically complex & involve higher value contracts and hence likely to evoke response from many reputed international bidders. Hence packages covering these systems may be tendered on International Competitive Bidding (ICB) basis. However, R&M of other BoP packages are not likely to see participation by many reputed international bidders and hence may be tendered on Domestic Competitive Bidding (DCB) basis.

Table-7.2
Nature of Bidding Recommended

S. No	Package	Nature of Bidding
1	Boiler & Auxiliaries (including but not limited to Pulverizes, Feeders, PA Fans, FD Fans, ID Fans), ESP, Auxiliary Steam system and MS, HRH, CRH, HPBP & LPBP piping and associated Electrical, C&I and Civil Works.	ICB
2	Turbo-Generator & Auxiliaries (including but not limited to Heaters, Deaerator, Condenser, BFPs, CEPs), TG Cycle piping including Boiler Feed piping and associated Electrical, C&I, and Civil Works. This package will also including R&M of C&I system common to both SG and TG.	ICB
3	Coal Handling Plant and associated Electrical, C&I, and civil works.	DCB
4	Ash Handling system and associated Electrical, C&I and civil works.	DCB
5	Mechanical Balance of Plant (BOP) systems which includes Plant Water System (Raw water intake system, Pre-treatment Plant, D.M.Plant, CW System including Cooling Towers, ACW & CCW System), Compressed Air System, Fuel Oil System, Fire Fighting System and Miscellaneous balance mechanical Systems	DCB
6	Electrical BoP including inter alia switchyard, power transformers and Switchgears	ICB

7.5.2 Lump Sum Price vs. Unit Rate

In a lump sum price contract, the entire scope of supply and services is grouped into a single overall contract price for the contractors to quote their price against. During execution of work, phasing of payment is done against progress of supply and services, but the sum total of all the

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payments is the contracted price and it remains unchanged irrespective of the quantity of supply and service required to complete the contracted scope of work. The payments are linked to contractual milestones.

The bidder quoting the lowest lump sum price for the overall contract scope of work is treated as the lowest price bidder.

For unit rate contract, the bidders quote the unit rates for each supply and service against an estimated bill of quantity. The bidder with lowest total price for the estimated BOQ is treated as the lowest price bidder. During execution, payment is made based on actual quantity of each item/type of supply and service.

Given the nature of renovation and modernization work, it is difficult to exhaustively indentify all the types/items of supply and service required and estimate quantities for them. Therefore, unit rate contract is difficult to design for renovation and modernization work. It is more practical to contract R&M work on lump sum price basis for the entire scope of plant, equipment, machinery, material, parts and including design, engineering, procurement, supply, assembly, construction, erection, testing & commissioning. Review of tender documents for R&M work of leading public utilities also suggests wide use of Lump Sum Price contracts for Renovation & Modernization work of power plants.

Each package therefore should be awarded on lump sum EPC contract basis based on the Scope and Terminal Points identified in the Bid Documents of the corresponding package.

7.5.3 Scope Change

The scope of Renovation & Modernization is defined in the bid documents of different packages on the basis of Residual Life Assessment / Condition Assessment and Energy Audit. During execution, in case there arises a need for any change in scope of work, change order should be issued by the owner after studying the need of change in scope pursuant to the proposal received from the R&M Contractor. Appropriate change order clause will be built into the contract to deal with the need to change the scope of the contract due to surprises encountered during the execution of the R&M work.

7.5.4 Price Basis & Price Variation

The Contract Price should include price of executing whole scope of work specified in the Contract. The price of the contract should be on lump sum price basis for the entire scope covered in the contract. The contract price should be subject to adjustment during the contract period to reflect change in labour and material price levels as per price variation formula specified in the tender document, which is subject to limits specified in the tender

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specification. This price basis is being practiced for procurement of power plant equipment by large utilities in India.

For adjustment in contract price, standard bidding document should specify base date for contract price and price variation formula. The price variation formula breaks down the total price into components that are not adjustable and components that are adjustable by indices specified for the various components. The bidders are asked to indicate the coefficients (in the techno-commercial bid) to distribute the adjustable price into different components.

7.6 RFQ and RFP for the R&M Consultant and ISC

RFQ and RFP for R&M Consultant and Implementation Support Consultant have been standardized.

The scope of work for the R&M Consultant has been bifurcated in two phases. Phase-I covers investigative studies, preparation of FR, DPR and obtaining the approval of regulatory agencies. Phase-II will start only if required after the approval of regulatory agencies. Phase-II covers preparation of bidding documents and bid evaluation till the selection of R&M Contractor(s).

7.7 Request for Qualification for R&M Contractor

For selecting R&M Contractor, the Technical and Financial Qualification Requirements have been standardized. However, the values of financial parameters have not been standardized as it will depend on the estimated cost of the Contract. Request for qualifications (RFQs) for the selection of Contractors for various packages like Boiler, Turbine & Generator, eBOP, Ash Handling plant, Coal Handling Plant and Balance of Plant have been prepared separately as it depends on the field specific qualification requirements. Standard formats and data sheets for all the split packages have been specified to be submitted as Qualification document.

The objective of the pre – qualification is to allow only the capable and qualified Consultancy Firms and Contractors having requisite technical expertise, relevant experience supported by adequate number of competent manpower and having adequate financial resources to fulfill their obligations.

Following aspects have been covered in RFQ document for each the split packages i.e RFQs for Boiler, Turbo – Generator, Electrical – Balance of plant, Ash Handling System, Coal Handling System and Balance of Plant:

1. A brief introduction of the Power plant of the Utility inviting Tender for Renovation & Modernization.
2. An Invitation to the bidders inviting sealed pre – qualification tenders from Experienced and interested bidders for the package wise

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Renovation & Modernization Works for the specified Plant/ Unit Capacity through International / Domestic Competitive bidding process.

3. The scope of work under the R&M packages covering disassembly and replacement of specified existing equipments / systems by supplying new equipments/ systems including supply of assembly materials, inspection & testing at suppliers works, supply of mandatory spares, packing & forwarding, transportation & insurance, receipt at site, unloading, handling & storage at site, pre – assembly, fabrication, repair, servicing/ overhauling, erection, carrying out of all associated civil works including supply of cement & steel etc., testing & commissioning and successful completion of trial operation & performance guarantee tests for the individual packages.
4. RFQ Details : This provides the following information:
 - Participation Fee
 - Publication date of RFQ
 - Last date for issue of RFQ document
 - Last Date & Time of Receipt of Pre-Qualification Tenders.
 - Date for identification of Qualified Bidders and Issuance of RFP
5. The Technical and Financial Qualification Requirement is also standardized for all the six split packages.

Technical Qualification Requirement

Technical Qualification Requirement for R&M Contractor primarily covers the following two aspects:

- a. Experience in design, engineering, manufacturing, supply, erection and commissioning of relevant package for a power plant unit of 200/210 MW or above capacity which should have completed satisfactory operation for a period of not less than two (2) years as on the date of opening of Pre – Qualification Bid.
- b. Experience in execution of Renovation & Modernization of one (1) unit of the specific package for a power plant unit of 100 MW or above capacity.

The RFQ stipulates that the bidder can be a Joint Venture of two firms who collectively meet the Technical Qualification Requirement specified. Each of the JV partner must have at least 26% equity in the JV and in case of award of contract, must maintain JV arrangement till the successful completion of the R&M work. The bidder can be a Consortium of two firms who collectively meet the Technical Qualification Requirement specified. The Consortium members shall designate one member as the Leader of the Consortium with whom the Contract will be entered into in case the Consortium emerges as the successful bidder.

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Financial Requirement

The Financial Qualification for R&M Contractor primarily covers the following:

- (a) The average annual turnover of the Bidder should be more than a specified value as per audited annual accounts during the preceding three consecutive years. The annual turnover requirement is specified based on the likely contract value. Other income is not considered for arriving at the annual turnover.
- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year should be positive.
- (c) The sum of bank balances (including fixed deposits) and available unutilized credit line of the bidder (including non fund based credit lines) should not be less than a specified value on not more than 30 days prior to the scheduled last date of submission of Pre-qualification Bid
- (d) In case the Bidder/Consortium Leader does not satisfy the Financial Criteria stipulated on its own and the Holding Company having controlling interest in the Bidder / Consortium Partner Company, as the case may be, meets the stipulated turn-over requirements, then Financial Criteria stipulated is deemed to have been met, provided that the Net worth of such Holding Company / Partner Company, as the case may be, as on the last day of the preceding financial year is at least equal to or more than a certain minimum value. In such a case, the Bidder / Consortium Leader has to submit a Letter of Undertaking from the Holding Company/ Partner company pledging unconditional and irrevocable financial support to the bidder for execution of the Contract.

To establish the financial capacity for performance of the contractual obligations, the Bidder is required to furnish documentary proof of their audited annual turnover and net worth for the last three (3) financial years

Exclusion Criteria

In line with KfW guidelines, the following exclusion criteria is specified

- (a) Any firm who is involved as a Consultant in the preparation for the concerned R&M Project for activities such as Feasibility Study or RLA/CA Study or Energy Audit or preparation of DPR/Tender Document or any other preparatory activity or any firm who is as a consultant for implementation of the concerned R&M project or whose associate or affiliate is involved as a consultant in the preparation or implementation of the concerned R&M project cannot participate as a bidder for the R&M Works Tender.
- (b) Any bidder who is legally barred from the procurement process of the owner on the grounds of previous violations of rules/regulations on fraud

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and corruption or any other reason cannot participate as a bidder for this R&M Tender.

- (c) Any firm or its associate company or parent company cannot participate as Bidder or JV Partner or Consortium Member in more than one Bid under the tender.

Prequalification Document

The pre-qualification documents requirement has been standardized. These include the following:

- (a) List of orders executed by the bidders along with copies of orders to demonstrate their qualifications.
- (b) Past Performance Certificates clearly indicating date of completion from the facility owner in respect of such completed contract(s).
- (c) Name of any proposed JV partner or Consortium member along with details of equity participation of JV partner or letter of consent of consortium partner.
- (d) Documents of company profile incorporating technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of bidder's capacity to the satisfaction of Employer. Firm's audited accounts for last three years along with copy of latest income tax return filed.
- (e) Contracts in hand / pending jobs and their status along with value.
- (f) Major pending legal cases.

Instruction to Bidders for Pre-qualification

The standard RFQ also elaborates the Instruction to Bidders. The bidders who qualify the pre – qualification requirement are only eligible to submit the Bid Proposal for R&M works. In case, certificate(s) /document(s) submitted by the Bidder or JV Partner or Consortium leader or Consortium partner are found to be factually incorrect or manipulated, the Bidder or JV Partner or Consortium leader or Consortium partner as the case may be, will be disqualified for the tender and will be liable to be blacklisted / debarred by the Employer for future tenders. The Contract shall be signed with the successful bidder or the Consortium Leader, and hence all the responsibilities and Liabilities for all the technical and managerial services shall be borne by the Bidder/Consortium Leader. The bidder meeting the Qualifying Requirement on the strength of the JV partners is required to enclose details of equity holding of the JV partners. However, in the event, the bidder is found pre – qualified and issued RFP document, while submitting the techno – commercial Bid Proposal for R&M work, the bidder shall furnish a copy of the Joint Venture Agreement. Further, while submitting the techno-commercial Bid Proposal for R&M work, the JV partners shall furnish a joint undertaking towards joint and several liability to

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the employer for the successful performance of the Contract. The undertaking shall be furnished as per the format to be specified in the RFP document.

The bidder meeting the Qualifying Requirement as a Consortium is required to enclose the Letter of Consent (as per the prescribed format) from the consortium Partner along with the Pre-Qualification Bid signed by the Consortium Partners indicating the scope of work. However, in the event, the bidder is found pre-qualified and issued RFP document, while submitting the techno-commercial Bid Proposal for R&M work, the bidder (consortium leader) shall furnish a Consortium Agreement with the other Consortium member. No new consortium partner, (other than those qualified at Pre-qualification stage) will be permitted at the time of submitting the Techno commercial Bid. Further, while submitting the techno-commercial Bid Proposal for R&M work, the Consortium leader and Consortium member will furnish a joint undertaking regarding diligent performance of their respective scope of work and towards joint and several liability to the employer for the successful performance of the Contract. The undertaking shall be furnished as per the format to be specified in the RFP document.

The Bidder shall provide satisfactory evidence that he and / or, where applicable, the consortium leader and consortium partners have adequate capability and capacity to perform the work properly and expeditiously within the time period specified. The evidence shall specifically cover, with written details, the installed manufacturing and / or fabrication capacities to meet the requirements appropriate to the works covered in his bid have an adequate field service organization to provide the necessary field erection and management services required to successfully erect, test and commission the equipment / system as required by the bidding documents. Pre-Qualification Bid submitted without the proper documentary evidence to substantiate fulfillment of the qualifying requirements as specified are liable for rejection without assigning any reason.

There is a participation amount as decided by the Employer which is to be given by all the interested Participants to participate in this bidding procedure.

The Pre – Qualification Bids received from the bidders would be opened on a pre decided date, time and venue mentioned in the RFQ document. Any clarification related to the RFQ document or RFQ process should be furnished before 15 days of opening of the bids.

Following standard Forms and the data sheets have been developed along with the RFQ document:

(a) Format for the Pre – qualification Bid

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- (b) Format for Letter of Undertaking by Holding Company pledging unconditional & irrevocable support to the bidder for the execution of R&M work
- (c) Format for Letter of Consent to be furnished by the Consortium Partners
- (d) Sample format for Data sheet regarding Technical Qualification Requirement
- (e) Sample format for Data sheet regarding Financial Qualification Requirement

7.8 Request for Proposal

The formats of Request for Proposal (RFP) for selection of Contractors have been standardized. The standard terms & conditions are based on practices followed by international funding agencies and leading Indian Utilities.

Selection of Contractor is based on price quoted by qualified bidders whose techno – commercial proposal is responsive to tender specification. Only bidders qualified in pre – qualification stage will be allowed to submit proposal. A single stage two envelope bidding procedure should be followed for selection of R&M Contractor.

The master index for a standardized RFP document is as below:

Table: 7.3
Master index for a Standardized RFP Document

Volume	Section	Part	Description
Volume – I	---	---	Commercial comprising the following parts. 1. Invitation For Bid 2. Instruction to Bidder 3. General Project Information 4. General Condition of Contract (GCC) 5. Special Condition of Contract (SCC) 6. Forms and Schedules
Volume – II	Section – I	---	Project Technical Specification
	Section – II	Part – A	Detailed Technical Specifications – Mechanical
		Part – B	Detailed Technical Specifications – Electrical
		Part – C	Detailed Technical Specifications – I&C
		Part – D	Detailed Technical Specifications – Civil
Volume – III	---	Part – A	Technical Schedules – Mechanical
	---	Part – B	Technical Schedules – Electrical
	---	Part – C	Technical Schedules – I&C

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General Conditions of Contract (GCC)

The GCC contains the Contracting Concept, the scope of the Contractor, the precedence of the Contract Documents, definitions and Acronyms used in the Contract Document, the severability of the Contract, the governing laws to the Contract, methods for settlement of disputes, Time of commencement and completion of the contract, Contractor's Responsibilities, Owner's Responsibilities, Taxes and Duties applicable, Confidential Clause, methodology for designing/ engineering/ procurement/ installation/ Testing & Inspection/ Completion of the Facilities and Commissioning of the Services. It also covers the Defect Liabilities, Completion Time and Liquidated damages, Conditions to Performance Guarantees, Limitations of Liability, Transfer of Ownership, Insurance, Force Majeure Conditions and Termination of the Contract.

Special Conditions of Contract (SCC)

SCC stipulate specific important terms and conditions of the Contract as explained below:

- i. Effective date: The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. The date of Letter of Acceptance will be the Effective Date for determining the Time for Completion of the facilities and other milestones for execution of the Renovation & Modernization work as per the scope of work under this tender by the Contractor. The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.
- ii. Time of Commencement and Completion: The Time Schedule for the execution of the scope of work by the Contractor and commencement of unit shut down by Owner will be specified.
- iii. Liquidated Damages: The Standard RFP envisages two types of Liquidated Damages viz. Liquidated Damage for Delay and Liquidated Damage for Non-fulfilment of Functional Guarantees.
- iv. If the Contractor fails to successfully achieve completion of R&M activities and commissioning of the retrofitted facilities as per the scope of work within the time period specified, the Contractor shall pay to the Owner amount calculated as per the specified rates as

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Liquidated Damage and not as penalty. Liquidated Damage for Delay is separately payable for two milestones:

1. Delay in completion (by Contractor) of Engineering and Supply activities and other resources mobilization that are required to be completed before unit shut down as per L-2 network.
2. Delay in Completion of all R&M activities that are to be carried out under unit shut down and subsequent commissioning activities including trial operation as per the scope of work.

The amount of Liquidated Damage for delay shall be limited to a maximum of 10 % of the total contracts price including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The aggregate amount of Liquidated Damage for non-fulfilment of functional guarantee shall be limited to a maximum of 10 % of the total contracts price including price variation as per the provisions of the contract and excluding price of Mandatory Spares.

The limit on maximum leviable Liquidated Damage for Delay and maximum leviable Liquidated Damage for non-fulfilment of functional guarantee are independent of each other and shall apply separately.

v. **Contract Securities**

- a) **Advance Payment Security:** The Contractor shall, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with validity of up to ninety (90) days beyond the date of Completion of Facilities.
- b) **Performance Security:** The Contractor shall provide a security for the due performance of the Contract for ten percent (10%) of the Contract Price with an initial validity up to ninety (90) days beyond the Defects Liability Period. If the Owner enters into the Contract with the Assignee of a foreign Contractor, the said Assignee, in addition to the Contract Performance Security to be provided by the Contractor for ten percent (10%) of the value of all the Contracts shall provide a separate Contract Performance Security equivalent to five percent (5%) of the value of Contract entered into with the assignee, for the due performance of Contract with an initial validity up Ninety (90) days beyond the Defects Liability Period. If the bidder is a joint venture of two firms who collectively meet the Qualifying Requirement, in addition to the Contract Performance Guarantee (CPG) of 10% furnished by the bidder, each of the JV partner shall furnish Additional Contract Performance Guarantee equal to 1% of

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Contract Price. If the bidder is a Consortium of two firms, in addition to the Contract Performance Guarantee (CPG) of 10% furnished by the Consortium Leader, the other consortium member will furnish Additional Contract Performance Guarantee equal to 2% of Contract Price.

- vi. The following Forms and Schedules to the Contract have been standardized:

Bid Forms and Schedules/Annexure to be submitted with Bid

1. Format of Bid Guarantee
2. Form of Part-I Bid
3. Form of Part-II Bid
4. Sample Format for Letter of Consent to be furnished by The Bidder And Associate(S) / Consortium Partners / Individual Companies of the Group
5. Sample Format
Letter Of Unequivocal Consent To Be Furnished By The Bidder and The Nominee
6. Summary Of Price Schedule
7. Price Schedule For Supply Of Plant And Equipment Including Packing And Forwarding Charges
8. Price Schedule For Mandatory Spares
9. Price Schedule For Recommended Spares
10. Price Schedule For Tools & Tackles.
11. Price Schedule For Unloading, Handling, Storage, Preservation At Site, Erection, Testing, Commissioning And Performance Guarantee Tests Of Plant And Equipment
12. Price Schedule For Civil works
13. Price Schedule For Training Charges
14. Schedule Of Performance Guarantee Parameters
15. Over All Time Schedule
16. Deviation Schedule To Tender Document Vol-I Commercial
17. Deviation Schedule To Technical Specification
18. Requirements Of The Contractor At Site
19. Contractor's Resource Deployment Schedule
20. Coefficients And Indices for Price Variation Formula

Forms and Appendices to form part of Contract

21. Form of Contract
22. Terms of Payment
23. Price Adjustment
24. Time Schedule

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Bid Forms and Schedules/Annexure to be submitted with Bid

25. List of Approved Subcontractors
26. Scope of Works and Supply by the Owner
27. Functional Guarantees
28. Formats for Contract Securities
29. Format for Contract Performance Security

7.9 Guidelines for the Goals/ Guaranteed Parameters to be achieved

Volume –II Section-I of the bidding documents contains the necessary guidelines for covering the Goals & Guaranteed Parameters to be achieved and also to be demonstrated during Performance Guarantee Acceptance Tests. It is clearly discussed in table 5.7 of chapter 5 above.

7.10 Tendering for R&M Consultant & Implementation Support Consultant

The Bidding procedure for appointment of R&M Consultant has been standardized. For hiring of Consultants, a two step process comprising Request for Qualification and Request for Proposal is recommended. For the Request for Proposal for selecting R&M Consultant and Implementation Support Consultant (ISC), a Single stage Two Envelope method has been specified since the consultants to be engaged for R&M services must be specialized in their respective fields and must have requisite experience of similar nature.

LII analyzed the following documents to study the process of hiring consultants:

1. World Bank Guideline (January 2011) for Selection and Employment of Consultants
2. KfW Guidelines for Assignment of Consultants in Financial Cooperation with developing countries.
3. Model Request for Proposal for Selection of Technical Consultants published by Planning Commission, Government of India
4. Request for Tender for Selection of Consultant for Feasibility Study for Renovation & Modernization of Unit-4 of Nasik Thermal Power Station.

The recommended Selection Criteria for R&M Consultant and Implementation Support Consultant broadly conforms to the Quality and Cost Based selection process of World Bank guidelines and Two-Stage selection process with pre-selection as per KfW Guideline. However, it is recommended that the first stage or pre-qualification stage will be Pass / No-Pass type without any limitation on number of consultants to be pre-qualified for quality and cost based competition in second stage. The evaluation criteria are in line with the Model RFP for Technical Consultants published by Planning Commission.

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Only Applicants found pre-qualified on the evaluation of qualification documents submitted in response to the RFQ will be issued RFP documents for the Consultancy work and will be eligible to submit Bid Proposal. The RFQ Documents specify the qualification criteria to be met by the prospective bidders to become eligible for participating in the tendering process. The bidders are required to submit evidence of their technical expertise, relevant past experience, competence of key personnel, project execution capability and financial resources to discharge the scope of service.

Single Stage Two Part Bidding Procedure will be followed for RFP stage.

The bidders are required to submit, the bids for the Consultancy Services in two parts. Both the parts are to be submitted together before the indicated Bid submission Time & Dates.

The Part-I Bid comprises the techno-commercial bid without prices. The main components of the Techno-Commercial Bid are Bid Guarantee, Methodology & Work Plan for discharging the consultancy services as per Terms of Reference, Details of Key Personnel along with their Curriculum Vitae, Deviations to Terms of Reference, Deviation to commercial Conditions, Overall Completion Time Period & Network Schedule, Resource Deployment Schedule, Detail of Sub-Consultants, Details of the present commitments & details of contracts in hand etc. Part-II Bid will comprise Quoted Price. Initially, only the Part-I Bid will be opened and Part-II Bid will be kept in safe custody.

The Part-I Bid will be checked for responsiveness to techno-commercial conditions and a detailed Technical Evaluation will be carried out to assign a Technical Score to each Bid. Part-II Bid (Price Bid) of only those Bidders will be opened, whose Part-I Bid is found to be responsive to Tender Specifications and Conditions and Technical Score is above a specified level.

7.11 Evaluation Criteria for Consultants (R&M Consultant and ISC)

The selection of the successful Bidder for award of the R&M Consultancy Services Contract and Implementation Support Consultancy (ISC) contract will be based on both Quality of the Technical Proposal and Price quoted by the Bidder for the entire scope of work. The selection process will comprise the following steps:

1. First, Techno-Commercial offer will be assessed for completeness and responsiveness to commercial/contractual conditions. Bidders qualifying the criteria would be considered for further evaluation on the basis of Quality and Price.
2. The Bidder's proposed methodology and Work Plan for discharging the Consultancy Assignment, experience of the Bidder and the experience &

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expertise of Key Personnel will be assigned a Technical Score 'St'. Only those Bidders whose Technical Proposals get a Technical Score of 70 marks or more out of 100 shall qualify for further consideration.

The Technical score of each Bidder will be equal to the weighted sum scores on three elements with indicated weights

$$S_t = 0.2 \times S_{t-1} + 0.4 \times S_{t-2} + 0.4 \times S_{t-3}$$

Where:

- S_t – Technical score
- S_{t-1} – should be less than or equal to 100 points, depending on the clarity, completeness, soundness of methodology and scope of work. The Bidder with the best submission will be assigned a score of 100 ($S_{t-1} = 100$). Other Bidders will be assigned scores below 100 considering the relative quality of the submission with respect to the best submission.
- S_{t-2} – should be less than or equal to 100 points, depending on the Bidders experience on the grounds of size, nature & complexity of scope and similarity with the subject R&M Consultancy Service / Implementation Support Consultancy Service for at least 5 projects.
- S_{t-3} – should be less than or equal to 100 points, depending on the experience list of at least a specified number of personnel who would be associated with the R&M Project.

- The Price Proposal of each qualified Technical Bidder will be assigned a Financial Score (S_f) on the basis of its cost competitiveness.

$$S_f = 100 \times (\text{Lowest Quoted Total Price} / \text{Total Price quoted by the Bidder})$$

- Each bidder will be assigned a Composite Score (S_c) equal to the weighted sum of Technical Score and Financial Score. Finally, the bidder with the highest Composite Score will be selected as R&M Consultant for the subject R&M Consultancy Services Contract or Implementation Support Consultancy (ISC) contract.

For selection of successful Bidder, the Technical Score will be a weight of 70% and Financial Score will be given a weight of 30%. For each Bidder, the Composite Score S_c will be computed as follows:

$$S_c = 0.7 \times S_t + 0.3 \times S_f$$

7.12 Request for Qualification for Consultants (R&M Consultant and ISC)

The RFQ document for selection of Consultants has been standardized. The Standard RFQ covers the following aspects:

- The scope of works for R&M Consultant
- The RFQ details regarding the

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- i. Participation fee
 - ii. Publication date of RFQ
 - iii. Last date for issue of RFQ document
 - iv. Last date and time for receipt of RFQ applications
 - v. Date for selection of qualified consultancy Firm
3. Qualification Requirement
 4. List of Qualification Document
 5. Instruction to Applicants
 6. Standard Application Forms and Data Sheets

The following Forms and Data Sheets have been standardized

- a. Format for the Pre – qualification Application
- b. Letter of Consent to be Furnished by the Associate
- c. Letter of Consent to be Furnished by the Consortium Partners
- d. Sample format for Data sheet regarding Technical Qualification Requirement
- e. Sample format for Data sheet regarding Financial Qualification Requirement

Qualification Requirement for Consultants (R&M Consultant and ISC)

The Technical Qualification Requirement and Financial Qualification Requirements have been standardized.

- i. **Technical Qualification Requirement** – The RFQ document for Consultants specifies that the Applicant should be an engineering consultancy firm with experience in specified technical consultancy assignments pertaining to at least two 200/210 MW or above unit and at least one technical consultancy assignment for Renovation and Modernization of coal/lignite fired thermal power plant of 50 MW or above capacity

ii. Financial Qualification Requirement

The Financial Qualification for consultant primarily covers the following:

- (a) The average annual turnover of the applicant should be more than a specified value as per audited annual accounts during the preceding three consecutive years. The annual turnover requirement is specified based on the likely contract value.
- (b) The Net Worth of the Bidder as on the last date of preceding Financial Year should be positive.

iii. Other Criteria

Any entity that is legally barred from participation in Consultancy assignments of the concerned utility on the grounds of previous violations of rules/regulations on fraud and corruption or any other

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reason cannot participate as an applicant or associate or consortium member for this R&M Consultancy Tender.

Any firm or its associate company cannot participate as Applicant or Associate or Consortium Member for more than one RFQ application under this Consultancy Tender

The Applicant, meeting the Qualifying Requirement on the strength of Associate(s) or as a Consortium, should enclose the Letter(s) of Association (as per the prescribed format) from the Associate(s)/ Consortium signed by the Associate(s)/ Consortium Partners indicating the scope of work along with the Pre – Qualification Application.

The Pre – Qualification Bids received from the bidders would be opened on a pre decided date, time and venue mentioned in the RFQ document.

Prequalification Document

The pre-qualification documents requirement for consultants has been standardized. These include the following:

- (i) List of orders executed by them, their Consortium Partners / Associates along with copies of orders to prove their qualifications.
- (ii) Past Performance Certificates from the previous employers in respect of such completed consultancy assignment(s) clearly indicating scope of and date of completion for each assignment.
- (iii) Names of proposed Associates or Consortium member if any, along with Letters of Consent from each Associate / Consortium Partner.
- (iv) Particulars of Key Personnel that must include inter alia their names, details regarding qualification, areas of expertise, professional experience and names of relevant projects.
- (v) Documents of company profile incorporating details of technical man power, financial strength, resources, organization and experience to undertake such jobs as an evidence of their capacity for the satisfaction of Employer.
- (vi) Firm's audited accounts for last three (3) years along with a copy of latest income tax return filed.
- (vii) Consultancy Assignments in hand / pending jobs and their status along with value.
- (viii) Pending legal cases, if any.

7.13 Request for Proposal for Consultants (R&M Consultant & ISC)

The Standard Request for Proposal for consultants comprises the sections as indicated in the Table below:

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Table: 7.4
Structure of Request for Proposal for Consultants

Section	Description
Section-I	Commercial <ol style="list-style-type: none"> 1. Invitation For Bid 2. Instruction to Bidder 3. General Project Information 4. General Condition of Contract (GCC) 5. Special Condition of Contract (SCC) 6. Forms and Schedules
Section-II	Terms of Reference

General Conditions of Contract (GCC)

The GCC contains the Contracting Concept, the scope of the Contractor, the precedence of the Contract Documents, definitions and Acronyms used in the Contract Document, the severability of the Contract, the governing laws to the Contract, methods for settlement of disputes, Time of commencement and completion of the contract, Contractor's Responsibilities, Owner's Responsibilities, Taxes and Duties applicable, Confidential Clause. It also covers the Defect Liabilities, Completion Time and Liquidated damages, Conditions to Performance Guarantees, Limitations of Liability, Transfer of Ownership, Insurance, Force Majeure Conditions and Termination of the Contract.

Special Conditions of Contract (SCC)

- Effective date: The Owner shall inform the successful Bidder of its acceptance of the Tender by a formal Letter of Acceptance. The date of this Letter of Acceptance will be the Effective Date for determining the Time for Completion of the milestones for Consultancy work as per the scope of work. The Owner will make the advance payment promptly once Contractor has fulfilled the necessary conditions specified in Terms of Payment. If payment of Advance is delayed beyond two months from the date of Letter of acceptance for reasons attributable to the Owner, the date of payment of advance shall be the effective date for determining the time for completion of facilities. However, failure of the contractor to provide all the required Bonds/Guarantees within the prescribed period will cause the Bid Security to be forfeited.
- Time of Commencement and Completion: The Time Schedule for the execution of the scope of work by the Consultant is to be specified.
- Liquidated Damages: The Standard RFP envisages Liquidated Damage for Delay in achievement of milestones of consultancy work. The amount of Liquidated Damage for delay shall be limited to a maximum

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of 10 % of the total contracts price including price adjustment as per the provisions of the contract

iv. Contract Securities

- a) Advance Payment Security: The Contractor shall, provide a security for an amount equal to the advance payment, and in the same currency or currencies, with validity of up to ninety (90) days beyond the date of the Scheduled Completion Date for R&M Consultancy Services.
- b) Performance Security: The Contractor shall provide a security for the due performance of the Contract for five percent (5%) of the Contract Price with an initial validity up to ninety (90) days beyond the the Scheduled Completion Date for R&M Consultancy Services.

The following forms and schedules have been standardized:

Table: 7.5
Documents to be submitted with the Bids

Title	Bid Forms and Schedules/Annexure to be submitted with Bid
Annexure-A	Format of Bid Guarantee
Annexure-B	Form of Part-I Bid
Annexure-C	Form of Part-II Bid
Annexure-D	Not Used
Schedule F1	Price Schedule
Schedule F2	Overall Time Schedule
Schedule F3	Deviation Schedule to Tender Document Section-I Commercial
Schedule F4	Deviation Schedule to Terms of Reference
Schedule F5	Details of Key Personnel
Schedule F6	Format for Curriculum Vitae (CV) of Key Personnel
II	Forms and Contract Schedules to form part of Contract
Annexure-F	Form of Contract
Contract Schedule-1	Terms of Payment
Contract Schedule-2	Price Adjustment
Contract Schedule-3	Time Schedule
Contract Schedule-4	List of Sub-Consultants

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Title	Bid Forms and Schedules/Annexure to be submitted with Bid
Contract Schedule-5	List of Key Personnel
III	Formats for Contract Securities
Annexure-G	Format for Contract Performance Security

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8 ROLE OF CONSULTANTS IN R&M PROJECTS

8.1 Need of Consultants

Renovation and Modernization of old Thermal Power Projects involves in-depth study of the power plant equipment, assessment of their health condition, identification of the root causes of the equipments for deficit performance, determination of the residual life of critical components, auditing of auxiliary power consumption of various equipments, finding solutions to various operational problems in terms of Run/ Retrofit/ Replacement options etc. This requires special knowledge, skill and experience which is normally not available with the Operating and Maintenance Engineers of the Power plants. Power plants therefore require the services of consultants who are specialized in the field of conducting various investigative studies and can deliver the services of this nature.

Support of consultants is also needed to review the design and engineering work done by the R&M Contractors, to monitor the progress of R&M works at the site and to evaluate the results of the Performance Guarantee Tests etc. The job of site supervision requires adequate experience of erection and construction activities which is not always available with O&M engineers of the power plants.

8.2 Different Categories of Consultants

Two types of Consultants have been suggested namely, 'R&M Consultants' and 'Implementation Support Consultants'(ISC). The consultancy work is initiated by the R&M Consultant who does all the investigative studies like RLA/CA and EA studies, provides the solutions to various operating problems in the form of formulation of R&M options, selects the most attractive R&M option to be implemented, prepares the DPR (Detailed Project Report), assists the utility in getting the approval of appropriate Regulatory Commission, prepares the Bidding Documents as well as appointment of R&M Contractor(s). Implementation of R&M works is finally done with the help of Implementation Support Consultant (ISC).

8.3 Single R&M Consultant up to approval from Regulatory Commission

LII reviewed this aspect and arrived at the considered opinion that a single R&M Consultant should be appointed for carrying out the investigative studies such as RLA, CA, Energy Audit etc., Preparation of DPR, facilitating approval from regulatory agency, preparation of technical specification and bidding documents and finalizing the contract for R&M Contractor(s). Standard Documents containing Qualifying Requirements and Bidding Documents for the selection of R&M Consultants have been developed accordingly.

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The scope of work for the R&M Consultant has been bifurcated in two phases. Phase-I covers investigative studies, preparation of FR, DPR and obtaining the approval of regulatory agencies. Phase-II will start only if required after the approval of regulatory agencies. Phase-II covers preparation of bidding documents and bid evaluation till the selection of R&M Contractor(s).

LII noted that during the implementation of many R&M Projects, various studies such as RLA, CA, Energy Audit etc. and preparation of DPR was done by one consultant and the preparation of technical specification for bidding by another consultant. In certain cases, it is quite likely that studies carried out by the first consultant are not accepted by the second consultant. Appointment of a single R&M Consultant will therefore solve this problem.

Appointment of a single R&M Consultant will also reduce the time gap between the completion of studies and the start of R&M works, which is one of the main reasons contributing to huge risk of technical surprises. LII noted that after the completion of investigative studies the process of appointing the R&M Contractor took three years and five months in case of Baruni TPS (110MW) and in other cases even more (Refer Table 9-1). From the data provided by CEA on Procurement, it is inferred that for Bandel Unit-5 (210 MW) of WBPDC, the time gap between the completion of RLA studies and placement of order to M/s Doosan for R&M works was more than 5 (five) years (December 2006 to 29.02.2012) and that in case of Koradi Unit-6 (210 MW) of MAHAGENCO, the time gap between the ordering of RLA studies and the ordering of R&M works contract to BHEL was also more than 5 (five) years (01.03.2008 to June 2013)

Table: 8-1
Time Gap between Studies and Execution of Works

Plant (Unit)	Completion of RLA study	Actual Date of Start of Work	Time Gap
Bathinda Unit 3 (110 MW), PSPCL	March 2001	January 2010	8 yrs 10 months
Bathinda Unit 4 (110 MW), PSPCL	December 2001	November 2011	10 yrs 11 months
Ukai TPS, Unit 2 (120 MW), GSECL	April 2003	August 2008	5 yrs 4 months
Barauni TPS, Unit 6 (110 MW), BSEB	May 2006	November 2009	3 yrs 5 months
Bandel TPS, Unit 5 (210 MW), WBPDC	January 2005	February 2012	7 yrs 1 month

Source* *Mercados Report on Developing Markets*

Once the decision is taken for the R&M intervention of the plant, there is a normal tendency to give it low maintenance priority. If the execution of R&M

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works is delayed, further deterioration takes place with the passage of time, which is not captured in the studies. As a result of this, when the plant is opened up for renovation, a lot of technical surprises spring up leading to increase in the scope of work requiring contractual settlements and resulting into consequential delay in completion of works.

In view of the above, it is therefore essential that the scope of single R&M consultant should cover the total responsibility starting from the investigative studies till the bid evaluation for the selection of R&M Contractor. This will minimize the time gap between the completion of studies and the start of R&M works.

8.4 Roles and Responsibilities of Consultants

The Roles and Responsibilities of R&M Consultants and Implementation Support Consultants are discussed below:

8.4.1 Role of R&M Consultant

The consultant to be selected for the role of R&M Consultant should have requisite experience of conducting the plant studies as well as for the preparation and evaluation of bidding documents. Role of R&M Consultant consists of the following activities:

Phase-I

- Conducting of Cold Walk-down and Hot Walk-down Survey.
- Review of the operational history of the power plant.
- Discussion with the Plant Engineers.
- Carrying out of technical studies namely, the Residual Life Assessment (RLA) and Condition assessment (CA) of BTG and BOP of the power plant.
- Carrying out Energy Audit of BTG and BOP to identify the reasons and sources of excess power consumption.
- Reviewing the results of studies mentioned at v) & vi) above.
- Identification of the equipments needing retrofitting / replacement.
- Studying the variations in the present quality of coal from the quality considered at the time of original design of the plant.
- Studying the average quality of coal likely to be available during the next twenty years.
- Studying the latest environment standards prescribed by the regulating agencies at the national and state level.
- Formulating alternative options including the cost impact for the refurbishment / replacement of specific plant equipments for enhancing their performance and extending their life.

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- Preparing a matrix of R&M options for the plant as a whole for extending the useful life by minimum 20 years by either restoring the performance parameters to the original level or for achieving better parameters than the original design.
- Carrying out detailed economic evaluation of each of the R&M options proposed in the matrix.
- Discussions with Plant Management.
- Selection of R&M option to be implemented.
- Finalizing the scope of R&M Works.
- Preparation of Detailed Project Report.
- Obtaining approval from appropriate Regulatory Commission.

Phase-II

- Preparation of Bidding Documents for the appointment of R&M Contractors.
- Evaluation of Bids of R&M Contractors.

8.4.2 Role of Implementation Support Consultant

The consultant to be selected for supporting the utilities for implementing the R&M works should have adequate experience of executing the consultancy projects of similar nature. The role of the Implementation Support Consultant consists of the following activities:

- Reviewing of design documents & drawings of the R&M contractors to ensure compliance of scope of works.
- Site supervision and monitoring the progress of works.
- Checking the quality of construction and erection.
- Holding review meetings with the contractor(s).
- Coordination between the Plant head and the R&M Contractor.
- Shop Testing at supplier's works and inspection at site.
- Supervising the commissioning activities.
- Witnessing and evaluation of Performance Guarantee Tests.

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9 SERVICES RENDERED

9.1 Services Rendered as per the Scope of Work

The following documents have been submitted by LII as per 'Scope of the Consulting Services' mentioned at Clause 6.0 of the Terms of Reference of the Contract:

**Table: 9.1
List of Documents Prepared**

S. No.	Title of Documents
1.	Model Feasibility Report
2.	Model RLA/CA Report
3.	Model Detailed Project Report
4.	Model Energy Audit Report
5.	Model Tendering Procedure
6.	Model RFQ and Model RFP documents for the following Six (6) numbers of R&M Contract Packages. i) Boiler & Auxiliaries. ii) Turbo-Generator & Auxiliaries. iii) Coal Handling Plant. iv) Ash Handling System. v) Mechanical Balance of Plant. vi) Electrical Balance of Plant.
7.	Model RFQ and Model RFP documents for R&M Consultant and Implementation Support Consultant (ISC).
8.	Report on Phase-II Activity

The detailed list of documents prepared by Lahmeyer is attached at Annexure-1.

9.2 Services Rendered beyond the scope of Work

On the suggestion & advice of CEA, the following services which are beyond the contractual scope of work were rendered by Lahmeyer, the Consultant, without charging additional fee.

1. Preparation of the Guidelines for conducting the following studies for the health assessment of critical power plant equipments:

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- a) Guidelines for conducting the Residual Life Assessment.
- b) Guidelines for conducting the Energy Audit.
2. Preparation of the following RFQ and RFP Documents.
 - a) RFQ Documents for ISC (Implementation Support Consultant).
 - b) RFP Documents for ISC (Implementation Support Consultant).

9.3 Problems Faced In Execution of Assignment

As per the contract, the development of Standard Documents by the LII was to be closely linked with the tender documents developed for the R&M programme for KfW funded Project of Nashik TPS Unit-3. According to the original plan LII was required to visit the above plant in July 2012, have discussions with MAHAGENCO and utilize the documents developed for Nashik TPS Unit-3 while standardizing the various documents and procedures. Subsequently, CEA and KfW had advised LII to visit Nasik TPP towards the end of September 2012, since NIT for selection of R&M contractor was expected to be issued during September 2012 after the receipt of 'NOC' from KfW. However, the proposed visit to Nashik TPS could not be made as planned, since, the NIT for selection of R&M Contractor could not be issued by MAHAGENCO.

During the meeting held in CEA on 8th January 2013, it was decided to plan the visit to MAHAGENCO and Nashik TPS Unit-3 in February 2013. Since the issue of NIT for selection of R&M Contractor Nashik TPS Unit-3 was deferred, it was decided that documents issued by MAHAGENCO for the World Bank funded Project Koradi Unit-6 would be collected and studied. The visit to MAHAGENCO could actually be made in April 2013 as against July 2012 originally planned.

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10 RECOMMENDATIONS

The following procedures are recommended for executing the R&M works:

1. Before deciding the scope of R&M works, the utilities have to determine the status of health of equipments of various systems as also their residual life by carrying out various Residual Life Assessment (RLA) / Condition Assessment (CA) studies and Energy Audit studies. Depending upon the review of the past performance and results of above studies, decision is required to be taken whether to run, retrofit or replace each of the critical equipments.
2. A single R&M Consultant should be appointed for carrying out the investigative studies such as RLA, CA, Energy Audit etc., preparing feasibility report & detailed project report, facilitating approval from regulatory agency, preparing technical specification for bidding documents and finalizing the R&M contract. Appointment of a single R&M Consultant will reduce the time gap between the investigative studies and the selection of R&M Contractor.
3. After the completion of investigative studies, a matrix of possibilities and options for carrying out R&M solutions should be evaluated in order to choose the most feasible and economic option of R&M to be implemented. Table 5.3 of this report may be referred for considering the matrix of such options.
4. Keeping in view the complexities involved with various contract packages and for having adequate number of eligible and willing bidders with relevant expertise and experience to carry out the R&M works under a package, it is recommended that multiple R&M contracts should be awarded for a maximum of six packages as mentioned below.
 - Boiler & Auxiliaries.
 - Turbo-Generator & Auxiliaries.
 - Coal Handling Plant.
 - Ash Handling System.
 - Mechanical Balance of Plant.
 - Electrical Balance of Plant.
5. It is advisable to engage the services of an Implementation Support Consultant (ISC) for supporting the utilities for implementing the R&M works through site supervision, monitoring the progress of works, checking the quality of construction & erection, supervising

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the commissioning activities and witnessing and evaluation of Performance Guarantee Tests.

6. To facilitate the engagement of Consultants and R&M Works Contractors in a planned, systematic and time bound manner, a two step process comprising Request for Qualification (RFQ) and Request for Proposal (RFP) is recommended. Pre-qualification is recommended to ensure that the interested bidders are capable of properly delivering as per the contractual scope of work. The capability of the bidders is assessed on the basis of qualification documents submitted as part of the pre-qualification exercise. Only such bidders who are found qualified in the pre-qualification stage are issued the tender documents and are allowed to submit the bid for the R&M work.
7. Considering the complexities of R&M Projects, it is recommended to invite the bids in two parts, Part-I (Techno-commercial Bids) and Part-II (Price Bids) in single stage (Single stage two envelope method). This tendering method has the advantage that the evaluation of techno-commercial bid and techno-commercial discussion is carried out without any influence of price quotes. The price-bid of techno-commercially non-responsive bid is not opened at all.

The rationale behind inviting Part-II along with Part-I is that bidders will make their quotes before the number of responsive techno commercial bids is known. This will encourage competitive price quotes. However in case a bidder is asked to make changes in its techno commercial offer that may have price implications, that bidder may be allowed to submit supplementary price against such changes before opening of Part-II bids (Price Bids).

8. Since the scope of work of the R&M Consultant makes him responsible for preparing the bidding documents for R&M Contractors and also to assist the utilities in bid evaluation for the appointment of R&M Contractors, the above two provisions will reduce the time gap between the completion of R&M studies and execution of R&M works thereby minimizing the technical surprises during execution. In case, some technical surprises are encountered during the course of execution of the R&M works, a change order should be issued by the owner after studying the need of change in scope, pursuant to the proposal received from the R&M Contractor.

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9. Based on the quantum of work involved for completing the R&M Projects, a reasonable time of 49 months to 57 months is recommended. Table 6.1 of this document may be referred, wherein; the indicative timelines for completing the various processes have been mentioned.
10. Performance Guarantee Test should be conducted as earlier as possible after the unit gets stabilized after re-commissioning. A maximum time gap of three (3) months for the completion of Performance Guarantee test of the BTG (Boiler, Turbine, Generator) as also any of the BOPs (Balance of Plant) is recommended since after this period some OEMs (Original Equipment Manufacturers) normally insist on the application of correction factors (due to deterioration) on the test results. Provision of Liquidated Damages (LDs) has been made in the Model Contracts to deal with the aspects of 'delay in completion of R&M works' as well as 'shortfall in performance parameters' demonstrated during Performance Guarantee Test.

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Annexure-1

List of Documents Prepared by Lahmeyer for R&M of Thermal Power Plants

S.No.	Title of Document	Document Number
1	Model Feasibility Report	LII -GETS12021-G-00100-002 Rev.R05 dt. January 2016
2	Model Residual Life Assessment / Condition Assessment Report	LII -GETS12021-G-00100-003 Rev.R04 dt. September 2014
3	Model Detailed Project Report	LII -GETS12021-G-00100-004 Rev.R04 dt. September 2014
4	Model Energy Audit Report	LII -GETS12021-G-00100-005 Rev.R02 dt. September 2013
5	Model Tendering Procedure for selection of R & M Contractor and Consultants	LII-GETS12021-G-00119-006 Rev.R01 dt. September 2014
6	Model Request for Qualification (RFQ) for Boiler & Aux., Package	LII-GETS12021-G-00100-006 Rev.R02 dt. September 2014
7	Model Request for Qualification (RFQ) for TG & Aux., Package	LII-GETS12021-G-00100-007 Rev.R02 dt. September 2014
8	Model Request for Qualification (RFQ) for Coal Handling Plant	LII-GETS12021-G-00100-008 Rev.R01 dt. September 2014
9	Model Request for Qualification (RFQ) for Ash Handling Plant	LII-GETS12021-G-00100-009 Rev.R01 dt. September 2014
10	Model Request for Qualification (RFQ) for Balance of Plant (Mechanical)	LII-GETS12021-G-00100-010 Rev.R01 dt. September 2014
11	Model Request for	LII-GETS12021-G-00100-011 Rev.R01 dt.

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S.No.	Title of Document	Document Number
	Qualification (RFQ) for Electrical Balance of Plant	September 2014
12	Model Request for Qualification (RFQ) for R & M Consultant	LII-GETS12021-G-00100-012 Rev.R01 dt. September 2014
13	Model Request for Qualification (RFQ) for Implementation Support Consultant (ISC)	LII-GETS12021-G-00100-013 Rev.R01 dt. September 2014
14	Model Tender Document (RFP) for selection of R&M Consultant	LII-GETS12021-G-00129-007 Rev R01 dt. September 2014
15	Model Tender Document (RFP) for selection of Implementation Support Consultant	LII-GETS12021-G-00129-008 Rev R01 dt. September 2014
16	Model Tender Document for Boiler & Aux., (Package -1) Vol 1 - Commercial, with Annexures & Schedules 1 to 3	LII-GETS12021-G-00129-001 Rev R03 dt. September 2015
17	Model Tender Document for Boiler & Aux., (Package -1) Vol- II, Section- I, Project Technical Specification, with Annexures- I to III	LII-GETS12021-G-00129-001 Rev R04 dt. January 2016
18	Model Tender Document for Boiler & Aux., (Package -1) Vol-II, Section-II, Detailed Technical Specifications, Part -A (Mechanical)	LII-GETS12021-G-00129-001 Rev R04 dt. January 2016
19	Model Tender Document for Boiler & Aux., (Package -1) Vol- II, Section- II, Detailed Technical Specifications,	LII-GETS12021-G-00129-001 Rev R02 dt. September 2014

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S.No.	Title of Document	Document Number
	Part- B (Electrical)	
20	Model Tender Document for Boiler & Aux., (Package -1) Vol- II, Section- II, Detailed Technical Specifications, Part -C (I&C)	LII-GETS12021-G-00129-001 Rev R03 dt. September 2015
21	Model Tender Document for Boiler & Aux., (Package -1) Vol-II, Section II, Detailed Technical Specifications, Part-D (Civil)	LII-GETS12021-G-00129-001 Rev R02 dt. September 2014
22	Model Tender Document for Boiler & Aux., (Package -1) Vol-II, Section-II, Detailed Technical Specifications, Part- A, Annexure M1 (CFBC Boiler)	LII-GETS12021-G-00129-001 Rev R04 dt. January 2016
23	Model Tender Document for Boiler & Aux., (Package -1) Vol- III- Technical Schedules, Part-A (Mechanical)	LII-GETS12021-G-00129-001 Rev R04 dt. January 2016
24	Model Tender Document for Boiler & Aux., (Package -1) Vol- III -Technical Schedules, Part-B (Electrical)	LII-GETS12021-G-00129-001 Rev R02 dt. September 2014
25	Model Tender Document for Boiler & Aux., (Package -1) Vol III- Technical Schedules Part-C (I&C)	LII-GETS12021-G-00129-001 Rev R02 dt. September 2014
26	Model Tender Documents for Turbine & Aux., (Package -2) Vol-I-	LII-GETS12021-G-00129-002 Rev R02 dt. September 2015

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S.No.	Title of Document	Document Number
	Commercial, with Annexure & Schedules 1 to 3	
27	Model Tender Documents for Turbine & Aux., (Package -2) Vol-II, Section-I, Project Technical Specification with Annexure I to III	LII-GETS12021-G-00129-002 Rev R03 dt. January 2015
28	Model Tender Documents for Turbine & Aux., (Package -2) Vol- II, Section- II, Detailed Technical Specifications, Part- A (Mechanical)	LII-GETS12021-G-00129-002 Rev R03 dt. January 2016
29	Model Tender Documents for Turbine & Aux., (Package -2) Vol-II, Section-II, Detailed Technical Specifications, Part- B (Electrical)	LII-GETS12021-G-00129-002 Rev R01 dt. September 2014
30	Model Tender Documents for Turbine & Aux., (Package -2) Vol-II, Section-II, Detailed Technical Specifications, Part- C (I&C)	LII-G-00129-002 Rev R02 dt. September 2015
31	Model Tender Documents for Turbine & Aux., (Package -2) Vol- II, Section- II, Detailed Technical Specifications, Part-D (Civil)	LII-GETS12021-G-00129-002 Rev R01 dt. September 2014
32	Model Tender Documents for Turbine & Aux. (Package -2), Vol- III-Technical Schedules, Part- A	LII-GETS12021-G-00129-002 Rev R03 dt. January 2016

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S.No.	Title of Document	Document Number
	(Mechanical)	
33	Model Tender Documents for Turbine & Aux. (Package -2) Vol- III, Technical Schedules, Part -B (Electrical)	LII-GETS12021-G-00129-002 Rev R01 dt. September 2014
34	Model Tender Documents for Turbine & Aux. (Package -2) Vol- III- Technical Schedules, Part- C (I&C)	LII-GETS12021-G-00129-002 Rev R01 dt. September 2014
35	Model Tender Documents for Balance of Plant - Mechanical, (Package -3), Vol- I-Commercial, with Annexures & Schedules -1 to 3	LII-GETS12021-G-00129-003 Rev R01 dt. September 2014
36	Model Tender Documents for Balance of Plant- Mechanical (Package -3) Vol- II, Section -I, Project Technical Specification with Annexures I to III.	LII-GETS12021-G-00129-003 Rev R02 dt. September 2015
37	Model Tender Documents for Balance of Plant - Mechanical (Package -3) Vol II, Section II, Detailed Technical Specification- Part -A (Mechanical)	LII-GETS12021-G-00129-003 Rev R03 dt. January 2016
38	Model Tender Documents for Balance of Plant- Mechanical (Package -3) Vol-II, Section -II, Detailed Technical Specification, Part- B (Electrical)	LII-GETS12021-G-00129-003 Rev R01 dt. September 2014

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S.No.	Title of Document	Document Number
39	Model Tender Documents for Balance of plant Mechanical (Package -3) Vol- II, Section II, Detailed Technical Specification- Part C (I &C)	LII-GETS12021-G-00129-003 Rev R02 dt. September 2015
40	Model Tender Documents for Balance of Plant- Mechanical (Package -3) Vol -II, Section -II, Detailed Technical Specification, Part D (Civil)	LII-GETS12021-G-00129-003 Rev R01 dt. September 2014
41	Model Tender Documents for Balance of Plant - Mechanical (Package -3) Vol III, Technical Schedules -Part A (Mechanical)	LII-GETS12021-G-00129-003 Rev R03 dt. January 2016
42	Model Tender Documents for Balance of Plant - Mechanical (Package -3) Vol III, Technical Schedules- Part B (Electrical)	LII-GETS12021-G-00129-003 Rev R01 dt. September 2014
43	Model Tender Documents for Balance of Plant - Mechanical (Package -3) Vol- III, Technical Schedules- Part C (Civil)	LII-GETS12021-G-00129-003 Rev R01 dt. September 2014
44	Model Tender Documents for Coal Handling Plant (Package 4) Vol I- Commercial, with Annexures & Schedules 1 to 3	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014
45	Model Tender Documents for Coal Handling Plant (Package 4) Vol- II, Section I, Project Technical	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014

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S.No.	Title of Document	Document Number
	Specification with Annexures I to III	
46	Model Tender Documents for Coal Handling Plant (Package 4) Vol- II, Section-II, Detailed Technical Specification - Part A (Mechanical)	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014
47	Model Tender Documents for Coal Handling Plant (Package 4) Vol- II, Section-II, Detailed Technical Specification - Part B (Electrical)	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014
48	Model Tender Documents for Coal Handling Plant (Package 4) Vol-II, Section II, Detailed Technical Specification, Part-C (I & C)	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014
49	Model Tender Documents for Coal Handling Plant (Package 4), Vol- II, Section- II, Detailed Technical Specification - Part- D (Civil)	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014
50	Model Tender Documents for Coal Handling Plant (Package 4) Vol III, Technical Schedules - Part A (Mechanical)	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014
51	Model Tender Documents for Coal Handling Plant (Package 4) Vol- III, Technical Schedules -Part B (Electrical)	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014

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S.No.	Title of Document	Document Number
52	Model Tender Documents for Coal Handling Plant (Package 4) Vol III, Technical Schedules- Part C (I&C)	LII -GETS12021-G-00129-004 Rev.R01 dt. September 2014
53	Model Tender Documents for Ash Handling System (Package 5), Vol-I - Commercial, with Annexures & Schedules 1 to 3	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
54	Model Tender Documents for Ash Handling System (Package 5) Vol.- II Section- I, Project Technical Specification with Annexures I to III	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
55	Model Tender Documents for Ash Handling System (Package 5) Vol.- II, Section II, Detailed Technical Specifications, Part A (Mechanical)	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
56	Model Tender Documents for Ash Handling System (Package 5) Vol. II Section II, Detailed Technical Specifications, Part B (Electrical)	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
57	Model Tender Documents for Ash Handling System (Package 5) Vol. II Section II, Detailed Technical Specifications, Part C (I&C)	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
58	Model Tender Documents for Ash Handling System (Package 5) Vol. II Section	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014

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S.No.	Title of Document	Document Number
	II Detailed Technical Specifications, Part- D (Civil)	
59	Model Tender Documents for Ash Handling System (Package 5), Vol- III, Technical Schedules, Part A (Mechanical)	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
60	Model Tender Documents for Ash Handling System (Package 5) Vol.- III, Technical Schedules , Part B (Electrical)	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
61	Model Tender Documents for Ash Handling System (Package 5) Vol. III, Technical Schedules -Part C (I&C)	LII -GETS12021-G-00129-005 Rev.R01 dt. September 2014
62	Model Tender Documents for Electrical Balance of Plant (Package 6) Vol.- I - Commercial, with Annexures & Schedules 1 to 3	LII -GETS12021-G-00129-006 Rev.R01 dt. September 2014
63	Model Tender Documents for Electrical Balance of Plant (Package 6) Vol.- II, Section- I, Project Technical Specification with Annexures I to III	LII -GETS12021-G-00129-006 Rev.R01 dt. September 2014
64	Model Tender Documents for Electrical Balance of Plant (Package 6), Vol.- II, Section- II, Detailed Technical Specification - Part B (Electrical)	LII -GETS12021-G-00129-006 Rev.R01 dt. September 2014

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S.No.	Title of Document	Document Number
65	Model Tender Documents for Electrical Balance of Plant (Package 6), Vol.- II Section- II, Detailed Technical Specification -Part C (I &C)	LII -GETS12021-G-00129-006 Rev.R02 dt. September 2015
66	Model Tender Documents for Electrical Balance of Plant (Package 6) Vol.-II, Section- II, Detailed Technical Specification-Part D (Civil)	LII -GETS12021-G-00129-006 Rev.R01 dt. September 2014
67	Model Tender Documents for Electrical Balance of Plant (Package 6) Vol. III, Technical Schedules, Part B (Electrical)	LII -GETS12021-G-00129-006 Rev.R01 dt. September 2014
68	Model Tender Documents for Electrical Balance of Plant (Package 6) Vol. III, Technical Schedules, Part-C (I&C)	LII -GETS12021-G-00129-006 Rev.R02 dt. September 2015
69	Report on Phase-II Activity	LII -GETS12021-G-00100-001 Rev.R01 dt. September 2014

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